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The effect of child maltreatment on illegal and problematic behaviour: new evidence on the 'cycle of violence' using twins data

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Abstract This paper investigates the effect of physical and sexual child maltreatment on several types of illegal and problematic behaviour. By using variation within pairs of twins, we are able to mitigate concerns about confounding factors from previous studies. Using ordinary least squares and twin fixed effects estimation approaches, we find that child maltreatment has a large effect on illegal and problematic behaviours such as drug abuse, conduct disorders, and crime. The estimated effects suggest an increase of illegal and problematic behaviour between 50 and 100%. Our findings are consistent with the so-called cycle of violence hypothesis.

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1 Introduction

Recent scandals with TV personalities, pop stars, and Catholic clergy have attracted massive media attention towards the problem of child maltreatment. However, these cases are only part of a much larger problem. According to The World Health Organisation, approximately 20% of women and 5–10% of men report being sexually maltreated as children, while 23% of people report physical maltreatment.[1] The consequences of childhood maltreatment might be significant, not only for the maltreated individual but also for society at large. A large literature has documented that maltreated and neglected children perform worse in school, have lower cognitive abilities, and display a number of mental problems such as depressions and difficulties to cope with everyday life. In addition, child maltreatment has been positively associated with the use of illegal drugs, antisocial behaviour, and crime (e.g. Gil 1970; Kempe et al. 1962; Hunter and Kilstorm 1979; Dinwiddie et al. 2000; Nelson et al. 2006).

In this paper, we investigate the effect of child maltreatment on illegal and problematic behaviour such as drug abuse, conduct disorder, and criminal involvement in adulthood, using unique data of Australian twins. This effect is proposed in the literature about the so-called cycle of violence hypothesis. This hypothesis links child maltreatment to future criminal behaviour (Widom 1989, 1992; Widom and Maxfeld 2001; Currie and Tekin 2012). Studying the long-term effects of child maltreatment might therefore add to the understanding of adult criminal behaviour. The effect is also particularly important because both drug abuse and criminal behaviour are associated with high social costs. For instance, the costs of crime for Australia, the context of this paper, have been estimated at 5% of GDP and the yearly costs of illicit drug use at $56 billion (Mayhew 2003).

Investigating the effects of childhood maltreatment on illegal and problematic behaviours poses several empirical challenges. First, obtaining reliable measures of child maltreatment is difficult. Administrative data are likely to capture only a small proportion of the actual occurrences of childhood maltreatment. In addition, parental reports on child maltreatment might not be reliable due to the high sensitivity of the topic and reluctance of parents to report about their own or other's misbehaviour. In this paper, we are able to use retrospective self-reports on childhood maltreatment from a sample of twins aged 24 to 36 years. The measures are based on an extensive questionnaire that focused on various severe types of sexual and physical child maltreatment.

Second, estimates of the effect of childhood maltreatment on illegal and problematic behaviour might be confounded by unobserved factors and by reverse causality. Nearly all previous studies on the long-term effects of child maltreatment use estimation strategies, such as matching or linear regression, that might suffer from omitted variable bias. However, children that are maltreated or the families in which maltreatment occurs are probably not a random draw from the population. For instance,

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[1] http://www.who.int/mediacentre/factsheets/fs150/en/

Paxson and Waldfogel (1999, 2002) find that children in families of lower socioeconomic status have a higher probability of being maltreated or neglected. As a consequence, unobserved factors that are correlated with childhood maltreatment and the outcome variables might bias the estimated effects of maltreatment. In this paper, we try to mitigate this concern by using within-family estimation. This approach might reduce the endogeneity problem as it controls for all unobserved factors that are shared by family members. In a recent paper, Currie and Tekin (2012) apply this approach and especially focus on variation within siblings.[2]

In this paper, we are able to apply this approach to a large sample of twins. As our data also contain information about the zygosity of the twins, we can distinguish between fraternal and identical twins. The advantage of using twins instead of siblings is that the family fixed effect is expected to capture more unobserved factors. For instance, the family circumstances will typically be more similar with twins than with siblings. In addition, identical twins are genetically identical, whereas siblings on average only share half of their genetic endowments. A further empirical challenge in estimating the effect of childhood maltreatment is reverse causality. Our data also include information about the timing of the childhood maltreatment and the timing of the illegal and problematic behaviour. We exploit this information to address the potential threat of reverse causality.

Although child maltreatment may have large economic and social consequences, it has hardly been studied by economists. To our knowledge, Currie and Tekin (2012) and Paxson and Waldfogel (1999, 2002) are the only studies on this topic in the economic literature. Our study contributes to the economic literature by adding a new piece of evidence. We follow the same empirical strategy as Currie and Tekin (2012; henceforth CT) but we can extend their analysis in several important ways. First, we are using a large sample of twins and we are able to distinguish between identical and fraternal twins. CT mainly focus on sibling comparisons. Their twin sample is small and they cannot control for zygosity. By using a large sample of twins and differentiating between identical and fraternal twins, we can improve the empirical strategy as twins, and especially identical twins, are expected to share more unobserved factors than siblings. Second, in the present paper, we are able to look at some other important outcomes new to the literature, such as drug dependence and conduct disorder, and we are able to differentiate the effect of sexual abuse according to the perpetrator. Third, we can take account of reverse causality by exploiting data about the timing of child maltreatment and the timing of illegal and problematic behaviour. Fourth, our study contributes to the understanding of the long-term effects of physical maltreatment as our data contain information about severe types of physical maltreatment. Finally, by looking at a different country, we can also test the external validity of the important findings on the 'cycle of violence' in CT (2012) .

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[2]Currie and Tekin (2012) also use a small sample of twins but their main estimates are based on a sample of siblings.

We find consistent evidence that childhood maltreatment has a large effect on illegal and problematic behaviour both between and within families. The estimated effects imply an increase of illegal and problematic behaviour of 50 to 100% relative to the baseline levels of individuals that have not been maltreated. This is consistent with the findings by Currie and Tekin (2012) who report a doubling of criminal behaviour due to childhood maltreatment. Both physical and sexual maltreatment have a large effect on all types of illegal and problematic behaviour. Sexual maltreatment by an outsider increases externalising behaviour such as conduct disorder and crime. Sexual maltreatment by a family member induces internalising behaviour such as drug abuse or drug dependence. For males, we find that physical and sexual maltreatment increase all types of illegal and problematic behaviour. For females, we find that both sexual maltreatment and physical maltreatment increase drug abuse (dependence) and conduct disorder. In sum, our estimation results, based on ordinary least squares (OLS) models with a large set of controls and twin fixed effect models, indicate a strong relationship between child maltreatment and illegal behaviour. We acknowledge that the variation that is used for obtaining these results is not as clean as the variation that is obtained in a randomised setting. However, in the context of child maltreatment, it is very difficult, and probably impossible, to obtain variation that is really exogenous. Therefore, our approach, which extends the control strategies applied in previous studies towards samples of twins and identical twins, might be considered as the best feasible approach for investigating the causal effect of child maltreatment. We believe that our results, which are consistent for different models and samples, should be interpreted as further evidence for the so-called cycle of violence.

The paper is organised in the following way. Section 2 discusses the theoretical background of the problem and summarises the previous literature. Section 3 discusses the data and the construction of the main variables, and provides descriptive statistics. In Section 4, we discuss the empirical strategy. Section 5 shows the main estimation results. Section 6 provides various robustness analyses, and Section 7 concludes.

2 Previous studies on child maltreatment and illegal behaviour

A large literature, both in economics and in other social sciences, has investigated the long-term effects of early childhood conditions. This literature studies the effects of negative shocks in early childhood, such as poverty, malnutrition, disease exposure, and stress. The effects of such negative shocks frequently manifest in chronic diseases later in life (Gluckman et al. 2008). Early-life conditions affect the infant's health and his/her educational attainment and labour market outcome. According to a model by Currie and Stabile (2002), individuals are endowed with their maximal health stock when they are born, and afterwards, they are exposed to various shocks which decrease it. Childhood maltreatment can be considered as an important topic within this literature as maltreatment can be seen as a severe negative shock that potentially may affect various future outcomes, such as academic performance, mental health, problematic behaviour, and crime.

