Chapter 4

The role of heart rate levels in the intergenerational transmission of crime

Abstract

Parental crime and a low resting heart rate are two major risk factors for criminal development. This study focuses on the biosocial interaction between these two risk factors. Prospectively collected conviction data on 794 men from three consecutive generations is used to examine the effects of parental (violent) crime and low resting heart rate levels on violent and non-violent offending. It is also examined whether the intergenerational transmission of crime can (partly) be explained by the intergenerational transmission of low heart rate levels and whether the effects of parental crime and heart rate levels on offspring offending interact. Results show that both paternal violence and low heart rate levels increase violent offending. These effects were shown to interact with each other: a relationship between low heart rate and violent offending was only found among those with a non-criminal father, and an intergenerational transmission of violence was only found among those with a low heart rate. No support was found for the explanations of the intergenerational transmission of violence that involve heart rate levels. Implications for theory and future research are discussed.

4.1 Introduction

Ever since the late 19th century and the early 20th century, when Richard L. Dugdale (1877) and Henry H. Goddard (1912) published their studies on the Jukes family and the Kallikak family, respectively, scientists have studied family influences on antisocial and criminal behavior. These studies, and the methods they used, are now outdated. Research methods improved considerably during the 20th century and several prospective multigenerational studies have shown that crime runs in the family (e.g. Bijleveld and Wijkman, 2009; Farrington, Barnes and Lambert, 1996; Farrington et al., 2001; Van de Rakt, Nieuwbeerta

9 This chapter was submitted as: Van de Weijer, S.G.A., de Jong, R., Bijleveld, C.C.J.H., Blokland, A.A.J. & Raine, A. (submitted). The role of heart rate levels in the intergenerational transmission of crime.
and De Graaf, 2008). During the last decades, empirical research on the biological causes of crime has also established that low heart rate is related to antisocial behavior (Ortiz and Raine, 2004). Despite this progress in determining psychosocial (e.g. parental crime) and biological (e.g. low heart rate) causes of crime, surprisingly little is known about how psychosocial and biological risk factors interact in predisposing to criminal behavior (Raine, 2002). In this study we will focus on the biosocial interaction between paternal crime and low heart rate by examining the role of heart rate levels in the intergenerational transmission of crime among three consecutive generations of men.

The effects of this biosocial interaction will be compared between violent and non-violent crime. A recent study from the Netherlands, the country in which also the current study is conducted, showed that the intergenerational transmission of violent crimes is significantly larger than the intergenerational transmission of non-violent crimes (Van de Weijer, Bijleveld and Blokland, in press). Moreover, on theoretical grounds, it can be expected that a low heart rate has a larger influence on violent crimes than on non-violent crimes. Low heart rate levels might, therefore, play a larger role in the intergenerational transmission of violent crime than in the intergenerational transmission of non-violent crime.

4.1.1 Crime runs in the family

Intergenerational transmission of crime can be assumed from several criminological perspectives. Farrington (2002) described six, non mutually exclusive, mechanisms that might explain why crime is transmitted across generations. First, exposure to risk factors (e.g. disrupted families, living in deprived neighborhoods, teenage parenting) may be transmitted intergenerationally, which leads to offending behavior in each successive generation. Second, the intergenerational transmission of crime may be mediated by risk factors for criminal behavior. Delinquent parents tend to live and raise their children in bad neighborhoods, give birth to children at younger ages and use inadequate child-rearing methods. Consequently, their children’s are at increased risk for criminal development. A third explanation suggests that the intergenerational transmission of crime is the consequence of assortative mating: female offenders tend to have relationships and children with male offenders. Children with two criminal parents have a disproportionally risk to become
criminal. The fourth mechanism, suggested by Farrington (2002), relates to theories about social learning. Children might imitate and learn criminal behavior from their parents. Fifth, the intergenerational transmission of crime might be attributable to genetic factors. According to this explanation, criminals have a genetic predisposition for criminal behavior, which might be transmitted intergenerationally. Farrington’s (2002) sixth explanation suggests that there exists an official bias towards known criminal families. Some criminal families are monitored more intensively by law enforcement bodies, which increases the risk for convictions of children of known criminal parents.

In accordance with these mechanisms, earlier research from the Cambridge Study in Delinquent Development (CSDD) (Farrington, Barnes and Lambert, 1996; Farrington, Coid and Murray, 2009; Rowe and Farrington, 1997) and the Pittsburgh Youth Study (PYS) (Farrington et al., 2001) showed that offending is transmitted between immediate and extended family members. Moreover, results from the Rochester Youth Development Study (RYDS) indicated that parental offending leads to early antisocial and externalizing behavior in their offspring, both directly (Thornberry et al., 2003) and indirectly, mediated by parents’ depressive symptoms (Thornberry, Freeman-Gallant and Lovegrove, 2009), parenting stress and parenting behaviors (Thornberry, 2009). Two Dutch intergenerational studies, the Criminal Careers and Life-Course Study (CCLS) and the Transfive study, also provided evidence for the transmission of offending from parents to children (Bijleveld and Wijkman, 2009; Van de Rakt, Nieuwebeerta and De Graaf, 2008; Van de Rakt et al., 2010) and between siblings (Van de Rakt, Nieuwebeerta and Apel, 2009). An intergenerational transmission of violent crimes is found in the CSDD (Besemer, 2012), Transfive study (Van de Weijer, Bijleveld and Blokland, in press) and the Swedish population (Frisell, Lichtenstein and Långström, 2011).

