Child maltreatment under the skin: Basal activity and stress reactivity of the autonomic nervous system and attachment representations in maltreating parents

Reijman, S.

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Child Maltreatment Under the Skin

Basal Activity and Stress Reactivity of the Autonomic Nervous System
and Attachment Representations in Maltreating Parents

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CHAPTER 1

GENERAL INTRODUCTION

General Introduction

Child maltreatment is a universally prevalent phenomenon (Stoltenborgh, Bakermans-Kranenburg, Alink, & Van IJzendoorn, 2015). In the Netherlands, 34 out of every 1,000 children were estimated to experience maltreatment in 2010, a prevalence rate similar to that of five years earlier (Euser et al., 2013). Child maltreatment includes physical and emotional abuse and neglect, as well as the infliction of sexual abuse, with (potentially) harmful consequences to the child (World Health Organization, 1999). In the past century, research on its etiology and sequelae was fostered by increased attention to the *battered child syndrome* (Kempe, Silverman, Steele, Droegemueller, & Silver, 1962) and studies have continued to focus mainly on abuse, particularly physical and sexual abuse. However, Kempe et al. (1962) already mentioned the common co-occurrence of physical neglect and abuse, an observation further emphasized by Fontana, Donovan, and Wong (1963). Nowadays, neglect is nevertheless still understudied, which is at odds with its relatively high prevalence. In the Netherlands, child neglect was found to be the most prevalent form of child maltreatment (Euser et al., 2013).

Child abuse and neglect increase the risk for detrimental developmental outcomes, short- and long-term, on a range of levels of functioning, including depression, maltreatment of one's own children, and cortisol dysregulation (Spinhoven et al., 2010; Pears & Capaldi, 2001; Alink, Cicchetti, Kim, & Rogosch, 2012, respectively). In sum, the occurrence of child maltreatment is not receding, it is liable to be transmitted from generation to generation, and it has severe consequences for child development. Research on its risk factors is therefore dire in order to inform intervention programs on foci of interest. The current thesis comprises an empirical study (Chapters 2, 3, and 4) and a meta-analysis (Chapter 5) aimed at assessing risk factors related to child maltreatment.

Risk factors for child maltreatment

Etiological studies have evaluated child factors, parent factors, family factors, and more distal environmental factors as potential sources of risk for child maltreatment. These wide-ranging factors were integrated into an ecological model that largely follows Bronfenbrenner's (1977) levels of ecology of human development (Belsky, 1980). In the model, *ontogenic development* refers to factors within parents that may lead to child maltreatment, such as the finding that having experienced maltreatment in childhood increases the risk for maltreating one's own offspring (e.g.,

Pears & Capaldi, 2001). The *microsystem* is the family setting and comprises risk factors like low marital satisfaction and low family cohesion (Stith et al., 2009). The *exosystem* refers to broader social structures that affect the child's direct environment. Low socioeconomic status of the family is an example of a risk factor that may be considered part of the child's exosystem. Abstract and more distal is the *macrosystem*, i.e., the beliefs and values of a (sub)culture, which shape the other ecological systems. Based on this perspective, an extensive ecological/transactional model was proposed in which the interaction of risk as well as protective factors within and across ecological levels dynamically determines whether child maltreatment actually occurs (Cicchetti & Lynch, 1993; Cicchetti & Valentino, 2006). This emphasizes that the occurrence of child maltreatment is not determined by single risk factors, but rather by intricate etiological pathways.

Currently, research is trying to assess the risk factors that play a role in this interactive model, and how much variance in child maltreatment perpetration they explain. In doing so, studies have mainly focused on parental risk factors (Stith et al., 2009, but see Jaffee et al., 2004). This seems prudent, given that parents, as perpetrators, are the main targets for interventions aiming to stop child maltreatment from occurring. This dissertation focuses on two parental risk factors: one on the psychophysiological level, namely autonomic stress reactivity (Chapters 2, 3, and 5), and one on the cognitive-affective level, namely parental attachment representation (Chapter 4).

Autonomic reactivity to infant crying

Parents from the general population have been found to respond to infant cries with increases in autonomic nervous system (ANS) activity (Del Vecchio, Walter, & O'Leary, 2009; Frodi, Lamb, Leavitt, & Donovan, 1978; Joosen et al., 2013a). This is functional, given that ANS activation enables caregiving behavior by mobilizing the body. For example, with increased heart rate, the blood is pumped through the circulatory system at a higher speed, providing organ tissues with more oxygen and nutrients such as glucose (Opie, 2004), necessary for energy consumption. Infants in distress are aroused and cry, thereby arousing the parent, which facilitates a behavioral caregiving response. Parental ANS reactivity has been attributed to physiological synchrony in parent-infant dyads and proposed to reflect feelings of empathy (Ebisch et al., 2012), while other studies suggest that it may be accompanied by feelings of aversion toward the cry (Del Vecchio et al., 2009; Frodi et al., 1978). One (rather forward) hypothesis could be that autonomic

*hyper*reactivity or *hypo*reactivity to infant crying may indicate excessive aversion and/or impaired empathic concern and lead to abusive and neglectful caregiving, respectively.

In the late 1970s research first tested whether maltreating parents showed greater ANS responses than control parents to infant stimuli such as crying (Disbrow, Doerr, & Caulfield, 1977; Frodi & Lamb, 1980). This hypothesis was in line with the irritable, aggressive model of child physical abuse (Frodi & Lamb, 1980) and most studies therefore focused on abusive parents or participants at-risk for abuse (e.g., Crowe & Zeskind, 1992; Wolfe, Fairbank, Kelly, & Bradlyn, 1983). A review concluded that while findings among and within studies also showed inconsistencies, they mainly suggested that autonomic hyperreactivity is a risk factor for child (physical) abuse (McCanne & Hagstrom, 1996). Although a few samples included neglectful parents (Disbrow et al., 1977; Friedrich, Tyler, & Clark, 1985), subgroups may have been too small to detect differential autonomic functioning underlying child abuse and child neglect. Conceptually, autonomic hyporeactivity is compatible with the omission of caregiving behavior which characterizes neglect, just as hyperreactivity is compatible with the aggression which marks child physical abuse. A complication in the attempt to discern differential autonomic reactivity patterns for child abuse vs neglect is that types of maltreatment often co-occur (Euser et al., 2013). Still, a distinction between (combinations of) subtypes is important, since different intervention approaches may be optimally suited for parents biologically at risk for child abuse and those at risk for neglect.

State of mind toward attachment

Another subliminal factor that may pose a risk for child maltreatment is state of mind with respect to attachment. It is usually measured with the Adult Attachment Interview (AAI; George, Kaplan, & Main, 1985) as a measure of the mental representation adults have regarding the relationship with their own parents. The AAI focuses in particular on salient moments in interviewees' early childhood, such as when they were ill, injured, or upset, to get a sense of their parents' typical attachment behavior on those occasions. These episodic memories are compared with how interviewees describe the relationship with their parents on an abstract, semantic level (e.g., "good", "loving"). The pattern of (in)consistencies between the semantic and episodic descriptions in combination with discourse characteristics (e.g., length and orderliness of answers) are considered indicative of the speaker's coherence of mind (Main, Goldwyn, & Hesse, 2003). Overall, three

organized states of mind can be discerned: autonomous, dismissing, and preoccupied. Autonomous speakers are coherent, with a high consistency between semantic and episodes descriptions, and an active collaboration with the interview process; dismissing speakers are not coherent, blocking the recall of episodic memories while not admitting to negative experiences on a semantic level; and a preoccupied state of mind is mainly inferred from speakers' overly lengthy and disorderly answers, often expressing anger at their caregiver(s). Finally, the AAI includes questions on experiences of child physical, sexual, or extreme cases of emotional abuse and experiences of loss (through death). When such experiences are present, the narrative is also coded for "lapses of reasoning or discourse", indicative of an unresolved/disoriented (U/d) state of mind (Main et al., 2003). Such lapses may manifest in many ways, e.g., an experience of abuse may be described in detail and later be denied, or discussions of someone's death may excessively invade other parts of the interview.

Individuals' attachment representations have been shown to predict their own parenting quality (Bernier, Matte-Gagné, Bélanger, & Whipple, 2014; Van IJzendoorn, 1995), with the U/d state of mind being a risk factor for anomalous parental behavior (Madigan et al., 2006). However, no studies to date have compared a representative sample of abusive and neglectful parents to a control group on the prevalence of U/d. This potential risk factor is of interest because it incorporates not only the traumas parents have experienced, but also their state of mind toward those traumas. Although experiencing childhood maltreatment increases the odds of becoming a maltreating parent, it is estimated that about two-thirds of maltreated individuals do *not* go on to maltreat their own offspring (Egeland, Jacobvitz, & Sroufe, 1988; Pears & Capaldi, 2001). Focusing on parents' state of mind toward trauma such as childhood abuse may result in a smaller (albeit fortunate) transmission gap. Indeed, disintegrated narrations of childhood experiences have been found to significantly account for the intergenerational perpetuation of child abuse (Egeland & Susman-Stillman, 1996).

Empirical study

The current thesis is comprised of an empirical study (Chapters 2, 3, and 4) and a meta-analysis (Chapter 5). For the empirical study, we recruited a sample of maltreating mothers through a mental health clinic, where they received therapy that focused on their parenting problems. The clinic consists of several subdivisions with treatment programs for a wide range of psychiatric disorders in different age groups, each located

in the area of Rotterdam, the Netherlands. Some mothers were inpatients, temporarily living with their children (and sometimes their partner) in an apartment unit under the supervision of therapists. Others were part of an ambulatory treatment program, which required them to attend group therapy with their child(ren) three full days per week over the course of six weeks. Some mothers had been referred by Child Protective Services (CPS) and had one or several of their children under consideration for out-of-home placement. Others had sought help on their own initiative. Participating mothers who were in therapy at the clinic gave us consent to access their family files, which had been created by the clinic's administrative services and contained CPS referrals and family histories, among other documents. These files allowed us to substantiate the occurrence of child maltreatment. All available documents were coded for incidents of physical and emotional abuse and neglect perpetrated by the mother.

Maltreating families have lower socioeconomic status, on average have more children, and experience more parenting stress compared to other families (Stith et al., 2009). Comparison groups need to be matched on these variables, or otherwise these variables need to be accounted for in statistical analyses, or they may confound research findings. As becomes clear from the previous paragraph, the lives of maltreating mothers were (temporarily) dominated by their intense contact with mental health services. For this reason we recruited a comparison group of mothers attending a different subdivision of the same mental health clinic, where their children were in therapy; this subdivision was dedicated to children with a developmental or learning disorder. Although these mothers were not in therapy themselves, their lives were also affected by having to attend the clinic regularly. The fact that at least one of their children had a developmental or learning disorder made their caregiving challenge comparable to that of the maltreating mothers, who also had at least one child with a clinical diagnosis (which we verified via their family files). Their socio-economic status was more comparable to that of the maltreating group than if we had drawn a control group from the general population. Overall, this qualifies as a high-risk control group. With these mothers we conducted an interview to verify the absence of incidents of child maltreatment. In sum, they were comparable to the maltreating group on many important aspects, but differed on maltreating behavior.

Research appointments were made at the clinic's location familiar to mothers. This was done to facilitate their participation, and had the advantage that the test environment was more natural than an unknown

lab setting would have been. Testing was done by our research assistants, who were all women under 30 years. During the first appointment mothers participated in three standardized computer paradigms: a cry paradigm consisting of infant cry sounds of different pitches (Zeskind & Shingler, 1991); an attachment-based comfort paradigm with several animated video clips of caregiver-child separation and reunion (Johnson, Dweck, & Chen, 2007); and a handgrip task. Results on the latter have been reported by Compier-de Block et al. (2015). Throughout the paradigms we assessed mothers' autonomic reactivity using cardiovascular measures and skin conductance. During the cry paradigm we additionally collected saliva samples multiple times, from which we assayed the salivary enzyme α-amylase, another ANS index. We tested whether maltreating and non-maltreating mothers differed in their autonomic responses to the cry sounds. Results for cardiovascular measures and skin conductance are reported in Chapter 2, and findings for salivary α-amylase are described in Chapter 3. During the second appointment we conducted the AAI with mothers (George et al., 1985). We tested whether attachment representation was related to maltreatment status as well as autonomic responses to the comfort paradigm (Johnson et al., 2007). This part of the study is reported in Chapter 4.

