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The effect of childhood conduct disorder on human capital

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Abstract in English

This paper estimates the longer-term effects of childhood conduct disorder on human capital accumulation and violent and criminal behaviour later in life using data of Australian twins. We measure conduct disorder with a rich set of indicators based on diagnostic criteria from psychiatry (e.g., aggression to people and animals, destruction of property, deceitfulness or theft, and/or serious violations of rules). Using ordinary least squares (OLS) and twin fixed effects (FE) estimation approaches, we find that early (pre-18) conduct disorder problems significantly affect both human capital accumulation and violent and criminal behaviour over the life course. For instance, within pairs of identical twins we find that conduct disorder reduces the probability of high school graduation with 4 to 13 percent points and increases the probability of being arrested with 7 to 16 percent points. Robustness checks suggest that these estimates may be lower bounds of the true effects of conduct disorder. In addition, we find that conduct disorder is more deleterious if these behaviours occur earlier in life. We conclude that childhood mental health problems have high human and financial costs for families and society at large. Effective treatments early in life might yield high returns.

Key words: conduct disorder, human capital, twins

JEL code: I2, K42

Abstract in Dutch

Deze studie onderzoekt de lange-termijneffecten van antisociale gedragsstoornis op jonge leeftijd. Aan de hand van gegevens van Australische tweelingen is gekeken naar het effect op het verwerven van menselijk kapitaal en op agressief en crimineel gedrag. Antisociale gedragsstoornis is gemeten met een indicatorenlijst die is gebaseerd op diagnostische criteria uit de psychiatrie. Antisociale gedragsstoornis blijkt een sterk effect te hebben op zowel het verwerven van menselijk kapitaal als op agressief en crimineel gedrag gedurende het leven. Antisociale gedragsstoornis vermindert de kans op het halen van een diploma van het voortgezet onderwijs (high school) met 4 tot 13 procentpunt binnen paren van eeneiige tweelingen en verhoogt de kans om ooit gearresteerd te worden met 7 tot 16 procentpunt. Ook is gevonden dat de effecten sterker zijn naarmate antisociale gedragsstoornis zich manifesteert op jongere leeftijd. De conclusie van deze studie is dat antisociale gedragsstoornis grote menselijke en financiële kosten genereert voor zowel het individu als de samenleving. Een effectieve behandeling op jonge leeftijd kan hoge opbrengsten geven.

Steekwoorden: menselijk kapitaal, antisociale gedragsstoornis, criminaliteit

Contents

Summary	7
1 Introduction	9
2 Previous studies	13
3 Data	17
4 Methodology	25
5 Main estimation results	27
5.1 The effect of three measures of conduct disorder on human capital	27
5.2 The effect of the timing of conduct disorder behaviours	30
6 Robustness checks	33
7 Conclusions	37
References	39

Summary

In this paper, we examine the relationship between conduct disorder problems before the age of 18 and human capital accumulation. We use three measures of conduct disorder: a 'conduct disorder score' based on 21 statements about behaviour problems, the APA definition (did you do at least three of these behaviours within 12 months) and an indicator of 'professional help' because of conduct disorder. We estimated the effect of conduct disorder on 6 measures of positive human capital and 6 measures of negative human capital. The estimates suggest that conduct disorder has a strong negative effect on positive human capital. We find large effects on grade retention and high school graduation, even within pairs of identical twins. The estimates also show a large effect of conduct disorder on negative human capital. Conduct disorder behaviours have a strong effect on violent and criminal behaviour since the age of 18. We also found that the effect of conduct disorder on human capital is more deleterious if these behaviours occur earlier in life.

Various robustness checks suggest that these estimates may be lower bounds of the true effect of conduct disorder on human capital. For instance, due to the routing of our survey twins with a conduct disorder score of zero did not answer most questions on negative human capital. The size of the estimates increases if we impute that these twins did not accumulate negative human capital. In addition, we found evidence for spill-over effects of conduct disorder within pairs of twins. These spill-over effects will bias downward the size of the within twin estimates. It should also be noted that our estimates might be biased towards zero because of measurement error in conduct disorder. The within-estimator exacerbates measured error which is likely to bias the estimates towards zero (Grilliches, 1979). Unfortunately, our data do not provide a second independent measure of conduct disorder that can be used as an instrumental variable and might solve the problem of measurement error (Ashenfelter, et al. 1994).

An important and well-known concern with our findings is that unobserved heterogeneity within twin pairs is biasing the results. For instance, one of the twins might be more able than the other twin and this unobserved ability may be correlated with conduct disorder. Unobserved heterogeneity might also come from differences within twins pairs in the treatment of parents. In this paper we addressed this issue by controlling for differences in birth weight within pairs of twins. In addition, we did a robustness check by excluding pairs of twins with large differences in educational attainment, as these twins might have major differences. These robustness checks did not change our main findings.

Previous research (Currie & Stabile, 2006, 2007; Fletcher & Wolfe, 2007) found that conduct disorder before the age of 18 can have large deleterious longer-term effects on positive and negative human capital. Our findings, which are based on a much richer set of indicators of conduct disorder and on data of twins instead of data of siblings, corroborate these results. Le et al. (2005), who used the same data, also investigated the effect of the conduct disorder score on one measure of human capital (high school graduation). For the sample of identical twins they

find that the estimated effect is not statistically significant. We find basically the same effect for this measure. However, by investigating a much broader set of indicators of human capital and by using three measures of conduct disorder we find strong evidence for detrimental effects of conduct disorder, even in the sample of identical twins. These findings lead us to conclude that conduct disorder decreases investment in positive human capital and increases negative human capital.

Our data also provide the opportunity to investigate whether the timing of conduct disorder matters. In general, we find that earlier occurrence of conduct disorder is more deleterious. This indicates that early intervention is important. Previous studies have shown that early intervention programmes, like the Perry Pre-School Programme (PPP), the Syracuse Programme (SP) or the Head Start Programme (HSP) in the U.S., can be highly effective in 'reducing criminal activity, promoting socioeconomic skills, and integrating disadvantaged children into mainstream society' (Carneiro & Heckman, 2003, Garces et al. 2002, Lally et al. 1988, Schweinhart et al. 1993). As such, our findings provide further evidence for the consequences of early behaviour problems and the possible gains of effective treatment early in life.

1 Introduction

Many children have mental health problems which hinder their normal development and functioning. Anxiety, conduct, attention, and depressive disorders are the most common. For example, up to 500,000 (14%) of Australian children between the ages of 4 and 18 years have significant mental health problems (Australian Centre for Community Child Health, 2006); up to 50% of 'hard to manage' pre-school children are likely to have continuing hardships requiring professional help; approximately one in five children and adolescents in the U.S. may have a mental health disorder (Currie & Stabile, 2006). Despite these large numbers, little is known on the longer-term effects of these mental health problems of children. Currie & Stabile (2007) note that most studies 'assume that early mental health problem will have negative effects and focus on the efficacy of specific interventions'. In the economic literature, several recent studies investigate the longer-term effects of mental health problems on human capital. Currie & Stabile (2006) and Fletcher & Wolfe (2008) investigate the effects of ADHD in the US and Canada. Currie & Stabile (2007) also investigate the effects of depression and conduct disorder. Le et al. (2005) analyse the effects of conduct disorder on early school leaving and labour market outcomes in Australia. These papers find that mental disorders, and especially ADHD, have large negative effects on human capital accumulation.

This paper analyses the longer-term effects of childhood conduct disorder on human capital accumulation and violent and criminal behaviour later in life using data of Australian twins. If someone shows "a repetitive and persistent pattern of behaviour in which the basic rights of others or major age-appropriate societal norms or rules are violated," then he/she falls into a category of individuals with a conduct disorder problem. Conduct disorder is known as a 'disruptive behaviour disorder' because of its impact on children and their families, neighbours, and schools, and is largely associated with delinquent or criminal activity. We measure conduct disorder using diagnostic criteria from the American Psychiatric Association (APA, 1994). In line with Currie & Stabile (2007) we estimate effects on positive human capital, including measures such as grade repetition, marks in school and educational attainment, and on 'negative' human capital, including measures such as being arrested, spent time in jail and physically attacking others.

The two main challenges in estimating the longer-term effects of childhood conduct disorder on human capital are the measurement of conduct disorder and omitted variable bias. This paper contributes to the economic literature by addressing these two main challenges. First, it is easy to know when a child has a fever but a child's mental health problem is harder to identify. Typically, mental health problems in children are diagnosed by asking a child's parents and teachers a series of questions about their behaviours. For instance, Currie and Stabile (2007) use 6 questions to form a conduct disorder scale. In this study, we can employ a much richer set of conduct disorder indicators. We use self reports of adult twins on 21 statements that follow the definition of conduct disorder according to the APA criteria. In

addition, the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) emphasizes that there should be at least three specific conduct disorder behaviours present within the same 12 month period to make the diagnosis of conduct disorder (APA, 1994). Our data include self reports on a question that exactly matches this definition. Moreover, we have information whether the twin saw a doctor, psychologist or other professional for these behaviours. We used this information for constructing three measures of conduct disorder. Another contribution of this study is that we also have information on the age at which the conduct disorder behaviours occurred. We use this information for investigating the effects of the timing of the problem behaviours on human capital.

Second, estimates of the effect of conduct disorder on human capital might be confounded by unobserved differences between children and their families. For example, in Australia the incidence of mental health problems is even higher in disadvantaged children, such as Aboriginal children (24%), children residing in 'out of home care' (55-60%) and children with a disability, who are up to four times more likely to have mental health problems than children without a disability (Australian Centre for Community Child Health, 2006).