2.1 Theories about the effects of child maltreatment

In the literature, several theories have been formulated to explain the link between childhood maltreatment and problematic behaviour. Antisocial behaviour and delinquency among victims of child sexual maltreatment usually are interpreted as anger stemming from the traumatic experience and representing a desire for retaliation (Finkelhor and Browne 1985). Childhood physical maltreatment could also lead to chronic aggressive behaviour by having an impact on the development of social-cognitive processes (Dodge et al. 1990). According to the so-called attachment theory, physical maltreatment will prompt the child to perceive the world as a threatening place, and maltreated children become hyper-vigilant towards hostile cues and respond to the behaviour of others with violence. The context of maltreatment can also be linked with control theory, which states that maltreatment disrupts social bonds and the individual does not restrain from violence but gratifies his natural impulses (Breda and Corwyn 2002). Finally, social learning theory says that being the victim of childhood maltreatment provides a model of violence the individual will follow in his/her adult life because experiencing violence leads one to evaluate aggressive behaviour as leading to efficacious positive outcomes (Dodge et al. 1990). Thus, social learning theory leads to the formulation of the cycle of violence hypothesis, according to which childhood maltreatment predisposes to violence in later years (Widom 1989).

Criminological literature indicates that antisocial behaviour tends to be fairly stable over the life course (Simons et al. 1995; Caspi and Moffitt 1992; Loeber 1982). That is, antisocial behaviour shows the characteristics of a behavioural trait. This is the so-called homotypic continuity (Pajer 1998). In our context, this means that someone who displays aggressive behaviour in adolescence will continue to do so in adulthood, which implies that conduct disorder might be a good predictor of criminal behaviour later in life.

From an economic perspective, individuals engage in crime after weighing the costs and benefits that stem from illegal behaviour and indulge in such behaviour if the benefits exceed the costs (Becker 1968). Control theory points out as a cost the broken social bonds but ignores the other costs and the benefits. Social learning theory suggests that the individual copies the violence he experiences and eventually accumulates capital as a criminal instead of as a regular worker (Currie and Tekin 2012). The 'homotypic continuity' hypothesis states that individuals adopt criminal careers throughout their lifetime, which is in line with the social learning theory.

In sum, the above theories imply that maltreated children will tend to grow up as aggressive and mistrusting individuals who will either escape reality by engaging in substance abuse or will externally express their aggression (or both). Furthermore, individuals who engage in conduct disorder have a high propensity to continue committing crimes throughout their adulthood.

2.2 Empirical studies on the effects of child maltreatment

A number of social studies deal with both the short- and long-term consequences of childhood sexual maltreatment. In a review study, Putnam (2003) confirms the

significance of child sexual maltreatment as a factor for psychopathology, especially depression and substance abuse. Using a community sample of British women, Mullen et al. (1993) establish a positive correlation between child sexual maltreatment and a range of psychopathology measures, among which substance abuse and suicidal behaviour. Dube et al. (2003) use a sample of adults from California to investigate the relationship between illicit drug use and adverse childhood experiences, among which were physical and sexual child maltreatment. These studies, though supporting the hypothesis of the negative effects of childhood sexual maltreatment, are based on associations which might be biased by unobserved factors that are related to childhood maltreatment and the outcomes variables. Several studies investigate the relationship between child maltreatment and drug addiction. The associated negative self-esteem or self-derogation resulting from child maltreatment might initiate self-destructive behaviour, such as illicit drug use and alcohol consumption (Kaplan 1980; Dembo et al. 1987; Dube et al. 2003). Maltreated children (both physically and sexually maltreated) are ill-equipped for meaningful relationships; they mistrust others and often are insecure and cognitively impaired, and many of them use drugs as a way to escape from their pain and problems (Garbarino and Gilliam 1980; Dembo et al. 1987).

There are very few studies that investigate the effect of maltreatment on delinquent behaviour and further criminal involvement of individuals. One such study was conducted by Widom (1989), who proposed the above-mentioned 'cycle of violence' hypothesis. Using a longitudinal study of substantiated cases of maltreatment and neglect, and matching them to non-maltreated children with the same background characteristics, she finds that childhood maltreatment and neglect increase the likelihood of being arrested as a juvenile by 53% and as an adult by 38%. This finding confirms the cycle of violence hypothesis. English et al. (2002) replicate these results and also find that emotional maltreatment increases the risk of later violent behaviour. However, the matching techniques that are used in these studies are based on the conditional independence assumption which might not hold as child maltreatment probably is not (conditionally) random.

Several studies have used data of twins to investigate the negative consequences of child maltreatment. Nelson et al. (2006) use the same data as used in this paper to investigate the association between a history of childhood sexual maltreatment and the use of specific licit (nicotine and alcohol) and illicit drugs (cannabis, sedatives, cocaine). They use a survival analysis without exploiting the twin dimension of the data. They find that a history of childhood sexual maltreatment is associated with a significant risk for regular smoking and illicit drug use. Dinwiddie et al. (2000) investigate the association between reporting childhood sexual maltreatment and psychopathology. They find that childhood sexual maltreatment is positively associated with lifetime diagnoses of major depression, conduct disorder, panic disorder, and alcoholism. Moreover, they find that individuals that report childhood sexual maltreatment are also more likely to report suicidal ideation and a history of suicide attempts.

In the economic literature, we are aware of only one paper that studies the long-term effects of child maltreatment. Currie and Tekin (2012) investigate the

impact of child maltreatment on the likelihood of committing crime using a national representative survey from the USA (the National Longitudinal Study of Adolescent Health). Using OLS, and sibling and twin fixed effect estimation, they find that maltreatment doubles the probability of engaging in crime, with sexual abuse having the largest impact. Moreover, they confirm that the probability of engaging in crime increases with the severity of maltreatment. These conclusions are mainly based on the results of the sibling fixed effect estimations.

3 Data

We use data from the so-called younger cohort of twins of the Australian Twin Register (ATR). This cohort consists of a sample of 4246 twin pairs born between 1964 and 1971. The twins were registered with the ATR as children by their parents in response to media appeals and systematic appeals through the school system in the period 1980–1982. The data have been collected in two surveys. The first survey was conducted by a mailed questionnaire in 1989–1990, when the twins were 18–25 years old. The response rate of this survey was 63%. The second survey was conducted by telephone interviews in 1996–2000. The telephone interviews were completed with 6267 individuals, 2805 men (889 complete and 1027 incomplete pairs) and 3462 women (1215 complete and 1032 incomplete pairs). At the time of the interview, the twins were 24–36 years old (on average 30 years). The individual response rate for the second survey 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), conduct disorder, personality, feelings, and attitudes. Zygosity was determined by a combination of diagnostic questions plus blood grouping and genotyping. The measures of child maltreatment and illegal behaviour were gathered in the second survey which is called the Semi-Structured Assessment for the Genetics of Alcoholism. In the analysis, we focus on complete twin pairs which give us a sample of 2330 identical and 3200 fraternal individual twins. In the analyses that look at the effects for male or female pairs of twins, we exclude the opposite sex twin pairs. This reduces the number of observations. Moreover, in some analyses, the number of observations will be smaller due to missing values on the outcome variable.

3.1 Measuring child maltreatment

Various questions about sexual and physical maltreatment are asked in the survey. We use these questions for constructing indicators of sexual and physical maltreatment.

3.1.1 Sexual maltreatment

As an indicator for sexual maltreatment, we constructed a dummy variable that equals one when the respondent answered positively to either of the questions below:

(1) *Before the age of 16, he/she was forced into any sexual contact with anyone else other than a family member (someone older by 5 years);*

(2) *Before the age of 16, he/she was forced into any sexual contact with a family member (someone older by 5 years);*

(3) *He/she was sexually molested as a child.*

The data also provide information about the frequency of sexual maltreatment (once or multiple times) and whether the offender was a family member or an outsider. We also use this information in the analysis.

3.1.2 Physical maltreatment

The questions about physical maltreatment refer to the ages between 6 and 13. From these questions, we constructed a dummy variable that equals one when the respondent replied positively to either of the statements below:

(1) *He/she was often or sometimes punched or hit with a belt or stick or something like that by either of the parents or physically punished so that he/she hurt the next day;*

(2) *The way in which either of the parents punished him/her was harsh or the respondent was ever physically injured or hurt on purpose as a child (examples include broken bones, bruises, punishments that included scalding water, or any other physical injuries).*

(3) *The respondent was physically abused as a child.*

Like Currie and Tekin (2012) and many other studies, this paper uses retrospective reports of maltreatment provided by the individuals themselves. The self-reported retrospective nature of the data might be a reason for concern as individuals tend to forget past experiences. The fact that we focus on severe types of maltreatment and use various questions for measuring these types of maltreatment might mitigate this concern. In addition, the data on maltreatment were collected when the twins were still relatively young (24–36 years old). We also checked whether twins aged below the sample mean more often reported sexual or physical maltreatment than twins aged above the sample mean. This was not the case (13 versus 12% for sexual maltreatment; 35 versus 34% for physical maltreatment).