Narrative review and meta-analysis

Several scholars have argued that we set too much scientific store by results from traditional significance testing (e.g., Cumming, 2014; Ioannidis, 2005). Our knowledge of a certain research field may be biased in a number of ways, such as through selective publishing, or studies being underpowered. These scholars have argued for different statistical approaches to social science, and emphasized the importance of meta-analysis as a tool for cumulative evidence (Rosenthal & DiMatteo, 2001; Van IJzendoorn & Kroonenberg, 1988). From this perspective we should "appreciate any study as part of a future meta-analysis" (Cumming, 2014, p. 27). Chapter 5 of this thesis presents a narrative review and meta-analysis on autonomic baseline activity and autonomic stress reactivity in maltreating parents or participants at risk for abuse. We selected relevant studies conducted between 1977 and 2015, including the empirical study outlined above, thereby placing it immediately in the perspective of the research field. This enables us to test whether our results are representative for findings in this field, and to offer some specific insights if they differ from previous findings.

CHAPTER 2

AUTONOMIC REACTIVITY TO INFANT CRYING IN MALTREATING MOTHERS

Reijman, S., Alink, L.R.A., Compier-de Block, L.H.C.G., Werner, C.D., Maras, A., Rijnberk, C., Van IJzendoorn, M. H., & Bakermans-Kranenburg, M.J. (2014). Autonomic reactivity to infant crying in maltreating mothers, *Child Maltreatment, 19,* 101-112.

Abstract

We examined autonomic reactivity to infant crying in a sample of 42 maltreating and 38 non-maltreating mothers. Exploratively, we tested if differential reactivity was related to child neglect versus the combination of neglect and abuse, and we tested whether mothers' experiences with maltreatment in their own childhood moderated the association between their current maltreatment status and physiology. During a standardized cry paradigm, mothers listened to cry sounds of various pitches. Heart rate (HR), pre-ejection period (PEP), skin conductance levels (SCLs), and vagal tone (root mean square of successive differences [RMSSD]) were measured as indicators of underlying sympathetic and parasympathetic reactivity. The maltreating mothers showed lower SCL reactivity to the cry sounds than non-maltreating mothers. Furthermore, significant negative correlations between HR and PEP in the non-maltreating group differed from nonsignificant correlations in the maltreating group, which suggests a lack of sympathetic cardiac control in maltreating mothers. We found no differences between neglectful mothers and those who were additionally abusive. Together, our findings support the notion of sympathetic hypoarousal as a risk factor for child maltreatment, which may be indicative of disengagement in a caregiving context. Intervention programs might focus on improving maternal sensitivity to improve responsiveness to child signals.

Keywords: child maltreatment, autonomic reactivity, infant crying

Introduction

Child maltreatment is the outcome of multiple pathways with various interacting risk factors, including parent and child characteristics (Cicchetti & Valentino, 2006). Infant cries, for example, can be perceived as aversive by parents and as such put children at risk for harsh caregiving responses (Out, Pieper, Bakermans-Kranenburg, Zeskind, & Van IJzendoorn, 2010). The ''early crying paradox'' (Barr, 1990) refers to how infant crying ensures survival by eliciting parental care, yet heightens the vulnerability to potentially harmful responses. A partial explanation for abusive responses of some parents but not others has long since been suggested to lie in physiological reactivity to negative infant stimuli such as crying (Frodi & Lamb, 1980; Out, Bakermans-Kranenburg, Van Pelt, & Van IJzendoorn, 2012), but findings have been inconsistent. This stresses the need for methodological consistency and a multidimensional measurement of autonomic arousal (McCanne & Hagstrom, 1996). Therefore, the current study aims to evaluate sympathetic and parasympathetic nervous system reactivity to infant crying in mothers with substantiated neglect and abuse as compared to non-maltreating mothers using a standardized cry paradigm. We included mothers' experiences with maltreatment in their own childhood as a possible moderator.

An integrated ecological/transactional model for the etiology of child maltreatment was proposed by Cicchetti and Lynch (1993). As suggested by these authors, dynamic transactions between risk and protective factors take place within and among levels of ecology, the outcome of which tips the balance toward or away from child maltreatment. They further proposed a distinction between enduring and transient risk factors. Well-researched pervasive risk factors include having been maltreated as a child (e.g., Pears & Capaldi, 2001), low socioeconomic status, and parental psychopathology (Stith et al., 2009). Risk factors of a potentially transient nature are, for example, parental unemployment and single parenthood (Stith et al., 2009). According to the model, deviant autonomic reactivity to infant crying might be seen as a vulnerability that, in interaction with other risk factors, adds weight to the scale of potentiating factors, thus increasing the risk for child maltreatment.

The autonomic nervous system (ANS; part of the peripheral nervous system) controls the internal organs, of which the sympathetic and the parasympathetic systems are two main divisions (Larsen, Schneiderman, & DeCarlo Pasin, 1986). Generally, the sympathetic branch procures

bodily energy mobilization when action is required, whereas the parasympathetic system is concerned with energy conservation and recuperation during resting states. Thus, stress commonly activates the sympathetic system while the parasympathetic system is inhibited (Michels et al., 2013; Viamontes & Nemeroff, 2009).

In psychophysiological research, heart rate (HR), which is under the influence of both the sympathetic and parasympathetic system (Cacioppo, 1994), requires complementing measures to reflect the activity of one system, more or less exclusively. For example, pre-ejection period (PEP; the systolic period of the cardiac cycle between the initiation of pressure on the left ventricles and the opening of the aortic valves) and skin conductance levels (SCLs; electrodermal activity of the skin) predominantly indicate underlying *sympathetic* activity (Mauss & Robinson, 2009). Respiratory sinus arrhythmia (RSA; HR variability associated with respiration) is frequently used as an indicator of *parasympathetic* activity. It is an indirect measure of vagal tone, which reflects parasympathetic influence on HR via the vagus nerve, a cranial nerve pertaining to the parasympathetic branch of the ANS. Therefore, in a typical response to stress, HR goes up; the systolic period shortens, so PEP decreases; the sweat glands are activated, increasing SCLs, and vagal cardiac control withdraws to make way for sympathetic cardiac control, as seen in an RSA decrease. Furthermore, correlations between the different measures are informative as to whether sympathetic or parasympathetic activity underlies HR *within* individuals.

It appears that ANS reactivity to children's signals is a requirement for sensitive parenting, of which *promptness* of response is a core component (Joosen et al., 2013a; Moore et al., 2009). This is consistent with the notion of autonomic contagion (the sharing of autonomic arousal) that has been found in mother–child dyads as mothers watched their child in distress, a possible indication of empathy (Ebisch et al., 2012). Studies on autonomic hyper- and hyporeactivity underlying maladaptive behavior have usually compared the focal group to a control group in which the maladaptive behavior was absent, whose reactivity pattern in response to stressful stimuli then served as referential norm. Hyperreactivity, therefore, is seen in stronger HR and SCL increases and stronger PEP and RSA *de*creases in the focal group than in the reference group. Hyporeactivity, on the other hand, implies weaker HR and SCL increases and weaker PEP and RSA decreases for the focal group than the comparison group.

In a review of eight early studies, in which mainly HR and SCLs were measured, physiological hyperreactivity was concluded to be related to

(increased risk for) abusive parenting (McCanne & Hagstrom, 1996). However, as indicated in the review, findings included inconsistent results and null results (Frodi & Lamb, 1980; Stasiewicz & Lisman, 1989, respectively). This may be because methodologies varied between studies, including parents and non-parents as participants, and child-related as well as non-child-related stimuli. More recently, hyperreactivity of SCLs to infant cry sounds predicted harsh discipline during mother–child interactions 9 months later (Joosen, Mesman, Bakermans-Kranenburg, & Van IJzendoorn, 2013b). In addition, using salivary a-amylase (sAA) as a marker of ANS activity in a sample of adult twin pairs (parents and non-parents), it was found that sAA hyperreactivity to infant cry sounds was associated with intended harsh caregiving responses (Out et al., 2012). Congruent with the *hypo*reactivity hypothesis, mothers of children with an avoidant attachment strategy showed less vagal withdrawal during the reunion episode of the Strange Situation Procedure (Hill-Soderlund et al., 2008). This may correspond to low responsiveness to child signals and an affectively disengaged representation of their child, as has been observed in mothers of avoidant dyads (Raval et al., 2001; Zeanah, Benoit, Hirshberg, Barton, & Regan, 1994). Furthermore, fathers of families with interparental physical aggression showed overall lower sAA levels and lower sAA reactivity to, and recovery from, a conflict discussion (Gordis, Margolin, Spies, Susman, & Granger, 2010). In half of these cases, interparental physical aggression was reported by the adolescent, indicating that in *at least* half of these families, children had witnessed physical conflicts between their parents. When witnessed by children, interparental aggression is a form of child neglect (Barnett, Manly, & Cicchetti, 1993). Interparental aggression was not related to sAA levels in mothers. Overall, these findings tentatively suggest that ANS hyperreactivity may mark child abuse while hyporeactivity may characterize neglect. Indeed, one study has suggested a possible association between autonomic hyperarousal and harsh or hostile caregiving behavior, while autonomic hypoarousal was related to maternal disengagement from her child (Sturge-Apple, Skibo, Rogosch, Ignjatovic, & Heinzelman, 2011).

An important aspect to consider in research on physiological reactivity underlying child maltreatment is the maltreatment experienced by current perpetrators in their youth. Evidence shows that early maltreatment experiences are associated with subsequent dysfunctional parenting (Pears & Capaldi, 2001). Furthermore, psychobiological development differs for individuals with and without childhood maltreatment experiences, though how exactly is not yet fully

understood. Results are diverse and have been suggested to vary according to genetic and temperamental disposition (Gunnar & Quevedo, 2007) and to change over time (Yates, 2007). For the ANS, findings seem to point mostly toward autonomic hyperreactivity as a function of child maltreatment experiences. For example, foster children with a history of child neglect and those with disordered attachment showed sympathetic hyperreactivity during the Strange Situation Procedure (Oosterman, De Schipper, Fisher, Dozier, & Schuengel, 2010). Increased HR reactivity was found in women who had been physically and sexually abused in childhood (Heim et al., 2000).

The current study extends the existing literature by evaluating mothers with substantiated maltreatment, taking their own experiences with childhood maltreatment into account, including a wide range of autonomic measures of both the SNS and the PNS, and using a standardized cry paradigm that enhances the comparability of results among studies. Since a recent prevalence study in the Netherlands found child neglect to be the most prevalent form of child maltreatment (Euser et al., 2013), we expected to find more neglect than abuse in our sample. Consequently, we expected HR, PEP, RSA, and SCL hyporeactivity to the cry sounds for the maltreating group as a whole compared to the non-maltreating group. We tentatively hypothesized that we would find autonomic hyperreactivity in the subgroup of mothers who additionally displayed child physical and/or emotional abuse compared to non-maltreating mothers. In an explorative way, we tested mothers' own maltreatment experiences as a possible moderator of the relation between maltreating parenting and autonomic reactivity, such that maltreating mothers who experienced severe maltreatment would show less hyporeactivity than maltreating mothers who experienced (almost) no maltreatment in childhood. We emphasize the preliminary nature of this analysis, since subgroup sizes were small.

Method

Participants

We recruited 45 maltreating and 45 non-maltreating mothers at a mental health clinic. Mothers in the maltreating group received therapy for their parenting problems and were informed about the study by their therapists. We coded Child Protection Services (CPS) records to substantiate recent or ongoing maltreatment using the Maltreatment Classification System (MCS; Barnett et al., 1993). When records were inconclusive, we interviewed the mother's psychiatrist about her

parenting problems using a semi-standardized interview. For three mothers, neither their records nor their psychiatrists provided proof of maternal maltreatment. In these cases, we conducted a Dutch adaptation of the Maternal Maltreatment Classification Interview (MMCI; Cicchetti, Toth, & Manly, 2003). Absence of maltreatment was verified for two mothers who were considered as non-maltreating in the analyses. One mother could not be reached for a follow-up MMCI and was excluded from analyses because of her inconclusive current maltreatment status (i.e., whether she was maltreating or not).