Parental substance abuse, marital conflict, psychiatric illness and child abuse and neglect have been identified as risk factors for conduct disorder (Searight, et al. 2001). Previous studies on the effects of childhood mental health problems mainly used cross sectional and within-sibling estimation (Currie and Stabile, 2006, 2007; Fletcher and Wolfe, 2008). In this paper we estimate within-family models using data of (identical) twins. We are aware of only one previous study (Le et al. 2005) that also uses data on twins. The advantage of using twins instead of siblings is that the family circumstances for twins will typically be more similar than with siblings. More importantly, identical twins are genetically identical, whereas siblings on average only share half of their genetic endowments. Therefore, using data on twins, in particular genetically identical twins, may reduce the bias caused by heterogeneity within families. In addition, we can further reduce this bias by controlling for differences in birth weight within pairs of identical twins. Recent research has shown that birth weight is an important predictor of later outcomes in life (Black et al., 2007).

We find large deleterious effects of conduct disorder on positive and negative human capital, even within pairs of identical twins. Conduct disorder increases the probability of grade retention and not completing high school. In addition, conduct disorder behaviours measured before the age of 18 have a strong effect on violent and criminal behaviour since the age of 18. For instance, within pairs of identical twins we find that conduct disorder reduces the probability of high school graduation with 4 to 13 percent points and increases the probability of being arrested with 7 to 16 percent points. Another important finding is that the effect of conduct disorder on human capital is more deleterious if these behaviours occur earlier in life. Various robustness checks, for instance sensitivity analyses that address the issue of spill-over effects within pairs of twins, suggest that our main estimates may be lower bounds of the true effect of conduct disorder on human capital. We conclude that childhood mental health

problems have high human and financial costs for families and society at large. Effective treatment early in life may yield high returns.

The remainder of this paper is organised as follows. The next section reviews previous studies. Section 3 describes the data and the methodology is explained in section 4. Section 5 shows the main estimation results. Robustness checks are presented in Section 6. Section 7 concludes and discusses some policy implications.

2 Previous studies

This paper examines the relationship between conduct disorder problems early in life and future human capital accumulation. We focus on conduct disorder problems as a measure of non-cognitive traits, as opposed to IQ tests that measure intelligence or cognitive ability. The line between the cognitive and non-cognitive traits is not very clear and has not been consistently defined in either the psychology or economics literature (Borghans et al., 2007).

Three strands of the previous literature are related to our study. The first one, which is probably most similar to our work, consists of health economics papers that look at early childhood health problems and their effects on school performance and educational attainment (Currie and Stabile, 2006, 2007; Fletcher and Wolfe, 2007; Slade and Wissow, 2007). The second strand of literature examines the relationship between child development, school attainment, and labour market outcomes (Gregg and Machin, 2000; Le et al., 2005). The third group of papers focuses on the importance of non-cognitive skills on labour market outcomes and social behaviour (Borghans et al., 2007; Carneiro and Heckman, 2003; Heckman et al., 2006; Blanden, et al., 2006; and Heckman and Masterov, 2007).

First, Currie and Stabile (2006) examine the relationship between hyperactivity (ADHD) symptoms and short-term human capital outcomes (test scores, grade repetition, special education, and delinquency) using longitudinal data. The measurement of ADHD was based on questions asked to parents and/or teachers of US children (aged 4-14) or Canadian children (aged 4-11). Using ordinary least squares and within sibling estimation they find large negative effects on test scores and schooling attainment. In a follow-up study, Currie and Stabile (2007) also pay attention to depression and conduct disorder (antisocial behaviour/ aggression). Conduct disorder has been measured using 6 questions. They find that children with mental health problems, especially with ADHD, suffer large negative consequences in terms of future human capital outcomes. For the US, they find that conduct disorder has negative effects on various human capital outcomes, while for Canada they find only negative effects on the probability that 16-19 year old youths are in school (fixed effect estimates for the other outcomes suggest negative effects but are statistically insignificant). In this ball park of literature fall recent papers by Fletcher and Wolfe (2008) and Slade and Wissow (2007). Fletcher and Wolfe (2008) estimate the effect of ADHD on human capital. Measuring ADHD using a series of survey questions, they look at the long-term relationship between childhood symptoms of ADHD and human capital accumulation (grade point average, secondary school indicators, years of education, and probability of attending college). Their OLS results imply that children with ADHD face longer-term educational disadvantages. Once family fixed effects are controlled for, standard errors become larger, thus rendering insignificant estimation results. However, they find evidence for spillover effects within families. Using the same U.S. data on adolescent health, Slade and Wissow (2007) look at the connection between childhood maltreatment, which causes emotional and behavioural problems throughout childhood, and

academic performance in middle and high school. Using within family estimation they find that more intense childhood maltreatment reduces grade point averages and leads to problems completing homework assignments.

Second, Gregg and Machin (2000) examine the relationship between child development and labour market outcomes. Using sequential modelling and UK data, they find that behavioural problems at age 7 are associated with poorer educational outcomes at age 16, which in turn is associated with poor labour market outcomes at ages 23 and 33. Further, the children of parents who grew up in the socially disadvantaged situation during their own childhood have lower early age cognitive abilities, suggesting an important cross-generational link. Le et al. (2005) investigate the effect of childhood conduct disorder on early school leaving and labour market outcomes, such as employment and earnings, in Australia. They find that individuals who experienced conduct disorder problems are more likely to leave school early, have poorer employment prospects and lower earnings. However, the within-twin estimates of the effect of conduct disorder on early school leaving conducted on the sample of identical twins are statistically not significant. They therefore conclude that genetic factors are responsible for the positive link between conduct disorder and early school leaving. In this paper we use the same data as Le et al. (2005) and also investigate the impact of conduct disorder on early school leaving. However, we look at a much broader range of human capital outcomes consisting of 6 measures of positive human capital and 6 measures of negative human capital. In addition, we use three different measures, instead of one measure, of conduct disorder (see next section).

Finally, several recent papers stress the importance of non-cognitive skills for labour market outcomes and social behaviour (Borghans et al. 2007; Carneiro and Heckman, 2003; Heckman et al. 2006; and Heckman and Masterov, 2007). Borghans et al. (2007) examine the line between economics and psychology and asks whether “economics would benefit from incorporating the findings of personality psychology to better predict and understand economic outcomes.” They present extensive evidence on the predictive power of personality traits and consider whether personality traits can be changed by intervention. Heckman et al. (2006) present evidence that both cognitive and non-cognitive skills play a dominant role in explaining personal achievement. They conclude that non-cognitive skills are as equally important as cognitive skills in determining social and economic success in life. Measures of non-cognitive skills are likely to capture some aspects of mental health as well as innate ability traits. Blanden et al. (2006) examine whether rising returns to non-cognitive skills can explain growing income inequality. Analysing 1958 and 1970 British birth cohort data sets, they include characteristics such as “hyper” and “anxious” as well as measures such as “self esteem” and “extrovert” as measures of non-cognitive skills and find that rising returns to positive mental characteristics do indeed account for some of the increase in inequality between the two cohorts. Carneiro and Heckman (2003) review the early childhood and adolescent years intervention programmes in the U.S. that proved to be effective “in reducing criminal activity, promoting social skills of

young adults, and integrating disadvantaged children into the mainstream society”.¹ They show that both cognitive and non-cognitive abilities affect schooling and economic successes. They also show that socio-economic differences in cognitive and non-cognitive abilities appear early in life and widen over the life cycle of the child. Hence, intervention programmes aimed at adolescents coming from bad family environments can positively affect learning and subsequent employment and earnings, but cannot reverse the early childhood damage. Heckman and Masterov (2007) go one step further and give a productivity argument for investing in young children from disadvantaged environments. Evidence shows that these children are more likely to commit crime, have out-of-wedlock births, and drop out of school. Early interventions that alleviate the effects of adverse environments can be beneficial not only to children themselves, but also to their own children, and society at large.

¹ Early intervention programmes in the US, like the Perry Pre-School Programme (PPP), the Syracuse Programme (SP) or the Head Start Programme (HSP), have shown to be successful, see Schweinhart et al. (1993), Donohue & Siegelman (1998), Lally et al. (1988), and Garces et al. (2002).

3 Data

In this study, we analyze data from the so-called younger cohort of twins of the Australian Twin Register (ATR). The data were gathered in two surveys, in 1989-1990 and in 1996-2000. In 1980-1982 a sample of 4,262 twin pairs, born between 1964 and 1971, were registered with the ATR as children by their parents in response to media appeals and systematic appeals through the school system. In 1989-1992, when the twins were 18-25 years old, the first survey by mailed questionnaire was conducted, called Alcohol Cohort 2. The response rate of this questionnaire survey was 63%. In 1996-2000, the second survey was launched, called TWIN89. Telephone interviews were completed with 6,267 individuals, 2,805 men (889 complete and 1,027 incomplete pairs) and 3,462 women (1,215 complete and 1,032 incomplete pairs), who were 30 years old on average (range from 24 to 39) at the time of the interview. The individual response rate for this telephone interview was 86%. The surveys gathered information on the respondent's family background (parents, siblings, marital status, and children), socioeconomic status (education, employment status, and income), health behaviour (body size, smoking and drinking habits), personality, feelings and attitudes. Zygosity was determined by a combination of diagnostic questions plus blood grouping and genotyping.

