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Sex and Age Differences in the Risk Threshold for Delinquency

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Abstract

This study examines sex differences in the risk threshold for adolescent delinquency. Analyses were based on longitudinal data from the Pittsburgh Youth Study (n = 503) and the Pittsburgh Girls Study (n = 856). The study identified risk factors, promotive factors, and accumulated levels of risks as predictors of delinquency and nondelinquency, respectively. The risk thresholds for boys and girls were established at two developmental stages (late childhood: ages 10–12 years, and adolescence: ages 13–16 years) and compared between boys and girls. Sex similarities as well as differences existed in risk and promotive factors for delinquency. ROC analyses revealed only small sex differences in delinquency thresholds, that varied by age. Accumulative risk level had a

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linear relationship with boys' delinquency and a quadratic relationship with girls' delinquency, indicating stronger effects for girls at higher levels of risk.

Keywords

Self-reported delinquency; Sex differences; Threshold hypothesis; Risk and promotive factors; Area under the curve

Introduction

Many girls involved in the juvenile justice system—those who are arrested, adjudicated or incarcerated—have been exposed to trauma or abuse, have mental health as well as academic problems, and come from multi-problem families (Chamberlain and Moore 2002; Kataoka et al. 2001; Lederman et al. 2004; Slotboom et al. 2011). Compared to arrested, adjudicated, or incarcerated boys, girls in the juvenile justice system have more problems and are exposed more to known risk factors (Belknap and Holsinger 2006; Emeka and Sorensen 2009; Gavazzi et al. 2006; Gover 2004; Johansson and Kempf-Leonard 2009). This has been interpreted as delinquent girls having a more problematic background than delinquent boys, which has also been rephrased as the 'threshold' hypothesis, i.e. that girls pass a higher critical 'risk level' in order to become delinquent. This hypothesis was initially defined for antisocial personality disorder (Cloninger and Gottesman 1987) and later expanded to other developmental disorders (Eme 1992).

A threshold has been defined as the point that must be exceeded to begin producing a given effect or result (www.thefreedictionary.com). Thresholds are encountered in many areas of (social) science and generally denote a critical value, under which a certain effect is not present and above which it is, such as the absolute hearing threshold in medicine, or the extinction theshold in ecology. In the manner in which the 'threshold'-hypothesis has been phrased in criminology, it denotes the 'risk level' above which the probability to be delinquent is larger than the probability not to be delinquent.

This 'risk level' that defines the risk threshold can, however, be operationalized in two ways. First, it can be opera-tionalized as the severity or level of a single risk factor: having a problematic relationship with parents is a risk factor for delinquency, and only those youth with a very problematic parent–child relationship have a risk level that is high enough to pass the threshold to offend. The other way of operationalizing risk level is derived from the cumulative risk approach (Rutter 1979; Sameroff et al. 1987) and defines the risk level as the number of risk factors. Thus, according to this operationalization the more risk factors someone experiences, the more likely he or she is to be delinquent. There is evidence for such a dose–response relationship between the number of risk factors and the likelihood of delinquency for boys and girls (Johansson and Kempf-Leonard 2009; Loeber, Slot and Stouthamer-Loeber 2008; Van der Laan and Van der Schans 2010; Wong et al. submitted).

A key issue that is unresolved in the literature and that is the focus of this study, is whether there are sex differences in the risk threshold for delinquency; differences between boys and

girls in such a threshold for delinquency, while often posited, have hardly been studied empirically.

Sex Difference in Risk Thresholds

Alemagno et al. (2006) examined the number of risk factors of 250 detained boys and girls and found that incarcerated girls were exposed to more risk factors than their male counterparts. Van der Laan and Van der Schans (2010) showed, using a similar analytical strategy, that arrested girls were exposed to more risk factors in the family domain than arrested boys. Although the results of these studies concurred with the differential risk threshold hypothesis, they did not show that such a differential threshold exists for delinquency, since all studies investigated samples of adjudicated or incarcerated juveniles. Given that girls and women are often treated differently in the juvenile justice system, the threshold for delinquency cannot be separated from the threshold to be arrested, prosecuted or convicted (e.g., Daly 1994). Thus it is problematic to attribute sex differences in the number of risk factors in officially delinquent samples to the threshold for delinquency. This may also explain seemingly incompatible findings, such as that arrested boys have in fact a higher number of risky lifestyle factors compared to arrested girls (Van der Laan and Van der Schans 2010). Self-reported delinquency studies tend not to have the confounding effect of justice processing.

Wong et al. (submitted) investigated sex differences in the delinquency threshold using self-reported data of a Dutch population-based sample, and did not find support for a sex-related threshold. In contrast to the previously mentioned studies, the authors included a comparison group of nondelinquents. The use of such a comparison group is necessary, as without this group it is impossible to determine whether delinquent girls have a higher risk level than delinquent boys or vice versa. Furthermore, the authors examined, in addition to risk factors, the extent to which promotive factors influenced the risk of later delinquency. Promotive factors are those factors associated with a decreased probability of delinquency (Sameroff et al. 1998; Stouthamer-Loeber et al. 2002).[1] Since promotive factors can neutralize risks (Stouthamer-Loeber et al. 2002; Van der Laan and Blom 2006), ignoring these factors might result in overstating the importance of risk factors and might make it impossible to assess any accurate threshold effect.

Although the study by Wong et al. (submitted) had fewer limitations than previous studies, the authors did not investigate the threshold as such as they compared risk levels of delinquents with those of nondelinquents. The present study will improve upon previous research firstly by actually assessing the threshold itself, i.e. identifying the exact cut off value, for boys and girls. Secondly, this study will improve on previous studies by investigating whether the threshold varies with age and/or sex. Boys' and girls' involvement in delinquency changes with age, and criminal careers develop differently for boys and girls (Junger-Tas et al. 2003; Wong et al. 2012). Girls' delinquency tends to peak earlier than that

[1]In the literature a distinction is made between promotive and protective factors. Protective factors refer to factors that moderate the effect of risk factors on problem behavior. There should be an interaction effect with risk factors to be denoted a protective factor (see for example Rutter 1987). In our study we refer to factors that directly decrease the probability of delinquency, there is no need for interaction with risk factors. In line with previous literature, we refer to these factors as promotive factors.

of boys, i.e. at age 15 versus at age 16 (Junger-Tas et al. 2003; Slotboom, et al. 2011). It remains to be seen whether delinquency thresholds vary with age for each sex. As Moffitt (1993) suggested, during puberty, it is almost normative to show some delinquent behavior. Thirdly, this study will add to previous research by incorporating sex-shared as well as sex-specific risk factors for delinquency (Wong et al. 2010; Zahn 2009).