Some of the mechanisms described by Farrington (2002) might apply more to the transmission of violent crime than to the transmission of non-violent crime. Social learning mechanisms are expected to play a bigger role in the transmission of violent crimes, since violent crimes are probably more often committed at home (e.g. marital violence and child abuse) than non-violent offenses (e.g. theft, traffic offenses, fraud). Moreover, violent offending may be a manifestation of an aggressive trait that can also be expressed by aggressive and violent behavior in everyday life. Consequently, children from violent parents
might be more likely to witness and learn the violent behavior of their parents. Moreover, although violent offending itself is not a genetically transmissible trait, personality traits associated with violence, like a low IQ (Devlin, Daniels and Roeder, 1997), aggression and impulsivity (Meyer-Lindenberg et al., 2006), are to some extent heritable. An official bias might also be larger towards families that commit more severe crimes, such as violence, which leads to more intensive monitoring of violent families by low enforcement bodies. In accordance with this line of reasoning, Van de Weijer, Bijleveld and Blokland (in press) showed, using a sample from the same dataset that is used in the current study, that the intergenerational transmission of violent crimes is larger than the intergenerational transmission of non-violent crimes.

4.1.2 Underarousal: fearlessness and stimulation-seeking

The most influential psychophysiological theories of antisocial behavior assume that antisocial individuals are chronically underaroused. Psychophysiological indicators for underarousal include low heart rate, low skin conductance and more excessive slow-wave electroencephalogram (Raine, 1997). In this study we will focus on low heart rate. According to fearlessness theory, underarousal, indicated by low heart rate levels, is a marker of low levels of fear (Raine, 1993; 1997). This may lead to criminal and violent behavior because a lack of fear might be to some extent required to commit (violent) crimes, while fear might inhibit crime. Moreover, a lack of fear, especially in childhood, reduces the effectiveness of social conditioning (Raine, 1993; 1997).

Stimulation-seeking theory explains the relationship between antisocial behavior and reduced arousal by arguing that low levels of arousal represent an aversive physiological state (Zuckerman, 1979). Underaroused individuals therefore engage in antisocial behavior or (violent) crime (e.g. fights and assaults) because they seek stimulation in order to increase their arousal levels to an optimal or normal level. Fearlessness theory and stimulation-seeking theory are complementary theories rather than competing ones because underarousal may lead to (violent) crime as it generates both fearlessness and stimulation-seeking (Raine, 1997). It is beyond the scope of this current study to test which of these two theories best explains the relationship between heart rate and antisocial behavior, but we will test whether the relationship is in the predicted direction.
In accordance with these theories, a meta-analysis by Ortiz and Raine (2004), covering 40 studies from seven different countries in both hemispheres, showed a relationship between low resting heart rate and antisocial behavior in children and adolescents. Previous studies showed that this relationship could not be accounted for by potential confounders such as physical characteristics, intelligence, drug and alcohol use, physical exercise and disadvantageous social factors (Farrington, 1997; Raine, Venables and Mednick, 1997; Raine, Venables and Williams, 1990; Wadsworth, 1976). In addition, several prospective studies showed that the causality of this relationship is in the predicted direction by ruling out the possibility that an antisocial lifestyle decreases heart rate levels (Farrington, 1997; Moffit and Caspi, 2001; Raine, Venables and Mednick, 1997; Raine, Venables and Williams, 1990; Wadsworth, 1976). Based on these results, Ortiz and Raine (2004: 154) concluded that “low resting heart rate appears to be the best-replicated biological correlate to date of antisocial and aggressive behavior in children and adolescents”. An effect of low heart rate on self-reported antisocial behavior (Armstrong et al., 2009) and criminal convictions (Raine, Venables and Williams, 1990; 1995; Wadsworth, 1976) was also found among young adults. Lorber (2004) further showed in a meta-analysis that low resting heart rate is correlated with aggression among adults as well. The meta-studies of Ortiz and Raine (2004) and Lorber (2004) however, do not include studies conducted in the Netherlands. More recent studies show that a relationship between low heart rate and externalizing behavior is found among 10 to 13 years old Dutch children (Dietrich et al., 2007), as well as between low heart rate and aggression among 16 years old Dutch boys (Sijtsema et al., 2010). No significant effect of resting heart rate was found, however, on the aggressive behavior of four-year-old Dutch children (Posthumus et al., 2009) nor on the recidivism rates of male adolescent Dutch delinquents (De Vries-Bouw et al., 2011). To our knowledge, no studies have been conducted on the relationship between heart rate and criminal behavior among Dutch adults.

It can be derived from fearlessness theory and stimulation-seeking theory that low heart rate may be more related to violent crime than to non-violent crime. Violent crimes are expected to involve more physical contact with the victim than non-violent crimes, and consequently increase the possibility to be physically harmed by the victim. Less fear for possible physical harm might therefore to a larger extent be required for violent crimes than for non-violent crimes. Moreover, violent acts such as fights and assaults might be more
stimulating as they involve more physical activity than non-violent crimes. Ortiz and Raine (2004) could not test this in their meta-study since too few studies compared between aggressive behavior and non-aggressive antisocial behavior. Lorber’s (2004) meta-study does not distinguish between aggressive and non-aggressive antisocial behavior for the adult population neither. Wadsworth (1976), however, found lower heart rates among sexual and violent offenders than among non-violent offenders and non-criminal controls. Based on fearlessness theory, stimulation-seeking theory and previous findings, we expect that: (Hypothesis 1a) Individuals with low resting heart rate levels are more likely to offend than individuals with high resting heart rate levels; and (Hypothesis 1b) this relationship is stronger for violent crime than for non-violent crime.

4.1.3 Transmission of heart rate levels

In addition to those two main effects of parental crime and heart rate levels on (violent) offending, heart rate levels may have an influence on the intergenerational transmission of crime in several ways. Heart rate levels could partly explain the transmission in two ways, and might mediate the degree of transmission. First of all, one of the six before discussed mechanisms of Farrington (2002) is that the intergenerational transmission of crime can be explained through genetic influences. Empirical research showed that a considerable proportion of the variance in heart rate levels is attributable to genetic influences (e.g. Boomsma and Plomin, 1986; Singh et al., 1999). Due to this heritability of heart rate levels, low heart rates may occur in consecutive generations and may lead to criminal behavior of family members from multiple generations. As low resting heart rate may correlate with violent behavior in particular as discussed above, this might particularly explain the intergenerational transmission of violence. We therefore hypothesize that: (Hypothesis 2a) The intergenerational transmission of crime is (partly) explained by the intergenerational transmission of heart rate levels; and (Hypothesis 2b) this explains the transmission of violent crime to a larger extent than the transmission of non-violent crime.