Non-maltreating mothers were recruited by research assistants in a clinical subdivision of the facility, where their child was in therapy for developmental or learning problems. To verify absence of maltreatment, the MMCI (Cicchetti et al., 2003) was used. Three mothers were counted as maltreating in the analyses because incidents were coded from the interview which had taken place less than 5 years ago. There were no mothers with incidents of maltreatment that had occurred more than 5 years ago.

Due to technical problems, eight participants had missing HR, PEP, root mean square of successive differences (RMSSD), and SCL data. Additionally, one mother had a heart condition incompatible with electrocardiogram (ECG) analysis. Therefore, the final sample consisted of 42 maltreating and 38 non-maltreating mothers. The maltreating group consisted of 20 neglectful and 22 neglectful and additionally abusive mothers who will henceforth be referred to as NE (neglectful) and AN (abusive and neglectful) mothers. Included and excluded mothers did not differ on any of the background variables (ethnicity, educational level, exercise during the week prior to the research appointment, smoking on the morning of the study, medication affecting HR, or hearing problems, maternal age, number of children, and children's mean age; *p*s > .24). In the final sample, 94% of mothers were of Caucasian ethnicity, 47% had completed secondary school, and 33% had finished elementary school or a short track of secondary school. Their mean age was 40.79 (*SD* = 7.26) and on average they had 2.41 children (*SD* = 1.19). Finally, three mothers in the maltreating group (one NE and two AN) had no data for PEP because of flat impedance cardiograms (ICGs). They did not differ from the other mothers on any of the background variables (*p*s > .06). Excluding them from the other analyses did not affect the results, so we included 80 mothers (42 maltreating and 38 non-maltreating) in the HR, SCL, and RMSSD analyses, and 77 mothers (39 maltreating and 38 non-maltreating) in the PEP analyses.

The study was approved by the Medical Ethics Review Committee for Mental Health Care (METiGG). All mothers gave informed consent for participation and, in the maltreating group, for researchers' access to the family files. As a compensation for participation, mothers received 40 Euros as well as traveling expenses.

Procedure

Two individual appointments took place at the facility. During the first session, mothers completed three computer tasks, of which the cry paradigm (Zeskind & Shingler, 1991) reported here was the first. During the task, an ECG signal, an ICG signal, and SCLs were recorded. Afterward, mothers completed a questionnaire on health-related issues, such as smoking and exercising prior to the session, and on their family situation, including educational level, number of children, and children's age. We administered the MMCI to the non-maltreating group. During the second session, the Adult Attachment Interview (George, Kaplan, & Main, 1985) was conducted (data will be presented elsewhere), after which mothers completed the short form of the Childhood Trauma Questionnaire (CTQ-SF; Bernstein et al., 1994; Bernstein & Fink, 1998).

Measures

MCS. We used the MCS (Barnett et al., 1993), a reliable and valid system to code incidents of maltreatment reported in the family's records from CPS and the child care office (Cicchetti, Rogosch, Gunnar, & Toth, 2010). According to the MCS, physical abuse is coded ''when a caregiver . . . inflicts physical injury upon a child by other than accidental means,'' including hitting or kicking, violent handling (e.g., shoving and dragging), smothering, burning, shaking, or other, and non-descript abuse. Physical neglect encompasses the failure to provide adequate food, clothing, shelter, health care, or hygiene, and a lack of adequate supervision that ensures the child's safety. Emotional maltreatment involves "persistent or extreme thwarting of children's basic emotional needs'' and ''parental acts that are harmful because they are insensitive to the child's developmental level.'' We further distinguished between incidents of emotional maltreatment directed *at* the child (emotional *abuse*, e.g., belittling the child, or calling the child derogatory names) and incidents demonstrative of inattentiveness rather than rejection (emotional *neglect*, e.g., expecting an inappropriate level of responsibility from the child, exposing the child to marital violence). In accordance with these operational definitions, we coded abuse (physical and emotional) and neglect (again, physical, and emotional). The fact that

certain types of maltreatment were recorded in the files suggests them to be of a structural rather than incidental nature. Since mothers were in therapy for their parenting problems, a relatively high level of severity of these problems may be assumed. Information on the consequences of recorded examples of maltreatment was often too unspecific to reliably distinguish between severity grades. Only incidents of *maternal* maltreatment were considered. Coding was done by trained research assistants. Interrater reliability on 15 files was excellent, with $\kappa = .82$ for abuse and $\kappa = 1.00$ for neglect. For the presence versus absence of maltreatment, there was full agreement ($\kappa = 1.00$). Subsequently, all records were coded by two different research assistants and discrepancies were resolved through discussion. We found that all mothers in the maltreatment group had been neglectful toward their children, either physically or emotionally. Fifty-four percent ($n = 22$) of maltreating mothers had been additionally abusive, physically or emotionally.

MMCI. The MMCI (Cicchetti et al., 2003) is a semi-structured interview that evaluates whether the mother has maltreated any of her children recently and during their lifetime. Mothers are asked about incidents of physical and emotional abuse and neglect, as well as sexual abuse, and about any contact the family may have had with the CPS. We translated the interview into Dutch for this study. Coding was done by trained research assistants. Interrater reliability on 12 interviews was excellent, with full agreement for the presence versus absence of maltreatment, incidents of neglect versus abuse, and severity of the incidents (for all κs = 1.00). Interviews were coded by two different research assistants and discrepancies were resolved through discussion.

Cry paradigm. The cry paradigm was presented on a laptop with E-prime software. A 6-min baseline of neutral images was followed by three blocks with three cry sounds each (for details on the sounds' derivation, see Out et al., 2010). Within each of the blocks, sounds differed in fundamental frequency, congruent with the idea of infant crying as a graded signal of varying acoustic properties that communicate the cause's urgency (Gustafson, Wood, & Green, 2000). In each block, the three cries, of 500, 700, and 900 Hz, were presented in a random order. All sounds lasted 10 s, containing seven cry expirations and were presented through Sennheiser HD202 headphones at a constant volume. The paradigm ended with another 4-min baseline of neutral images. As a manipulation check, we tested whether the perception of the cry sounds differed for sounds with different fundamental frequencies. After each cry sound, mothers were presented

with four questions on the extent to which they perceived the sound as urgent, aversive, the child as sick, and themselves as aroused (Out et al., 2012; Zeskind & Lester, 1978; Zeskind & Marshall, 1988). They answered on a 5-point scale, ranging from very little to very much. Each fundamental frequency was presented 3 times, resulting in 12 ratings per pitch. Following Out, Pieper, Bakermans-Kranenburg, Zeskind, and Van IJzendoorn (2010), who found one component underlying these 12 ratings, averages were aggregated to form the overall perceived urgency. Cronbach's αs ranged from .88 to .89. There was an overall main effect of pitch ($p < .001$), with a significant increase in perceived urgency from 500 to 700 Hz, from 500 to 900 Hz, and from 700 to 900 Hz (*p*s < .001). Maltreating and non-maltreating mothers did not rate the sounds differently, not overall nor as a function of pitch (*p*s > .54). To get acquainted with a cry sound and the questions, participants practiced with one cry sound of 500 Hz. The cry paradigm has been used in previous studies with childless adults and parents and has been shown to evoke physiological stress responses, harsh caregiving intentions, and emotional irritation (e.g., Joosen et al., 2013a; Out et al., 2010).

HR, RSA, PEP, and SCL. During the cry paradigm, an ECG, ICG, and SCL were measured using an ambulatory monitoring system (VU-AMS5 fs; TD-FPP, Vrije Universiteit, Amsterdam, the Netherlands). For the ECG, three disposable pre-gelled Ag-AgCI electrodes (ConMed, New York, USA) were placed slightly below the right collar bone 4 cm to the right of the sternum, between the two lower ribs on the right side, and under the left breast (4 cm under the nipple). For the ICG, four electrodes were attached at the top end of the sternum between the tips of the collarbones, on the spine (at least 3 cm above the previous one), at the low end of the sternum where the ribs meet, and again on the spine (at least 3 cm under the previous one). Before the assessment of the SCLs, mothers washed their hands with a mild soap. Then two Ag-AGCI electrodes, filled with isotonic GEL101 electrode paste, were placed on the middle and index finger of mothers' non-dominant hand. E-prime had been pro-grammed so that markers were sent to the ECG and SCL recording during baseline, the presentation of each cry sound, the answering of the questions, and recovery.

A complementary VU-DAMS software package derived interbeat interval time series (IBIs) by visual peak detection of the R-wave. For HR, we inspected each ECG recording and corrected it manually when necessary (following VU-DAMS instructions). We labeled the data according to the markers sent by the E-prime. From each ICG recording, the PEP was scored manually per labeled segment by trained research

assistants. Interrater reliability was excellent, with intraclass correlations ≥ .97. The short duration of our labeled segments of interest (i.e., 10 s of cry sounds) resulted in missings on RSA. Therefore, RMSSD was used as an indication of RSA. RMSSD and RSA have been shown to correlate highly and stably across time and ambulatory conditions (Goedhart, Van der Sluis, Houtveen, Willemsen, & De Geus, 2007). As a correlate of RSA, it has previously been used as a measure of vagal tone (e.g., in Joosen et al., 2013a, 2013b). In our sample, the mean of same-time correlations between RSA and RMSSD (e.g., RSA baseline with RMSSD baseline and RSA recovery with RMSSD recovery) was r = .70. Average HR, PEP, SCL, and RMSSD were derived per labeled segment, after which the mean over the segments was calculated per episode (baseline; blocks 1, 2, and 3 of cry sounds; and recovery) in SPSS. We checked for outliers (using standardized scores of -3.29 and 3.29 as cutoff) per labeled segment as well as per aggregated episode. For SCL one participant, and for RMSSD seven participants showed outliers for individual segments, which were winsorized (Tabachnik & Fidell, 2001). The least extreme outlier was replaced with a value .10 above the highest non-outlying score, and for each next outlier .10 was added to its preceding value, preserving the original order. For RMSSD, its combined episodes showed four outliers, which were winsorized as well. Combined episodes showed no further outliers.

CTQ-SF. The CTQ-SF (Bernstein et al., 1994; Bernstein & Fink, 1998; Thombs, Bernstein, Lobbestael, & Arntz, 2009) is a self-report questionnaire that consists of 27 items (24 clinical items and 3 validity items), with which the childhood experiences of abuse and neglect are retrospectively assessed. It has shown measurement invariance across four different populations (clinical and normal; Bernstein et al., 2003), and contains five subscales: physical abuse (α = .88), emotional abuse (α = .88), physical neglect (α = .65), emotional neglect (α = .88), and sexual abuse (α = .90; Cronbach's αs for the current sample). Each scale consists of 5 items with a 5-point scale ranging from *never true* to *very often true*.

We categorized scores per subscale according to severity using the manual's cutoff scores (minimal, low, moderate, and severe, taking into account that the Dutch version of the CTQ has 4 instead of 5 items for sexual abuse). They were then assigned a total severity score that was equal to their highest severity score on the subscales. Two mothers (3%) had missing data on the CTQ. These were imputed with the average of mothers with the same current maltreatment status. Finally, we distinguished mothers with minimal/low scores (n = 43, 18 maltreating and 25 non-maltreating) from mothers with moderate/severe scores (n =

37, 24 maltreating and 13 non-maltreating). Fifty-seven percent of maltreating mothers scored high on experienced maltreatment compared to 34% of non-maltreating mothers. For both groups emotional neglect was the most frequently reported type of experienced maltreatment.

Data Analysis

We performed Pearson's χ^2 tests to compare maltreating (NE and AN together as well as separately) and non-maltreating mothers on ethnicity, educational level, medication, hearing problems, whether their children had a clinical diagnosis, exercise, smoking, and CTQ scores (minimal/low vs. moderate/severe). *T*-tests were done to check for differences in maternal age, children's mean age, and number of children. We calculated Pearson's correlation coefficients for the relation between maternal age and children's mean age, between maternal age and the baseline levels of the autonomic measures, and between the number of days maltreating mothers had been in therapy before participation and the baseline levels of the autonomic measures. We performed *t*-tests to evaluate whether exercise and smoking had an effect on the baseline levels of the physiological variables.