We will address the following research questions: 1) Is the age-crime curve for girls lower than that of boys? 2) Which shared and sex-specific risk and promotive factors measured in middle childhood (ages 7 to 9) and late childhood (ages 10 to 12), respectively, predict self-reported delinquency in late childhood (ages 10 to 12) and adolescence (ages 13 to 16)? 3) Are there sex differences in exposure to risk and promotive factors? 4) Are there linear or quadratic differences in the relationship between cumulative risk and promotive factor score and delinquency for each sex? 5) Are there differences by sex and age in the optimal cumulative threshold to predict delinquency?

The questions are addressed using data from the Pittsburgh Youth Study (PYS) and the Pittsburgh Girls Study (PGS) using self-reported delinquency as outcomes at late childhood and adolescence. The studies contain a broad array of risk and promotive factors known to predict delinquency in previous studies (e.g., Hoeve et al. 2009; Hubbard and Pratt 2002; Lipsey and Derzon 1998; Maguin and Loeber 1996; Pratt and Cullen 2005; Simourd and Andrews 1994; Wong et al. 2010; Zahn 2009). These include individual (problem) factors (i.e., birth problems, early disruptive behavior disorder, callous unemotional behavior, anxiety, early puberty), family factors (i.e., poor education of parents, single parent household, physical punishment, communication with parents, positive parenting, supervision, parent–child relationship), school factors (i.e., truancy, school motivation, school achievement), peer delinquency, and neighborhood problems.

Methods

Sample

The PYS is a longitudinal study that started in 1987 (Loeber et al. 2008), consisting of three samples of boys who were in grades one, four, and seven, respectively, at the start of the study. Boys who attended public schools in Pittsburgh participated in the study. In the initial screening assessment, information about the boys' antisocial behavior was collected through the boys themselves, the caretakers, and their teachers. On the basis of this information, a risk score was calculated and all of the boys with the highest scores on antisocial behavior (n = c. 250, for every sample) were selected for follow-up, while a random sample of the remaining boys (N = c. 250) were also included in the follow-ups. Only boys from the youngest sample (n = 503) were included in the present study. In the first four years of the follow-ups, interviews were conducted by trained interviewers every half year with the boys and one or both caretakers. In the same period, one of the boys' teachers was asked to rate the boys' behavior. Subsequently, interviews were held every year. For the current analyses, information about grades was transformed in age-specific data.

The PGS is also a longitudinal study, but is based on a stratified, random sample from all households in Pittsburgh with a girl between the age of 5 and 8 (Keenan et al. 2010).

Disadvantaged neighborhoods were oversampled. The final sample consists of 2,451 families. To make the samples of PGS and PYS youth comparable, the current study included only girls aged 7 or 8 at the initial assessment, who attended public schools at the first assessments in 2000 (n = 856). Follow-ups in the PGS consisted of yearly interviews with the girls, their caretaker and teacher ratings.

Measurements

To achieve comparability between the sexes, only measurements were included that were comparable across the PYS and the PGS.

Delinquency Delinquency was measured at ages 11–16 through the 40-item *Self-Reported Delinquency Scale* (SRD; Loeber et al. 1998) which was based on an adaptation of the National Youth Survey (Elliott et al. 1985). For each of the offenses, respondents indicated whether they had committed a delinquent act, and if so, how often in the previous year. For this study we focused on moderate to serious delinquency (see details in Loeber et al. 1998), which included breaking-and-entering, stealing things worth more than 5 dollars, purse snatching, stealing from a car, dealing in stolen goods, joyriding, vehicle theft, attacking with intent to injure, forcible robbery, and gang fighting. All offences were summed and dichotomized into 0 (no offence committed—nondeliquent) and 1 (1 or more offences committed—delinquent). At age 11 the dealing in stolen goods item was accidentally not assessed in the PGS, so we did not include this item in the delinquency construct for both boys and girls.

The SRD was judged to be too difficult to understand for the youngest respondents. For that reason, the *Self-Reported Antisocial Behavior Scale (SRA)* instead of the SRD was administered at age 10. Since boys were selected in the first wave by grade and therefore had different ages, and since the switch from SRA to SRD was made in one phase for all boys, some of the 10-year-old boys filled out the SRA en some the SRD. For girls, the switch was made after the age of 10 and therefore all 10-year-old girls reported on the SRA. The SRA consisted of 27 items of delinquent behavior that were appropriate to younger children (Loeber et al. 1998). For the current study, only those items from the SRA that were comparable to the selected SRD items were used to construct the delinquency scale: theft from building, theft from a car, and purse snatching. After the creation of the moderate and serious delinquency constructs for each age, we prepared summary constructs for age blocks in late childhood (ages 10 to 12) and adolescence (ages 13 to 16), contrasting nondelinquents with delinquents (1 or more offences committed at this age).

Risk and Promotive Factors Table 1 lists all constructs used in this study based on comparable measures in the PYS and PGS. For most factors, we created two age blocks: for late childhood and adolescence. Birth problems and early disruptive behavior disorder were only assessed in the first assessment and regarding early pubertal development only the measurements prior to the delinquency age blocks were included (i.e. age 9 and age 12). In the PGS, no information about single parent households was available at the age of 7, so the late childhood age block regarding single parent households only contained age 8 and 9. Truancy was only measured at age 11 and 12, so the late childhood age block was not created.

In creating the constructs from reported waves, missing constructs were coded as missing if more than 33 % was missing. If fewer were missing, the mean of the available responses was substituted for the missing data. In creating the age blocks, only the non-missing ages were used to calculate the age blocks for a respondent. The age block was set to be missing if the construct was missing at all ages.