One important consideration is whether the data from the ATR is nationally respresentative and whether comparable patterns are found in other data samples and analyses. Based on several studies that have also used ATR data, it seems that the patterns found in the ATR data are consistent with the patterns found in nationally representative data. For instance, Le et al. (2005) compared this twin sample with data of Australian individuals from the Youth in Transition surveys and concluded that the patterns in relation to school-leaving decisions are broadly similar to those obtained from samples representative of the general population. Slutske et al. (1997) noted that twins seem representative of the general population with respect to conduct disorder. Moreover, Webbink et al. (2013) compared several crime outcomes with population statistics and concluded that the ATR data were in line with population statistics.

Table 1 shows the proportions of individual twins that report some kind of maltreatment measured by the indicators described above. Approximately 12% of the sample reports sexual maltreatment. This proportion lies in the same ball park as the proportions reported in other studies for Australia, and as collected by the Australian Insitute of Family Studies.[3] The prevalence of sexual maltreatment for males in Australia ranges from around 10 (Mamun et al. 2007) to 16% (Dunne et al. 2003) and from 12 (Dunne et al. 2003) to 42% (Mazza et al. 2001) for females.[4] Table 1 also shows substantial variation in reporting sexual maltreatment within families (columns (2) and (5)); in 67% of the twin pairs that reported sexual maltreatment, there is variation in reporting (52% in the identical twins sample), and 64 (52)% of those reporting sexual maltreatment by a family member or by an outsider have a discordant report from their (identical) co-twin. Physical abuse refers to severe physical maltreatment. It is the most common maltreatment in the data set, reported by 34% of all pairs. The fraction reporting physical abuse is higher than the fraction reporting sexual abuse, and it is higher than the prevalence rate of physical abuse for Australia that other studies discover (Mouzos and Makkai 2004 report a rate of physical abuse of 18%). The higher prevalence of physical maltreatment might be explained by the specific nature of our sample consisting of twins. Previous studies have found increased rates of maltreatment (and neglect) for twins (Robarge et al. 1982; Nelson and Martin 1985; Currie and Tekin 2012). The higher prevalence of physical maltreatment among twins might result from the higher stress parents are under, exhaustion, financial pressures, neonatal complications, and higher rates of premature birth among twin pairs (Robarge et al. 1982; Nelson and Martin 1985). We also observe substantial variation in the physical maltreatment reported within families: 47% in the whole sample of physically maltreated twins (42% of the physically maltreated identical twins) have a physical maltreatment report different from that of their co-twin. This variation within twin pairs is important for the identification of the effects of maltreatment.

The reasons for within-twin variation in maltreatment are important for the interpretation of the estimated effects (see also Section 4). Unfortunately, our data do not provide direct information that can explain the differential treatment by parents. However, previous studies provide insight in this important question. Currie and Tekin (2012) note that, in cases of child maltreatment, it is not uncommon for one child to be abused while the other children in the family are unharmed. Jaffee et al. (2004) investigates cases of abuse within pairs of identical twins and reports four reasons why twins were treated differently:

(1) *One twin had been ill;*
(2) *The mother had a folk belief that children had to have opposite personalities, or that one had to be dominant;*
(3) *The mother identified one of the twins with herself;*
(4) *The mother identified one of the twins with a partner or ex-partner.*

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[3] https://aifs.gov.au/cfca/publications/prevalence-child-abuse-and-neglect
[4] These studies were found on the site with statistics by the Australian Institute of Family Studies, quoted above.

Table 1 Fraction reporting maltreatment in the total sample

Maltreatment	(1) All twins	(2) Pairs with different reports (%)	(3) Fraternal twins	(4) Identical twins	(5) Pairs with different reports (%)
Sexual	0.12	0.67	0.12	0.11	0.52
Sexual by outsider	0.04	0.78	0.04	0.04	0.61
Sexual by family member	0.04	0.64	0.04	0.04	0.52
Physical	0.34	0.47	0.34	0.34	0.42
Any	0.40	0.44	0.40	0.40	0.39
Observations	5530		3200	2330	

The sum of those reporting sexual maltreatment by a family member and those reporting sexual maltreatment by an outsider is smaller than the total fraction because sexual maltreatment is defined by three variables

Importantly, there was no consistent pattern in terms of which twin was treated worse. Jaffee et al. (2004) also notes that abusive parents might target a single child instead of both twins in the family in order not to attract much outside attention, or prevent cooperation between the children and their reporting to the authorities. Other explanations for the 'single child' targeting are related to characteristics of the child (gender, idiosyncratic behaviour, physical and mental problems), or to parental characteristics (mental disorders, abuse of alcohol, drugs, etc.). It is a phenomenon, which has been extensively reported in the media.[5]

Furthermore, in our data, child maltreatment might also be done by other family members than the parents or by outsiders.

3.2 Measuring illegal and problematic behaviour

In the questionnaire, several questions about illegal and problematic behaviour have been asked. We use these questions for constructing indicators for drug abuse, drug dependence, conduct disorder, and crime.

3.2.1 Drug abuse

We follow the American Psychiatric Association's (APA) definition of drug abuse based on the Diagnostic and Statistics Manual of Mental Disorders (DSM-IV). As

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[5]For example, http://www.kansascity.com/news/article304620/It-isnt-rare-for-parent-to-single-out-one-child-for-abuse.html, http://www.post-gazette.com/local/region/2014/07/22/Phenomenon-exists-in-which-one-child-is-abused-while-others-are-not-experts-say/stories/201407220054, and for a book describing such a case, refer to David Peltzer's A Child Called "It" (1995), ISBN13: 9781558743663.

an indicator of drug abuse, we use a dummy variable that equals one when the respondent answered positively to either of the statements below:

(1) *He/she has been under the influence of a certain drug, which increased his/hers chances of getting hurt (examples include driving a car or a boat, using knives, machinery or guns, crossing against traffic, climbing, or swimming);*
(2) *Being under the influence of the drug ever interfered with working, studying, or taking care of household responsibilities.*

3.2.2 Drug dependence

Our indicator for drug dependence is based on a series of questions. The indicator has a value of one when the respondent replied positively to at least two of the following questions dealing with drug dependence:

(1) *He/she has ever used the respective drug(s) for more days or in larger amounts than intended;*
(2) *Whether compared to the first time the respondent used the respective drug(s), he/she needed increasingly larger amounts to get any effect or he/she no longer was getting high on the same amounts as before;*
(3) *The respective drug(s) has ever caused emotional or psychological problems, like feeling depressed or uninterested in things, feeling grumpy or easily irritated, having trouble thinking clearly for more than 24 hours, feeling paranoid, or suspicious of people;*
(4) *Whether there have been three or more times that the respondent wanted to cut on the respective drug(s).*

This definition of drug abuse includes three out of the four criteria used in the APA definition and does not completely cover the DSM-IV diagnostic criteria. However, previous studies using the same data also use this definition and show that it provides a valid measure of drug abuse and dependence (see Lynskey et al. 2002, 2003).

3.2.3 Conduct disorder

The American Psychiatric Association (APA) defines conduct disorder as '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 the following: often initiated physical fights; has deliberately destroyed others' property; has broken into someone else's house, building, or a car; and has often been truant from school. Our data contain self-reported information on 21 statements that reflect behavioural problems before the age of 18. We used this information to construct two measures of conduct disorder. Our first measure follows the APA definition and is based on the 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' were coded as 0. We call this measure the APA definition of conduct

disorder. For our second measure of conduct disorder, we created a conduct disorder score based on the 21 statements.[6] We call this measure the conduct disorder score.

3.2.4 Crime

Our indicators of crime are based on three general questions about criminal behaviour. The first indicator is coded as one in case the respondent answered positively to at least one of the following questions:

(1) *He/she has ever spent time in jail;*
(2) *Has ever been arrested (for anything else other than drunk driving or drunken behaviour);*
(3) *Has ever done something (else) that he/she could have been arrested for (even though he/she was not).*

The last question is about crime that has remained unnoticed by the authorities. It is important to also take these crimes into account as they may generate high social costs. We call this first indicator 'total crime'. The second indicator of crime is based on the first two crime questions only. We call this 'detected crime'. It should be noted that due to the routing of the questionnaires not all individuals had to answers these 'crime' questions. Individuals that did not report any of a series of problematic behaviours related to conduct disorder did not have to answer the 'crime' questions. This implies that our indicator of crime is conditional on having at least one behavioural problem used in measuring conduct disorder. As mentioned above, conduct disorder is defined as displaying at least three problematic behaviours within 1 year. Since conduct disorder and other problematic adolescent behaviour is viewed in the social literature as a relatively good predictor of later crime engagement (Simons et al. 1995; Loeber 1982; Pajer 1998), it might be expected that the rooting of the questionnaire will not induce substantial measurement error for the crime indicator.

These measures of illegal and problematic behaviour are also based on self-reports. The reliability of these self-reported data is an important issue. In criminology, the use of self-reported data is well established. Self-reported data collection has been the dominant technique used for measuring illegal behaviour since its introduction in the 1950s by Short and Nye (1957). A large literature shows that self-reported data have consistently acceptable reliability and validity (see Webbink et al. 2013).