Partial correlation coefficients were calculated for the association between HR, PEP, SCL, and RMSSD on all measurement points, with smoking and maternal age as covariates. Univariate analyses of covariance (ANCOVAs) were conducted to compare maltreating and non-maltreating mothers on baseline levels of HR, PEP, SCL, and RMSSD, with only smoking as covariate. To evaluate the association between current and experienced maltreatment status and physiological reactivity to cry sounds, we performed repeated measures ANCOVAs for HR, PEP, SCL, and RMSSD. Current and experienced maltreatment status refer to whether mothers are currently maltreating or not and whether they were maltreated in their own childhood, respectively, and these terms will be maintained throughout. To reduce the number of statistical tests, we included three episodes (rather than five) as within-subjects factor: baseline, block 3 of cry sounds, and recovery. We chose the third block because previous research has found an accumulative effect of the cry sounds on autonomic reactivity using the same cry paradigm (Out et al., 2012), as well as group differences being most pronounced during block 3 (Joosen et al., 2013b). Current maltreatment status (maltreating vs. non-maltreating) and experienced maltreatment (minimal/low vs. moderate/severe) were entered as between-subjects factors. We included smoking and maternal age as covariates. We repeated the analyses with three levels of current maltreatment status as

between-subjects factor: NE mothers, AN mothers, and non-maltreating mothers.

Results

Preliminary Analyses

Maltreating and non-maltreating mothers did not differ on ethnicity, educational level, medication, hearing problems, number of children, or whether their children had been clinically diagnosed (*p*s > .12). However, fewer maltreating mothers (48%) than non-maltreating mothers (71%) had exercised in the week prior to the research appointment, $\chi^2(1, N = 80) = 4.52$, $p < .05$; specifically, fewer NE mothers (35%) than non-maltreating mothers had exercised, $\chi^2(2, N = 80) = 7.03$, $p < .05$. More maltreating mothers (45%) than non-maltreating mothers (13%) had smoked on the morning of the research appointment, $\chi^2(1, N = 80) = 9.78$, $p < .01$; specifically, more AN mothers (55%) than non-maltreating mothers had smoked, $\chi^2(2, N = 80) = 11.68$, $p < .01$. Mothers and their children in the maltreating group were significantly younger than their counterparts in the non-maltreating group, $t(72.55) = 4.86$, $p < .001$ and $t(78) = 4.36$, $p < .01$, respectively. Maltreating mothers' mean age was 37.52 (*SD* = 7.45), while that of non-maltreating mothers was 44.39 (*SD* = 5.06). This was true for both NE and AN mothers (*p*s < .05). Maltreating mothers' children's mean age was 9.38 (*SD* = 5.06), while non-maltreating mothers' children on average were 13.78 years old (*SD* = 3.84). Since maternal age and children's average age were highly correlated (*r* = .79), only maternal age was considered as a covariate for the analyses. Exercise and maternal age were not correlated to baseline levels of HR, PEP, RMSSD, or SCL (*p*s > 09). Smokers differed significantly from non-smokers on baseline levels of HR and PEP (*p*s ≤ .02). For the maltreating group, the number of days they had been in therapy before participating in the study was not related to baseline levels of the autonomic measures (*p*s > .11). Finally, more maltreating mothers (57%) than non-maltreating mothers (34%) had moderate/ severe childhood maltreatment experiences, $\chi^2(1, N = 80) = 4.22$, $p = .04$, $\varphi = .23$.

Correlations Between Autonomic Measures for Maltreating and Non-Maltreating Mothers

Partial correlations between HR and PEP as well as between HR and RMSSD for maltreating mothers and non-maltreating mothers are displayed in Table 1. HR and PEP were not significantly associated in

maltreating mothers, whereas they were significantly negatively correlated for non-maltreating mothers. The differences between the correlations for maltreating and non-maltreating mothers were significant across all episodes of the cry paradigm (*p*s < .05). HR and RMSSD were significantly, negatively correlated for both groups. There were no significant correlations between SCL and any of the other physiological measures for either group (*p*s > .08).

Differences in Autonomic Measures for Maltreating and Non-Maltreating Mothers

Table 2 shows means (*SD*s) for all autonomic measures for episode (baseline, block 3, and recovery) by maltreatment group. No differences were found between maltreating and non-maltreating mothers in the baseline levels of any of the physiological variables, when controlling for smoking (*p*s > .16).

Skin conductance level. We found an overall (multivariate) effect of episode, with SCL increasing from baseline to the third block of cry sounds and decreasing from block 3 to recovery (*p*s < .03). In line with our expectations, Figure 1 shows a significant overall interaction effect of current maltreatment status with episode, $F(1.41, 73) = 3.79$, $p = .04$, partial $\eta^2 = .05$ (Greenhouse-Geisser correction for sphericity). Contrast analyses showed that from baseline to block 3, maltreating mothers showed a significantly smaller increase from baseline to the third block of cry sounds compared to non-maltreating mothers, $F(1, 74) = 4.54$, $p = .04$, partial $\eta^2 = .06$. Furthermore, there was a significant interaction effect of current maltreatment status with episode from baseline to recovery, $F(1, 74) = 3.85$, $p = .05$, partial $\eta^2 = .05$, with the increase in SCL being less pronounced for maltreating mothers. There were no effects of experienced maltreatment (*p*s > .19).

PEP. There was an overall interaction effect between current maltreatment status and episode, $F(1.83, 70) = 3.70$, $p = .03$, partial $\eta^2 = .05$ (Greenhouse Geisser correction for sphericity). In the direction opposite to our hypothesis, contrast analyses showed that the decreasing trend of PEP for maltreating mothers from baseline to block 3 was significantly different from the increasing trend of PEP for non-maltreating mothers, $F(1, 71) = 5.31$, $p = .02$, partial $\eta^2 = .07$. Furthermore, for the contrast from block 3 to recovery, the increasing trend of PEP for maltreating mothers was significantly different from the stable PEP of non-maltreating mothers, $F(1, 71) = 4.13$, $p = .046$, partial $\eta^2 = .06$. Figure 2 shows how this effect was further qualified by a three-way interaction of episode with current maltreatment status and experienced maltreatment, $F(1, 71) =$

3.96, p = .050, partial η^2 =.05, indicating that for the non-maltreating group, the PEP values for mothers who experienced low levels of maltreatment tended toward declination, whereas the PEP for mothers who experienced high levels of maltreatment showed an upward trend from block 3 to recovery. The direction of these reactivity patterns held when analyses were done only with unambiguous ICGs (i.e., indicated by the coders as straightforward to score; Riese et al., 2003). There were no overall (multivariate) or main (between-subjects) effects for episode, current maltreatment status, or experienced maltreatment (ps > .20).

HR. We found an overall (multivariate) effect of episode on HR, with HR increasing from baseline to the cry sounds, and decreasing from the cry sounds to recovery (ps < .01). Unexpectedly, there were no significant overall (between-subjects) main effects of current maltreatment status or experienced maltreatment or interaction (multivariate) effects with episode (ps > .11).

Vagal tone. For RMSSD, not in accordance with our expectations, we found no significant main (between-subjects) effect of current maltreatment status or experienced maltreatment, or overall interaction (multivariate) effects with episode (ps > .26).

Differences in Autonomic Measures Between NE, AN, and Non-Maltreating Mothers

There were no differences between NE, AN, and non-maltreating mothers in the baseline levels for any of the autonomic measures, controlling for smoking (ps > .25). For HR and SCL, there was an overall (multivariate) effect of episode, with HR and SCL increasing to the cry sounds and decreasing to recovery (ps < .03). There were no significant main (between-subjects) effects of current maltreatment status or experienced maltreatment or overall (multivariate) interaction effects with episode (ps > .13).

Table 1

Partial Correlations between HR and PEP, and HR and RMSSD for Maltreating (M) *and Non-maltreating* (N-m) *Mothers*

	HR baseline			HR block 3			HR recovery		
	M	N-m	*z*	M	N-m	*z*	M	N-m	*z*
PEP									
Baseline	.13	-.41*	2.39	.15	-.49**	2.89	.21	-.42*	2.78
Block 3	.17	-.48**	2.93	.18	-.53**	3.25	.23	-.48**	3.19
Recovery	.13	-.45**	2.59	.14	-.49**	2.85	.19	-.46**	2.91
RMSSD									
Baseline	-.50**	-.51**	ns.	-.46**	-.47**	ns.	-.47**	-.46**	ns.
Block 3	-.44**	-.45**	ns.	-.50**	-.46**	ns.	-.48**	-.44**	ns.
Recovery	-.34*	-.52**	ns.	-.32	-.51**	ns.	-.34*	-.56**	ns.

Note: M = maltreating; N-m = non-maltreating; HR = heart rate; PEP = pre-ejection period; RMSSD = root mean square of successive differences (measure for vagal tone). For HR – PEP correlations $N = 77$; for HR- RMSSD correlations $N = 80$. Correlations were controlled for smoking and maternal age. All reported Fisher's *z*s were significant, *p*s < .01.

* $p < .05$ ** $p < .01$

Table 2

Estimated Means and Standard Deviations on Autonomic Measures for Maltreating and Non-Maltreating Mothers Who Experienced High and Low Levels of Maltreatment

		Maltreating mothers			Non-maltreating mothers		
		Total (N = 42)	High (n = 24)	Low (n = 18)	Total (N = 38)	High (n = 13)	Low (n = 25)
SCL							
Baseline	M	4.52	4.86	4.19	4.20	4.42	3.98
	SD	2.43	2.20	2.76	2.16	2.57	1.96
Block 3	M	5.35	5.79	4.91	5.71	6.24	5.18
	SD	2.68	2.58	2.86	2.92	3.76	2.39
Recovery	M	4.86	5.30	4.42	5.07	5.35	4.80
	SD	2.46	2.51	2.44	2.52	3.20	2.15
PEP*							
Baseline	M	110.05	109.45	110.64	105.24	107.95	102.53
	SD	19.45	20.73	18.29	24.88	21.43	26.48
Block 3	M	108.67	108.74	108.61	106.89	109.91	103.86
	SD	19.95	21.36	18.60	23.27	20.85	24.27
Recovery	M	110.99	110.32	111.67	106.99	111.16	102.82
	SD	19.79	21.58	17.85	24.38	23.46	24.40

HR							
Baseline	M	76.18	76.06	76.29	72.54	70.31	74.78
	SD	10.51	10.16	11.13	10.13	7.86	11.05
Block 3	M	79.67	79.30	80.04	77.68	76.66	78.71
	SD	11.35	10.82	12.20	10.36	9.46	10.92
Recovery	M	73.78	73.56	74.01	71.72	70.47	72.98
	SD	10.11	9.84	10.68	8.9	8.82	9.13
RMSSD							
Baseline	M	35.79	34.61	36.96	33.33	36.61	30.06
	SD	22.39	22.07	23.30	17.25	22.62	13.85
Block 3	M	26.72	26.84	26.60	27.33	27.83	26.83
	SD	17.23	18.88	15.26	14.93	18.21	13.33
Recovery	M	35.43	32.45	38.42	31.15	32.67	29.63
	SD	20.93	20.62	21.22	14.97	18.40	13.20

Note: High = moderate / high scores on experienced maltreatment; low = minimal / low scores on experienced maltreatment; HR = heart rate; *M* = mean; PEP = pre-ejection period; RMSSD = root mean square of successive differences (measure for vagal tone); SCLs = skin conductance levels; SD = standard deviation.
Estimated means were controlled for maternal age and smoking.
* *N* was decreased for PEP analyses: 3 maltreating mothers (2 high on experienced maltreatment) had missing PEP data.