Conduct disorder

The measurement of conduct disorder is crucial for our analysis. According to the American Psychiatric Association (APA), a person with conduct disorder problems shows "a repetitive and persistent pattern of behaviour in which the basic rights of others or major age-appropriate societal norms or rules are violated, as manifested by the presence of three (or more) of the following criteria in the past 12 months". For instance criteria like: often initiated physical fights; has deliberately destroyed others' property; has broken into someone else's house, building, or a car; has often been truant from school, etc. (for a full definition see Table A.2 in the Appendix). Our data contains self-reported information on 21 statements that reflect behavioural problems before the age of 18 (see Table A.1). The information on conduct disorder is based on the second survey among adult twins (ages 24-39). Twins were asked to reflect on their experiences before the age of 18. As our first measure of conduct disorder we created a conduct disorder score based on these 21 statements. We first constructed a conduct disorder index by using factor analysis. However, the main factor appeared to be highly correlated with a conduct disorder score based on summing occurrences of these 21 statements². As this conduct disorder score is more comparable to measures used in previous studies, for instance the 'Antisocial/aggression score' from Currie and Stabile (2007), we prefer to use this measure, which we call the 'Conduct disorder score'. Le et al. (2005) used 19 statements for their measure of conduct disorder³. Our second measure of conduct disorder is based on the

² The correlation between the conduct disorder index based on factor analysis and the conduct disorder score is 0.994.

³ We also included 'misbehaved' and 'suspended/expelled'.

question ‘Did you do at least 3 of these things within the same 12-month period?’. Twins who responded ‘yes’ were coded as 1, twins who responded no or twins with a conduct disorder score of 0, 1 or 2 were coded as 0. As this measure perfectly matches the APA definition of conduct disorder we will use it as our main measure in the analysis. We call this measure the ‘APA Definition’. Our survey also asked ‘How old were you the first time you did at least 3 of these things within the same 12-month period?’. We use this information for investigating the effect of the timing of conduct disorder. Our third measure of conduct disorder is based on the question ‘Did you ever see a doctor, psychologist, social worker or any other professional like that because of these behaviours?’. Twins who responded ‘yes’ were coded as 1, twins who responded ‘no’ or twins who were coded as 0 on the APA definition were coded as 0 on this third measure. We call this measure ‘Professional help’. Seeking professional help may signal that conduct disorders hinder normal development and human capital accumulation. Obviously, this measure is endogenous as people choose or are advised to seek professional help. Le et al. (2005) did not use the second and third measures of conduct disorder.

The second measure of conduct disorder, which is directly based on the APA definition, might be a better indicator than the conduct disorder score because of the additional restriction on the time range for the occurrence of the conduct disorders. Small variations on the conduct disorder score (the first definition) might not reflect real differences in conduct disorder if the conduct disorder behaviors occur with relatively large time lags and not within a short period. The psychiatric handbook (DSM-IV) emphasizes that at least three such behaviors should occur within the same 12 month period to make the diagnosis of conduct disorder. The advantage of the third measure is that seeking professional help is a clear signal that the behavior of the child is considered problematic, making it likely that this indicator really measures a difference in conduct disorder.

Positive and negative human capital

In line with Currie and Stabile (2007), we distinguish between positive and negative human capital. Positive human capital is the type of human capital that is generally accumulated through schooling. Negative human capital is related with criminal, antisocial and violent activities. Our data contain five measures of positive human capital: grade repetition, marks in primary and high school, more than three college or university drop-outs and educational attainment. Marks in primary and high school are measured with a three point scale (below average, average, better than average). Educational attainment was measured using an eight point scale: less than 7 years schooling; 8-10 years schooling; 8-10 years of schooling and apprenticeship or diploma; 11-12 years schooling; apprenticeship, diploma, certificate; technical or teachers’ college; university, first degree; university, postgraduate degree. These eight categories have been recorded as 5, 9, 9, 11.5, 11.5, 13, 15 and 17 years of education, respectively (Miller et al., 2006). From this variable we created a dummy for high school graduation (at least 11.5 years of education completed), which is our sixth measure of positive

human capital. We also use 6 measures of ‘negative’ human capital: ‘more than three job quits’; ‘lying, using false names or alias, or conning others’; ‘physically attacking others’; ‘failing to pay debts’; ‘being arrested since you were 18’; ‘spent time in jail’). All these negative human capital variables are dichotomous variables. Unfortunately, due to the routing of the questionnaire twins with a conduct disorder score of zero did not answer several questions on human capital. As this may bias the estimates downward we checked the sensitivity of the results by imputing zeros on these outcomes for twins with no childhood conduct disorder (see section 6). In the analysis we use as covariates: mother’s and father’s education, age, age squared, gender and birth weight.

The main variables in our analysis (conduct disorder, positive and negative human capital) are all based on self reports. The reliability of these self-report data is an important issue. In this paper we use three different measures of conduct disorder and one of our measures is based on 21 statements. We expect that the use of such a rich set of indicators improves the reliability of the data. In criminology, a large literature shows that self-report data have consistently acceptable reliability and validity. Many studies find high correlations of self-report data with other criterion related measures of criminal frequency and arrest histories (Farrington, 1973; Hardt & Hardt, 1977; Horney & Marshall, 1992; Huizinga & Elliott, 1986; Maddux & Desmond, 1975; Mieczkowski, 1990; Weiss, 1998). Thornberry and Krohn (2000) conclude that “self-reported measures of delinquency are as reliable as, if not more reliable than, most social science measures”.

Descriptive statistics

Table 3.1 reports means of all measures for pairs of twins with non-missing information on conduct disorder symptoms. Column 1 (3) shows means for complete pairs of all (identical) twins. Column 2 (4) shows the number of twins with a within-family difference in the variable in question for the sample of all (identical) twins.

The top panel shows that the average conduct disorder score is nearly 2. Currie and Stabile (2007) report averages of nearly 5 for the US and 1.5 for Canada using a scale from 0 to 16. Hence, our Australian sample seems more comparable to the Canadian sample than to the US sample. The second row of table 3.1 shows that 13 percent of our sample would be diagnosed as having conduct disorder according to the APA definition, for men and women this is respectively 20 and 8 %. This is roughly in line with Searight et al. (2001) who report that approximately 6 to 16 percent of boys and 2 to 9 percent of girls meet the diagnostic criteria for conduct disorder. The fraction of our sample that saw professional help is much smaller, approximately 3 percent.

Table 3.1 Means table for sample of children with all conduct disorder measures non-missing

	All twin pairs		Identical twins	
	Mean	Twin differences	Mean	Twin differences
Conduct disorder measures				
Conduct disorder score (1-21)	1.880	3596	1.674	1394
APA definition	0.131	956	0.112	330
Professional help	0.027	264	0.024	92
Positive human capital				
Grade repetition	0.157	792	0.167	250
Marks primary school (1-3)	2.337	2184	2.322	660
Marks high school (1-3)	2.268	2186	2.269	748
3+ school drop-out	0.018	58	0.016	22
Years of education	12.247	2872	12.284	1096
High school graduation	0.792	1102	0.790	197
Negative human capital				
3+ job quit	0.102	408	0.100	144
Lies	0.044	412	0.035	134
3+ Attacking others	0.192	658	0.191	252
Failed to pay debts	0.073	286	0.067	102
Arrested since 18	0.074	290	0.069	102
Jail	0.019	70	0.018	22
Covariates				
Education mother	10.337		10.320	
Education father	10.495		10.515	
Age in 1996	29.891		29.870	
Gender (male=1)	0.442		0.409	
Birth weight (grams) N	2540		2430	
N	5322		2250	

The number of twins with a within-family difference on one of the three measures of conduct disorder is much larger in the sample of all twins than in the sample of identical twins (column 2 and 4). This illustrates that genetic factors, that are exactly the same within pairs of identical twins, are important for the development of conduct disorder. The average (standard deviation) of the within twin differences for the conduct disorder score is 2.0 (2.3) for the sample of all twins and 1.3 (1.5) for the sample of identical twins. The intra class correlation for the conduct disorder score is 0.63 for identical twins and 0.30 for fraternal twins. The smaller amount of variation in the sample of identical twins makes the estimates more vulnerable for measurement error (Grilliches, 1979) and may limit the opportunities for finding effects on human capital. It should also be noted that the number of pairs used in the estimation may be smaller due to missing values for human capital outcomes.

Table 3.2 shows the distribution of the conduct disorder score for the sample of all twins (column 1) and for both categories of the other two definitions of conduct disorder.