To identify the risk versus promotive effect of the factors we used the same method as Stouthamer-Loeber et al. (1993). All age blocks were trichotimized into a promotive, a neutral and a risk component using the sex-specific 25^{th} and 75^{th} percentiles of the age block distributions as cutoffs. The age blocks were recoded into two variables: a risk variable and a promotive variable. The reference category in each variable was the neutral component (the 26^{th} to the 74^{th} percentile of the distribution). The exceptions were birth problems, early disruptive behavior disorder, poor education of the parents, and child's truancy, because these were inherently dichotomous. Another exception was the age block for single parent households. In this case, it was more appropriate to trichotimize according to the number of years the household consisted of a single parent (i.e. risk: single parent in all years of age block; promotive: both parents in all years of age block; neutral see Table 1).

Analyses

First, we established which risk and promotive factors predicted delinquency at late childhood and adolescence, respectively. These analyses were carried out separately for boys and girls and separately for the two age periods. If a factor predicted delinquency ($p<0.05$), this was regarded as a risk effect; if a factor predicted low or nondelinquency this was regarded a promotive effect. If both variables were related to delinquency, this was regarded both a combined risk and a promotive effect. Some risk factors predicted delinquency in boys and girls and were labeled shared risk factors. The same applied to factors predicting nondelinquency in boys and girls and were labeled shared promotive factors. Factors that were only related to delinquency in either boys or girls were labeled sex-specific risk and promotive factors. Odds Ratios were calculated for the risk and promotive factors: an Odds Ratio larger than 1 with a p-value<0.05 indicates that the presence of the risk factor significantly increased the prediction of delinquency, while an Odds Ratio smaller than 1 with a $p<0.05$ indicates a promotive factor that significantly predicted nondelinquency[2]

Next, we created three types of cumulative risk level indexes. The first index consisted of the number of significant risk factors in the data set. A second index indicated the number of significant promotive factors in the data set. The third, called the combined risk index indicated the number of significant risk factors minus the number of significant promotive factors. Because the three risk indexes were created by taking into account shared factors as well as sex-specific factors, each risk index consisted of slightly different risk and promotive components for boys and girls.

[2]The large number of tests is done to create a subset of variables on which to run a comprehensive analysis, to filter out those that are not relevant. Subsequently, boys and girls are compared. So, while this increases the risk for type I errors because of the multiple testing, this occurs for boys as well as girls. For that reason, the comparison is still valid.

Thresholds were studied at two levels. First, we studied whether the distribution of the relationships between cumulative risk were similar for boys and girls; for this we carried out a curve fitting analysis to see whether cumulative risk indexes predicted delinquency in a linear or quadratic way for boys and girls. If, for example, a quadratic function applied to one but not the other sex, this indicated that the risk of future delinquency accelerated faster for one sex compared to the other.

In a second set of analyses, we examined whether a threshold could be empirically established by means of signal detection theory (Swets 1964). Receiver Operating Curves (ROC) were calculated with Area Under the Curve (AUC) indicating how well a cumulative risk index predicted delinquency. The analyses also allow the identification of optimal prediction thresholds in which, for every possible cut-off, the trade-off between the false negative and false positive rates is calculated. AUC values can range from 0 (total inaccuracy) to 1 (perfect accuracy). A value of 0.5 indicates that the model is not better than chance, a value between 0.5 and 0.75 is regarded as fair, between 0.75 and 0.92 as good, between 0.92 and 0.97 as very good and between 0.97 and 1 as excellent (McFall and Treat 1999). The Youden's index, a function of sensitivity (number of true positives) and specificity (number of true negatives), was used to identify the optimal cut-off point (Youden 1950). The optimal cut-off is the value with the highest combination of sensitivity and specificity. This cut-off point is the threshold for delinquency. We carried out these analyses separately for late childhood and adolescence and for boys and girls. List wise deletion was used to deal with the missing information in the analyses.

Results

Table 2 shows the descriptive results. The average number of measured risk and promotive factors are presented for boys and girls in middle and late childhood as well as the number of delinquents in late childhood and adolescence. No sex differences were found regarding the average number of measured risk and promotive factors. The prevalence of delinquency differed by gender in both late childhood as well as in adolescence.

The first question we addressed was: Is the age-crime curve for girls lower than that of boys? Figure 1 shows that at age 10 there was only a small, although significant (3.6 % vs. 1.8 %; $p<0.05$) sex difference in the prevalence of moderate to serious delinquency, but at all other older ages the prevalence of delinquency was higher for boys than girls (for all ages $p<0.01$). However, the peak age of the age-crime was the same for the two sexes (age 14).

The second question that we posed was: Which shared and sex-specific risk and promotive factors measured in middle childhood (ages 7 to 9) and late childhood (ages 10 to 12), respectively, predict self-reported delinquency in late childhood (ages 10 to 12) and adolescence (ages 13 to 16)? Table 3 shows the odds ratios of the risk and promotive factors for boys and girls in the two age periods. An empty cell indicates that there is no statistically significant risk (or promotive) effect of a given factor.

The results showed that delinquent behavior of boys and girls is related to many different factors. As Table 3 shows, many risk and promotive factors are shared by boys and girls, but

some differences were found between boys and girls, and between age periods as well. Risk and promotive factors that were shared were callous-unemotional behaviour, supervision by parents, relationship with parents, and almost all risk and promotive factors in the school and peer domain. Differences between boys and girls were found in the individual domain regarding birth problems, early disruptive behaviour and anxiety. Birth problems appeared to be a risk factor for delinquency in late childhood for girls and not for boys. Furthermore, early disruptive behaviour was a risk for delinquency at both age periods for girls, but not for boys. Also, high anxiety had a promotive effect on boys in their late childhood, but not on adolescent boys, while it had an age-invariant effect on adolescent girls. Besides, low anxiety was a risk factor for adolescent girls. Other interesting differences were found in the family domain. Living with both parents had a promotive effect on boys' delinquency in both age periods. For girls, however, it was only promotive for delinquency in adolescence. Furthermore, not being exposed to physical punishment was a promotive factor for girls in both age periods, but not for boys. By contrast, for boys, physical punishment was a risk factor regarding delinquency in adolescence. Another remarkable difference is that communication about activities with parents only affected delinquency for girls and only during puberty, both as a risk and a promotive factor. Positive parenting was also only related to girls' delinquency. More specifically, lack of positive parenting was a risk for girls in both age periods and a promotive factor for delinquency in adolescence.