4.1.4 Heart rate levels of criminal’s offspring

Another possible mechanism behind the intergenerational transmission of crime distinguished by Farrington (2002) is that criminal parents expose their children
to risk factors for criminal development. One of these risk factors that children of
criminal parents may be exposed to, is a low resting heart rate, as children of
offenders have been shown to have lower heart rate levels than controls
(Farrington, 1997; Venables, 1987). It is suggested that this is the consequence of
experiencing environmental stress in early childhood (Raine, 1997). Young
children from broken homes, for example, have lower resting heart rates
(Wadsworth, 1976), and experiencing stress such as maternal separation or
physical abuse at young age could also make children more resistant to later life
stress (Raine, 1997). We might expect that young children of violent offenders
experience more stress than young children of non-violent offenders because
violent offenses (e.g. marital violence, child abuse) are more likely to be
committed at home than non-violent offenses (e.g. theft, traffic offenses). In
addition, violent crimes may be a manifestation of an aggressive trait that can
also be expressed by aggressive and violent behavior in everyday life.
Consequently, young children of violent offenders in particular may have lower
heart rates. We therefore expect that: (Hypothesis 3a) The intergenerational
transmission of crime is (partly) explained by lower heart rate levels of
offenders’ children; and (Hypothesis 3b) this explains the transmission of violent
crime to a larger extent than the transmission of non-violent crime.

4.1.5 The social push perspective

Several studies showed that the influence of resting heart rate levels on antisocial
behavior is stronger for those from benign social backgrounds than for those
from deprived social backgrounds. Raine and Venables (1984) found a
relationship between low resting heart rate and antisocial behavior among
individuals from higher social classes but not among those from lower social
classes. A prospective study among Creole Mauritians also showed that low
resting heart rate at age 3 years was related to aggressive behavior at age 11 years
for those from high but not low social classes (Raine et al., 1997). In addition,
Wadsworth (1976) found that low resting heart rate levels lead to antisocial
behavior among persons from intact homes, but not for those from broken homes.
The “social push” perspective offers a possible explanation for these findings.
Antisocial individuals from benign social background have fewer social risk
factors that “push” them to antisocial behavior. As a consequence, biological
factors are more likely to emerge as explanation for antisocial behavior.
Antisocial individuals from deprived social backgrounds have biological risk
factors for antisocial behavior as well, but these are masked by the many social risk factors that “push” these persons to antisocial behavior (Raine, 2002). With respect to the intergenerational transmission of (violent) crime, this would imply that low resting heart rate is particularly a risk factor for the development of crime for those from families without a criminal father relative to persons from families with a criminal father. Our fourth hypothesis therefore is: (Hypothesis 4a) The effect of resting heart rate levels on crime is stronger for persons with a never convicted father than for persons with a convicted father; and (Hypothesis 4b) this interaction-effect is stronger for violent crimes than for non-violent crimes.

4.1.6 Compensatory model of protection

As it is shown that low resting heart rate levels lead to antisocial behavior (e.g. Ortiz and Raine, 2004), it can also be expected that high resting heart rate levels might play a protective role for the development of antisocial behavior. According to the compensatory model, protective factors help individuals to compensate for risk factors or high levels of stress (Brennan et al., 1997). Support for this model was found by Raine, Venables and Williams (1995). They matched 17 antisocial adolescents who desisted from crime as adults with 17 antisocial adolescents who were convicted at age 29 years and 17 non-antisocial controls. They showed that the desisters had significantly higher resting heart rate levels than their more persistent criminal counterparts. The control subjects’ heart rates were intermediate between these two groups but did not differ significantly from either one. Farrington (1997) also found some protective influences of low heart rate levels, among 389 British men. He showed that in many cases the effects of several risk factors (e.g. large family size, low job status, low nonverbal IQ) on violent behavior were smaller for men with high heart rates than for those with low heart rates. Moreover, the influence of having a convicted parent on violent behavior (both convictions and teacher reported violence) was smaller when the son had a higher heart rate. De Vries-Bouw and colleagues (2011), however, found less support for a compensating influence of high heart rate levels. Among a sample of 68 male adolescents who had committed a minor offense, they did not find significant differences in resting heart rate levels between those who reoffended during their adolescence and those who did not. The evidence that high heart rate levels can protect individuals who are at high risk for criminal behavior (e.g. by having a criminal father or by
behaving antisocially as adolescents), to become criminal is thus ambiguous. In order to further explore this possible protective influence of high heart rate levels we will test the hypothesis that: *(Hypothesis 5a) The intergenerational transmission of crime is larger for children with low heart rate levels than for children with high heart rate levels; and (Hypothesis 5b) this interaction-effect is stronger for violent crimes than for non-violent crimes.*

### 4.1.7 The current study

In this study, the influence of heart rate levels and parental crime on the criminal behavior of Dutch males is studied. Heart rate levels are used in an attempt to explain the intergenerational transmission of crime between three consecutive generations, while also a possible mediating influence of heart rate on the intergenerational transmission of crime is examined. Analyses are conducted separately for violent crimes and non-violent crimes.

Our research question is fourfold. First, we study the effects of resting heart rate levels and parental criminality on the criminal behavior of Dutch adults. Second, we examine whether resting heart rate levels (partly) explain the intergenerational transmission of crime between three consecutive generations in the Netherlands. Third, we examine whether resting heart rate levels mediate the intergenerational transmission of crime between three consecutive generations in the Netherlands. Fourth, we explore whether these effects of resting heart rate levels are different for the intergenerational transmission of violent and non-violent crime.