Table 2 shows the proportion of the twins that report some type of illegal or problematic behaviour. In addition, this table reports the proportions for each category of maltreatment. The first column of Table 2 shows that 17% of the total sample reports drug abuse. Official reports about drug prevalence in Australia (Australian Institute of Health and Welfare 2006) indicate that around 38% of Australians aged 14 and more used some illicit drug at a certain point in their life, and around 15% had used illicit drugs at least once in the past 12 months. Although these statistics refer to any

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[6]Further details about the construction of these measures can be found in Webbink et al. (2012).

Table 2 Means of outcome variables by maltreatment and type of maltreatment

	Maltreatment						
	(1) Full sample	(2) None	(3) Any	(4) Physical	(5) Sexual	(6) Sexual by family	(7) Sexual by outsider
Drug abuse	0.17	0.13	0.23	0.23	0.29	0.27	0.25
	[0.37]	[0.33]	[0.42]	[0.42]	[0.45]	[0.44]	[0.48]
Drug dependence	0.15	0.11	0.21	0.21	0.28	0.20	0.20
	[0.36]	[0.32]	[0.40]	[0.41]	[0.45]	[0.46]	[0.46]
Conduct disorder:							
APA definition	0.13	0.08	0.19	0.22	0.22	0.10	0.11
	[0.33]	[0.27]	[0.39]	[0.41]	[0.42]	[0.30]	[0.31]
Score	1.79	1.32	2.49	2.58	2.79	2.70	2.93
	[2.39]	[1.95]	[2.78]	[2.86]	[2.87]	[2.79]	[2.94]
Crime:							
Total	0.27	0.21	0.35	0.37	0.32	0.31	0.27
	[0.44]	[0.41]	[0.48]	[0.48]	[0.47]	[0.46]	[0.44]
Detected	0.05	0.03	0.08	0.09	0.09	0.08	0.12
	[0.22]	[0.18]	[028]	[0.28]	[0.28]	[0.27]	[0.33]
Any illegal behaviour	0.37	0.31	0.47	0.49	0.45	0.39	0.37
	[0.48]	[0.46]	[0.50]	[0.50]	[0.50]	[0.49]	[0.48]
Observations	5530	3322	2208	1894	653	227	

Standard deviations are given in brackets

drug use, which does not necessarily imply drug abuse and/or dependence, the prevalence rates in our sample do not seem implausibly high or low compared to these statistics. In the total sample we find a prevalence rate of conduct disorder of 13%. This is in line with Searight et al. (2001) who report that approximately 6 to 16% of boys and 2 to 9% of girls meet the diagnostic criteria for conduct disorder. In the total sample, 27% of the twins report positively about one of the three crime questions. The answers on the first two crime questions reported in our sample seem consistent with population statistics (Webbink et al. 2013).

Table 2 also shows the proportions that report some type of illegal or problematic behaviour within each category of maltreatment. We observe that drug abuse is much more prevalent among those that report any or a specific type of maltreatment (columns (3) to (7)) than among those who report no maltreatment (column (2)). For instance, the prevalence of drug abuse among those who report no maltreatment is 13 against 23% among those who report any maltreatment. A similar pattern can be observed for the other types of illegal behaviour; the prevalence of illegal behaviour is substantially higher among those that report maltreatment than among those that do not report maltreatment. In addition, it can be observed that the prevalence of any

illegal behaviour is 16 percentage points higher among those that have been mal-treated versus those that have not been maltreated from a baseline of 31%. These statistics suggest a link between maltreatment and illegal and problematic behaviour. However, these statistics might provide a biased picture because the occurrence of maltreatment is probably not random.

3.2.5 Control variables

The data provide information on various individual characteristics which can be used as control variables in the OLS models. These variables also provide insight in the type of families in which the occurrence of child maltreatment is more likely. Infor-mation is available about age and gender of the respondent. We also have information about the educational attainment (years of schooling) and about the use of alcohol of both parents. This could be important since the social science literature relates child maltreatment with both alcoholism of the parents and with their level of school attain-ment (McLaughlin et al. 2000). We can also account for whether the child has been raised by his natural parents and whether an adoptive/step-parent was present (the presence of a step-parent is often associated with an increased risk of maltreatment). Another variable of interest is whether the child has witnessed conflict in the family (did the parents fight in front of the children). Moreover, we include control variables for the age of the mother (teenage mother, 18–30 years, 30–40 years, and above 40).

Table 3 shows the means of the explanatory variables by the different maltreat-ment categories. A comparison of individuals that report some type of maltreatment with individuals that do not report maltreatment reveals that maltreated individuals are less often raised by both natural parents, more often had an adoptive or step-parents, more often saw their parents fighting, more often report that mom or dad were alcoholic, and more often had a teen mother. Hence, these statistics suggest that child maltreatment is more likely in families that seem to have more problems.

4 Empirical strategy

For investigating the effect of child maltreatment on illegal and problematic behaviour, we start by estimating OLS regressions without exploiting the twin-dimension of our data. The OLS models that we estimate have the following form:

$$Y_i = \alpha_0 + \alpha_1 M_i + \alpha_2 X_i' + \varepsilon_i, \tag{1}$$

where Y_i is a dummy variable for illegal and problematic behaviour (drug abuse, drug dependence, conduct disorder, or criminal involvement) of individual i, X_i is a vector of control variables, M_i is a dummy variable for (a type of) maltreatment, and ε_i is the error term. Estimation of Eq. 1 will yield the causal effect of maltreatment on illegal and problematic behaviour if maltreatment is not correlated with unobserved factors that are also important for illegal behaviour. However, this conditional independence assumption might not hold as the occurrence of child maltreatment is probably not random. For instance, previous studies indicate that child maltreatment is related to observable characteristics of families (Paxson and Waldfogel 1999, 2002). Including

Table 3 Means of control variables for those reporting physical, sexual, or no maltreatment

Maltreatment	All twins			Identical twins		
	Physical	Sexual	None	Physical	Sexual	None
Male (%)	0.53	0.35	0.40	0.50	0.34	0.37
	[0.50]	[0.48]	[0.49]	[0.50]	[0.47]	[0.48]
Mother has a high	0.26	0.26	0.27	0.26	0.23	0.26
school degree (%)	[0.44]	[0.44]	[0.44]	[0.44]	[0.42]	[0.44]
Mother has more than a	0.17	0.22	0.21	0.16	0.23	0.21
high school degree (%)	[0.28]	[0.41]	[0.41]	[0.37]	[0.42]	[0.41]
Father has a high school degree (%)	0.20	0.20	0.21	0.21	0.24	0.21
	[0.40]	[0.40]	[0.41]	[0.41]	[0.43]	[0.40]
Father has more than a	0.24	0.27	0.27	0.24	0.27	0.27
high school degree (%)	[0.43]	[0.45]	[0.44]	[0.43]	[0.44]	[0.44]
Raised by natural parents (%)	0.78	0.73	0.84	0.76	0.71	0.83
	[0.42]	[0.45]	[0.36]	[0.43]	[0.46]	[0.37]
Adoptive/step-parent (%)	0.09	0.11	0.07	0.10	0.13	0.08
	[0.28]	[0.31]	[0.25]	[0.30]	[0.34]	[0.27]
Parents fought in front	0.42	0.39	0.26	0.41	0.42	0.27
of children (%)	[0.49]	[0.49]	[0.44]	[0.49]	[0.49]	[0.44]
Respondent said mother had	0.04	0.05	0.02	0.04	0.04	0.02
problems with alcohol (%)	[0.20]	[0.21]	[0.14]	[0.18]	[0.20]	[0.14]
Respondent said father had	0.23	0.23	0.13	0.21	0.25	0.12
problems with alcohol (%)	[0.42]	[0.42]	[0.34]	[0.40]	[0.44]	[0.33]
Mother gave birth as a teenager (%)	0.014	0.01	0.006	0.018	0.013	0.005
	[0.12]	[0.10]	[0.08]	[0.13]	[0.11]	[0.07]
Mom's age at birth 18–30 (%)	0.59	0.59	0.56	0.67	0.67	0.60
	[0.49]	[0.49]	[0.50]	[0.47]	[0.47]	[0.49]
Mom's age at birth 30–40 (%)	0.24	0.23	0.28	0.18	0.18	0.26
	[0.42]	[0.42]	[0.45]	[0.38]	[0.38]	[0.44]
Mom's age at birth >40 (%)	0.08	0.10	0.08	0.07	0.08	0.07
	[0.27]	[0.30]	[0.27]	[0.26]	[0.28]	[0.25]