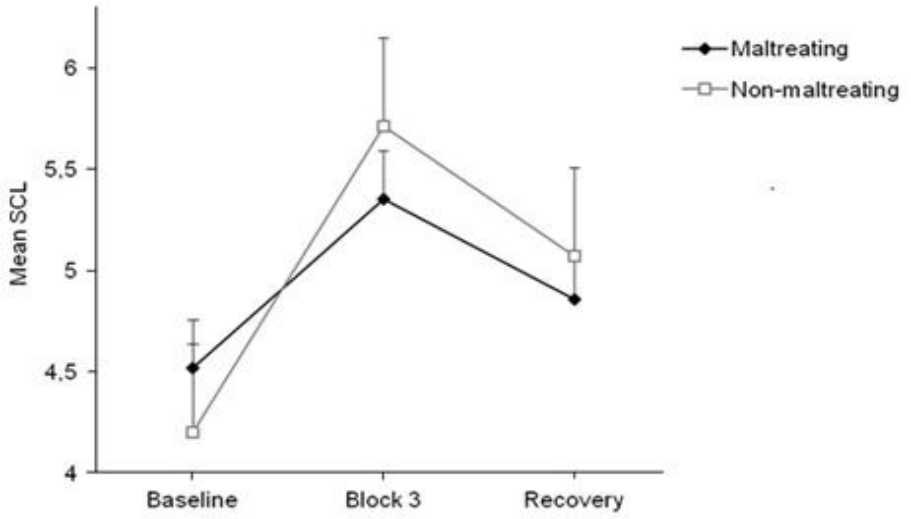

Figure 1. Responses of skin conductance levels (SCLs) to cry sounds for maltreating and non-maltreating mothers. *Note:* Baseline to Block 3: smaller increase in SCLs for maltreating mothers as compared to non-maltreating mothers (N = 80).

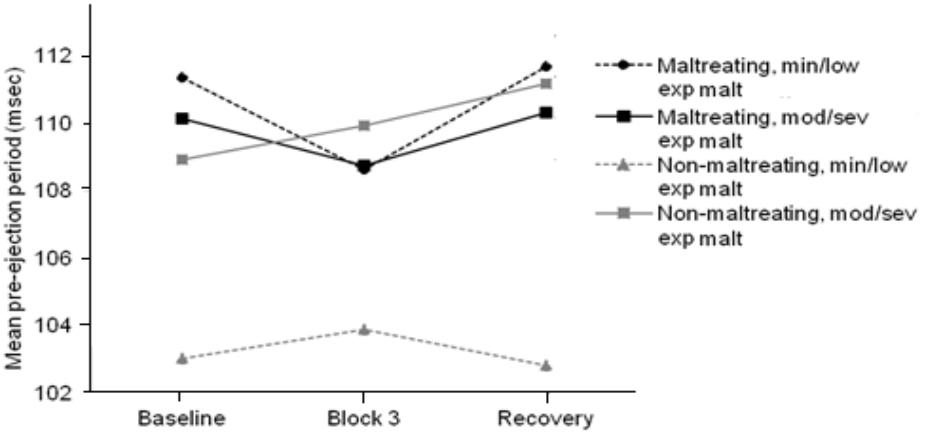

Figure 2. Pre-ejection period (PEP) responses to cry sounds in maltreating mothers moderated by experienced maltreatment. *Note:* Block 3 to recovery: decreasing PEP values for non-maltreating mothers who experienced low levels of maltreatment, as opposed to increasing PEP values for other subgroups (N = 77). Min/low = minimal/low; mod/sev = moderate/severe; exp malt = experienced maltreatment.

Summary of Main Findings

Maltreating mothers showed a significantly weaker SCL increase in response to the cry sounds than non-maltreating mothers. Furthermore, the decreasing trend of PEP for maltreating mothers in response to the cry sounds was significantly different from the increasing trend of PEP for non-maltreating mothers. During recovery, the increasing trend of PEP values for maltreating mothers was significantly different from the stable PEP of non-maltreating mothers. This effect was further qualified by an interaction with mothers' experienced maltreatment, such that for the non-maltreating group, PEP values for mothers low on experienced maltreatment tended to decline, whereas PEP for non-maltreating mothers high on experienced maltreatment tended to increase. This was different for maltreating mothers, for whom the PEP recovery did not vary according to the severity of experienced maltreatment. We found no differences in HR and vagal tone levels or reactivity patterns as a function of the current maltreatment status or the experienced maltreatment severity. Finally, nonsignificant positive correlations between HR and PEP in maltreating mothers differed significantly from moderate negative correlations between HR and PEP in non-maltreating mothers.

Discussion

Congruent with our hyporeactivity hypothesis, we found that maltreating mothers showed lower SCL reactivity to infant cry sounds than non-maltreating mothers, despite the fact that perceived urgency of the sounds was equal for both groups. Unexpectedly, our findings for PEP seemed to be in the opposite direction, but they were less pronounced. Even though the PEP reactivity patterns differed significantly between maltreating and non-maltreating mothers, for neither group did the PEP levels change in reaction to infant crying. PEP and SCL are both considered to be reliable measures of sympathetic activity (Goedhart, Willemsen, Houtveen, Boomsma, & De Geus, 2008), but SCL reacts quickly (see Lim et al., 1997), whereas sympathetic action on the heart (i.e., PEP) shows a long latency (Berntson, Cacioppo, & Quigley, 1993). Compared to PEP, SCL may therefore be a more appropriate measure of sympathetic reaction to stimuli of short duration (as our cry sounds were).

The hyporeactivity hypothesis was not supported by our findings for HR and vagal tone. For all mothers, HR increased as a response to infant crying, while vagal tone did not decrease significantly for either group.

The limited vagal tone reactivity in our study concurs with the previous findings in harsh and non-harsh mothers during the same cry paradigm (Joosen et al., 2013b). In another study, only highly sensitive mothers showed a pronounced withdrawal of vagal tone in reaction to the cry sounds (Joosen et al., 2013a). Considered together, these results may indicate that this particular reactivity pattern is specific to caregivers at the positive end of the sensitivity spectrum. Furthermore, the fact that there were no differences between maltreating and non-maltreating mothers in HR and vagal tone reactivity might reflect the extent to which the groups are comparable. Although they differed on several aspects (e.g., age and health-related issues, as discussed subsequently), children of both groups had at least one clinical diagnosis. This entails a minimum of family-related or caregiving challenges in the non-maltreating group as well, perhaps even rendering it as a high-risk control group.

Shorter PEP was associated with higher HR in non-maltreating mothers, but not in maltreating mothers, which suggests a lack of sympathetic cardiac boost in maltreating mothers. Low vagal tone was associated with high HR in both groups throughout the cry paradigm. For maltreating mothers, this lack of vagal cardiac control in combination with a lack of sympathetic cardiac control suggests the so-called *co-inhibition* of the PNS and SNS, which has been associated with externalizing problem behavior (El-Sheikh et al., 2009). In sum, although our findings are not unequivocal, the differences found between maltreating and non-maltreating mothers support the notion of sympathetic hypoactivity and reactivity as a risk factor contributing to child maltreatment.

The observed hyporeactivity to infant crying could be indicative of a dissociative coping strategy in maltreating mothers. A dissociative subtype of posttraumatic stress disorder has been distinguished from the reexperiencing/hyperaroused subtype and is marked by neurological overregulation of affect and arousal, accompanied by a lack of autonomic arousal in response to traumatic stimuli (Lanius et al., 2010). Based on the evidence of attenuated skin conductance responses in patients with derealization (a form of dissociation characterized by feelings of unreality or detachment), a neurobiological model of autonomic dampening was proposed (Sierra & Berrios, 1998). It conveyed that once a certain level of anxiety is reached, the medial prefrontal cortex inhibits emotional processing on the amygdala, resulting in attenuated sympathetic output and reduced emotional experience of stimuli. On a subclinical level, maltreating mothers may

similarly disengage from the emotional content of infant cry sounds. Future studies could include functional magnetic resonance imaging as a method to test this possibility.

Contrary to our expectations, we did not find evidence for hyperreactivity in the subgroup of maltreating mothers who were AN. This might be because of insufficient statistical power due to smaller subgroup sizes. Another explanation could be that all maltreating mothers in our sample neglected their children, so that a clear-cut distinction based on the type of maltreatment was impossible. Future research would benefit from an operationalized distinction between emotional and physical abuse and neglect to see whether different patterns of dysfunctional autonomic reactivity are associated with different types of child maltreatment. As evident from our study, a complication may be that different types of maltreatment rarely occur in isolation (e.g., Manly, Cicchetti, & Barnett, 1994). Large sample sizes may facilitate the comparison of differential risk factors as related to subtypes of maltreatment, both separately and in co-occurrence.

However, another possibility is that sympathetic hyporeactivity marks both child abuse and neglect and reflects a certain inherent similarity between the two groups. Less affection, play behavior, and initiative to interact with their children was observed in both abusive and neglectful mothers compared to non-maltreating mothers at home (Bousha & Twentyman, 1984). More recently, no differences between abusive and neglectful mothers were found in their (limited) display of positive parenting and strict or hostile control toward their children during a challenge task, and both groups showed affective inconsistency (Skowron, Cipriano-Essel, Benjamin, Pincus, & Van Ryzin, 2013). The cry sounds we presented mothers with were mild child-related stressors of an intensity that mothers are likely to encounter on a daily basis. It is possible that abusive and neglectful mothers show limited responsiveness to children's quotidian signals on a physiological, affective, and behavioral level. Their behavioral (and possibly psychophysiological) coping strategies might diverge when presented with more severe educational challenges. Indeed, the risk of abuse has been known to increase during infant crying that is deemed excessive in duration (Reijneveld, Van der Wal, Brugman, Hira Sing, & Verloove-Vanhorick, 2004). Studies that include childrelated stimuli of an increasingly enduring and stressful nature as well as home observations of a wide range of natural scenarios are needed to enhance our understanding of this issue.

Finally, the severity of maltreatment experienced by mothers in their own childhood only moderated the relationship between current maltreatment status and PEP reactivity. PEP reactivity was not different for maltreating mothers who experienced low or high levels of maltreatment. However, for nonmaltreating mothers PEP recovery patterns differed according to maltreatment experiences, that is, those with more maltreatment experiences showed an increasing trend similar to that of maltreating mothers, while those with few or no childhood maltreatment experiences showed a declining trend. Since we would expect to see the most adaptive physiological pattern in non-maltreating mothers with minimal childhood maltreatment experiences, a possible inference might be that the recovery pattern of PEP in the other three groups is maladaptive. For the non-maltreating group, having experienced substantial maltreatment as a child appears to put their PEP recovery pattern together with that of maltreating mothers. However, as mentioned earlier, PEP reaction patterns were not pronounced and these results should therefore be interpreted with caution.

It is important to note that maltreating mothers were younger than non-maltreating mothers, and more maltreating mothers had smoked on the day of the research appointment (despite our request not to do so), while fewer had exercised the previous week. This seems in itself a meaningful profile. It is consistent with the finding that low parental age is modestly associated with risk for maltreatment (Stith et al., 2009). Smoking and lack of exercise are coping behaviors observed in people with early life trauma, such as experiences of child abuse and neglect (Kibler, 2013). We controlled for the potentially confounding influence of smoking and maternal age by including them as covariates in the analyses. In other important aspects maltreating and non-maltreating mothers were similar, such as the fact that children of both groups had at least one clinical diagnosis. This reduces the probability that observed differences stemmed from mothers' experiences with their own children and suggests a link to differences in caregiving.

Limitations of our study include the generalizability of the results. We presented short, standardized cry sounds in an experimental setting (albeit an environment familiar to the participants). Although child signals of a longer duration might have evoked stronger physiological effects, the length of the cry bouts we used rendered them comparable to infant crying on an everyday level. Furthermore, we compensated for their shortness by looking at the cumulative effect of repeated crying on physiological reactivity. Standardization enhances the comparability of results among studies, but it is unknown to what extent the results can

be generalized to mothers' natural caregiving context. As indicated, studies using observational methods in parents' natural surroundings are needed. Finally, our sample was homogeneous in various aspects, such as gender and ethnicity. Studies including heterogeneous samples need to be done to see to what extent these findings apply to different populations.