### 4.2 Methods

#### 4.2.1 Sample

A sample from the Transfive study, which contains data on five consecutive generations from 198 Dutch families, was used. The starting point of this study is the first 198 boys who were placed in a Dutch Catholic reform school between 1911 and 1914. Some boys were placed in this institution because of concern about their character and problem behavior, including minor delinquency. Others were in the reform school because their parents, according to guardian organizations, were not able to take proper care of them. Therefore, these 198 boys can be said to constitute a high-risk sample in terms of delinquency.
The parents and all descendants of these boys were traced in Dutch genealogical and municipal records, with a retrieval rate of 100 percent. Emigrated sample members and their descendents were not traced further. As the parents of the 198 boys are the oldest generation in the sample, they will be called ‘Generation 1’ (G1). The 198 boys are called G2, while their children, grandchildren and great-grandchildren are called G3, G4 and G5, respectively. The G3 to G5 are studied prospectively. On average, the G3 were born in 1932; the G4 in 1960; and the G5 in 1986. At the moment of data collection, the surviving G3 were approximately 76 years old, on average. The surviving G4 were about 48 years old and the G5 were approximately 22 years old. Information on the partners is also included to the dataset in order that transmission from both parents can be examined. More detailed information may be found in Bijleveld and Wijkman (2009).

Only men from G3, G4 and G5 who underwent medical examination prior to their obligatory military service were included to the sample, because the heart rate levels were measured during this medical examination. Women were excluded because they did not undergo this medical examination. In 1992 it was decided to suspend the mandatory military service – and thus also the medical examination - and four years later the last draft ended their duty (Moelker, et al., 2005). Persons who turned 17 after 1996 were therefore not medically examined by the Dutch Army. Consequently, heart rate levels were not available for them and they were therefore not included to the sample. Information from the medical examination might also be missing for men from older cohorts for several reasons. If it was clear that someone would be exempt from military service, the medical examination could be cancelled. Men could be exempted if they were the main source of income in their family, were indispensible in their work (often in family businesses) or if they resided outside the European Community (Imbens and Van der Klaauw, 1995). Moreover, men with extensive prior criminal behavior (i.e. more than six months imprisonment) were deemed ineligible, and not all brothers from large nuclear families had to serve (Van Schellen, Apel and Nieuwbeerta, 2012). Until 1966 the three oldest brothers had to serve, and from that year on only the two oldest brothers were obliged to go into the army. Persons who did not undergo medical examination for these, or other, reasons were excluded from the sample as well.
Participants who emigrated were also excluded from the sample since the information on their offending behavior might be truncated. Moreover, men from G1 and G2 were excluded because their conviction data was collected from different (archival) sources and in all likelihood had less good coverage than the conviction data of the later generations. All G3 born before 1916 were excluded from analysis as well since the judicial documentation did not contain data on individuals born before 1912 and may have missed people born between 1912 and 1916. Finally, this resulted in a sample of 794 men for whom judicial and medical data was available. Judicial information of the fathers was available for 557 of these men, and in 184 cases medical information was available for both father and son.

4.2.2 Measurements

Criminal Behavior

Information on offending was obtained from computerized, paper and microfilmed archives of the Dutch Criminal Records Documentation Service (judicial documentation), in December 2007. Offenses were classified based on the Statistics Netherlands standard classification for offenses (Eggen and Van der Heide, 2005). The violent crimes in this classification included: all hands-on sex crimes (i.e. rape, sexual assault, sexual abuse), crimes against life (i.e. murder and manslaughter), threats, assaults, physical injury, robbery and extortion. All other crimes were considered as non-violent offenses. Only information on the registrations that resulted in a conviction or a policy dismissal (i.e. dismissal of a case because the prosecutor deemed it unfeasible to prosecute, for instance because the perpetrator had already paid damages) were used, offenses followed by an acquittal or so-called ‘technical’ dismissal (i.e. dismissal of a case by the

---

10 The criminal records were complete for the remaining participants, apart for those sample members born in one prosecution region (the Almelo “arrondissement”) before 1967, which applied to no more than 3% of G3 and G4.

11 Judicial information was not available for 237 fathers because the conviction data of fathers of the G3 (i.e. the G2 men) was collected from different sources (N=186), because the fathers were born before 1916 (N=31), because the fathers emigrated (N=4) or because the biological father was not known (N=16).

12 Medical information was not available for 610 fathers because this data was not available for fathers of the G3 (i.e. the G2 men), because not all fathers were medically examined or because medical information was not available for the male partners of the female descendants of the 198 G2 men (i.e. the partners of the female G3 and G4).
public prosecutor because of insufficient evidence and the case being expected to result in acquittal) were not taken into account. Offenses were timed to the date the crimes were committed. If the commission date was unknown it was estimated as one year before the conviction date, since that is the average time period between conviction dates and known commission dates. If the conviction date was missing as well, the commission date was timed as July 1 of the year of registration. Although several prospective studies ruled out the possibility that a delinquent lifestyle causes low heart rate (Farrington, 1997; Moffitt and Caspi, 2001; Raine, Venables and Mednick, 1997; Raine, Venables and Williams, 1990; Wadsworth, 1976), we only included offenses after the year in which the resting heart rate levels were measured, during the medical examination, in order to test whether low heart rates lead to offending and not vice versa.

**Heart Rate Levels**

Heart rate levels were obtained from the data of medical examinations of conscripts at the “Defensie Archieven- Registratie- en Informatiecentrum” (DARIC). In the Netherlands, every man was eligible for conscription since 1898. Prior to the mandatory military service, men underwent medical examination around age 18. During this examination the resting heart rate of the conscripts was measured. Little is known about the equipment that the medical examiners used to measure heart rates. There is, however, no reason to doubt the military equipment and Ortiz and Raine (2004) concluded that the use of technically sophisticated equipment is not necessary to find reliable results.