Next we asked: Are there sex differences in exposure to risk and promotive factors? Table 4 shows the average number of (significant) risk factors and (significant) risk minus promotive factors for nondelinquent and delinquent boys and girls during middle and late childhood. Delinquent boys and girls averaged higher risk scores than nondelinquent boys and girls, respectively. Furthermore, delinquent girls averaged a higher number of risk factors than delinquent boys at each age period. When averages of risk and promotive factors were considered, delinquent girls compared to delinquent boys scored higher at middle childhood only. At late childhood, average exposure to risk and promotive factors was similar for of delinquent boys and girls.

The fourth question we asked was: Are there linear or quadratic differences in the relationship between cumulative risk and promotive factor score and delinquency for each sex?

Curve fitting analyses showed that for both age periods positive linear relationships between the risk levels and delinquency were found for boys (with R^2 of 0.07 and 0.15 respectively; other relationships had a worse fit to the data), but positive quadratic relationships for girls (with R^2 of 0.06 and 0.17 respectively, again other relationships had a worse fit to the data; see the modeled relationships in Fig. 2 and Fig. 3). This indicates that, regardless of sex, the more risk factors boys and girls were exposed to, the more likely they were to be delinquent. However, for boys the increase in likelihood for delinquency was similar across risk levels, whereas for girls the increase in likelihood was amplified at every next risk level. More specifically, because of the linear relationship for boys, every increase in the number of risk factors was associated with 5.2 % more delinquent boys in late childhood and 7.3 % more delinquent boys in adolescence. For girls, because of the quadratic relationship, this increase depended on the risk level. An increase in the risk level from 3 to 2 promotive factors (in

middle and late childhood respectively), for instance, was associated with 0.6 % more delinquent girls in late childhood and to 3.3 % more in adolescence, whereas an increase in the risk level from 3 to 4 or more risk factors (in middle and late childhood) was associated with 5.4 % and 10.5 % more delinquent girls in late childhood and adolescence, respectively. Thus, for girls we see that the effect of a one-step risk increase becomes ever stronger: the higher the risk level, the larger the corresponding shift in delinquency at an increase in risk.

The final question concerned: Are there differences by sex and age in the optimal cumulative threshold to predict delinquency? The results regarding the predictive power of the combined risk levels on late childhood delinquency for boys and girls are in Fig. 2: girls had slightly higher AUC values than boys (0.74 vs. 0.68). Furthermore, the optimal cut-off point for girls was higher than for boys (1 vs. 0 risk factors) [3] which indicates that girls have a higher threshold for delinquency in late childhood than boys.

Next, adolescent delinquency was predicted from risk levels at the age of 10 to 12 (see Fig. 3). Girls had slightly higher AUC values (0.77 vs. 0.72), but boys had a higher optimal cut-off point than girls (1 vs. 0 risk factors).[4] Boys therefore have a higher threshold than girls to become delinquent in adolescence. Thus, we see that there are no consistent differences in the delinquency threshold for boys and girls: the thresholds differ by age period. The differences are also small; however, as the threshold is a group-value and not the average of a set of individual-level values, we cannot test whether it differs significantly for boys and girls.

Discussion

This study examined whether boys and girls had different risk thresholds for delinquency at two age periods (late childhood and adolescence). Using data from the PYS and PGS studies, we first tested which factors (at ages 7 to 9 and 10 to 12) had a risk effect, a promotive effect, or both. Boys and girls appeared to share many risk and promotive factors, but sex differences and differences between age periods were found as well. This indicates that delinquent girls might need different types of interventions than delinquent boys, and that the age of the delinquent should be taken into account.

Not surprisingly, boys and girls who were delinquent appeared to have higher risk levels than their nondelinquent counterparts. Within the delinquents, girls on average had higher number of risk factors than boys when only risk factors were considered. When promotive factors were taken into account as well, girls compared to boys had on average a higher risk levels in middle childhood. In late childhood, the risk level of delinquent boys and girls was similar.

[3]Sensitivity and specificity at the selected threshold for late childhood delinquency were respectively 0.57 and 0.69 for boys and respectively 0.74 and 0.63 for girls.

[4]Sensitivity and specificity at the selected threshold for adolescent delinquency were respectively 0.47 and 0.85 for boys and respectively 0.67 and 0.74 for girls.

The relationship between the risk level and delinquency was linear for boys, indicating that every extra risk factor resulted in a similar step-wise increase regarding delinquency probability. For girls, however, this relationship turned out to be non-linear, with the increase in the probability of delinquency larger at the higher risk level ranges than in the lower part. Thus, at low risk levels, an additional risk factor gives but a small increase in the delinquency probability. However, at higher risk levels, one extra risk factor augments this probability substantially for girls. Due to this amplification, delinquent girls would—even with a same delinquency threshold—have higher average risk levels than boys. Therefore, previous studies that focused on the average risk level for boys and girls found higher risk levels among delinquent girls than among delinquent boys (Alemagno et al. 2006; Van der Laan and Van der Schans 2010).

While higher risk levels are associated with a stronger increase in likelihood of delinquency in girls than in boys, this study implies that girls do not have a higher threshold for delinquency. Differences in the threshold are not apparent and fluctuate with age which might suggests that no actual sex difference in the threshold for delinquency exists. All in all, in this study—that was appropriately designed with a control group, and sex-specific risk as well as promotive factors—no evidence for a sex-specific delinquency threshold emerged.