Table 3.2 Distribution of conduct disorder score (% of twins with each score)

Score	All	APA definition		Professional help	
		No	Yes	No	Yes
0	38.67	44.81	0.00	39.78	0.00
1	20.37	23.61	0.00	20.72	8.28
2	13.62	15.79	0.00	13.78	8.28
3	8.89	8.23	10.12	8.78	12.41
4	5.62	3.71	17.30	5.60	6.21
5	3.56	1.75	14.81	3.45	7.59
6	3.15	1.09	17.01	2.85	13.10
7	1.85	0.55	10.56	1.63	8.97
8	1.22	0.20	8.21	1.10	5.52
9	1.17	0.20	7.77	0.93	9.66
10	0.81	0.07	5.87	0.60	8.28
11	0.38	0.00	2.93	0.35	1.38
12	0.40	0.00	3.08	0.23	6.21
13	0.15	0.00	1.17	0.12	1.38
14	0.02	0.00	0.15	0.02	0.00
15	0.09	0.00	0.73	0.04	2.07
17	0.04	0.00	0.29	0.02	0.69
Mean	1.92	1.18	6.46	1.75	6.30
N	5307	4579	682	5159	145

Table 3.3 Means of conduct disorder items

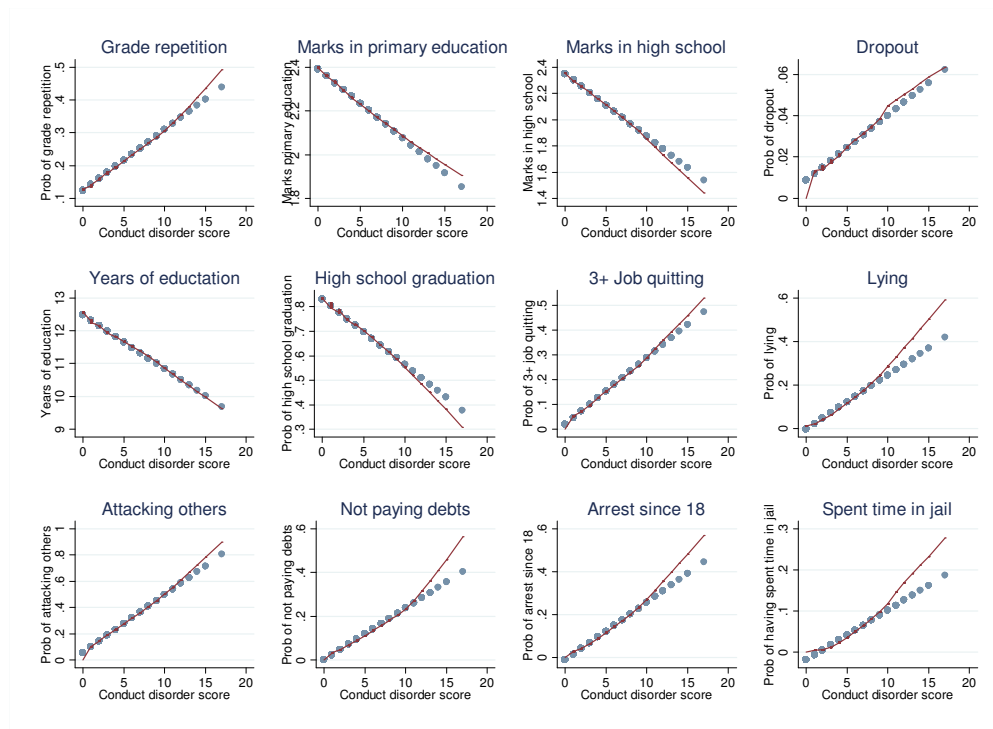
Item	All	APA definition		Professional help	
		No	Yes	No	Yes
Misbehaved in school	0.148	0.095	0.489	0.136	0.593
Wagged school	0.336	0.260	0.806	0.327	0.728
Suspended/expelled	0.091	0.062	0.277	0.085	0.335
Stay out late	0.183	0.118	0.594	0.176	0.474
Sneak out at night	0.078	0.032	0.374	0.071	0.358
Run away overnight	0.064	0.028	0.241	0.056	0.366
Lied, used false name	0.097	0.046	0.426	0.088	0.445
Outsmarted, conned others	0.065	0.028	0.301	0.060	0.262
Stole from home or family	0.150	0.102	0.460	0.143	0.457
Shoplifted	0.179	0.122	0.552	0.171	0.486
Forged signature	0.003	0.001	0.016	0.003	0.029
Damaged property	0.090	0.048	0.364	0.086	0.283
Started physical fights	0.069	0.037	0.277	0.065	0.237
Used a weapon	0.027	0.015	0.108	0.025	0.127
Physically injured someone	0.065	0.043	0.207	0.063	0.173
Bullied others	0.028	0.013	0.128	0.025	0.133
Mean to animals	0.032	0.020	0.105	0.031	0.064
Lighted fires	0.141	0.105	0.370	0.138	0.272
Broke into someone's car/house	0.068	0.027	0.331	0.062	0.289
Forcefully stole money or property	0.002	0.000	0.015	0.002	0.023
Forced someone into sexual activity	0.001	0.000	0.010	0.001	0.006

Nearly 39 percent of all twins reported negatively on all 21 statements of conduct disorder and nearly 73 percent have a conduct disorder score of less than three. This distribution is remarkably similar to the distribution of conduct disorder (antisocial/aggression) for Canada reported in Currie and Stabile (2007). As expected, the conduct disorder score for twins that reported ‘yes’ on the APA definition (column 3) or those who sought professional help (column 5) are much higher, on average more than 5 (4) points higher for the second (third) definition. The frequencies of specific behaviours underlying the conduct disorder scores are shown in table 3.3.

Behaviours most frequently reported are: wagged school, stay out late, shop lifted, misbehaved at school, stole from home and family. The largest differences between the categories of the second definition (column 2 and 3) and the third definition of conduct disorder (column 4 and 5) are also found on these behaviours.

A first exploration of the relationship between conduct disorder and human capital is shown in figure 3.1. The figure shows Lowess plots of the association between the conduct disorder score and our measures of positive and negative human capital.

Figure 3.1 The associations between conduct disorder scores and human capital



The association between conduct disorder and human capital seems remarkably consistent for all measures of human capital. An increase of conduct disorder is associated with a decrease in positive human capital and increase in negative human capital. For instance, higher levels of conduct disorder are associated with higher probabilities of grade repetition and drop out, and with lower marks in school (primary or high school), less years of education and a lower probability of graduating from high school. In addition, higher levels of conduct disorder are associated with higher probabilities of lying, attacking others, being arrested since the age of 18 or having been incarcerated. In line with previous studies for the US and Canada (Currie and Stabile, 2006, 2007) we find that the association between conduct disorder and human capital seems quite linear. Even low scores of conduct disorder are associated with lower human capital accumulation.

4 Methodology

We follow the same approach as in previous papers on the effects of childhood mental health problems on human capital. First, we estimate OLS models of the relationship between conduct disorder and positive and negative human capital outcomes. As these estimates might be biased by unobserved factors we proceed with estimating within twin fixed effect models:

$$HC_{ij} = \alpha + \beta CD_{ij} + \gamma X_{ij} + f_j + \varepsilon_{ij} \quad (4.1)$$

where HC_{ij} is a measure of positive/negative human capital; CD_{ij} is one of our three measures of conduct disorder; X_{ij} is a vector of covariates, consisting of age, gender, birth weight, and mothers' and fathers education; f_j captures unobserved family effects common to all twins within the same family, and ε_{ij} is a random error term. Index i corresponds to the twin number; index j corresponds to the twin family. In this model the family fixed effect is removed by differencing within pairs of twins. We also use OLS and within-twin models for estimating the effect of the age at which conduct disorder behaviours occur on human capital accumulation. Our data contains information on the age of onset of the behaviours according to the APA definition. We created a variable 'years of conduct disorder' as the years before the age of 18 that these behaviours first occurred (18 - age of onset). Hence, twins coded as zero on the APA definition have a value of zero on this variable. Twins with age of onset of 17 have a value of one on this variable; twins with an age of onset of 16 have a value of 2 on this variable. For investigating the effect of age of onset of conduct disorder we estimated the following fixed effect model:

$$HC_{ij} = \alpha + \beta yearscd_{ij} + \delta (yearscd_{ij})^2 + \gamma X_{ij} + f_j + \varepsilon_{ij} \quad (4.2)$$

There are several concerns with estimates based on within-family models. First, the estimates might be biased by within-family heterogeneity. Most previous papers on mental health problems of children estimate within-family models using data of siblings. However, siblings may differ in genetic endowments. In addition, the socioeconomic conditions facing siblings and the parental inputs received by siblings may differ if family circumstances change over time. As we use data on (identical) twins it seems less likely that our estimates will be biased by within family heterogeneity. The family circumstances for twins will probably be more equal than for siblings, which differ in age. More importantly, identical twins share exactly the same genes whereas siblings on average only share half of their genetic endowments. By estimating fixed effect models for separate samples of identical twins, we control for all differences in genetic endowments. In addition, we test the robustness of the estimates by excluding pairs of twins with very large differences in educational attainment. These large education differences

might indicate that these twins are quantitatively different from the rest of the sample and introduce heterogeneity which will confound the effects we are looking for.

A second concern for our analysis is that there might be spill-over effects within pairs of twins. If severe conduct disorder behaviours of one twin also have negative effects on the human capital accumulation of the other twin, then using within twin estimation would underestimate the effect of conduct disorder. Spill-over effects seem quite likely here as conduct disorder is known as a 'disruptive behaviour disorder' because of its impact on children and their families, neighbours, and schools. We address this issue in the same way as Fletcher and Wolfe (2008). They included the mental problems of the other twin in random effects regression controlling for mental problems. Although the estimates can be biased by omitted variables they might provide insights on spill-over effects.

5 Main estimation results

In this section, we present the main estimation results. Section 5.1 shows the estimates of the effect of conduct disorder on human capital using three measures of conduct disorder. In section 5.2 we investigate whether the age of onset of conduct disorder matters for human capital accumulation.

5.1 The effect of three measures of conduct disorder on human capital

We examine the effect of conduct disorder problems, as a measure of non-cognitive traits, on different human capital outcomes using three measures of conduct disorder. Table 5.1 (5.2) reports the estimated effects of conduct disorder on 6 types of positive (negative) human capital using linear regression (probability) models. The top panel shows the results using the conduct disorder score, the middle panel shows the results for the APA definition of conduct disorder and the bottom panel shows the results using the professional help definition. In each panel we first report OLS estimates, next we report fixed effect estimates for the sample of all twins (FE All) and finally we report fixed effect estimates for the sample of identical twins (FE Identical). All regressions include birth weight, age, age squared, gender, and parents' education as controls. Obviously, some of these variables drop out from the fixed effect specifications. Each cell shows the results of a separate estimation.