**4.2.3 Analyses**

Odds ratios were calculated in order to test whether violent and non-violent offending is transmitted from father to son and to test whether low heart rates are related to (violent) offending. Moreover, odds ratios were used to test whether the intergenerational transmission of (violent) crime can be explained by the heritability of heart rate levels or by low heart rates of offender’s offspring. In order to test the mediating influence of heart rate levels on the intergenerational transmission of (violent) crime, we will estimate separate odds ratios for sons with low heart rates and sons with high heart rates. Separate odds ratios indicating the relation between heart rate and offending will be estimated for those with criminal fathers and non-criminal fathers in order to test the social push hypothesis. Because participants were born in different years and not all
participants were medically examined at the same age, the odds ratios in all analyses were controlled for exposure. Exposure was measured as the number of years between the medical examination and the moment of data collection (or the year of death, in case of deceased participants).

Odds ratios are simple to interpret and widely used measures in intergenerational studies to assess the transmission of offending. However, odds ratios do not control for the fact that parents with more offspring appear more often in the equation. Therefore, GEE models are estimated to control for this intra-cluster correlation (Ghisletta and Spini, 2004). All odds ratios and corresponding confidence intervals displayed in the following section, are those from the GEE models. In order to examine whether two odds ratios are significantly different from each other, a Ratio between Odds Ratios (ROR) with corresponding confidence intervals was calculated (Altman and Bland, 2003). The significance of those RORs should however be taken as not more than indicative, as there is dependency between the compared samples.

4.3 Results

4.3.1 Descriptives

Variables indicating criminal and violent behavior were measured as the number of convictions of a participant. These variables were highly right-skewed since most of the participants were either not convicted for a (violent) offense or were only convicted for one or a couple of offenses. We therefore chose to recode the offending variables into dichotomous variables, indicating whether or not a participant was convicted for a crime after his medical examination. For the same reason, also the variables indicating paternal crime and the experience of paternal crime at young age (0-5 years), were recoded into dichotomous variables. The measured resting heart rate levels of participants ranged from 48 to 120 beats per minutes. The mean heart rate was 74.18 beats per minutes, and the most frequent measured heart rate was 72 beats per minute (28.3%)\textsuperscript{13}. Due to this large number of participants with a heart rate level of 72, we decided to consider all

\textsuperscript{13} This high prevalence of participants with a heart rate level of 72 beats per minute might be the consequences of the used method to measure heart rates by the Dutch army. Since heart rate levels that can be divided by four (e.g. 60, 64, 68, 72, 76, 80 beats per minute) were often found, we suspect that in many cases the heart rate was only measured for fifteen seconds and then multiplied by four.
participants with a heart rate lower than 72 beats per minutes to have a low heart rate, and all participants with a heart rate higher than 72 beats per minutes to have a high heart rate\textsuperscript{14}.

Table 4.1 shows the descriptives of all the variables that were used in the analyses. These descriptives show that 53 percent of the participants were convicted for a crime after the medical examination, that 50 percent was convicted for a non-violent crime and fifteen percent for a violent crime. The offending rates for paternal crime were approximately the same. This could partly be a consequence of the fact that the G4 in our sample were included both as fathers and as sons. Table 4.1 further shows that thirteen percent of the participants experienced paternal crime during the first five years of their lives, while only two percent of them experienced paternal violence. Finally, 56 percent of the participants and 73 percent of their fathers had a resting heart rate above 72 beats per minutes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any crime</td>
<td>794</td>
<td>0 (not convicted)</td>
<td>1 (convicted)</td>
<td>0.53</td>
</tr>
<tr>
<td>Non-violent crime</td>
<td>794</td>
<td>0 (not convicted)</td>
<td>1 (convicted)</td>
<td>0.50</td>
</tr>
<tr>
<td>Violent crime</td>
<td>794</td>
<td>0 (not convicted)</td>
<td>1 (convicted)</td>
<td>0.15</td>
</tr>
<tr>
<td>Any crime father</td>
<td>557</td>
<td>0 (not convicted)</td>
<td>1 (convicted)</td>
<td>0.54</td>
</tr>
<tr>
<td>Non-violent crime father</td>
<td>557</td>
<td>0 (not convicted)</td>
<td>1 (convicted)</td>
<td>0.51</td>
</tr>
<tr>
<td>Violent crime father</td>
<td>557</td>
<td>0 (not convicted)</td>
<td>1 (convicted)</td>
<td>0.13</td>
</tr>
<tr>
<td>Experience paternal crime</td>
<td>557</td>
<td>0 (not experienced)</td>
<td>1 (experienced)</td>
<td>0.13</td>
</tr>
<tr>
<td>Experience paternal violence</td>
<td>557</td>
<td>0 (not experienced)</td>
<td>1 (experienced)</td>
<td>0.02</td>
</tr>
<tr>
<td>Heart rate</td>
<td>569</td>
<td>0 (low)</td>
<td>1 (high)</td>
<td>0.56</td>
</tr>
<tr>
<td>Heart rate father</td>
<td>126</td>
<td>0 (low)</td>
<td>1 (high)</td>
<td>0.73</td>
</tr>
</tbody>
</table>

\subsection*{4.3.2 Intergenerational transmission of crime}

We started our analyses by testing to what extent crime is transmitted between generations. Table 4.2 shows the odds ratios for the intergenerational transmission of all crime, violent crime and non-violent crime. All three odds ratios are significantly higher than 1. This indicates that all crime, non-violent

\textsuperscript{14} As a consequence of this dichotomy, all 225 respondents with a heart rate of 72 beats per minute are not taken into account in further analyses.

74
crime and violent crime are transmitted between generations. As expected, the odds ratio of violent crime is larger than the odds ratio of non-violent crime which shows that the intergenerational transmission of violent crime is larger than the intergenerational transmission of non-violent crime. The difference between these two odds ratios, however, is not significant (ROR=1.449 (0.734-2.862); p=.29).