The threshold hypothesis was examined using two complementary approaches: curve fitting and ROC analyses. The curve estimation analyses showed a linear association between risk level and delinquency for boys and a curvilinear relationship for girls. The ROC analyses examined the location of the threshold and did not show sex differences. While there appears to be no different threshold as such, increases of the risk level beyond this threshold impact differently on girls than on boys. That is, from the threshold onwards, risks contribute more and more to the delinquency risk for girls (due to the quadratic relationship), but not for boys (due to the linear relationship). This indicates that delinquent girls might have more problematic backgrounds than their male counterparts. This has also been shown in previous research regarding characteristics of juveniles in the juvenile justice system (Belknap and Holsinger 2006; Emeka and Sorensen 2009). Zahn et al. (2009) showed that interventions that target multiple risk factors can reduce delinquent behavior in both boys and girls. However, given the more problematic background of girls in the juvenile justice system, for them it might be even more important to address multiple problems simultaneously. Likely, gender-specific interventions are necessary for girls. There is no clear evidence yet about the effectiveness of existing gender-specific interventions (Zahn et al. 2009).

It is noteworthy that the risk level is a (much) better predictor for delinquency among girls than among boys, shown by the AUC level as well as the results regarding sensitivity and specificity. For boys, the threshold detects 57 % of the delinquents in late childhood and only 47 % in adolescence. For girls, however, these percentages were 74 % and 67 % respectively. This indicates that the risk level alone is not enough to predict delinquency, especially for boys.

Differences with Previous Studies

Several explanations can be put forward for the fact that most previous studies on the threshold had such different results than the present study. These explanations regard differences between previous studies and the present study regarding the sample, the definition of the threshold, and regarding the operationalization of risk. With regard to sample differences, previous studies mainly examined adjudicated or incarcerated samples. In these samples the threshold for delinquency is confounded with the threshold for criminal justice system involvement. The fact that our study showed that the threshold for delinquency differs minimally for boys and girls, these studies probably picked up on arrest, prosecution or incarceration thresholds.

Concerning differences in the definition of the threshold, previous studies based their conclusions about sex different thresholds on risk levels of delinquent boys and girls (Alemagno et al. 2006; Belknap and Holsinger 2006; Emeka and Sorensen 2009; Johansson and Kempf-Leonard 2009; Van der Laan and Van der Schans 2010), whereas the current study identified the location of the threshold. Because delinquent girls had on average higher risk levels than boys and because delinquency is less prevalent in girls, previous studies concluded that girls have a higher threshold for delinquency. However, the (difference in) location of the threshold was not assessed.

Regarding the operationalization of risk, there are two main differences between previous studies and the present study. First, previous studies did not include promotive factors to measure risk. However, since the number of promotive factors can buffer the influence of risk factors only (Stouthamer-Loeber et al. 2002; Van der Laan and Blom 2006), it is inadequate to examine only risk factors. To see how the results would differ if we would have considered risk factors only, the analyses of the present study were carried out as well for the risk index that only considered the number of risk factors.[5] Just like in previous studies (Alemagno et al. 2006; Van der Laan, and Van der Schans 2010), we found a higher threshold for girls when we focused solely on risk factors, for both age periods. Slightly better AUC values showed, however, that models that included both risk factors and promotive factors were more adequate than models that considered risk factors only. Not including promotive factors can lead to overestimation of the risk and therefore of the threshold. This indeed turned out to be the case for girls.

Second, the present study included shared as well as sex-specific factors while other studies only focused on shared factors (see Moffitt et al. 2001; Junger-Tas et al. 2004). Again, for the sake of comparison, the analyses of the present study were carried out as well with models that only considered shared factors.[6] Models that considered both shared factors and sex-specific factors resulted in a better prediction of delinquency at puberty for girls than analyses based on shared factors only. In these latter models, that were utilized in previous studies, girls' risks are underestimated and their risk threshold cannot be examined properly.

[5]These results are not presented here, but are available from the first author.
[6]See footnote 5.

Our study showed that girls and boys do not differ to a large extent in their delinquency 'threshold', i.e. the risk level beyond which the probability to be delinquent is greater than the probability to be not delinquent. It is likely that the threshold that was picked up in previous studies among criminal justice samples may actually have been a criminal justice-involvement threshold. Difference in the average risk levels of delinquent boys and girls are generated by the increasing impact of risk factors on girls beyond the delinquency threshold.

Strengths and Limitations

This study had several limitations. First, only moderate to serious delinquency was taken into account. It might be, however, that although no large sex differences were found in the threshold for delinquency in general, boys' and girls' thresholds do differ to a large extent for violent or serious delinquency. As Moffitt (1993) claimed, during puberty, delinquent behavior is more normative, which as we argued may explain the lack of a clear differential threshold. For less normative behavior, such a threshold may well emerge. This is difficult to test, however, since serious (violent) delinquent behavior is a rare phenomenon in juvenile females and therefore such analyses would have suffered from a lack of power.

Another limitation is that not all factors that have an important risk or promotive effect on delinquency could be taken into account. This is because two different studies (the PYS and the PGS) were combined and we were strict in our decision not to consider factors that were not conistently measured in both studies. For instance, negative life events (i.e. crime victimization, abuse, neglect), that have been shown to be important in predicting delinquency especially for girls (Wong et al. 2010), could not be included because of assessment differences.

Furthermore, delinquency in late childhood might be somewhat underrated since some of the 10-year-old boys but all of the 10-year-old girls filled out the SRA instead. The SRD was not filled out by these juveniles, and therefore the SRA was the only option to compare their delinquent behavior. However, the SRA included fewer delinquency items which might have led to underestimation of delinquency.

In line with other studies using the Pittsburgh Youth Study and the Pittsburgh Girls Study we used mean substitution in case of missing items. Even though mean substitution is in principle suboptimal, the data preparation was meant to create dichotomous variables that represented risk versus no risk (and promotive versus not promotive). These dichotomous variables were created by trichotimizing variables into a promotive, a neutral and a risk component using the 25th and 75th percentiles of the variables as cut-offs. As the mean of a variable falls most often not above the 75th percentile or below the 25th percentile, the imputed value falls mostly within the neutral category representing neither risk nor promotion. This is therefore a conservative method, but it is also in line with what one might suppose to be the case when scores on a risk factor are missing (namely that there is no marked high or low score). Therefore, imputing the variables differently might mean a likely small methodological gain at the cost of being not congruent any more with previous analyses and descriptive statistics on these data sets.