Standard deviations are given in brackets

a large set of controls in the model of Eq. 1 might help but unobserved factors can still be important determinants of child maltreatment and illegal or problematic behaviour. Random variation in maltreatment can solve this problem but, for obvious reasons, it seems not feasible to find variation in maltreatment induced by controlled or natural experiments. Therefore, exploiting variation in maltreatment within families might be the best feasible solution for identifying the causal effect of maltreatment on illegal behaviour. Models that exploit variation within families control for all observed and unobserved factors within families that are shared by the siblings or twins. In

line with Currie and Tekin (2012), we use variation in maltreatment within families. Currie and Tekin (2012) are able to use variation within sibling and within twins of which the zygosity is unknown. Our data also allow us to distinguish between fraternal and identical twins. As a second step in our analysis, we will estimate models that include family fixed effects of the following form:

$$Y_{ij} = \beta_0 + \beta_1 M_{ij} + \beta_2 X_{ij} + \mu_j + \varepsilon_{ij}, \tag{2}$$

where the index j refer to family j and μ_j is the unobserved family fixed effect. This family fixed effect captures all factors that are shared by both twins. Fraternal twins share, just like siblings, approximately half of their genes. Identical twins have exactly the same genes. In addition, most twins are raised within the same family and will share many components of this social environment. Estimation of Eq. 2 reduces the problem of omitted variables bias by differencing out all observed and unobserved factors shared by both twins. We will estimate models for the total sample of twins and separately for samples of identical twins only. The latter sample might be preferred as identical twins share all genes. However, focusing on identical twins only also reduces the sample size and the variation in child maltreatment that can be used in the estimation.

Although the within-twin estimator controls for all unobserved genetic and family factors that are shared by the twins, there are several concerns with this approach. To address these concerns, we perform several robustness analyses. The first concern is reverse causality; does child maltreatment lead to illegal behaviour or does early illegal behaviour induce childhood maltreatment? To address this issue, we exploit information about the timing of child maltreatment and the timing of the various types of illegal behaviour. To reduce the probability that our estimates will be inflicted by potential reverse causality, we re-estimate the main models after excluding all observations for which the illegal or problematic behaviour might have preceded the reported maltreatment.

The second concern is measurement error as pointed out by Griliches (1979) and Bound and Solon (1999). The within-family estimator exacerbates measurement error, which is likely to bias the estimates towards zero. In Section 3, we already discussed the potential for misreporting due to forgetting. We further investigate the potential retrospective bias in the responses by looking at the reports of relatively younger and older parts of our sample by outcome value with the aim of observing whether there is a relationship between measurement error and the outcome. Our analysis in Section 6.3 shows no evidence for a correlation between measurement error and the outcomes.

The third concern is spillover effects within pairs of twins. As twins grow up in the same family and might share a lot of time together, they might also influence each other's behaviour. For instance, if the co-twin copies the illegal behaviour of the twin that experienced childhood maltreatment, we will underestimate the effect of maltreatment. It is also possible that the behaviour of one twin restrains the other twin from doing a specific type of behaviour. This might bias the estimated effects of maltreatment. We investigate the potential bias of these spillover effects by excluding twins from our estimation sample that reported to be very close with their co-twin.

Spillover effects will probably be less important for the sample of twins that do not report to be very close with their co-twin.

The fourth concern with within family estimates is endogeneity bias. Although twins, and especially identical twins, share many observed and unobserved factors, they probably are not exactly identical. Hence, unobserved factors within pairs of twins might bias the estimated effects. The bias in the within-family estimator may not always be smaller than the bias in the cross-sectional estimator (Bound and Solon 1999). This depends on the importance of the fixed family component in the unobservable factors that both affect child maltreatment and the outcome variable. This concern, which is typical for all sibling and twin studies that do not exploit exogenous variation within families, is important for the interpretation of the estimates. For establishing a causal effect of child maltreatment on illegal and problematic behaviour, we should assume that unobservable factors within families do not bias the estimates. This assumption might be difficult to defend as the variation in child maltreatment within pairs of twins is not as clean as the variation that is obtained in a randomised setting. This implies that a causal interpretation of our estimates might not be fully justified. The aim of our empirical strategy is to extend (and improve) the control strategies applied in previous studies by taking account of fixed effects within pairs of twins and within pairs of identical twins. Using twin fixed effects allows us to control for all genetic factors and for all environmental factors shared by (identical) twins. As it is very difficult, and probably impossible, to obtain random variation in maltreatment, this might be considered as the best feasible approach for investigating the causal effect of child maltreatment. Although this strategy has potential limitations, we believe that the estimates provide important evidence about the long-term effects of childhood maltreatment and about the so-called cycle of violence.

5 Main estimation results

In this section, we report the main estimation results. We start by investigating the effect of any maltreatment on three types of illegal and problematic behaviour. Next, we investigate the effect of specific types of maltreatment (sexual or physical maltreatment) on illegal and problematic behaviour.

5.1 The effect of any maltreatment on illegal and problematic behaviour

This section presents the main estimation results of the effect of any child maltreatment on illegal or problematic behaviour, using both OLS and twin-fixed effect models. The main independent variable in these models is 'any maltreatment' which measures whether an individual has experienced sexual or physical maltreatment. We estimate the effect of any maltreatment on six dependent variables: drug abuse, drug dependence, two measures of conduct disorder (APA definition and conduct disorder score), and two indicators of crime (total and detected crime). Table 4 shows the estimation results; each cell shows the estimate of a separate regression. Column (1) shows the results of an OLS regression of a type of illegal behaviour on any maltreatment without any controls, and column (2)—with full set of controls. All models

Table 4 Estimates of the effect of any maltreatment on the outcome variables

| | (1) | (2) | FE | | |
| | | | (3) | (4) | (5) |
	OLS no controls	OLS	All twins	Fraternal twins	Identical twins
Drug abuse	0.104***	0.080***	0.054**	0.057**	0.047**
	[0.010	[0.011]	[0.014]	[0.019]	[0.021]
Observations	5530	5530	5530	3220	2330
Mean dependent	0.13			0.13	0.13
Drug dependence	0.102***	0.080***	0.062**	0.075***	0.041**
	[0.010]	[0.011]	[0.014]	[0.018]	[0.020]
Observations	5530	5530	5530	3220	2330
Mean dependent	0.11			0.11	0.11
Conduct disorder:					
APA definition	0.129***	0.110***	0.067***	0.074***	0.053**
	[0.009]	[0.010]	[0.013]	[0.018]	[0.020]
Observations	5530	5530	5530	3220	2330
Mean dependent	0.08			0.08	0.08
Score	1.168***	0.980***	0.535***	0.658***	0.313**
	[0.054]	[0.070]	[0.082]	[0.117]	[0.104]
Observations	5530	5530	5530	3220	2330
Mean dependent	1.32			1.32	1.32
Crime:					
Total	0.158***	0.152***	0.144***	0.181***	0.081
	[0.021]	[0.021]	[0.032]	[0.041]	[0.051]
Observations	5530	2254	2254	1336	918
Mean dependent	0.21			0.21	0.21
Detected	0.065***	0.055***	0.017	0.028	−0.003
	[0.013]	[0.013]	[0.020]	[0.027]	[0.030]
Observations	2254	2254	2254	1336	918
Mean dependent	0.03			0.03	0.03

Standard errors are given in brackets; Column (2) controls for gender, age, mother/father have only a high school degree, mother/father have more than a high school degree, raised by both natural parents, adoptive/step-parent present, parents fought in front of children, respondent said mother/father had problems with alcohol, mother gave birth as a teenager, and mother's age at birth was between 18 and 30, 30 and 40, or above 40. Columns (5) include twin-pair fixed effects.

Mean dependent are the outcome levels for individuals who have not been maltreated. They can also be located in column (2) of Table 2. * indicates statistically significant at the 10% level, ** at the 5% level, and *** at 1% level

control for age, gender, parental education, age of the mother at the time of birth, parental alcohol abuse, whether the individual was raised by his/her natural parents, the presence of a step/adoptive parent, parental fights observed during childhood,

birth weight, and birth order. The standard errors are corrected for clustering at the twin pair level. Columns (3) to (5) show the fixed effect estimates for the sample of all twins, the sample of fraternal twins, and the sample of identical twins, respectively. Robust standard errors are shown in brackets.