Table 4.2 Odds Ratios for Intergenerational Transmission of Crime

<table>
<thead>
<tr>
<th>Transmission of:</th>
<th>Odds Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-violent crime</td>
<td>1.513 (1.054-2.168)</td>
</tr>
<tr>
<td>Violent crime</td>
<td>2.192 (1.230-3.904)</td>
</tr>
<tr>
<td>All crime</td>
<td>1.511 (1.058-2.160)</td>
</tr>
</tbody>
</table>

*Note:* Numbers in parentheses are the 95%-confidence intervals.

4.3.3 Heart rate levels

In order to test our first hypothesis, we examined the influence of heart rate levels on offending behavior by calculating the odds ratios between heart rate and the offending behavior of participants. These odds ratios are shown in Table 4.3. In line with hypothesis 1a, all odds ratios were below one. However, only the odds ratio for violent crime was significant, indicating that persons with high heart rates were less likely to be convicted for a violent crime than persons with a low heart rate. Although we did not find a significant effect of heart rate on non-violent crime (p=.26), hypothesis 1b cannot be confirmed because the difference between the odds ratios for violent crime and non-violent crime was not significant (ROR: 0.727 (0.433-1.219); p=.23).

Table 4.3 Odds Ratios between Heart Rate and Crime

<table>
<thead>
<tr>
<th>Effect heart rate on:</th>
<th>Odds Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-violent crime</td>
<td>0.834 (0.608-1.142)</td>
</tr>
<tr>
<td>Violent crime</td>
<td>0.606 (0.402-0.914)</td>
</tr>
<tr>
<td>All crime</td>
<td>0.795 (0.581-1.087)</td>
</tr>
</tbody>
</table>

*Note:* Numbers in parentheses are the 95%-confidence intervals.
4.3.4 Intergenerational transmission of heart rate levels

The first possible explanation for the intergenerational transmission of crime that involves heart rate levels was that it is (partly) a consequence of the intergenerational transmission of heart rate levels. In order to examine this explanation, we started with estimating the intergenerational transmission of heart rate levels. The odds ratio that indicates this intergenerational transmission, however, was not significant (\( p = .83 \)): 1.111 (0.421-2.942). The correlation between the original, not recoded, heart rate variables (on a ratio scale) was small and not significant (\( r = .13 \), \( p = .08 \)) either. No intergenerational transmission of heart rate levels was thus found in this sample. Due to this lack of significance hypothesis 2a and 2b could not be confirmed.

4.3.5 Heart rate levels of criminal’s offspring

Next, it was examined whether the intergenerational transmission of crime could (partly) be explained by low heart rate levels of criminal’s offspring. In order to test this hypothesis, the influence of experiencing paternal (violent) crime during early childhood (0-5 years) on participant’s heart rate levels was examined. The results showed that those participant who experienced paternal crime during early childhood did not have a significantly lower heart rate than those who did not experience paternal crime. The odds ratio of 1.493 (0.762-2.930) even indicates that experiencing paternal crime during early childhood leads to a higher heart rate, although this finding is not significant (\( p = .24 \)). Participants who experienced paternal violence during early childhood do have a lower heart rate than their counterparts who did not experience this, but the odds ratio of 0.689 (0.206-2.303) is not significant either (\( p = .55 \)). These insignificant odds ratios are not the consequence of the age range (0-5 years) we used: additional analyses showed that the odds ratios were similar if other age ranges were used. Hypothesis 3a and 3b could therefore not be confirmed.

4.3.6 Social push perspective

According to the social push perspective, and our fourth hypothesis, the relationship between low heart rates and offending is especially strong among persons from benign social backgrounds. In order to test this hypothesis we examined whether the effect of heart rate on offending is different for participants with a criminal father and participants without a criminal father.
Table 4.4 shows that the odds ratios between heart rate and the different types of offending are larger if the father was never convicted than when the father has been convicted. In addition, these odds ratios are significant if the father was never convicted, but not when the father has been convicted. This indicates that low heart rate increases the chance to be convicted for a violent crime, a non-violent crime and any crime for those with a non-criminal father, but not for those with a criminal father. The ratio between odds ratios was significant for violent crimes (0.285 (0.085-0.961)), but not for non-violent crimes (p=.31) nor all crimes (p=.27). Hypothesis 4a could therefore only be confirmed for violent crimes. In addition, the fact that a social push effect was only found for violent crimes and not for non-violent crimes is in line with hypothesis 4b.

Table 4.4 Odds Ratios between Heart Rate and Crime, divided by Type of Father

<table>
<thead>
<tr>
<th>Effect heart rate on:</th>
<th>Non-criminal father</th>
<th>Criminal father</th>
<th>ROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-violent crime</td>
<td>0.522</td>
<td>0.817</td>
<td>0.639</td>
</tr>
<tr>
<td></td>
<td>(0.276-0.985)</td>
<td>(0.465-1.435)</td>
<td>(0.273-1.494)</td>
</tr>
<tr>
<td>Violent crime</td>
<td>0.309</td>
<td>1.084</td>
<td>0.285</td>
</tr>
<tr>
<td></td>
<td>(0.125-0.764)</td>
<td>(0.482-2.442)</td>
<td>(0.085-0.961)</td>
</tr>
<tr>
<td>All crime</td>
<td>0.492</td>
<td>0.788</td>
<td>0.624</td>
</tr>
<tr>
<td></td>
<td>(0.264-0.918)</td>
<td>(0.445-1.395)</td>
<td>(0.268-1.454)</td>
</tr>
</tbody>
</table>

Note: Numbers in parentheses are the 95%-confidence intervals.