Despite these limitations, the present study improved on previous studies by identifying thresholds for delinquency, and by taking into account promotive factors. Furthermore this study focused on self-reports of delinquency, and included shared as well as sex-specific risk and promotive factors, and examined thresholds longitudinally at two age periods. Moreover, we showed that some of our design improvements actually improved predictions compared to previously studies.

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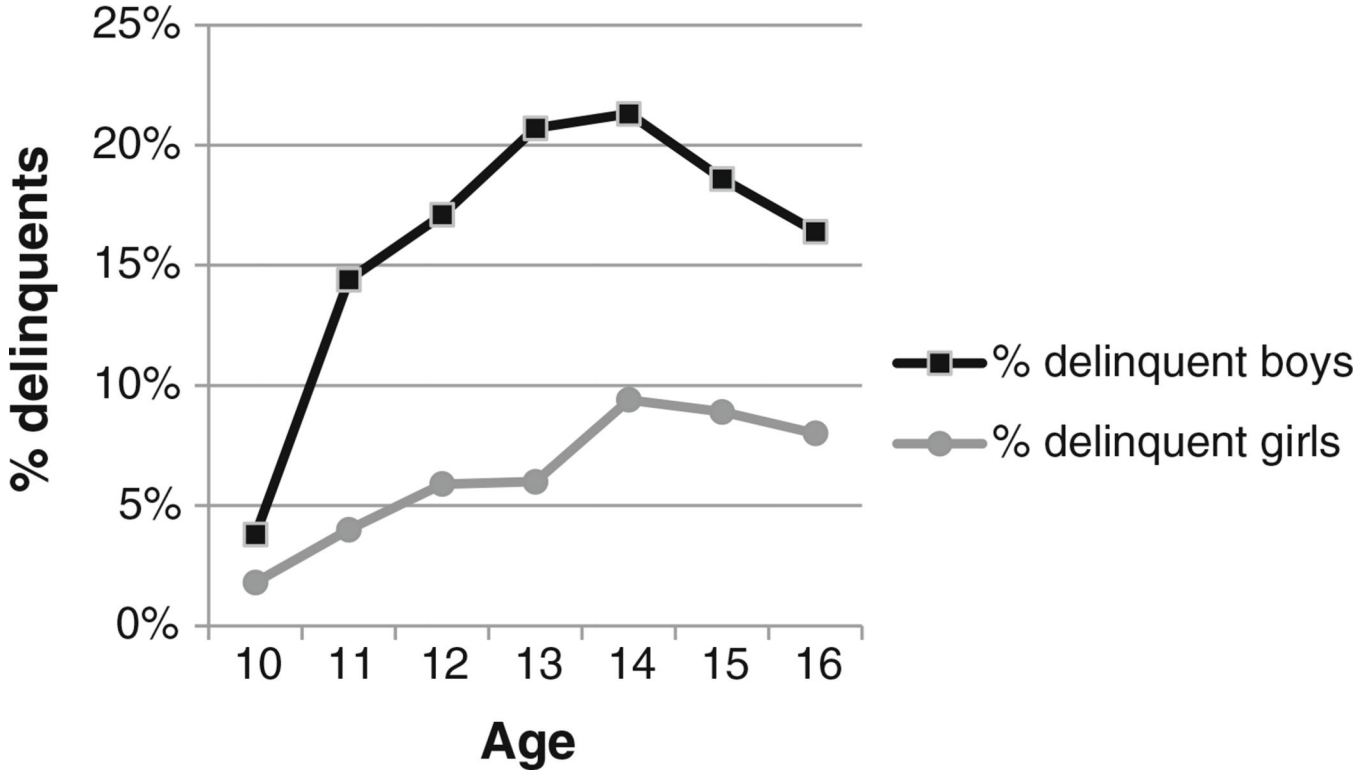

Fig. 1.
Age crime curve for moderate to serious delinquency by sex

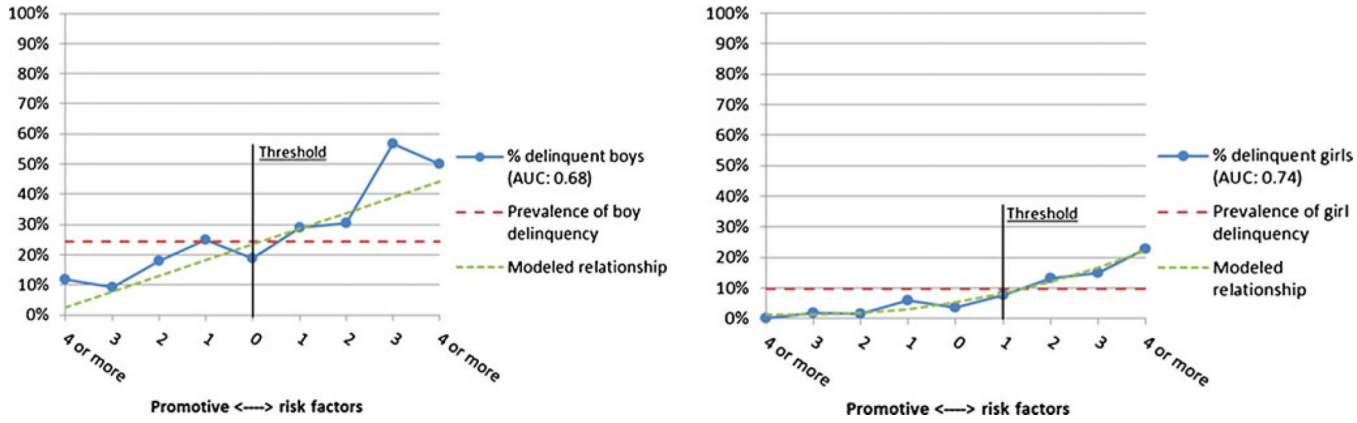

Fig. 2.