The OLS estimates in the first two columns of Table 4 suggest a strong association between maltreatment and illegal or problematic behaviour. Maltreatment is associated with an increase in drug abuse or drug dependence of 8 (model with controls in column (2)) to 10 percentage points (model with no controls, column (1)). In addition, maltreatment is associated with an increase in the occurrence of conduct disorder as defined by APA of 11 percentage points (13 according to the model in column (1)) and an increase in the number of conduct disorder behaviours with one. Moreover, maltreatment is associated with an increase in total crime of 15 percentage points and an increase in detected crime of 6 percentage points. Compared to the sample means in the first column of Table 2, these increases are substantial. Although these models include a large set of controls, the estimates might be biased by unobserved factors. The estimates in columns (3) to (5) control for all factors that are fixed within twin pairs. For the first four outcomes, we observe that child maltreatment has a statistically significant effect. The estimated effects are somewhat smaller than the OLS estimates but remain substantial. Even within pairs of identical twins, we find that child maltreatment increases drug abuse, drug dependence, and conduct disorder. We also find a statistically significant and large effect of child maltreatment on total crime. For the sample of identical twins, we find a positive point estimate but the estimated effect is no longer statistically significant. This might be explained by the strong reduction of the sample that could be used for this estimation because the crime outcome is not measured for individuals that report negative on all types of problematic behaviour related to conduct disorder (Section 3) and the focus on identical twins only. Furthermore, our estimation results are robust to using a non-linear model such as the fixed effect logit model. In sum, the estimated effects are large. Compared to the sample means (column (1) of Table 2), the fixed effects estimates indicate an increase of illegal and problematic behaviour with one third to two thirds. The OLS estimates are even larger.

Table 5 shows estimation results obtained from separate samples of males and females. The estimation samples are smaller than in Table 4 because opposite sex pairs are not included.

For males, we find large effects of child maltreatment on the first five outcomes. Even within pairs of identical twins, we find that child maltreatment has a large and statistically significant effect on these five outcomes. For women, we find a similar pattern but the estimated effects are smaller and not always statistically significant, especially in the sample of identical twins. These differences might be related with a gender difference in dealing with trauma. Females have been found to deal with trauma such as maltreatment by internalising behaviour (mental disorders such as PTSD and suicide ideation), whereas males have been found to deal with trauma by externalising coping mechanisms (Adams et al. 2013; Fagan 2005). Fagan (2005) also suggest that for males, the association between child maltreatment and delinquent behaviour is stronger than that for females.

Table 5 Estimates of the effect of any maltreatment by gender

	(1) OLS	FE (2) All twins	(3) Fraternal twins	(4) Identical twins
Panel A. Estimates for males				
Drug abuse	0.084***	0.066**	0.040	0.090**
	[0.022]	[0.026]	[0.042]	[0.032]
Observations	1778	1778	826	952
Drug dependence	0.085***	0.079**	0.076*	0.089**
	[0.020]	[0.025]	[0.039]	[0.032]
Observations	1778	1778	826	952
Conduct disorder:				
APA definition	0.133***	0.066**	0.040	0.087**
	[0.020]	[0.027]	[0.040]	[0.037]
Observations	1778	1778	826	952
Score	1.118***	0.498***	0.546**	0.437**
	[0.140]	[0.154]	[0.255]	[0.183]
Observations	1778	1778	826	952
Crime:				
Total	0.121***	0.117**	0.093	0.155**
	[0.031]	[0.051]	[0.076]	[0.070]
Observations	946	946	458	488
Detected	0.051**	−0.024	−0.005	−0.045
	[0.024]	[0.035]	[0.054]	[0.044]
Observations	946	946	458	488
Panel B. Estimates for females				
Drug abuse	0.079***	0.032	0.056*	0.013
	[0.015]	[0.020]	[0.030]	[0.027]
Observations	2430	2430	1052	1378
Drug dependence	0.083***	0.033*	0.057	0.011
	[0.015]	[0.019]	[0.030]	[0.025]
Observations	2430	2430	1052	1378
Conduct disorder:				
APA definition	0.099***	0.050**	0.075**	0.023
	[0.014]	[0.016]	[0.025]	[0.022]
Observations	2430	2430	1052	1378
Score	0.943***	0.430***	0.617***	0.251**
	[0.092]	[0.101]	[0.172]	[0.119]
Observations	2430	2430	1052	1378

Table 5 (continued)

	(1) OLS	FE		
		(2) All twins	(3) Fraternal twins	(4) Identical twins
Crime:				
Total	0.194***	0.142**	0.254***	0.019
	[0.037]	[0.052]	[0.077]	[0.075]
Observations	772	772	342	430
Detected	0.038**	0.050*	0.036	0.076**
	[0.017]	[0.026]	[0.037]	[0.038]
Observations	772	772	342	430

Standard errors are given in brackets; control variables included (see Table 4)

* indicates statistically significant at 10% level, ** at 5%, and *** at 1%

5.2 The effect of different types of maltreatment on illegal and problematic behaviour

In Table 6, we proceed with investigating the effect of different types of maltreatment on each type of illegal or problematic behaviour. Each row shows the estimated effects of a specific type of maltreatment (physical, sexual, sexual by offender, and sexual by frequency) on the six outcomes. All models include a twin fixed effect and controls for birth weight and birth order, and are separately estimated for the sample of all twins and for the sample of identical twins only (MZ).

The first row in Table 6 shows the effect of physical maltreatment on the three types of illegal or problematic behaviour. The estimates show that physical maltreatment increases each type of illegal or problematic behaviour. The estimated effects are statistically significant both for the sample of all twins as for the sample of identical twins only. The size of the estimates is slightly smaller when we use variation within pairs of identical twins. Only for the second indicator of crime, we find no effect of physical maltreatment. The point estimates for the other five outcomes suggest large effects relative to the sample mean. For instance, physical maltreatment increases drug abuse or drug dependence with more than a half; it approximately doubles conduct disorder as defined by the APA and increases total crime with 50%. The second row in Table 6 shows the estimated effects of sexual maltreatment. For the sample of all twins, we observe that sexual maltreatment has a large and statistically significant effect on all indicators of the three types of illegal or problematic behaviour. The estimates for the sample of identical twins are less precise but indicate that sexual maltreatment increases the three types of behaviour. Within pairs of identical twins, we also find a statistically significant effect on crime detected by the authorities.

Table 6 Estimates of the effect of types of maltreatment

	Drug abuse		Drug dependence		CD APA definition		CD score		Total crime		Detected	
	(1) All twins	(2) MZ twins	(3) All twins	(4) MZ twins	(5) All twins	(6) MZ twins	(7) All twins	(8) MZ twins	(9) All twins	(10) MZ twins	(11) All twins	(12) MZ twins
Physical maltreatment	0.048** [0.015]	0.043** [0.022]	0.060*** [0.014]	0.053** [0.021]	0.067*** [0.014]	0.047** [0.021]	0.517*** [0.086]	0.296** [0.109]	0.116*** [0.032]	0.087* [0.051]	-0.003 [0.020]	-0.013 [0.030]
Sexual maltreatment	0.094*** [0.021]	0.053 [0.033]	0.078*** [0.020]	0.031 [0.032]	0.084*** [0.020]	0.106** [0.033]	0.684** [0.122]	0.428** [0.169]	0.096** [0.043]	0.010 [0.072]	0.045* [0.026]	0.085** [0.042]
By family member	0.067* [0.037]	0.008 [0.058]	0.109** [0.035]	0.125** [0.055]	0.044 [0.035]	0.034 [0.057]	0.200 [0.213]	0.279 [0.293]	-0.009 [0.068]	-0.041 [0.110]	-0.033 [0.042]	0.003 [0.064]
By outsider	0.092** [0.035]	0.018 [0.054]	0.056* [0.033]	0.004 [0.051]	0.079** [0.033]	0.114* [0.053]	0.706*** [0.200]	0.371 [0.272]	0.132* [0.068]	0.085 [0.104]	0.106** [0.042]	0.200** [0.061]
One-time	0.055 [0.041]	-0.011 [0.063]	0.043 [0.039]	0.033 [0.060]	0.016 [0.039]	0.041 [0.062]	0.763** [0.237]	0.417 [0.320]	0.047 [0.077]	0.156 [0.131]	0.077 [0.047]	0.071 [0.077]
Multiple times	0.102** [0.033]	0.066 [0.051]	0.105** [0.031]	0.077 [0.048]	0.087** [0.031]	0.085* [0.050]	0.268 [0.187]	0.187 [0.256]	0.030 [0.061]	-0.084 [0.096]	-0.009 [0.038]	0.078 [0.056]
Observations	5530	2330	5530	2330	5530	2330	5530	2330	2254	918	2254	918

CD stands for conduct disorder, and MZ is monozygotic twins. Standard errors are given in brackets; control variables included (see Table 4)

* indicates statistically significant at 10% level, ** at 5%, and *** at 1%

The data allow us to distinguish between the types of sexual maltreatment. The third and fourth rows show the estimated effect of sexual maltreatment by a family member or sexual maltreatment by an outsider. We observe that sexual maltreatment by a family member increases drug dependence for the sample of all twins and also for the sample of identical twins only, but does not have an effect on criminal behaviour. Remarkably, sexual maltreatment by an outsider affects the two other types of behaviour (conduct disorder and crime). The difference in findings between the third and fourth row suggests that the perpetrator is important for the long-term effects. An outside perpetrator seems to increase externalising behaviour whereas maltreatment by a family member increases internalising behaviour. The last two rows of Table 6 use data on the frequency of sexual maltreatment. We do not observe a clear pattern for the effects of sexual maltreatment that occurred once. Multiple sexual maltreatment increases drug abuse and dependence, and also increases conduct disorder. This pattern is quite similar to the estimated result from sexual maltreatment by a family member.