Effect sizes were small, similar to those found in other studies on physiological reactivity using the same cry paradigm (Joosen et al., 2013a, 2013b). This is not surprising, given that sympathetic hyporeactivity is one risk factor in a complex constellation of interacting risk factors (Cicchetti & Lynch, 1993). However, the suggestion that in common caregiving situations, maltreating mothers might be primarily disengaged from their children is useful for the focus of potentially effective intervention programs. Maternal unresponsiveness to infant signals and interactional withdrawal were found to predict infant disorganization of attachment (Lyons-Ruth, Bronfman, & Parsons, 1999), which is a risk factor for clinical problems later in life (particularly dissociative disorder; Dozier, Stovall-McClough, & Albus, 2008). A meta-analysis has shown that interventions that focus on increasing maternal sensitivity appear to be most effective in reversing disorganized attachment classifications (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2005). This focus may be adequate for maltreating, disengaged mothers as well, not in the least by redirecting mothers' attention toward the child and making them continually aware of their child's signals (Bakermans-Kranenburg et al., 2005). Interestingly, it has been suggested that positive parenting might be taxing for abusive mothers, since they displayed low RSA levels during relatively positive parenting behaviors, which were then followed by an episode of strict control (Skowron et al., 2013). Intervention programs would therefore do well to include parental self-esteem and satisfaction as outcome measures to see whether interactional improvement between mother and child also changes mothers' intrinsic experience of parenting.

CHAPTER 3

SALIVARY ALPHA-AMYLASE REACTIVITY TO INFANT CRYING IN MALTREATING MOTHERS

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Abstract

Deviant physiological reactivity to infant stimuli has been suggested to underlie maladaptive parenting behavior. Our study involved 44 maltreating and 42 non-maltreating mothers. During a standardized cry paradigm, mothers listened to nine cry sounds of varying pitches. Saliva was collected at baseline, after each cry sound, and after a recovery episode. Salivary α-amylase (sAA) as a marker of autonomic nervous system (ANS) activity was assayed from saliva samples. Maltreating mothers showed lower overall sAA levels and an attenuated reactivity pattern to infant crying as compared to non-maltreating mothers. No effect of type of maltreatment (neglect only vs. neglect and abuse) was found. Furthermore, positive correlations between sAA and heart rate (HR) for nonmaltreating mothers differed significantly from non-significant correlations between sAA and HR for maltreating mothers. This suggests anomalous asynchrony between different aspects of the ANS in maltreating mothers. Results indicate a lack of functional autonomic (re)activity as a contributing risk factor to child maltreatment.

Keywords: Child maltreatment Salivary α-amylase Autonomic reactivity Infant crying

Introduction

The detrimental consequences for victims of child abuse and neglect are long-term and wide-ranging (Alink, Cicchetti, Kim, & Rogosch, 2012; Cicchetti & Toth, 2005; Spinhoven et al., 2010). The need for effective prevention and intervention programs urges extensive research on risk factors for child maltreatment, but the complex etiology of child maltreatment is challenging: Risk factors include various parent and child characteristics which dynamically interact with each other (Cicchetti & Valentino, 2006). Most studies have focused on (and found) parent characteristics as risk factors for child maltreatment, such as psychopathology and personal stress (Stith et al., 2009), and there is some evidence for different stress-reactivity to child signals in maltreating parents (McCanne & Hagstrom, 1996). However, most research has focused on physical maltreatment, or milder parenting problems, and severe neglect has often not been taken into account. This study aims to evaluate stress-reactivity to child signals in maltreating mothers who all had severely neglected their children, using salivary α-amylase (sAA) as a novel marker of physiological responsiveness.

A universally prevalent child behavior known to evoke differential responses from parents is infant crying (Soltis, 2004). Through crying infants communicate their distress and effectuate parental proximity and nurturance (LaGasse, Neal, & Lester, 2005), though some parents may perceive infant cries as aversive and respond harshly rather than provide the required care (Out, Pieper, Bakermans-Kranenburg, Zeskind, & Van IJzendoorn, 2010). Parents' harsh attempts to stop their infants from crying has been related to whether they judged the crying excessive, but not to the actual crying duration (Reijneveld, Van der Wal, Brugman, Hira Sing, & Verloove-Vanhorick, 2004). Neglectful parents may fail to respond at all (Crittenden, 1993).

Autonomic reactivity may be an underlying factor contributing to parents' differential responses to infant crying. Through the autonomic nervous system (ANS; part of the peripheral nervous system) the brain regulates the internal organs. The sympathetic and the parasympathetic systems (SNS and PNS, respectively) are the two main components that comprise the ANS (Larsen, Schneiderman, & DeCarlo, 1986). Stress typically activates the sympathetic division in order to procure bodily energy mobilization required for a behavioral response. Inversely, the parasympathetic system, which is involved in saving and recovering energy during rest, is inhibited during stress (Viamontes & Nemeroff, 2009). This results, for instance, in accelerated breathing, increased heart

rate (HR), and heightened skin conductance (SCL; electrodermal activity of the skin, a SNS measure). Additional to the comparison of normative and deviant reactivity patterns, differences in within-individual coherence of autonomic arousal may also point to anomalous disconnections between ANS indicators (El-Sheikh et al., 2009). For instance, correlations between HR and pre-ejection period (PEP; a measure of sympathetic cardiac control) were found to differ significantly in maltreating mothers versus non-maltreating mothers (Reijman et al., 2014), suggesting that in maltreating mothers, PEP may not serve its expected function of sympathetic cardiac boost.

A relatively recently discovered measure of ANS (re)activity is sAA. It is an important salivary enzyme whose main function involves the initiation of the digestion of macromolecules, such as carbohydrates and starch, in the oral cavity (Granger, Kivlighan, El-Sheikh, Gordis, & Stroud, 2007; Nater & Rohleder, 2009). It is produced locally by the salivary glands, which are innervated by sympathetic and parasympathetic nerves stimulating its secretion into saliva (Nater & Rohleder, 2009; Baum, 1993). The focus on sAA as a biomarker of stress initiated when positive correlations were found between sAA and norepinephrine, a hormone of the sympathetic branch of the ANS (Chatterton, Vogelsong, Lu, Ellman, & Hudgens, 1996). Since then, studies have reported sAA response patterns similar to sympathetic response patterns during physical exercise and psychological stress (showing an increase in response to presentation of the stressor, and a recovery afterwards), as well as correlations between sAA and other sympathetic measures (Takai et al., 2004; El-Sheikh, Erath, Buckhalt, Granger, & Mize, 2008; see Nater & Rohleder, 2009, for an overview). However, sAA has also been shown to be indicative of parasympathetic activity, as well as combined sympathetic and parasympathetic activity (e.g., Bosch, De Geus, Veerman, Hoogstraten, & Nieuw Amerongen, 2003). This is congruent with the fact that the salivary glands are innervated by both sympathetic and parasympathetic nerves. The glands differ from one another in the extent of their sympathetic and parasympathetic innervation, as well as the amount of sAA they produce (Bosch, Veerman, De Geus, & Proctor, 2011). sAA can thus be used as a general measure of ANS (re)activity.

It has been suggested that infant crying leads to autonomic arousal in the caregiver, which consequently triggers caregiving behavior (Zeskind, Sale, Maio, Huntington, & Weiseman, 1985). Autonomic contagion (the sharing of autonomic arousal) in mother–child dyads has indeed been found (Ebisch et al., 2012). Maladaptive parenting responses might then

partly stem from deviant ANS arousal. In accordance with this principle, McCanne and Hagstrom (1996) concluded from a series of early studies that harsh or abusive caregiving responses appeared to be associated with autonomic *hyper*reactivity. However, as acknowledged in the review, inconsistency of findings among and within studies was notable. Recent studies have shown mixed findings as well. Congruent with the hyperreactivity hypothesis, increased SCL responsiveness to infant cry sounds predicted the use of harsh discipline during mother–child challenge tasks 9 months later (Joosen, Mesman, Bakermans-Kranenburg, & Van IJzendoorn, 2013b). However, HR *hypo*reactivity has also been related to less sensitive caregiving, while increased HR reactivity was observed in more sensitive mothers (Joosen et al., 2013a). This might be indicative of autonomic hypoarousal in relation to less adequate caregiving. Finally, mothers who showed autonomic hyperarousal during the Strange Situation (an experimental procedure to assess the quality of the attachment relationship between the child and the caregiver, in which they are separated and reunited in order to activate the child's attachment system through moderate stress) displayed more harsh/hostile caregiving during a dyadic free-play session, while maternal hypoarousal was related to observed disengaged parenting behavior (Sturge-Apple, Skibo, Rogosch, Ignjatovic, & Heinzelman, 2011). These findings could be suggestive of distinct ANS reactivity associated with child abuse and neglect: ANS hyperreactivity may be related to child abuse, while hyporeactivity may underlie neglect. However, the number of studies addressing severe neglect is small and abuse and neglect often co-occur (Euser et al., 2013), so underlying mechanisms may not be independent.

Studies on parenting, and especially child maltreatment, that include sAA as an autonomic measure are scarce. Congruent with the hyperreactivity hypothesis, increased sAA responsiveness to infant crying was associated with intended harsh caregiving responses in a sample of adult twin pairs, including parents and non-parents (Out, Bakermans-Kranenburg, Van Pelt, & Van IJzendoorn, 2012). Another study looked at sAA reactivity to a conflict discussion between family members, at least one of which (mother, father, or the adolescent child) had reported the occurrence of interparental physical aggression during the previous year (Gordis, Margolin, Spies, Susman, & Granger, 2010). In families with interparental physical aggression, fathers showed lower absolute sAA levels throughout the experiment, as well as attenuated sAA reactivity to the conflict discussion, and during recovery. Notably, in at least half of these families interparental physical aggression had

been witnessed by the adolescent child, which is considered a form of child emotional neglect (e.g., Barnett, Manly, & Cicchetti, 1993; Euser et al., 2013; Sedlak et al., 2010). There was no effect of interparental aggression on mothers' sAA levels. These studies, too, support the possibility of hyper- and hyporeactivity underlying harsh or abusive versus neglectful parenting, respectively.

An explanation for seemingly inconsistent findings may be that studies have focused on varied ranges of caregiving quality, used different stimuli, and included varying measures of ANS activity. This exposes the need for systematic substantiation and classification of child maltreatment, and standardized experimental tasks. Furthermore, there are several potentially confounding factors that should be taken into consideration in research on physiological arousal related to child maltreatment. For example, experiences of maltreatment in parents' own youth affects current dysfunctional parenting (Newcomb & Locke, 2001; Pears & Capaldi, 2001) as well as subsequent psychobiological development (e.g., Gordis, Feres, Olezeski, Rabkin, & Trickett, 2010). Associated with both childhood maltreatment experiences (Spinhoven et al., 2010) and child maltreatment perpetration (Stith et al., 2009), depression has also been characterized by dysregulated (mainly increased) ANS (re)activity (see Carney, Freedland, & Veith, 2005, for an overview).

In the current study we aim to evaluate whether maltreating mothers differ from non-maltreating mothers in their autonomic reactivity to infant crying. ANS activity was measured with sAA, a non-invasive and relatively novel biomarker. Following methodological guidelines suggested by McCanne and Hagstrom (1996) we used a standardized cry paradigm to make results among studies more comparable. For the maltreating group, maltreatment was substantiated. In an explorative way, we distinguished between neglectful and additionally abusive mothers to evaluate whether differential reactivity was related to these subtypes of maltreatment. In accordance with previous studies, we tentatively expected hyporeactivity in neglectful mothers, and hyperreactivity for additionally abusive mothers, as compared to non-maltreating mothers. We considered mothers' own childhood maltreatment experiences and current depression tendencies to control for their possible effect on sAA reactivity to infant crying.

Method

Participants

We recruited 45 maltreating and 45 non-maltreating mothers at a mental health clinic. Mothers in the maltreating group received therapy that revolved around their parenting problems and were informed about the study by their therapists at the beginning of their treatment. We coded Child Protective Services (CPS) records to substantiate recent or ongoing maltreatment using the Maltreatment Classification System (MCS; Barnett et al., 1993). When records were inconclusive, we interviewed the mother's psychiatrist about her parenting problems using a semi-standardized interview. For three mothers, neither their records nor their psychiatrists provided proof of maternal maltreatment. In these cases, we conducted a Dutch adaptation of the Maternal Maltreatment Classification Interview (MMCI; Cicchetti, Toth, & Manly, 2003) with which absence of maltreatment was verified for two mothers. We considered them as non-maltreating in the analyses. One mother could not be reached for a follow-up MMCI and was excluded from analyses because of her inconclusive current maltreatment status.

Non-maltreating mothers were recruited in a clinical subdivision of the facility, where their child was in therapy for developmental or learning problems. To verify absence of maltreatment, the MMCI (Cicchetti et al., 2003) was used. For three mothers, incidents of sufficient severity to classify as maltreatment were coded from the interview. These mothers were counted as maltreating in the analyses. All currently maltreating mothers in our sample were in contact with CPS or were in therapy.