Combined risk levels (number of risk factors minus number of promotive factors) at the age of 7 to 9 predicting moderate to serious delinquency at age 10 to 12, for boys and girls

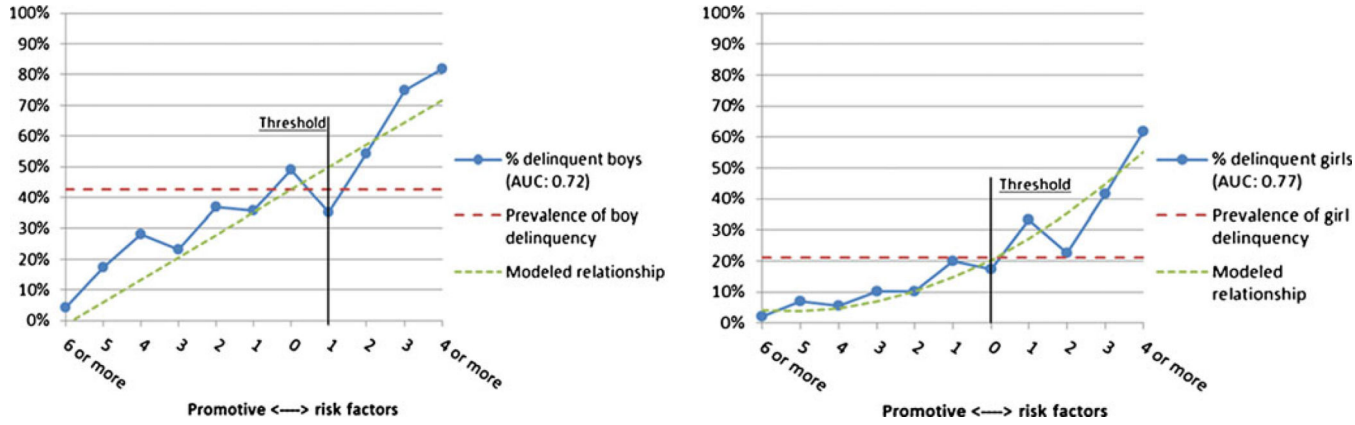

Fig. 3.

Combined risk levels (number of risk factors minus number of promotive factors) at the age of 10 to 12 predicting moderate to serious delinquency at age 13 to 16, for boys and girls

Table 1

Constructs used in this study

Constructs	Instruments		Assessed by	Ages	Reliability		Risk	Promotive
	Boys	Girls			Boys	Girls		
Birth problems	Birth and developmental history	Pre and Perinatal Risk Factors	Parent	First assessment (n = 1177)	15 items	7 items	Any pre- or perinatal birth problem	NA
Early disruptive behavior disorder[a]	Diagnostic Interview Schedule for Children (DISC)	Child Symptom Inventory (CSI)	Parent	First assessment (n = 1359)	ADHD: 27 items; ODD: 18 items; CD: 18 items	ADHD: 14 items; ODD: 8 items; CD: 12 items	At least one of the following disorders: ADHD. ODD, CD	NA
Callous unemotional behavior[b]	Child Behavioral Checklist (CBCL)	Psychopathy Screening Device	Parent	7–9 (n = 1324); 10–12 (n = 1285)	32 items (alpha from 0.90 to 0.93)	6 items (alpha from 0.56 to 0.69)	Highest 25 %	Lowest 25 %
Anxiety	CBCL	Scared	Parent	7–9 (n = 1297); 10–12 (n = 1281)	7 items (alpha from 0.54 to 0.61)	29 items (alpha from 0.90 to 0.92)	Highest 25 %	Lowest 25 %
Poor education of parents	Highest degree of education	Highest degree of education	Parent	7–9 (n = 1327); 10–12 (n = 1310)	1 item	1 item	No diploma or a General Education Diploma (GED) for both parents at all ages	NA
Early pubertal development	Petersen Pubertal Development Scale (PPDS)	Petersen Pubertal Development Scale (PPDS)	Child	9(n = 1126); 12 (n = 1258)	5 items (alpha from 0.56 to 0.75)	5 items (alpha from 0.50 to 0.69)	Highest 25 %	Lowest 25 %
Single parent household	How many caretakers?	How many caretakers?	Parent	8–9 (n = 1348); 10–12 (n = 1282)	1 item	1 item	Living with one parent at all ages	Living with both parents at all ages
Physical punishment of both parents	Discipline	Parent-child Conflict Tactics Scale (CTSPC)	Child	7–9 (n = 1304); 10–12 (n = 1284)	1 item	1 item	Highest 25 %	No physical punishment at all ages
Low communication about activities with both parents	Supervision and Involvement Scale (SIS)	Supervision and Involvement Scale (SIS)	Child	7–9 (n = 1291); 10–12 (n = 1274)	10 items (alpha from 0.64 to 0.84)	10 items (alpha from 0.52 to 0.87)	Highest 25 %	Lowest 25 %
Low positive parenting of both parents	Parent Practices Scale (PPS)	Parent Practices Scale (PPS)	Child	7–9 (n = 1308); 10–12 (n = 1283)	14 items (alpha from 0.71 to 0.97)	14 items (alpha from 0.71 to 0.97)	Highest 25 %	Lowest 25 %
Low supervision	SIS	SIS	Child	7–9 (n = 1306); 10–12 (n = 1282)	4 items (alpha from 0.54 to 70)	4 items (alpha from 0.45 to 0.61)	Highest 25 %	Lowest 25 %

Constructs	Instruments		Assessed by	Ages	Reliability		Risk	Promotive
	Boys	Girls			Boys	Girls		
Bad quality relationship with primary caretaker	Parent-child Relationship Survey (PCRS)	Parent–child Relationship Survey (PCRS)	Child	7–9 (*n* =1320); 10–12 (*n* = 1282)	16 items (alpha from 0.83 to 0.91)	16 items (alpha from 0.86 to 97)	Highest 25 %	Lowest 25 %
Truancy	SRD	SRD	Child	11–12 (*n* = 1273)	1 item	1 item	Truant at both ages	NA
Low school motivation	Works not hard compared to peers	Works not hard compared to peers	Teacher	7–9 (*n* = 1223); 10–12 (*n* = 1225)	1 item	1 item	Highest 25 %	Lowest 25 %
Low school achievement	CBCL & TRF	CBCL & TRF	Parent and teacher	7–9 (*n* = 1212); 10–12 (*n* = 1188)	9 items (alpha from 0.64 to 0.71)	9 items (alpha from 0.88 to 0.97)	Highest 25 %	Lowest 25 %
Peer delinquency[c]	Peer Delinquency Scale (PDS)	Peer Delinquency Scale (PDS)	Child	7–9 (*n* = 1271); 10–12 (*n* = 1248)	5 items (alpha from 0.68 to 0.84)	7–9: 5 items (alpha from 0.78 to 0.80); 10–12: 6 items	Highest 25 %	Lowest 25 %
Neighborhood problems	Your Neighborhood	Your Neighborhood	Parent	7–9(*n* = 1312) 10–12 (*n* = 1282)	17 items (alpha from 0.93 to 0.96)	(alpha from 0.75 to 0.78) 17 items (alpha from 0.94 to 0.96)	Highest 25 %	Lowest 25 %