All estimates in table 5.1 suggest that conduct disorder has a negative effect on human capital accumulation by increasing the probability of grade repetition and dropping out of school, and decreasing marks in school, years of education completed and the probability of graduating from high school. The largest effects are found when using the OLS estimation. The size of the estimates reduces when twin fixed effects are taken into account. For the sample of all twins all estimates, except for one, remain statistically significant. The standard errors increase when we restrict the sample to identical twins only. However, even for the sample of identical twins, where the variation in conduct disorder is much smaller than in the sample of all twins (see table 3.1), several estimates suggest substantial effects of conduct disorder on human capital accumulation. Most remarkable are the effect on grade retention and high school completion. One additional point on the conduct disorder score increase the probability of grade retention with 1.1 percent point (0.9 for the sample of all twins). This estimate is remarkably close to the within sibling estimate of 0.8 percent point both for the US and Canada reported by Currie and Stabile (2007). Conduct disorder as classified by the APA definition increases the probability of grade retention with 9 percent points and with the third definition the estimated effect is 11 percent points. The estimates of the effects on high school completion are also large although not always statistically significant in the sample of identical twins. The estimates for the third definition suggest that conduct disorder decreases the probability of high school graduation with 13 percent points. The size of these estimates seems large when compared with

other covariates. For instance, in the OLS regression we find that one year of father's education is associated with a decrease of the probability of grade retention with 0.5 % and an increase of the probability of high school graduation with 2.2 %.

Table 5.1 Estimates of the effect of conduct disorder on positive human capital

Conduct Disorder Score	Grade repetition	Marks primary	Marks high school	3+ Dropout	Education years	High school
OLS	0.017 (0.003)***	- 0.029 (0.004)***	- 0.049 (0.004)***	0.005 (0.002)**	- 0.160 (0.013)***	- 0.026 (0.003)***
N	5286	5276	5270	1732	5288	5288
FE All	0.009 (0.003)***	- 0.024 (0.005)***	- 0.038 (0.005)***	0.005 (0.002)**	- 0.082 (0.018)***	- 0.013 (0.003)***
N	5286	5276	5270	1732	5288	5288
Fe Identical	0.011 (0.005)**	- 0.014 (0.008)*	- 0.017 (0.009)**	0.009 (0.004)**	- 0.037 (0.032)	- 0.010 (0.006)
N	2238	2234	2238	720	2236	2236
APA Definition						
OLS	0.096 (0.019)***	- 0.171 (0.026)***	- 0.267 (0.026)***	0.029 (0.011)**	- 0.818 (0.095)***	- 0.136 (0.019)***
N	5224	5214	5210	1700	5226	5226
FE All	0.057 (0.018)***	- 0.100 (0.032)***	- 0.180 (0.031)***	0.031 (0.011)***	- 0.335 (0.111)***	- 0.054 (0.020)***
N	5224	5214	5210	1700	5226	5226
Fe Identical	0.091 (0.026)***	- 0.031 (0.043)	- 0.025 (0.045)	0.028 (0.017)	- 0.095 (0.169)	- 0.036 (0.032)
N	2220	2216	2220	714	2218	2218
Professional help						
OLS	0.201 (0.039)***	- 0.194 (0.054)***	- 0.308 (0.049)***	0.045 (0.026)*	- 1.135 (0.187)***	- 0.218 (0.040)***
N	5370	5360	5354	1794	5372	5372
Fe All	0.105 (0.033)***	- 0.102 (0.060)*	- 0.157 (0.059)***	0.014 (0.021)	- 0.661 (0.208)***	- 0.126 (0.038)***
N	5370	5360	5354	1794	5372	5372
Fe Identical	0.109 (0.048)**	- 0.067 (0.082)	- 0.088 (0.085)	- 0.034 (0.032)	- 0.480 (0.317)	- 0.130 (0.061)**
N	2274	2270	2274	744	2272	2272

The pattern of findings in table 5.2 is quite similar and, considering the statistical significance of the estimates, even more compelling. We find large and statistically significant effects of conduct disorder on negative human capital, even in the sample of identical twins only. The estimates of the effects on the probability of being arrested since the age of 18 and on the probability of spending time in jail seems quite large and robust. In addition, the estimates of the effects of conduct disorder on the probability of physically attacking others are very large for the first two measures of conduct disorder. For the third measure, the effects are only found in the OLS estimates. It should be noted that the sample size is much smaller for five measures of negative human capital. This is caused by the routing of the questionnaire and may bias the

results. In the next section, we will investigate the sensitivity of the results with respect to the smaller sample size. In general, we find the largest effects of conduct disorder for the third measure. It is likely that this measure identifies individuals with severe behaviour problems which hinder their development. The size of the estimates for the first and the second measure seems roughly comparable if we consider that twins with conduct disorder according to the APA definition score approximately 5 points higher on the conduct disorder score.

Table 5.2 Estimates of the effect of conduct disorder on negative human capital

Conduct disorder score	3+ Job quits	Lies	Attacking others	Debts	Arrested since 18	Jail
OLS	0.025 (0.003)***	0.027 (0.002)***	0.041 (0.004)***	0.026 (0.003)***	0.026 (0.003)***	0.014 (0.003)***
N	2182	5288	2180	2182	2178	2176
FE All	0.022 (0.004)***	0.028 (0.002)***	0.037 (0.006)***	0.027 (0.004)***	0.019 (0.004)***	0.011 (0.002)***
N	2182	5288	2180	2182	2178	2176
FE Identical	0.009 (0.008)	0.021 (0.004)***	0.029 (0.011)***	0.031 (0.007)***	0.011 (0.007)	0.007 (0.003)**
N	888	2234	888	888	888	886
APA Definition						
OLS	0.103 (0.018)***	0.162 (0.016)***	0.179 (0.022)***	0.088 (0.016)***	0.124 (0.017)***	0.048 (0.011)***
N	2142	5226	2140	2142	2138	2136
FE All	0.061 (0.023)***	0.128 (0.013)***	0.146 (0.029)***	0.051 (0.019)***	0.076 (0.019)***	0.020 (0.010)**
N	2142	5226	2140	2142	2138	2136
FE Identical	0.038 (0.034)	0.091 (0.019)***	0.162 (0.044)***	0.037 (0.028)	0.067 (0.028)**	0.022 (0.013)*
N	876	2216	876	876	876	874
Professional help						
OLS	0.089 (0.038)**	0.112 (0.030)***	0.153 (0.045)***	0.150 (0.040)***	0.125 (0.038)***	0.137 (0.035)***
N	2248	5370	2246	2248	2244	2242
FE All	0.022 (0.042)	0.053 (0.024)**	0.022 (0.054)	0.030 (0.035)	0.061 (0.036)*	0.101 (0.017)***
N	2248	5370	2246	2248	2244	2242
FE Identical	-0.002 (0.064)	0.065 (0.036)*	0.001 (0.085)	0.024 (0.054)	0.157 (0.054)***	0.081 (0.025)***
N	916	2268	916	916	916	914

Non linearity

We also investigated whether the effects are non linear by looking at the top percentiles of conduct disorder score. Table A.3 and A.4 in the appendix show the estimation results of a dummy for having a conduct disorder score of more than 5 or at least 10. This corresponds to the 90th and 99th percentile. It should be noted that focusing on these top percentiles reduces the variation in conduct disorder that can be used, especially in the sample of identical twins. For

most outcomes the estimates suggest that the effects of conduct disorder are quite linear. For instance, for the sample of all twins the within estimates using the dummy for at least 10 conduct disorder behaviours (above the 98 percentile) seem quite comparable with most estimates in table 5.2. Hence, we find no clear evidence for non linear effects of conduct disorder.

Effects of four subscales of conduct disorder

The APA criteria (see table A.2) suggests that conduct disorder has four underlying components: aggression to people and animals, destruction of property, deceitfulness or theft and serious violations of rules. We investigated the effects of these components by decomposing the conduct disorder score into these four groups of the APA criteria. The estimation results are shown in the appendix (table A.5 and A.6). The results in table A.5 suggest that ‘serious violations of rules’ are the most important component of conduct disorder for the accumulation of positive human capital. This not very surprising if we consider that this subscale includes items like ‘misbehaved’, ‘wagged school’ and ‘suspended/expelled’. For the other subscales the estimates do not show a clear pattern. The estimates of the effect on negative human capital (table A.5) suggest that all subscales are important. The size of the effects of ‘aggression’ and ‘destruction’ on ‘attacking others’ and ‘failing to pay debts’ is remarkable. ‘Destruction’, ‘deceit/theft’ and ‘violation of rules’ seem the most important factors for the probability of arrest or jail.

Summary

Using a rich set of indicators of conduct disorder we find large effects of conduct disorder on positive and negative human capital. Even for the sample of identical twins we find substantial effects. These findings corroborate findings from previous studies based on within-sibling estimation and using smaller sets of indicators of conduct disorder. Although the within-twin estimates suggest substantial deleterious effects of conduct disorder, these estimates are considerably smaller than the OLS-estimates. This difference between the OLS estimates and the within-twin estimates might result from measurement error in conduct disorder or spill-over effects within pairs of twins. We will address these issues in section 6.

5.2 The effect of the timing of conduct disorder behaviours

Several recent studies suggest that the timing of intervention programmes for disadvantaged children is important. For instance, Carneiro and Heckman (2003) show that socio-economic differences in cognitive and non-cognitive abilities appear early in life and widen over the life cycle of the child. Currie and Stabile (2007) find that early mental health problems have large significant effects on cognitive test scores even controlling for later mental health problems.