Next, we investigate whether the effects of specific types of maltreatment differ by gender. Table 7 shows the estimated effect for physical and sexual maltreatment for males (panel A) and females (panel B). Sample size limitations do not permit to further differentiate between sexual maltreatment by perpetrator or between one-time or multiple-times one. The most prominent difference in the estimates in panel A and panel B is related to the type of illegal or problematic behaviour. For males, we find that physical maltreatment and sexual maltreatment increase all three types of illegal or problematic behaviour. The effects are also found within pairs of identical twins. For women we especially find effects on drug abuse, drug dependence, and conduct disorder. The effects on crime are less clear.

In sum, we find consistent evidence that childhood maltreatment has a large effect on illegal and problematic behaviour both between and within families. Both physical and sexual maltreatment have a large effect on all three types of illegal or problematic behaviour. Sexual maltreatment by an outsider increases externalising behaviour whereas sexual maltreatment by a family member increases internalising behaviours such as drug abuse or drug dependence. For males, we find that physical and sexual maltreatment increase all types of illegal behaviour. For females, we find that both sexual maltreatment and physical maltreatment increase drug abuse (dependence) and conduct disorder.

6 Robustness analysis

In this section, we investigate several issues that may threaten the validity of our results. First, we investigate the issue of reverse causality. Next, we investigate the potential bias due to measurement error. Finally, we address the issue of spillovers within twin pairs.

Table 7 Estimates of the effect of physical and sexual maltreatment by gender

	Drug abuse		Drug dependence		CD APA definition		CD score		Total crime		Detected	
	(1) All twins	(2) MZ twins	(3) All twins	(4) MZ twins	(5) All twins	(6) MZ twins	(7) All twins	(8) MZ twins	(9) All twins	(10) MZ twins	(11) All twins	(12) MZ twins
Panel A. Estimates for males												
Physical maltreatment	0.066** [0.027]	0.084** [0.033]	0.069** [0.026]	0.068** [0.033]	0.073** [0.027]	0.070* [0.037]	0.505** [0.156]	0.395** [0.185]	0.110** [0.051]	0.127* [0.069]	−0.036 [0.035]	−0.039 [0.043]
Observations	1778	952	1778	952	1778	952	1778	952	946	488	946	488
Sexual maltreatment	0.151** [0.052]	0.050 [0.075]	0.176*** [0.050]	0.173** [0.073]	0.085 [0.054]	0.174** [0.084]	0.861** [0.305]	0.419 [0.417]	0.146 [0.093]	0.174 [0.142]	0.199*** [0.062]	0.231** [0.087]
Observations	1778	952	1778	952	1778	952	1778	952	946	488	946	488
Panel B. Estimates for females												
Physical maltreatment	0.032 [0.021]	0.002 [0.029]	0.042** [0.021]	0.048* [0.027]	0.053** [0.018]	0.024 [0.024]	0.415*** [0.109]	0.240* [0.139]	0.139** [0.053]	0.061 [0.078]	0.013 [0.026]	0.036 [0.040]
Observations	2430	1378	2430	1378	2430	1378	2430	1378	772	430	772	430
Sexual maltreatment	0.067** [0.026]	0.062* [0.036]	0.045* [0.025]	−0.002 [0.034]	0.097*** [0.022]	0.088** [0.030]	0.577*** [0.134]	0.468** [0.162]	0.039 [0.060]	−0.028 [0.082]	0.002 [0.030]	0.029 [0.042]
Observations	2430	1378	2430	1378	2430	1378	2430	1378	772	430	772	430

CD stands for conduct disorder, and MZ is monozygotic twins. Standard errors are given in brackets; * indicates statistically significant at 10% level, ** at 5%, and *** at 1% Control variables included (see Table 4)

Table 8 Estimates of the effect of any maltreatment accounting for reverse causality

		FE		
	(1)	(2)	(3)	(4)
	OLS	All twins	Fraternal twins	Identical twins
Drug abuse	0.131***	0.187**	0.206**	0.154
	[0.037]	[0.055]	[0.071]	[0.094]
Observations	726	726	376	350
Drug dependence	0.094**	0.156**	0.160**	0.158*
	[0.037]	[0.056]	[0.075]	[0.090]
Observations	726	726	376	350
Conduct disorder:				
APA definition	0.098***	0.065***	0.073***	0.049**
	[0.010]	[0.014]	[0.018]	[0.020]
Observations	4700	4700	2692	2008
Score	0.940***	0.568***	0.707***	0.321**
	[0.072]	[0.085]	[0.126]	[0.103]
Observations	4700	4700	2692	2008

Individuals for whom the illegal or problematic behaviour might have preceded maltreatment have been excluded. Standard errors are given in brackets; control variables included (see Table 4)

* indicates statistically significant at 10% level, ** at 5%, and *** at 1%

6.1 Reverse causality

An important concern for our previous estimates is reverse causality. Our estimates might be biased if early illegal or problematic behaviour induces childhood maltreatment. To address this issue, we use information about the timing of child maltreatment and the timing of the various types of illegal or problematic behaviour. We re-estimated the main models of Table 4 after excluding all observations for which the illegal or problematic behaviour might have preceded the reported maltreatment.[7] For the analysis using drug abuse or drug dependence as outcome variable, we excluded all individuals for which the onset of drug use might have taken place before the first reported act of maltreatment. More specifically, we excluded all individuals that used any type of drugs in the age category of 6 to 13 years. This implies a very large reduction of our sample and probably is too restrictive. For the analysis of the effect on conduct disorder, we excluded all individuals that reported displaying conduct disorder before the age of 13.

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[7]Unfortunately, the information on the timing of behaviours and maltreatment is not detailed enough to allow a straightforward regression of maltreatment on early illegal or problematic behaviour.

Table 8 shows the estimation results after excluding individuals for which reversed causation might have happened. We do not show the result on the crime outcomes because for all individuals the crimes reported occurred after the maltreatment. Hence, the results can be found in Table 4. The main pattern of findings is quite similar to the results in Table 4. Child maltreatment increases both types of illegal or problematic behaviour. These effects are found between families but also within twin pairs. The estimates using pairs of identical twins are less precise which might be explained by the smaller samples that can be used in the estimation. These estimates suggest that it is unlikely that the previous results are driven by reverse causality.

6.2 Measurement error

Retrospective reports might induce measurement error because individuals might forget their past experience. In addition, reporting on sexual maltreatment might be especially prone to measurement error because of the sensitive nature of this subject. Individuals may feel embarrassed to report about their true experiences or it is possible that painful experiences have been subconsciously repressed. It is well known that the within-family estimator exacerbates the errors-in-variables inconsistency due to measurement error in the treatment variable (Griliches 1979; Bound and Solon 1999). A well-known solution to deal with measurement error in twin studies is to use a second independent measure obtained from answers of the co-twin as an instrumental variable (Ashenfelter and Krueger 1994). This approach produces consistent estimates when the measurement error is classical. In case of non-classical measurement error, like in our situation with binary treatment variables, this approach can be used to obtain bounds on the treatment effects (Black et al. 2000). Unfortunately, in our questionnaire, twins were only asked about their own experiences with childhood maltreatment and not about the experiences of their co-twin. The literature in econometrics on non-classical measurement error provides some guidance for the potential bias of our estimates. It has been shown that non-classical measurement error biases the estimates towards zero if the degree of measurement error is not too large, and if the measurement error is conditionally independent of the outcome given the true value as well as the observed covariates (e.g., Aigner 1973; Bollinger 1996; Klepper 1988; Lewbel 2007). If the measurement error is independent of the outcome, it is said to be 'non-differential'. The first assumption implies that there should be a positive correlation between the true and mismeasured treatment variables. It seems likely that this assumption holds as several studies have found reliability ratios of self-report of sexual maltreatment close to 0.7 (Nelson et al. 2010; Williams 1994). In addition, Hardt and Rutter (2004) conclude that false positives are very rare, and false negatives are more likely that false positives. It is more difficult to assess whether the measurement error is non-differential (the second assumption). Currie and Tekin (2012) have investigated whether people with negative outcomes are more likely to report childhood maltreatment. Their findings are consistent with the assumption that the measurement error is non-differential. Hardt and Rutter (2004) also conclude that there is little evidence that 'individuals who are well functioning in adult life may be more likely to forget early adversities, compared with those suffering social impairment'. We investigated this issue in our data by comparing the

reporting of the youngest part of our sample with the reporting of the oldest part of our sample. By assuming that the report of the youngest part of the sample will be closer to the true values, we may gain insight into the process of forgetting. We compare the reports of the 'young' and 'old' parts of our sample by outcome value with the aim of observing whether there is a relationship between measurement error and the outcome value. Table 9 shows the proportion of individuals that report 'any maltreatment' within each cell (hence, by outcome value and age group).