Three participants (3 %) had insufficient specimen volumes for sAA measures and were also excluded from analyses. The final sample consisted of 44 maltreating mothers and 42 non-maltreating mothers. Twenty-one maltreating mothers were neglectful only (henceforth abbreviated as NE) while 23 maltreating mothers were abusive *and* neglectful (AN).

Procedure

The study and its proceedings were approved by the Medical Ethics Review Committee for Mental Health Care (METiGG). All mothers gave informed consent for participation and, in the maltreating group, for researchers' access to the family files. As a compensation for participation, mothers received 40 Euros as well as travelling expenses.

Two individual appointments took place at the mental health facility. During the first session, mothers completed three computer tasks, of which the cry paradigm (Zeskind & Shingler, 1991) reported here was the first. sAA measures were collected during the task. Afterwards, mothers completed a questionnaire on health-related issues, such as smoking and exercising prior to the session, and on their family situation, including educational level, number of children, and children's ages. We administered the MMCI to the non-maltreating group. They took the Adult Self-Report (ASR; Achenback & Rescorla, 2003) home and were asked to bring it filled out to the second appointment. During the second session the Adult Attachment Interview (George, Kaplan, & Main, 1985) was conducted (data will be presented elsewhere). At the end of that visit mothers completed the short form of the Childhood Trauma Questionnaire (CTQ; Bernstein & Fink, 1998; Bernstein et al., 1994).

Measures

Maltreatment Classification System (MCS). We used the MCS (Barnett et al., 1993), a reliable and valid system to code incidents of maltreatment reported in the clinic's records from CPS and the child care office (Cicchetti, Rogosch, Gunnar, & Toth, 2010). Only incidents of *maternal* maltreatment were considered. According to the MCS, physical abuse is coded 'when a caregiver … inflicts physical injury upon a child by other than accidental means', including hitting or kicking, violent handling (e.g., shoving, dragging), smothering, burning, shaking, or other, nondescript abuse. Physical neglect encompasses the failure to provide adequate food, clothing, shelter, health care, or hygiene, and a lack of adequate supervision that ensures the child's safety. Emotional maltreatment involves 'persistent or extreme thwarting of children's basic emotional needs' and 'parental acts that are harmful because they are insensitive to the child's developmental level'. We further distinguished between incidents of emotional maltreatment directed *at* the child (emotional *abuse*, e.g., belittling the child, or calling the child derogatory names) and incidents demonstrative of inattentiveness rather than rejection (emotional *neglect*, e.g., expecting an inappropriate level of responsibility from the child, exposing the child to interparental violence). In accordance with these operational definitions, we coded abuse (physical and/or emotional) and neglect (physical and/or emotional). No mother was found to have sexually abused any of her children. Coding was done by trained research assistants. Inter-rater reliability on 15 files was excellent, with $\kappa = .82$ for abuse and $\kappa = 1.00$ for

neglect. For the presence versus absence of maltreatment there was full agreement (κ = 1.00). Subsequently, all records were coded by two different research assistants and discrepancies were resolved through discussion. We found that all mothers in the maltreatment group had been neglectful towards their children, either physically or emotionally. 52 % (*n* = 23) of the maltreating mothers had also abused their child(ren) physically or emotionally.

Maternal Maltreatment Classification Interview (MMCI). The MMCI (Cicchetti et al., 2003) is a semi-structured interview that evaluates whether the mother has maltreated any of her children recently or during their lifetime. Mothers are asked about incidents of physical and emotional abuse and neglect, as well as sexual abuse, and about any contact the family may have had with CPS. We translated the interview into Dutch for this study. Coding was done by trained research assistants. We used the operationalized definitions of emotional and physical neglect and abuse from the MCS (Barnett et al., 1993; for details see above]. Inter-rater reliability on 12 interviews was excellent, with full agreement for the presence versus absence of maltreatment (κ = 1.00). All interviews were coded by two research assistants and discrepancies were resolved through discussion.

Cry Paradigm. The cry paradigm was presented on a laptop with E-prime software. A 6-min baseline of neutral images was followed by three blocks with three cry sounds each (for details on the sounds' derivation, see Out et al., 2010). Within each of the blocks, sounds differed in fundamental frequency, congruent with the idea of infant crying as a graded signal of varying acoustic properties that communicate the cause's urgency (Gustafson, Wood, & Green, 2000). In each block, the three cries, of 500, 700, and 900 Hz, were presented in a random order. All sounds lasted 10 s, containing seven cry expirations, and were presented through Sennheiser HD202 headphones at a constant volume. The paradigm ended with another 4-min baseline of neutral images.

As a manipulation check, we tested whether the perception of the cry sounds differed for sounds with different fundamental frequencies. After each cry sound, mothers were presented with four questions on the extent to which they perceived the sound as urgent and aversive, the child as sick, and themselves as aroused (Out et al., 2012; Zeskind & Lester, 1978; Zeskind & Marshall, 1988). They answered on a 5-point scale, ranging from *very little* to *very much*. Each fundamental frequency was presented three times, resulting in 12 ratings per pitch. Following Out et al. (2010), who found one component underlying these twelve

ratings, averages were aggregated to form the overall perceived urgency. Cronbach's alphas ranged from .88 to .89. As expected, there was an overall main effect of pitch (p < .001), with a significant increase in perceived urgency from 500 to 700 Hz, from 500 to 900 Hz, and from 700 to 900 Hz (ps < .001). There was no main effect of current maltreatment status, nor an interaction effect of current maltreatment status with pitch (ps > .54).

To get acquainted with the cry sounds and the questions, participants practiced with one cry sound of 500 Hz. The cry paradigm has been used in previous studies with childless adults and parents and has been shown to evoke physiological stress responses, harsh caregiving intentions, and emotional irritation (Joosen et al., 2013b; Out et al., 2010; Riem, Bakermans-Kranenburg, Van IJzendoorn, Out, & Rombouts, 2012).

Salivary α-Amylase (sAA). After each pair of baseline images, each cry sound (save the practice trial), and at the end of the four recovery images, mothers were handed a salivette (Salimetrics Oral Swab). They were instructed to place it transversely under their tongue and keep it still for 90 s. E-prime was programmed to clock this interval, after which the experimenter sealed the salivette in a small tube. This led to a total of 13 sAA samples per participant. Samples were immediately stored frozen at -20 °C at the facility and transported regularly on dry ice to the university, where they were stored at -80 °C.

After overnight thawing of the saliva at 4 °C, samples were centrifuged during 5 min at 2,773 g to remove debris, particles, and buccal cells. Saliva supernatants were then diluted 100-fold in physiological saline solution (Versylene1Fresenius Kabi, Zeist, the Netherlands; cat no. B230551) and mixed. Levels of sAA were measured in singlet, using a commercially available enzymatic colorimetric assay (cat no. 03183742; Roche Diagnostics, Mannheim, Germany). The amylase test kit consists of 4,6-ethylidene(G7)-1[4-nitrophenyl(G1)]-1,4-[alpha]-D-maltoheptaoside (EPS-G7) substrate and bacterial alphaglucosidase ([alpha]-D-glucoside glucohydrolase; EC3.2.1.20). sAA degrades the EPS-G7 substrate to reaction products. Alpha-glucosidase degrades uniformly all reaction products to 4-nitrophenol and glucose in the indicator reaction. The color intensity of the 4-nitrophenol formed in the indicator reaction is directly proportional to α-amylase activity. The test was applied on Integra 800 analyzer from Roche Diagnostics (Mannheim, Germany), according to the instructions of the manufacturer. CFAS (Calibrator For Automated Systems, cat no. 10759350) was used for calibration. The Roche routine amylase assay is standardized to the IFCC reference measurement procedure (Lorentz,

1999), guaranteeing worldwide comparability of the data. sAA activities were measured in IU/L at 37 °C and expressed in U/ml in the current report. Within-run imprecision for the control pool ranged from 0.7 to 2.7 % for the combined predilution step and the analysis across the entire study period. Between-run analytical imprecision was lower than 5 % throughout this study. Accuracy of the amylase activity procedure was guaranteed by regular participation in the Dutch External Quality Assessment Scheme (SKML, the Netherlands).

Outlying values on sAA measurements were found for six participants. Winsorizing is a commonly used procedure, also in studies on sAA (e.g., in Allwood, Handwerger, Kivlighan, Granger, & Stroud, 2011; De Veld, Riksen-Walraven, & De Weerth, 2012), to adjust outlying values without excluding them, thus doing more justice to the data of the complete sample. We used the winsorizing procedure following Tabachnik and Fidell (2001): Outliers were replaced with a value of .10 just above the highest *non*-outlying score (using standardized scores of -3.29 and 3.29 as cut-off). For the next more extreme outlier .10 was added to the preceding value, preserving the original order of scores. We also checked whether this procedure did not affect participants' original *individual* response patterns. When necessary, outlying values were adjusted taking into account the participant's original response pattern. Excluding the six participants with outlying values from the analyses did not affect the results, so we decided to report the results with these participants included. For 15 participants for whom at least 50 % of the values were present, missing values were imputed using curve fitting, by estimation of a quadratic curve. Next, mean sAA was calculated per *episode* (baseline; block 1, 2, 3 of cry sounds; recovery) in SPSS. Within the combined episodes, we found outliers for four more participants, which were winsorized following the same procedure. Finally, a square root transformation was applied to the combined episodes to correct for a positively skewed distribution. The transformed values showed no further outliers.

Childhood Trauma Questionnaire Short Form (CTQ-SF). The CTQ-short form (CTQ-SF; Bernstein & Fink, 1998; Bernstein et al., 1994; Thombs, Bernstein, Lobbestael, & Arntz, 2009) is a self-report instrument that consists of 27 items (24 clinical items and 3 validity items) with which childhood experiences of abuse and neglect are retrospectively assessed. It has shown measurement invariance across four different populations (clinical and normal; Bernstein et al., 2003), and contains five subscales: physical abuse (α = .88), emotional abuse (α = .89), physical neglect (α = .70), emotional neglect (α = .89), and sexual abuse (α = .93).

Each scale consists of five items with a 5-point scale ranging from *never true* to *very often true*. Two mothers (2 %) had missing data on the CTQ. These were imputed with the average of mothers with the same current maltreatment status.

Adult Self-Report (ASR). The ASR (Achenbach & Rescorla, 2003) is a measure of psychopathological symptoms in adults aged between 18 and 59 years. The total scale consists of several subscales, including anxious/depressed symptoms, aggressive behavior, and somatic complaints. We used a shortened version (77 items) of the ASR, and focused on the anxious/depressed subscale (18 items; $\alpha = .93$ in the current sample). Items were presented as statements referring to emotions, cognitions, and behaviors and participants rated how applicable the statement had been to them during the last 6 months, ranging from 0 (*not at all*) to 2 (*clearly or often*). For nine mothers (10 %) data on the anxiety/depression subscale were missing. These were imputed with the average of mothers with the same maltreatment status.

Heart Rate (HR), Respiratory Sinus Arrhythmia (RSA), Pre-ejection Period (PEP), and Skin Conductance Level (SCL). Throughout the cry paradigm electrocardiogram (ECG), impedance cardiogram (ICG), and SCL were measured using an ambulatory monitoring system (VU-AMS5 fs; TD-FPP, Vrije Universiteit, Amsterdam, the Netherlands). Average HR, RSA, PEP, and SCL were calculated per episode. HR, like sAA, is an autonomic measure that may reflect both underlying sympathetic and parasympathic activity. PEP and SCL are markers of the SNS, while RSA reflects underlying PNS activity. Their correlation with sAA was examined to test for any disconnection within the autonomic system in maltreating mothers.