4.3.7 Compensatory model

Finally, we ended the analyses with testing whether the negative effect of having a criminal or violent father could be compensated by having a high resting heart rate. In order to test this, we examined whether the intergenerational transmission of (violent) crime is different for participants with a low heart rate and participants with a high heart rate. The odds ratios are shown in Table 4.5. The odds ratios that indicate an intergenerational transmission of non-violent crime are not significant (p=.32) for participants with a low heart rate nor for those with a high heart rate (p=.11). This might be a consequence of reduced statistical power after splitting the participants up into two groups. A large and significant odds ratio was found for the intergenerational transmission of violent crimes for those with a low heart rate: 3.435 (1.201-9.816). In accordance with the compensatory model and hypothesis 5a, no significant (p=.51) intergenerational transmission of violent crimes was found for participants with a high heart rate:
The difference between these two odds ratios was large but not significant (ROR: 2.376 (0.518-10.896); p=.26), and hypotheses 5a and 5b can therefore not be confirmed. Remarkably and in contrast with hypothesis 5a, a significant odds ratio for the intergenerational transmission of all crime was found for those with a high heart rate (1.848 (1.024-3.333)) but not for those with a low heart rate (1.250 (0.676-2.312); p=.48). The difference between these two odds ratios, however, was relatively small and not significant (ROR: 0.676 (0.288-1.586); p=.37).

Table 4.5 Odds Ratios for Intergenerational Transmission of Crime, divided by Son’s Heart Rate

<table>
<thead>
<tr>
<th>Transmission of:</th>
<th>Low heart rate son</th>
<th>High heart rate son</th>
<th>ROR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-violent crime</td>
<td>1.369 (0.736-2.545)</td>
<td>1.634 (0.900-2.968)</td>
<td>0.838 (0.201-3.487)</td>
</tr>
<tr>
<td>Violent crime</td>
<td>3.435 (1.201-9.816)</td>
<td>1.446 (0.480-4.358)</td>
<td>2.376 (0.518-10.896)</td>
</tr>
<tr>
<td>All crime</td>
<td>1.250 (0.676-2.312)</td>
<td>1.848 (1.024-3.333)</td>
<td>0.676 (0.288-1.586)</td>
</tr>
</tbody>
</table>

*Note:* Numbers in parentheses are the 95%-confidence intervals.
4.4 Discussion

In this study, data on 794 Dutch conscripts is used to examine the effects of parental crime and low resting heart rates on offending. The biosocial-interaction between these two risk factors for criminal behavior is examined as well. Moreover, it is examined whether low resting heart rates can offer an explanation for intergenerational transmission of offending. This all has been done separately for violent and non-violent crimes.

The results show support for an intergenerational transmission of crime: if the father was ever convicted, his son was at increased risk to be convicted as well. As expected, the intergenerational transmission of violent crime is larger than the intergenerational transmission of non-violent crime. The difference between the two odds ratios is, however, not significant. The odds ratio for the intergenerational transmission of violence was also smaller than the previously found odds ratio among the complete sample of the Transfive study (Van de Weijer, Bijleveld and Blokland, in press). This might be the consequence of the policy of the Dutch army to exclude persons with an extensive criminal record from military service. Consequently, these people were not medically examined prior to the military service and, thus, excluded from this sample. Possibly, these persons who already had an extensive criminal record at young age were already convicted for violent crimes or are more likely to become violent offenders at older age. Due to the fact that these persons are excluded from the sample, the intergenerational transmission of violence might be underestimated. Moreover, we only took into account offspring offending after the medical examination. If children of violent parents commit violent crimes at younger age than children of non-violent parents, the intergenerational transmission of violence is again underestimated. This might explain why no significant difference was found between the intergenerational transmission of violent and non-violent crimes.

Previous research showed that a low resting heart rate is related to antisocial and criminal behavior among children, adolescents and young adults (Lorber, 2004; Ortiz and Raine, 2004). In the current study, we showed that a low resting heart rate was related to violent offending but not to non-violent offending among Dutch adults. This difference between violent and non-violent offending was not found in previous studies since they could or did not differentiate between these different types of offending. This finding, however, is
in line with our expectations based on the fearlessness-theory and stimulation-seeking theory. If violent crimes presuppose a higher degree of fearlessness or are more stimulating than non-violent crimes, this would offer an explanation for the fact that a low resting heart rate is related to violent offending but not to non-violent offending. An alternative explanation for the negative relationship between heart rate and violent crimes might be that the violent participants in our sample had lower resting heart rates and were less ‘fearful’ prior to the medical examination because they had experienced more stressful situations in their life (e.g. parental crime, parental divorce, sexual or physical abuse, living in bad neighborhoods). Moreover, possible confounding variables that may influence both the heart rate levels at early age and adult offending should not be ruled out. Watching violent films, for example, has been shown to reduce heart rate by as much as 10 to 15 beats per minute (Carruthers and Taggart, 1973), and may lead to violent behavior through learning mechanisms. On the other hand, it could be argued that the effect of heart rate on offending is underestimated due to confounders. Alcohol intake and cigarette smoking, for example, increase heart rate levels and are more frequent among antisocial individuals (Raine, 1993). Since we only measured heart rate at age 18 years our results should be interpreted with some caution.

We further tested whether resting heart rate levels could explain the intergenerational transmission of crime in two ways. First, we tested whether the intergenerational transmission of crime was (partly) caused by an intergenerational transmission of heart rate levels. Support for this explanation was not found since we did not find evidence for an intergenerational transmission of heart rate levels. This is a remarkable finding since previous studies showed that a considerable part of the variation in heart rate levels could be explained by genetic influences (Boomsma and Plomil, 1986; Singh et al., 1999). This finding could not be the consequence of the fact that we used a dichotomous variable indicating a low or high heart rate, since an additional analysis showed that the correlation between the original heart rate variables (on a ratio-scale) was not significant either. It might, however, be the consequence of the fact that the heart rate levels were not known for many fathers. This led to a decreased sample size and less statistical power, which makes it hard to reach significant results.
Second, we tested whether the intergenerational transmission of crime was (partly) caused by low heart rate levels of criminal’s offspring. Children of criminal and violent parents were expected to have lower heart rate levels since previous research showed that stress during early childhood can lead to a low heart rate (Farrington, 1997; Venables, 1987). This finding was, however, not replicated in the current study. This might possibly be the consequence of the fact that we only took parental (violent) crimes into account as stressors in children’s early life. Other possible stressors for young children, such as parental divorce (Wadsworth, 1976), were not taken into account and could therefore suppress the relationship between experiencing parental crime and heart rate level. In addition, the use of conviction data might influence the relationship between experiencing parental crime and heart rate levels as well. Possibly, many more participants were exposed to the antisocial or criminal behavior of their fathers than is displayed by the conviction data.