Loeber (1982) suggests that the earlier a child began displaying antisocial behaviour, the more likely he or she was to persist in such behaviour. Farmer (1995), on the other hand, does not support the hypothesis that earlier onset is associated with more deleterious outcomes. She finds that later onset, rather than earlier, is associated with earlier school leaving and lower level qualifications. In this section we analyse the impact of the timing of conduct disorder behaviours.

Our data contains information on the age of onset of the behaviours according to the APA definition. We created a variable ‘onset of conduct disorder’ as the years before the age of 18 that these behaviours first occurred (18 - age of onset). The age of onset of conduct disorder appears to be strongly associated with the number of conduct disorder behaviours manifested before the age of 18 (see table A.7). More years of conduct disorder is associated with a higher conduct disorder score. We estimated the effect of the timing of conduct disorder on human capital by including ‘years of conduct disorder’ and ‘years of conduct disorder squared’ in our main models (equation (2) from section 4). Table 5.3 shows the estimation results.

The estimates suggest that the timing of conduct disorder behaviours is very important for human capital accumulation. All the estimates corroborate the previous findings and indicate that the effect of conduct disorder on human capital is more deleterious if these behaviours occur earlier. Even in the sample of identical twins we find statistically significant effects of the timing of conduct disorder on grade retention, dropout, high school graduation, attacking other people and the probability of being arrested since the age of 18. The impact of the timing differs between the outcomes. For instance, the quadratic specification suggests that conduct disorder is most deleterious for high school completion when manifested between the ages of 13 to 16. In addition, the effect of conduct disorder on the probability of arrest since the age of 18 is largest when conduct disorder manifests itself between the ages of 10 to 16.

We also investigated whether there is a relationship between the socioeconomic background of the twins and the effect of the timing of conduct disorder on human capital. As wealthier families have more resources to mitigate conduct disorder problems we might expect smaller effects for twins from these families. We separated our sample in families with a father that completed high school and families with a father that did not complete high school. However, estimations which include an interaction between socioeconomic background and years of conduct disorder show little effect of socioeconomic background. We only find that conduct disorder has a larger effect on the probability of physically attacking others in families in which the father did not complete high school than in other families. Currie and Stabile (2007) also find little evidence that parents income mitigates negative effects of mental health problems of children.

Table 5.3 The effect of the timing of conduct disorder on human capital

APA Definition	Grade retention	Marks primary	Marks high school	3+ Dropout	Education years	High school
OLS						
Years of CD	0.040 (0.009)***	-0.060 (0.014)***	-0.110 (0.013)***	0.013 (0.006)**	-0.333 (0.043)***	-0.058 (0.009)***
Years of CD squared	-0.003 (0.001)***	0.004 (0.002)**	0.009 (0.002)***	-0.001 (0.001)	0.026 (0.005)***	0.004 (0.001)***
N	5222	5212	5208	1698	5224	5224
Fixed effect All						
Years of CD	0.024 (0.009)***	-0.041 (0.016)**	-0.083 (0.016)***	0.023 (0.006)***	-0.153 (0.056)***	-0.036 (0.010)***
Years of CD squared	-0.002 (0.001)*	0.004 (0.002)*	0.008 (0.002)***	-0.003 (0.001)***	0.013 (0.007)*	0.004 (0.001)***
N	5222	5212	5208	1698	5224	5224
Fixed effect Identical						
Years of CD	0.044 (0.013)***	0.015 (0.023)	-0.000 (0.024)	0.026 (0.010)***	-0.009 (0.088)	-0.033 (0.017)*
Years of CD squared	-0.004 (0.002)**	-0.004 (0.003)	-0.001 (0.003)	-0.003 (0.001)**	-0.001 (0.012)	0.005 (0.002)*
N	2220	2216	2220	714	2218	2218
	3+ Job quits	Lies	Attacking others	Debts	Arrested since 18	Jail
OLS						
Years of CD	0.027 (0.010)***	0.057 (0.009)***	0.061 (0.011)***	0.033 (0.009)***	0.042 (0.009)***	0.012 (0.007)*
Years of CD squared	-0.000 (0.001)	-0.004 (0.001)***	-0.004 (0.002)**	-0.002 (0.001)*	-0.003 (0.001)**	-0.000 (0.001)
N	2140	5224	2138	2140	2136	2134
Fixed effect All						
Years of CD	0.005 (0.011)	0.049 (0.006)***	0.060 (0.014)***	0.012 (0.009)	0.035 (0.009)***	0.011 (0.005)**
Years of CD squared	0.002 (0.001)	-0.004 (0.001)***	-0.005 (0.002)**	-0.000 (0.001)	-0.003 (0.001)***	-0.001 (0.001)**
N	2140	5224	2138	2140	2136	2134
Fixed effect Identical						
Years of CD	0.006 (0.017)	0.042 (0.010)***	0.056 (0.023)**	0.019 (0.014)	0.032 (0.014)**	0.004 (0.007)
Years of CD squared	0.001 (0.002)	-0.003 (0.001)**	-0.003 (0.003)	-0.002 (0.002)	-0.003 (0.002)*	0.000 (0.001)
N	876	2216	876	876	876	874

Summary

We conclude that the timing of conduct disorder is very important for human capital accumulation. In line with previous studies, this suggests that programmes that succeed in changing conduct disorder behaviours at an early age might yield large returns, both for individuals and society at large

6 Robustness checks

In this section, we investigate the robustness of the findings by addressing three issues. First, we test the sensitivity of the results by imputing missing values on human capital outcomes which are due to the routing of the questionnaire. Second, we exclude pairs of twins with large differences in educational attainment. These large differences might indicate that there are other major differences between these twins. Third, we investigate whether spill-over effects of conduct disorder within pairs of twins play a role. In the robustness checks we mainly use the APA Definition of conduct disorder because of the precise match of this measure with the psychiatric definition.

Missing values due to the routing of the questionnaire

In the previous section, we noted that the number of observations is much smaller in the estimations of the effect on dropout and 5 measures of negative human capital. Due to the routing of the questionnaire twins with a conduct disorder score of zero did not answer these questions. This may bias the estimates downward as it seems likely that twins with no childhood conduct disorder behaviour will on average accumulate more positive and less negative human capital than twins with problem behaviour early in life. We checked the sensitivity of the results by imputing zeros for twins with missing values on these outcomes and a conduct disorder score of zero. Table 6.1 shows the estimation results for the APA definition of conduct disorder.

APA definition	3+ Dropout	3+ Job quits	Attacking others	Debts	Arrested since 18	Jail
OLS	0.029 (0.009)***	0.154 (0.016)***	0.259 (0.019)***	0.109 (0.014)***	0.147 (0.015)***	0.051 (0.010)***
N	4586	5184	5184	5184	5180	5178
FE All twins	0.025 (0.007)***	0.108 (0.015)***	0.201 (0.019)***	0.066 (0.012)***	0.100 (0.012)***	0.029 (0.006)***
N	4586	5184	5184	5184	5180	5178
FE Identical twins	0.023 (0.011)**	0.072 (0.023)***	0.200 (0.030)***	0.060 (0.019)***	0.073 (0.018)***	0.025 (0.008)***
N	1980	2198	2200	2200	2198	2196

After the imputation of these missing values, all estimates become statistically significant. We also observe that the size of most estimates increases. This suggests that due to the routing of the questionnaire we underestimate the deleterious effects of conduct disorder on negative human capital. Hence, the size of the estimates in the previous section may be considered as a lower bound of the true effects of conduct disorder on these outcomes.

Excluding pairs of twins with large differences in educational attainment

Second, we excluded pairs of twins with large differences in educational attainment. These differences might indicate that these twins are quantitatively different from the rest of the sample and introduce heterogeneity which will confound the effects we are looking for. Table 6.2 shows estimates of the effect of the APA definition of conduct disorder on positive and negative human capital after excluding pairs of twins that differ more than 5.5 years of education.

APA Definition	Grade retention	Marks primary	Marks high school	3+ dropout	Education years	High school
OLS	0.095 (0.019)***	- 0.176 (0.027)***	- 0.264 (0.027)***	0.030 (0.012)**	- 0.810 (0.095)***	- 0.137 (0.019)***
N	5076	5070	5066	1642	5078	5078
FE All	0.051 (0.018)***	- 0.104 (0.032)***	- 0.166 (0.031)***	0.031 (0.012)***	- 0.281 (0.101)***	- 0.048 (0.019)**
N	5076	5070	5066	1642	5078	5078
FE Identical	0.086 (0.026)***	- 0.032 (0.043)	- 0.019 (0.045)	0.028 (0.017)	- 0.096 (0.159)	- 0.037 (0.031)
N	1094	1092	1094	350	1093	1093
	3+ Job quits	Lies	Attacking others	Debts	Arrested since 18	Jail
OLS	0.105 (0.018)***	0.159 (0.016)***	0.178 (0.022)***	0.088 (0.016)***	0.121 (0.017)***	0.046 (0.011)***
N	2070	5078	2068	2070	2066	2064
FE All	0.061 (0.023)***	0.121 (0.013)***	0.148 (0.029)***	0.048 (0.019)**	0.076 (0.020)***	0.020 (0.010)**
N	2070	5078	2068	2070	2066	2064
FE Identical	0.038 (0.034)	0.086 (0.019)***	0.164 (0.045)***	0.030 (0.029)	0.068 (0.028)**	0.022 (0.013)*
N	860	2184	860	860	860	858

The estimates in table 6.2 are quite similar to the estimates in the previous section. Hence, the results are robust for exclusion of these pairs of twins.