[a] Due to the time of the assessment, the diagnoses of ADHD, ODD, and CD in the PYS were based on the DSM-III-R, whereas the diagnoses in the PGS were based on the DSM-IV. To make diagnoses comparable, we only included those symptoms that were assessed in both studies. For ADHD, the age of onset, that is usually part of the diagnosis, could not be taken into account since it was not assessed in the PGS. To reach the diagnosis of ADHD, boys and girls had to have 9 symptoms or more. For the diagnosis of CD, 3 or more symptoms were required, and for the diagnosis of ODD, 4 or more symptoms.

[b] In the PYS a construct is created that measures psychopathic features in childhood, assessed by the CBCL. Examples of items are Tying or cheating' 'sudden changes in mood or feelings', and 'behaving irresponsibly'. In the PGS, items from the PSD were used to create a similar construct for girls. The following items are included: concerned about school or tasks, keeps promises, feels bad about doing wrong, concerned about others' feelings, shows feelings and emotions, keeps the same friends.

[c] For 7-to-9-year-olds, exactly the same offences were included (vandalism, shoplifting, stealing at school, stealing from building, violence against adult) in the PYS and the PGS. For 10-to-12-year-olds, the peer delinquency scale was similar in the PGS, but included more serious offences in the PYS. Therefore, we only took those offences of the PYS into account that were comparable to those of the PGS (and which are also similar to the offences considered at earlier ages), i.e. vandalism, stolen something up to $100, stealing from building, and hitting someone with intent to hurt. We corrected for the number of possible items.

Table 2

Descriptive results

	Boys (*n*=503)	**Girls (*n*=856)**	**Average**
Middle childhood			
Average number of risk factors (*n*= 1316)	3.43 (2.33)	3.29 (2.28)	3.34 (2.30)
Average number of promotive factors (*n*= 1282)	2.92 (2.11)	3.00 (2.37)	2.97 (2.28)
Late childhood			
Average number of risk factors (*n*= 1318)	3.41 (2.24)	3.19 (2.34)	3.27(2.31)
Average number of promotive factors* (*n* = 1281)	2.95 (2.17)	3.42 (2.51)	3.24 (2.40)
% delinquent*	24.5 %	9.7 %	15.2 %
Adolescence			
% delinquent*	42.6 %	21.2 %	29.2 %

Standard deviations are in parentheses. With t-tests it was tested whether boys and girls differed in number of risk and promotive factors. Crosstabs were used to test the difference in delinquency prevalence

* significantly different for boys and girls at $p<0.05$

Table 3

Odds ratios of risk and promotive factors for delinquency at ages 10 to 12 and ages 13 to 16, by sex

Factors	Delinquency (10 to 12 years)				Delinquency (13 to 16 years)			
	Risk		Promotive		Risk		Promotive	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Birth problems		1.82**						
Disruptive behavior		3.22**				2.64**		
Callous unemotional behavior	2.39**	3.21**	0.35**	0.18**	2.15**	3.16**	0.41**	0.35**
Anxiety			0.62*			2.28**		0.47**
Poor education of parents						3.37**		
Early pubertal development								
Single parent household			0.64*				0.62*	0.53**
Physical punishment of parents				0.37**	1.82*			0.64*
Communication with parents							2.08**	0.34**
Positive parenting		1.88*				1.63*		0.55*
Supervision		1.83*		0.41*	2 44**	2.31**	0.41**	0.35**
Relationship with primary caretaker	2.20**	2.80**		0.20**	2.83**	2.86**	0.44**	0.29**
Truancy					4.18**	6.10**		
School motivation	2.59**	2.32**	0.35**	0.44*	2 29**	2.13**	0.46**	0.28**
School achievement	1.93**	2.20**	0.48*	0.38*		1.93**	0.50**	0.42**
Peer delinquency	2 19**	2.57**	0.32**	0.12**	3.78**	4.96**	0.23**	0.18**
Neighborhood problems		1 97**	0.52*		1.60*	1.79**	0.54**	0.58*

* $p<0.05$,

** $p<0.01$

Table 4

Means and standard deviations of risk levels for nondeliquent and delinquent boys and girls

	Boys (*n*=503)			Girls (*n* = 856)			Sex difference between delinquents
	Nondelinquent	**Delinquent**	**Difference within boys**	**Nondelinquent**	**Delinquent**	**Difference within girls**	
Middle childhood							
Average number of risk factors	1.15 (1.27)	1.95(1.41)	t(468) = 5.66**	2.19(1.76)	3.82(1.81)	t(804)=7.85**	t(192) = 8.11**
Average number of risk minus promotive factors	−0.89 (2.41)	0.65 (2.40)	t(468)=4.96**	0.61 (2.61)	2.91 (2.11)	t(804)=7.58**	t(192)=6.77**
Late childhood							
Average number of risk factors	1.13 (1.25)	2.32(1.62)	t(444) = 8.83**	1.63 (1.50)	3.39(1.89)	t (747)= 12.39**	t(347) = 5.70**
Average number of risk minus promotive factors	−1.39 (2.72)	0.92 (2.69)	t(444) = 8.91**	−1.68(3.18)	1.43(2.61)	t(747) = 11.35**	t (347) = 1.80

Standard deviations in parentheses. Means of nondelinquent and delinquent boys and of nondelinquent and delinquent girls are compared with T-tests as well as those of delinquent boys and girls

* $p<0.05$,

** $p<0.01$