The results further showed support for the social push model: an effect of low heart rate on offending was only found among men from more benign backgrounds. It should, however, be noted that we considered all families without a criminal father as benign families, while there are many more factors that might determine whether someone is from a benign or deprived social background (e.g. social economical status, family income, parental divorce). Moreover, all persons in our sample are descendants of 198 boys who were placed in a Catholic reform school and who were from families that were part of the lower social strata of Dutch society around the 1900s. Our sample, therefore, constitutes a high-risk sample for delinquency and most participants will probably be from deprived social backgrounds rather than benign social backgrounds. The social push effect might, therefore, even be underestimated.

Some support for the compensatory model was also found; intergenerational transmission of violence was only found among participants with a low heart rate and not among those with a high heart rate. A high heart rate thus seems to compensate for the increased risk that children of violent offenders have to become violent offenders themselves. On the other hand, the results could also be interpreted as a cumulative effect. Since we have shown that paternal violence and resting heart rate levels influence the risk to become a violent offender, children of violent fathers with a low heart rate are exposed to at least two risk factors for violent offending. Not only may they inherit or learn
their father’s violent behavior, they also may show more violent behavior due to their low heart rate. As a consequence, those risk factors may cumulate and further increase the risk to become violent. Based on our results, it is impossible to conclude whether there is a compensating influence of high heart rate levels or that the effects of paternal violence and low heart rate levels cumulate.

4.4.1 Strengths and limitations

This study contributes to the existing literature on the intergenerational transmission of crime and to the existing literature on effects of resting heart rate levels in several ways. First of all, we are the first to examine the effects of low resting heart rate levels on the criminal behavior among adults in The Netherlands. We also prospectively examined the influence of heart rate levels on convictions over the whole life-course, while other studies focused on children, adolescents or young adults. In addition, we examined the influence of low heart rate levels on both non-violent and violent crimes, which turned out to be an important distinction since most results were only significant for violent crimes. Finally, we are among the first to study the biosocial interaction between the effects of low resting heart rates and parental crime, which showed that the effects of these two risk factors on criminal behavior are conditional on each other.

Besides these strengths, this study is also limited in several ways. First of all, the use of conviction data as measurement of offending behavior is a limitation, since much actual (violent) crime is not captured by these official statistics. This might have an influence on our findings. We did, for example, not find a significant influence of experiencing paternal crime as a young child on resting heart rate levels. Possibly many more participants experienced paternal crime during early childhood than is displayed by the conviction data, which might lead to an underestimation of the effect.

Another limitation is the measurement of the resting heart rate levels. First, little is known about the equipment that the medical examiners used. Although Ortiz and Raine (2004) showed that the use of technically sophisticated equipment is not necessary to find reliable results, our results should be interpreted with some caution. Second, since heart rate levels are measured during the medical examination prior to military service - usually at the age of 18 - confounding factors at young age, that have an influence on both heart rate
levels and offending behavior, cannot be ruled out. Third, one might question whether a heart rate measured during a medical examination is truly at rest. The medical examination might be experienced as very stressful for some participants because the important decision whether or not they had to serve in the Dutch army was (partly) determined by this medical examination. Therefore, some participants might be nervous and have a higher heart rate. Moreover, some participant might have intentionally tried to sabotage the medical examination if they did not want to serve in the army.

A final limitation concerns the generalizability of our results. First of all, we use a sample that is at risk for criminal and violent behavior because they are all descendants of men who were placed in a Dutch Catholic reform school because of concern about their character and problem behavior. Second, persons who were not medically examined for military service were excluded from the sample. Due to the policy of the Dutch army, individuals with certain characteristics (e.g. extensive delinquency during adolescence, having a large family) were less likely to be medically examined and thus less likely to be in our sample. Finally, only males were included in our sample. It would be an interesting topic for future research to test whether our results could be replicated among a sample of females.

4.4.2 Implications

The results from this study underline the importance of research that focus on the interaction between biological risk factors and psychosocial risk factors for criminal behavior, since we showed that the effects of low heart rate and paternal violence interact with each other. As it is shown that the intergenerational transmission of violence is only large and significant among men with low heart rates, it would be desirable if interventions aimed at stopping this transmission are especially aimed at boys with low heart rates. It would be an interesting topic for future research to study whether other biological risk factors (e.g. low skin conductance) have an influence on the intergenerational transmission of (violent) crime as well, in order that interventions can be aimed at those with the highest risk to inherit their father’s criminal behavior.

Moreover, it would be an important topic for further research to study what the exact mechanism is that leads to the effect of low heart rate on criminal behavior, in order that suitable interventions for antisocials with low heart rates
could be developed. If, for example, this effect is the consequence of stimulation-seeking, antisocials with low heart rates could be stimulated to find stimulation in other activities, such as sports or academic achievements. As this study shows that low heart rate levels are related to (violent) crime among men from benign families in particular, such interventions would probably be most effective among those men.
References


Thornberry, Terence P. 2009. The apple doesn’t fall far from the tree (or does it?): Intergenerational patters of antisocial behavior – The American Society of Criminology 2008 Sutherland Address. *Criminology* 47:297-325.