Spill-over effects within pairs of twins

As a third robustness check we investigate whether spill-over effects might play a role. Our within-twin estimates will be biased downward if conduct disorder behaviours of one twin also have negative effects on the other twin. We investigated this issue by including the effect of the conduct disorder of the other twin in a random effects regression controlling for own conduct disorder. This approach has also been applied by Fletcher and Wolfe (2008). The estimates are shown in table 6.3.

Table 6.3 Random effect estimates of own and sibling's conduct disorder on human capital

APA Definition	Grade retention	Marks primary	Marks high school	3+ dropout	Education years	High school
Own conduct disorder	0.091 (0.015)***	- 0.159 (0.024)***	- 0.253 (0.023)***	0.029 (0.008)***	- 0.735 (0.092)***	- 0.122 (0.016)***
Sibling's disorder	0.037 (0.014)**	- 0.052 (0.023)**	- 0.071 (0.023)***	- 0.001 (0.008)	- 0.378 (0.091)***	- 0.064 (0.016)***
N	5224	5214	5210	1700	5226	5226
	3+ Job quits	Lies	Attacking others	Debts	Arrested since 18	Jail
Own conduct disorder	0.099 (0.016)***	0.156 (0.008)***	0.175 (0.020)***	0.084 (0.013)***	0.118 (0.013)***	0.045 (0.007)***
Sibling's disorder	0.029 (0.015)*	0.034 (0.008)***	0.029 (0.019)	0.032 (0.013)**	0.044 (0.013)***	0.025 (0.007)***
N	2142	5226	2140	2142	2138	2136

The estimates suggest that the sibling's conduct disorder is important for human capital accumulation. Nearly all the estimates of the effect of the conduct disorder of the other twin are statistically significant and substantially increase the deleterious effects of conduct disorder on human capital. For some measures of human capital, years of education, high school graduation, spent time in jail, we find that the estimated effect of the other twins conduct disorder is approximately half the size of the estimated effect of the own conduct disorder. Although these estimates might be biased by unobserved differences they indicate that spill-over effects within pairs of twins might be important.

In sum, this section investigated the robustness of the estimates in section 5. We find that imputations of missing values due to the routing of the questionnaire increase the size of the estimates of conduct disorder on negative human capital. Excluding pairs of twins with large differences in educational attainment does not change the main findings. Finally, we find evidence for spill-over effects of conduct disorder within pairs of twins. If anything, these robustness checks suggest that the estimated effects of conduct disorder on human capital in the previous section might be lower bounds of the true effects.

7 Conclusions

In this paper, we examine the relationship between conduct disorder problems before the age of 18 and human capital accumulation. We use three measures of conduct disorder: a 'conduct disorder score' based on 21 statements about behaviour problems, the APA definition (did you do at least three of these behaviours within 12 months) and an indicator of 'professional help' because of conduct disorder. We estimated the effect of conduct disorder on 6 measures of positive human capital and 6 measures of negative human capital. The estimates suggest that conduct disorder has a strong negative effect on positive human capital. We find large effects on grade retention and high school graduation, even within pairs of identical twins. The estimates also show a large effect of conduct disorder on negative human capital. Conduct disorder behaviours have a strong effect on violent and criminal behaviour since the age of 18. We also found that the effect of conduct disorder on human capital is more deleterious if these behaviours occur earlier in life.

Various robustness checks suggest that these estimates may be lower bounds of the true effect of conduct disorder on human capital. For instance, due to the routing of our survey twins with a conduct disorder score of zero did not answer most questions on negative human capital. The size of the estimates increases if we impute that these twins did not accumulate negative human capital. In addition, we found evidence for spill-over effects of conduct disorder within pairs of twins. These spill-over effects will bias downward the size of the within twin estimates. It should also be noted that our estimates might be biased towards zero because of measurement error in conduct disorder. The within-estimator exacerbates measured error which is likely to bias the estimates towards zero (Griliches, 1979). Unfortunately, our data do not provide a second independent measure of conduct disorder that can be used as an instrumental variable and might solve the problem of measurement error (Ashenfelter, et al. 1994).

An important and well-known concern with our findings is that unobserved heterogeneity within twin pairs is biasing the results. For instance, one of the twins might be more able than the other twin and this unobserved ability may be correlated with conduct disorder. Unobserved heterogeneity might also come from differences within twins pairs in the treatment of parents. In this paper we addressed this issue by controlling for differences in birth weight within pairs of twins. In addition, we did a robustness check by excluding pairs of twins with large differences in educational attainment, as these twins might have major differences. These robustness checks did not change our main findings.

Previous research (Currie & Stabile, 2006, 2007; Fletcher & Wolfe, 2007) found that conduct disorder before the age of 18 can have large deleterious longer-term effects on positive and negative human capital. Our findings, which are based on a much richer set of indicators of conduct disorder and on data of twins instead of data of siblings, corroborate these results. Le et al. (2005), who used the same data, also investigated the effect of the conduct disorder score on one measure of human capital (high school graduation). For the sample of identical

twins they find that the estimated effect is not statistically significant. We find basically the same effect for this measure. However, by investigating a much broader set of indicators of human capital and by using three measures of conduct disorder we find strong evidence for detrimental effects of conduct disorder, even in the sample of identical twins. These findings lead us to conclude that conduct disorder decreases investment in positive human capital and increases negative human capital.

Our data also provide the opportunity to investigate whether the timing of conduct disorder matters. In general, we find that earlier occurrence of conduct disorder is more deleterious. This indicates that early intervention is important. Previous studies have shown that early intervention programmes, like the Perry Pre-School Programme (PPP), the Syracuse Programme (SP) or the Head Start Programme (HSP) in the U.S., can be highly effective in 'reducing criminal activity, promoting socioeconomic skills, and integrating disadvantaged children into mainstream society' (Carneiro & Heckman, 2003, Garces et al. 2002, Lally et al. 1988, Schweinhart et al. 1993). As such, our findings provide further evidence for the consequences of early behaviour problems and the possible gains of effective treatment early in life.

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Appendix

A1. Variable Definitions

Table A.1 Conduct disorder statements from the TWIN89 questionnaire	
Variable	Question
Misbehaved	L3 Did you <u>frequently</u> get into a lot of trouble with the teacher or principal for misbehaving in school (primary or secondary school)?
Wagged school	L4 Before age 18, did you ever wag school for an entire day at least twice in 1 year?
Suspended/expelled	L5 Were you ever suspended or expelled from school?
Stay out late	L6 As a child or a teenager, did you <u>often</u> stay out <u>much later</u> than you were supposed to?
Sneak out at night	L6A Did you <u>often</u> sneak out of the house at night?
Run away overnight	L6C Before age 18, did you ever run away from home <u>overnight</u> ?
Lied, used false name	L7 Before 18, did you ever tell <u>a lot</u> of lies or use a false name or alias?
Outsmarted, conned others	L7B Before age of 18, was there ever a period when you often outsmarted others and "conned" them?
Stole from home or family	L8 Before age 18, did you steal money or things from your home or family more than once? If yes, did you only steal things of trivial value, like loose change or things like that?
Shoplifted	L8A Before age 18, did you steal or shoplift from shops or other people (without their knowing) more than once? If yes, did you only steal things of trivial value like comics or lollies?
Forged signature	L8B Before age 18, did you forge anyone's signature on a cheque or credit card more than once?
Damaged property	L9 Have you ever damaged someone's property <u>on purpose</u> ?
Started physical fights	L10 Before age 18, did you <u>start</u> physical fights (with persons <u>other than</u> your brothers or sisters) 3 or more times?
Used a weapon	L11 Before age 18, did you ever use a weapon like a bat, brick, broken bottle, gun or a knife (other than in combat, when hunting, or as part of your job) to threaten or harm someone?
Physically injured someone	L12 Before age 18, (other than fighting or using a weapon) did you ever physically injure anyone on purpose?
Bullied others	L13 Before age 18, were you <u>often</u> a bully, deliberately hurting or being mean to others?
Mean to animals	L14 Before age 18, were you ever mean to animals including pets or did you hurt animals on purpose?
Lighted fires	L15 Before 18, did you ever deliberately light any fires you were not supposed to?
Broke into someone's car/house	L16 Before 18, did you ever break into someone's car or house or anywhere else (not because you were locked out)?
Forcefully stole money or property	L17 Before age 18, did you ever take money or property from someone else by threatening them or using force, like snatching a purse or robbing them?
Forced someone into sexual activity	L20 Before age 18, did you ever force anyone into intercourse or any other form of sexual activity?

A.2 APA Criteria for Conduct Disorder

Table 1.2 DSM-IV Diagnostic Criteria for Conduct Disorder^a

A Repetitive and persistent pattern of behaviour in which the basic rights of others or major age-appropriate societal norms or rules are violated, as manifested by the presence of three (or more) of the following criteria in the past 12 months, with at least one criterion present in the past 6 months:

Aggression to people and animals

1. Often bullies, threatens, or intimidates others
2. Often initiates physical fights
3. Has used a weapon that can cause serious physical harm to others (e.g., a bat, brick, broken bottle, knife, gun)
4. Has been physically cruel to people
5. Has been physically cruel to animals
6. Has stolen while confronting a victim (e.g., mugging, purse snatching, extortion, armed robbery)
7. Has forced someone into sexual activity

Destruction of property

1. Has deliberately engaged in fire setting with the intention of causing serious damage
2. Has deliberately destroyed other's property (other than by fire setting)

Deceitfulness or theft

1. Has broken into someone else's house, building, or car
2. Often lies to obtain goods or favours to avoid obligations (i.e., "cons" others)
3. Has stolen items of nontrivial value without confronting a victim (e.g., shoplifting, but without breaking and entering; forgery)

Serious violations of rules

1. Often stays out at night despite parental prohibitions, beginning before age 13 years
2. Has run away from home overnight at least twice while living in parental or parental surrogate home (or once without returning for a lengthy period)
3. Is often truant from school, beginning before age 13 years.