We find that the reporting of the old and young parts of our sample is quite similar. For each outcome variable, we find that within the group of individuals that do not report illegal or problematic behaviour the oldest part of the sample reports slightly more childhood maltreatment. This seems inconsistent with the idea that well-functioning individuals are more likely to forget early adversities. Moreover, within the group of individuals that report illegal or problematic behaviour, we find that the youngest part of the sample reports slightly more childhood maltreatment. This is not consistent with an increasing tendency to ascribe bad outcomes later in life to childhood problems. Hence, this analysis provides no evidence for a correlation between measurement error and the outcomes. From this analysis and previous studies on childhood maltreatment, it seems likely that the measurement error in child maltreatment biases the estimates towards zero.

6.3 Spillover effects within pairs of twins

If twins have a strong effect on each other this might bias the estimates. For instance, if the co-twin copies the illegal behaviour of the twin that experienced childhood maltreatment, we will underestimate the effect of maltreatment. It is also possible that the behaviour of one twin restrains the other twin from doing a specific type of

Table 9 Proportion reporting 'any maltreatment' by outcome and age group (older vs. younger individuals in our sample)

	Any maltreatment	Younger	Older
Drug dependence	No	0.35	0.39
	Yes	0.58	0.55
Drug abuse	No	0.35	0.38
	Yes	0.55	0.54
Conduct disorder: APA definition	No	0.34	0.38
	Yes	0.66	0.63
Crime: total	No	0.33	0.36
	Yes	0.53	0.55
Crime: detected	No	0.37	0.40
	Yes	0.62	0.63

This table shows the proportion of the different outcomes by age group (young, or those below the mean age and old, those above the mean age) and by reporting any vs. no maltreatment

Table 10 Fixed effect estimates for the effect of maltreatment for samples of twins who do not have frequent contact with each other

	(1) OLS	(2) All twins	(3) Fraternal twins	(4) Identical twins
Panel A. Twins see each other once/twice a month				
Drug abuse	0.075**	0.067**	0.055	0.178**
	[0.023]	[0.029]	[0.034]	[0.055]
Observations	1466	1466	1114	352
Drug dependence	0.089***	0.079**	0.102**	0.045
	[0.022]	[0.027]	[0.032]	[0.053]
Observations	1466	1466	1114	352
Conduct disorder:				
APA definition	0.135***	0.076**	0.077**	0.055
	[0.021]	[0.028]	[0.032]	0.055
Observations	1466	1466	1114	352
Score	1.172***	0.630***	0.814***	0.084
	[0.151]	[0.178]	[0.211]	[0.330]
Observations	1466	1466	1114	352
Crime:				
Total	0.141***	0.139**	0.156**	0.197
	[0.038]	[0.060]	[0.070]	[0.140]
Observations	606	606	606	606
Detected	0.064**	0.013	0.030	−0.085
	[0.027]	[0.044]	[0.052]	[0.092]
Observations	606	606	606	606
Panel B. Twins see each other a few times a year				
Drug abuse	0.062*	0.046	−0.015	0.268**
	[0.038]	[0.055]	[0.066]	[0.110]
Observations	432	432	320	112
Drug dependence	0.088**	0.103**	0.105	0.222**
	[0.035]	[0.051]	[0.065]	[0.092]
Observations	432	432	320	112
Conduct disorder:				
APA definition	0.131**	0.118**	0.080	0.121
	[0.038]	[0.054]	[0.065]	[0.103]
Observations	432	432	320	112
Score	0.862**	0.650**	0.696	0.188
	[0.245]	[0.344]	[0.427]	[0.672]

Table 10 (continued)

	(1) OLS	(2) All twins	(3) Fraternal twins	(4) Identical twins
Observations	432	432	320	112
Crime:				
Total	0.165**	0.103	0.155	0.333
	[0.067]	[0.120]	[0.141]	[0.464]
Observations	184	184	142	42
Detected	0.089**	−0.014	−0.016	0.243
	[0.036]	[0.080]	[0.087]	[0.323]
Observations	184	184	142	42

Standard errors shown in brackets; * indicates statistically significant at 10% level, ** at 5%, and *** at 1%

behaviour. It is very difficult to investigate the importance of these potential spillover effects. We investigate the importance of this issue by exploiting information about 'the closeness of the twins'. Twins were asked about how often they see their co-twin. We re-estimated the main models after excluding twins that report to be very close with their co-twin. Hence, we keep in our sample only individuals who really do not see or contact each other very often. This implies a strong reduction of the sample size as most twins report seeing each other quite regularly. Table 10 shows the estimation results for these restricted samples. Panel A shows the results for twins that report seeing each other 'once or twice a month' or less. Panel B shows the results for twins that report seeing each other 'a few times a year' or less.

Despite the strong reduction of the sample, we observe that the estimated effects remain quite similar to the findings in Table 4, especially when using all twins (columns (1) and (2)). The results in panel A for fraternal and identical twins (columns (3) and (4)) are also very similar to the estimates in Table 4. In panel B, the sample sizes become very small for columns (3) and (4) but nearly all estimates suggest that child maltreatment increases illegal or problematic behaviour. Hence, for a sample of twins for which we expect that spillover effects will be less likely, the estimated effects are quite similar to our main estimation results. This suggests that spillover effects might not be a major concern for our estimates.

7 Conclusion

This study investigates the long-term effects of childhood maltreatment on illegal or problematic behaviour using a sample of Australian twins. Previous studies have found a strong association between child maltreatment and illegal behaviour which

supports the so-called cycle of violence hypothesis. Our study investigates whether the link between child maltreatment and illegal or problematic behaviour also exists with pairs of twins and within pairs of identical twins.

We find consistent evidence that childhood maltreatment has a large effect on illegal and problematic behaviour both between and within families. The estimated effects imply an increase of illegal or problematic behaviour of 50 to 100% relative to the baseline levels of individuals that have not been maltreated. This is consistent with the findings by Currie and Tekin (2012) who report a doubling of criminal behaviour due to childhood maltreatment. Physical and sexual maltreatment have a large effect on all types of illegal or problematic behaviour. Sexual maltreatment by an outsider increases externalising behaviour whereas sexual maltreatment by a family member induces internalising behaviour. For males, we find that physical and sexual maltreatment increase all types of illegal behaviour. For females, we find that both sexual maltreatment and physical maltreatment increase drug abuse (dependence) and conduct disorder. The effect of maltreatment on detected crime in our case is not statistically significant, which is inconsistent with the findings of other studies on child maltreatment. This difference might be explained by the measurement of crime in the questionnaire. Due to the routing of the questionnaire, not all individuals had to answer the crime questions. In particular, individuals that did not report any conduct disorder did not have to answer the crime questions.

Furthermore, the differences in the effect of child maltreatment across fraternal and identical twins in some cases are large. The main factors that can be important in explaining this are differences in genes, differences in the power of the estimation samples, and differences in spillovers within pairs of twins. In particular, identical twins are more similar in their genetic makeup. Moreover, the variation in the treatment variables within pairs of twins is smaller for identical twins. This reduces the power of the estimations and makes it more difficult to detect statistically significant estimates. A final difference has to do with spillovers within pairs of twins. In general, identical twins have a closer relationship with each other than fraternal twins. If, as a result, identical twins have more influence on each other, this will also induce a difference between the estimated effect for identical and fraternal twins.

In sum, our estimation results, based on OLS models with a large set of controls and twin fixed effect models, indicate a strong relationship between child maltreatment and illegal or problematic behaviour. We acknowledge that our approach has potential limitations because the variation in child maltreatment is not derived from a randomised setting. In addition, the asymmetry in victimization within pairs of twins—'why just me?'—might generate additional resentfulness enhancing the 'cycle of violence'. However, our approach, which extends the control strategies applied in previous studies towards samples of twins and identical twins, might be considered as the most complete control strategy that is feasible. Therefore, we believe that our results should be interpreted as further evidence for the so-called cycle of violence hypothesis. These results imply that child maltreatment not only has large private costs but also large social costs, which further legitimises substantial governmental spending on prevention of child maltreatment and treatment of victims of child maltreatment.

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