B The disturbance in behaviour causes clinically significant impairment in social, academic, or occupational functioning.

C If the individual is age 18 years or older, criteria are not met for antisocial personality disorder.

Specify severity:

Mild: few if any conduct problems in excess of those required to make the diagnosis and conduct problems cause only minor harms to others.

Moderate: number of conduct problems and effect on others intermediate between "mild" and "severe."

Severe: many conduct problems in excess of those required to make the diagnosis or conduct problems cause considerable harm to others.

^a Source: American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th ed. Washington, DC: American Psychiatric Association, 1994:98-99.

Table A.3 Estimates of the effect of more than 5 conduct disorder behaviours (above 90 percentile)

CD >5	Grade retention	Marks primary	Marks high school	3+ dropout	Education years	High school
OLS	0.103 (0.022)***	- 0.169 (0.033)***	- 0.303 (0.032)***	0.020 (0.013)	- 0.897 (0.111)***	- 0.158 (0.024)***
N	5286	5276	5270	1732	5288	5288
FE All	0.032 (0.022)	- 0.106 (0.039)***	- 0.207 (0.039)***	0.018 (0.014)	- 0.372 (0.136)***	- 0.073 (0.025)***
N	5286	5276	5270	1732	5288	5288
FE Identical	0.069 (0.035)*	- 0.069 (0.059)	- 0.103 (0.062)*	0.040 (0.025)	- 0.207 (0.232)	- 0.069 (0.044)
N	2238	2234	2238	720	2236	2236
	3+ Job quits	Lies	Attacking others	Debts	Arrested since 18	Jail
OLS	0.132 (0.022)***	0.192 (0.019)***	0.198 (0.026)***	0.131 (0.020)***	0.137 (0.021)***	0.075 (0.015)***
N	2182	5288	2180	2182	2178	2176
FE All	0.099 (0.028)***	0.185 (0.015)***	0.139 (0.035)***	0.131 (0.023)***	0.085 (0.023)***	0.039 (0.011)***
N	2182	5288	2180	2182	2178	2176
FE Identical	0.001 (0.047)	0.128 (0.026)***	0.041 (0.062)	0.112 (0.039)***	0.014 (0.039)	0.028 (0.018)
N	888	2234	888	888	888	886

Table A.4 Estimates of the effect of at least 10 conduct disorder behaviours (above 98 percentile)

CD >=10	Grade retention	Marks primary	Marks high school	3+ dropout	Education years	High school
OLS	0.236 (0.050)***	- 0.227 (0.069)***	- 0.474 (0.071)***	0.039 (0.032)	- 1.335 (0.201)***	- 0.267 (0.050)***
N	5286	5276	5270	1732	5288	5288
FE All	0.131 (0.041)***	- 0.070 (0.075)	- 0.201 (0.074)***	0.022 (0.027)	- 0.617 (0.260)**	- 0.148 (0.048)***
N	5286	5276	5270	1732	5288	5288
FE Identical	0.169 (0.078)**	- 0.061 (0.131)	- 0.060 (0.136)	0.092 (0.052)*	0.134 (0.510)	0.003 (0.097)
N	2238	2234	2238	720	2236	2236
	3+ Job quits	Lies	Attacking others	Debts	Arrested since 18	Jail
OLS	0.171 (0.051)***	0.343 (0.050)***	0.384 (0.055)***	0.249 (0.051)***	0.257 (0.052)***	0.157 (0.042)***
N	2182	5288	2180	2182	2178	2176
FE All	0.068 (0.051)	0.270 (0.029)***	0.285 (0.065)***	0.185 (0.043)***	0.163 (0.043)***	0.131 (0.021)***
N	2182	5288	2180	2182	2178	2176
FE Identical	- 0.123 (0.097)	0.055 (0.056)	0.237 (0.127)*	0.232 (0.081)***	-0.002 (0.080)	0.126 (0.037)***
N	888	2234	888	888	888	886

Table A.5 The effect of four subscales of conduct disorder on positive human capital

Subscales of conduct disorder	Grade retention	Marks primary	Marks high school	3+ Dropout	Education years	High school
OLS	0.005	0.008	0.014	0.001	0.052	-0.019
Aggression	(0.012)	(0.017)	(0.017)	(0.004)	(0.061)	(0.012)*
	0.012	0.045	0.046	0.002	0.052	0.019
Destruction	(0.013)	(0.019)**	(0.018)**	(0.005)	(0.070)	(0.013)
	0.009	- 0.020	- 0.016	0.005	0.007	- 0.005
Deceit/theft	(0.007)	(0.011)*	(0.010)	(0.003)	(0.039)	(0.007)
	0.029	- 0.065	- 0.119	0.006	- 0.409	- 0.056
Violation of rules	(0.006)***	(0.008)***	(0.008)***	(0.002)**	(0.029)***	(0.006)***
N	5286	5276	5270	4642	5288	5288
Fixed effect All	- 0.011	- 0.006	0.028	- 0.007	0.035	- 0.009
Aggression	(0.011)	(0.020)	(0.019)	(0.004)*	(0.068)	(0.013)
	0.009	0.015	0.019	0.006	0.005	0.011
Destruction	(0.013)	(0.024)	(0.023)	(0.005)	(0.083)	(0.015)
	- 0.001	- 0.022	- 0.035	0.006	- 0.072	- 0.005
Deceit/theft	(0.007)	(0.013)	(0.013)***	(0.003)**	(0.046)	(0.008)
	0.024	- 0.044	- 0.081	0.006	- 0.159	- 0.029
Violation of rules	(0.006)***	(0.011)***	(0.011)***	(0.002)**	(0.039)***	(0.007)***
N	5286	5276	5270	4642	5288	5288
Fixed effect Identical	0.013	- 0.020	0.001	- 0.003	- 0.020	0.003
Aggression	(0.016)	(0.027)	(0.028)	(0.007)	(0.106)	(0.020)
	- 0.004	- 0.006	- 0.046	0.017	- 0.070	- 0.002
Destruction	(0.019)	(0.032)	(0.033)	(0.008)**	(0.125)	(0.024)
	0.010	0.013	0.038	0.011	- 0.037	- 0.024
Deceit/theft	(0.011)	(0.019)	(0.019)*	(0.005)**	(0.073)	(0.014)*
	0.016	- 0.035	- 0.061	0.001	- 0.034	- 0.006
Violation of rules	(0.009)*	(0.016)**	(0.016)***	(0.004)	(0.062)	(0.012)
N	2238	2234	2238	1992	2236	2236

Table A.6 The effect of specific components of conduct disorder on negative human capital

Subscales of conduct disorder	3+ Dropout	3+ Job quits	Attacking others	Debts	Arrested since 18	Jail
OLS	0.004	0.036	0.116	0.028	0.016	0.015
Aggression	(0.006)	(0.012)***	(0.015)***	(0.011)**	(0.012)	(0.008)*
	-0.004	0.014	0.040	0.019	0.025	0.012
Destruction	(0.006)	(0.013)	(0.016)**	(0.011)*	(0.013)**	(0.007)*
	0.008	0.025	0.031	0.024	0.030	0.012
Deceit/theft	(0.005)*	(0.007)***	(0.009)***	(0.007)***	(0.006)***	(0.004)***
	0.005	0.024	0.020	0.030	0.027	0.015
Violation of rules	(0.004)	(0.006)***	(0.007)***	(0.005)***	(0.005)***	(0.003)***
N	1732	2182	2180	2182	2178	2176
Fixed effect All	-0.008	0.038	0.100	0.032	0.007	0.004
Aggression	(0.007)	(0.014)***	(0.018)***	(0.012)***	(0.012)	(0.006)
	0.004	0.018	0.062	0.021	0.016	-0.006
Destruction	(0.009)	(0.018)	(0.022)***	(0.015)	(0.015)	(0.007)
	0.010	0.028	0.032	0.035	0.020	0.009
Deceit/theft	(0.005)**	(0.010)***	(0.012)***	(0.008)***	(0.008)**	(0.004)**
	0.006	0.008	0.004	0.019	0.024	0.019
Violation of rules	(0.004)	(0.009)	(0.011)	(0.007)**	(0.008)***	(0.004)***
N	1732	2182	2180	2182	2178	2176
Fixed effect Identical	-0.002	0.005	0.080	0.051	-0.000	-0.005
Aggression	(0.011)	(0.022)	(0.029)***	(0.018)***	(0.018)	(0.008)
	0.023	-0.002	0.116	0.042	0.030	-0.004
Destruction	(0.014)*	(0.028)	(0.037)***	(0.023)*	(0.023)	(0.011)
	0.017	-0.006	0.013	0.023	0.010	0.007
Deceit/theft	(0.008)**	(0.016)	(0.021)	(0.013)*	(0.013)	(0.006)
	0.004	0.028	-0.009	0.024	0.012	0.017
Violation of rules	(0.008)	(0.015)*	(0.019)	(0.012)**	(0.012)	(0.006)***
N	720	888	888	888	888	886

Table A.7 The effect of the timing of conduct disorder on the conduct disorder score

	OLS	Fixed Effect All	Identical
Years of CD	1.883 (0.080)***	1.397 (0.050)***	1.035 (0.069)***
Years of CD squared	-0.134 (0.012)***	-0.102 (0.007)***	-0.073 (0.010)***
N	5198	5198	2208