Data Analysis

We tested whether the four mothers excluded from analyses differed from the mothers included in our final sample ($N = 86$) in terms of ethnicity, educational level, child clinical diagnosis, childhood maltreatment experienced, anxious/depressed symptoms, maternal age and child age, and number of children. Next, we compared maltreating (NE and AN together as well as separately) and non-maltreating mothers on these variables. Additionally, we checked whether maltreating and non-maltreating mothers differed on hearing problems, exercise, smoking, and substance (ab)use. We examined the associations between sAA levels and all background variables. Controlling for maternal age (which correlated with sAA levels during blocks 1 and 3; see below), we computed partial correlation coefficients to see whether correlations

between sAA and other autonomic measures differed significantly for maltreating and non-maltreating mothers. Correlations between cardiovascular/electrodermal measures and sAA within corresponding episodes (e.g., HR baseline with sAA baseline) were examined, as well as between cardiovascular/electrodermal levels of each episode with the *following* sAA episode (e.g., HR baseline with sAA block 1), because sAA responses are slower than those of the cardiovascular/electrodermal measures.

As for the primary hypothesis, to evaluate the association between current maltreatment status and autonomic reactivity to cry sounds, we performed repeated measures ANCOVAs. Current maltreatment status (maltreating vs. non-maltreating) was entered as between-subjects factor. The five *episodes* (baseline, block 1, 2, 3, and recovery) were entered as within-subjects factor. None of the background variables on which maltreating and non-maltreating mothers differed were related to baseline levels of sAA. However, since they might moderate the sAA *response pattern*, they were initially entered as covariates in the repeated measures ANCOVAs. Number of days mothers had been in therapy before participation (with a 0 assigned to non-maltreating mothers), and the time of the first sAA measurement were also entered as covariates. Leaving the non-significant covariates out, childhood maltreatment experiences, anxious/depressed symptoms, maternal age, smoking, and number of days in therapy were included as covariates in the final analyses. With a more exploratory aim, we repeated the analyses with three levels of current maltreatment status (NE, AN, and non-maltreating) as between-subjects factor.

Results

Preliminary Results

Excluded mothers (n = 4) were less anxious/depressed than mothers included in the sample (N = 86), on average had more children, and fewer excluded than included mothers were of Caucasian ethnicity (ps < .02). Excluded and included mothers were similar on childhood maltreatment experiences (total CTQ scale), educational level, maternal age, children's mean age, and whether children had a clinical diagnosis (ps > .27). Table 1 displays characteristics of maltreating mothers and non-maltreating mothers. Maltreating mothers (both NE and AN) had more childhood maltreatment experiences (total CTQ scale) than non-maltreating mothers [t (72.98) = -2.85, p = .01] and were more anxious/depressed, t (76.80) = -2.90, p = .01. Somewhat more maltreating

mothers (both NE and AN) had a lower educational level, χ^2 (3, N = 84) = 7.90, p = .048. Mothers and their children in the maltreating group were significantly younger than their counterparts in the non-maltreating group, t(78.28) = 4.58, p < .001 and t(84) = 4.31, p < .001, respectively. There were no differences between NE and AN mothers (ps > .39). Since maternal age and children's average age were highly correlated (r = .80), only maternal age was included as a potential covariate in further analyses. Maternal age was not correlated with sAA baseline (p = .18). The two groups did not differ on ethnicity, number of children or whether their children had a clinical diagnosis (ps > .16).

Furthermore, fewer maltreating mothers than non-maltreating mothers had exercised in the week prior to the research appointment, χ^2 (1, N = 84) = 8.60, p = .003; specifically, fewer NE mothers had exercised compared to non-maltreating mothers, χ^2 (1, N = 61) = 9.44, p = .002. More maltreating mothers than non-maltreating mothers had smoked on the morning of the research appointment, χ^2 (1, N = 84) = 8.77, p = .003; specifically more AN mothers than non-maltreating mothers had smoked, χ^2 (1, N = 64) = 10.27, p = .001. The two groups were similar on hearing problems and substance (ab)use (ps ≥ .10). None of the variables on which maltreating and non-maltreating mothers differed (i.e., educational level, maternal age, CTQ sum score, ASR depression scores, exercise, and smoking) were related to sAA baseline levels (ps > .14). Maternal age correlated positively with sAA during blocks 1 and 3 (ps < .05).

Correlations Between Autonomic Measures

Partial correlations between HR baseline and sAA block 1, HR block 1 and sAA block 1, HR block 1 and sAA block 2, and HR block 2 and sAA block 2 differed significantly for maltreating and non-maltreating mothers (ps < .05; Table 2). For non-maltreating mothers, all correlations between HR and sAA were positive, and those between HR baseline and sAA block 1, as well as HR block 1 and sAA block 1 were significant (p < .05). For maltreating mothers, the correlations between HR and sAA were non-significant in the negative direction. For RSA, PEP, or SCL correlations with sAA did not differ between maltreating and non-maltreating mothers (ps > .05).

Differences in sAA for Maltreating and Nonmaltreating Mothers

There was a main effect of current maltreatment status, F(1, 79) = 8.13, p = .01, partial η^2 = .09, with maltreating mothers showing lower sAA levels than non-maltreating mothers (Fig. 1). Furthermore, we found an

overall (multivariate) interaction effect of current maltreatment status with episode, $F(4, 76) = 3.39$, $p = .01$, partial $\eta^2 = .15$. Contrast analyses showed that maltreating mothers' stable sAA levels differed from non-maltreating mothers' sAA increase from baseline to block 1, $F(1, 79) = 5.63$, $p = .02$, partial $\eta^2 = .06$. Furthermore, maltreating mothers' stable sAA levels differed from non-maltreating mothers' decreasing sAA from block 1 to recovery, block 2 to recovery, and block 3 to recovery [F (1, 79) = 11.49, $p = .001$, partial $\eta^2 = .13$; F (1, 79) = 5.23, $p = .03$, partial $\eta^2 = .06$; F (1, 79) = 4.45, $p = .04$, partial $\eta^2 = .05$, respectively; see Fig. 1].

Differences in sAA Between NE, AN and Nonmaltreating Mothers

We found a main effect of current maltreatment status, $F(2, 78) = 4.30$, $p = .02$, partial $\eta^2 = .10$, with NE and AN mothers showing overall lower sAA levels than non-maltreating mothers. There were no differences between NE and AN mothers in overall sAA levels or reactivity patterns (ps > .14).

Table 1
Sample Characteristics for Maltreating, Neglectful, Abusive, and Non-maltreating Mothers

	Maltreating (total group) $N = 44$	Neglectful Only $n = 21$	Abusive and Neglectful $n = 23$	Non-maltreating $N = 42$
Ethnicity (%)				
Caucasian	93	91	96	93
Completed education (%)				
None	2.3	5.0	0.0	0.0
Elementary/short track secondary	44.2 [a]	45.0	43.5	22.0 [b]
Secondary/vocational	44.2	40.0	47.8	51.2
College/university	9.3 [a]	10.0	8.7	26.8 [b]
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Childhood malt exp	48.28 (21.25)[a]	48.88 (21.08)[a]	47.74 (21.86)[a]	37.40 (13.39)[b]
Anxiety/depression	12.85 (8.36)[a]	12.10 (8.62)[a]	13.54 (8.24)[a]	8.37 (5.80)[b]
Maternal age	37.84 (7.35)[a]	38.86 (6.78)[a]	36.91 (7.87)[a]	44.14 (5.30)[b]
Children's age	9.34 (4.97)[a]	10.00 (5.34)[a]	8.74 (4.65)[a]	13.53 (3.97)[b]
Number of children	2.48 (1.25)	2.38 (1.24)	2.57 (1.27)	2.40 (1.11)

Note: Childhood malt exp childhood maltreatment experiences.
[a] differed significantly from [b] on the respective variable at $p < .05$.

Table 2

Differences in sAA – HR Partial Correlations Between Maltreating and Non-maltreating Mothers

	sAA Baseline		sAA Block 1		sAA Block 2		sAA Block 3		sAA Recovery	
	M	N-m	M	N-m	M	N-m	M	N-m	M	N-m
HR										
Baseline	-.10	.33	-.04 [a]	.41* [b]	-	-	-	-	-	-
Block 1	-	-	-.08 [a]	.40* [b]	-.20 [a]	.29 [b]	-	-	-	-
Block 2	-	-	-	-	-.19 [a]	.31 [b]	-.11	.31	-	-
Block 3	-	-	-	-	-	-	-.12	.28	-.04	.16
Recovery	-	-	-	-	-	-	-	-	.03	.10

Note: M maltreating, *N-m* non-maltreating, *sAA* salivary α-amylase, *HR* heart rate. For maltreating group $n = 41$, for non-maltreating group $n = 36$; controlled for maternal age.

[a] [b] correlations differed significantly between maltreating and non-maltreating mothers, $p < .05$.

* $p < .05$

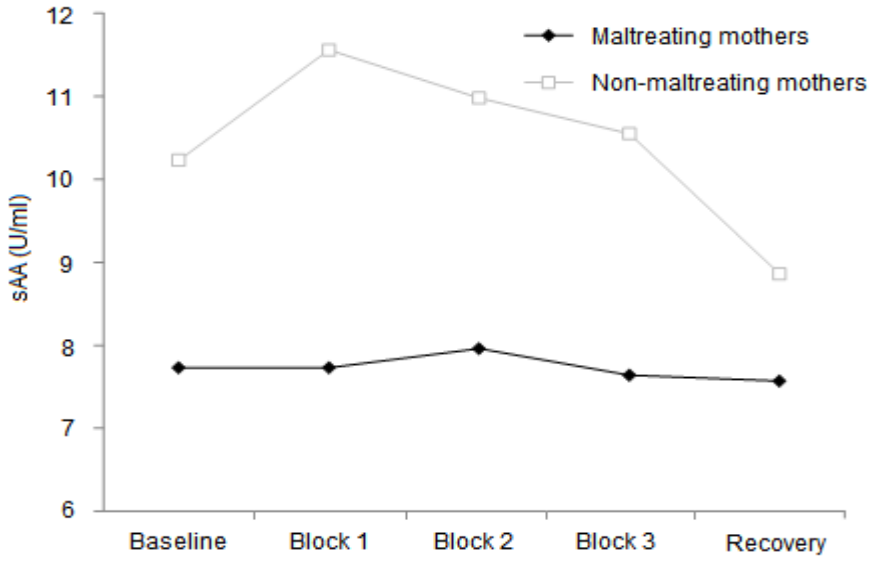

Figure 1. Overall lower sAA levels for maltreating than for non-maltreating mothers; baseline to block 1: no increase in sAA levels for maltreating mothers; from block 1, block 2, block 3 to recovery: stable sAA for maltreating mothers (N = 86: maltreating mothers, n = 44; non-maltreating mothers, n = 42).

Discussion

We found that maltreating mothers had overall lower sAA levels than non-maltreating mothers. Though traditionally studies have focused mainly on sAA reactivity, sAA levels have been shown to be stable across time and conditions, their variation largely explained by genetic factors (Out, Bakermans-Kranenburg, Granger, Cobbaert, & Van IJzendoorn, 2011). They are therefore a valuable indicator of autonomic activity. Furthermore, while listening to infant crying maltreating mothers showed attenuated sAA arousal as compared to non-maltreating mothers. The difference in autonomic reactivity patterns was evident despite the fact that perceived urgency of the sounds was equal for both groups. The lack of autonomic arousal in response to children's distressed arousal might reflect limited empathy in maltreating mothers (Ebisch et al., 2012). Since empathy implies an understanding of the child's needs and in that way facilitates an appropriate response, maltreating mothers might experience a disconnection from their children on a physiological, affective, and behavioral level, impeding adequate responsiveness even to common caregiving demands. This is congruent with a study by Sturge-Apple et al. (2011), in which ANS

hyporeactivity was found to be associated with maternal disengagement from her child.

Somewhat contrary to our expectations, there were no differences in overall sAA levels or reactivity patterns between NE and AN mothers. This might be because of insufficient statistical power due to small subgroup sizes: Whereas the power to find a medium-sized difference between the maltreating and the non-maltreating mothers amounted to .86 (taking into account the covariates), the power to find a significant effect for the difference between the NE and AN mothers was only .70, and lower for smaller effects. Furthermore, in our sample, all mothers neglected their children, so that a true distinction between perpetrated abuse and neglect was impossible. Alternatively, autonomic hypo(re)activity for both abusive and neglectful parents might reflect a common behavioral disconnection from their children. Both abusive and neglectful mothers showed significantly less affection, play behavior, and initiated less interaction with their children than comparison mothers during systematic home observations (Bousha & Twentyman, 1984). In an early review of the literature, Wolfe (1985) argued the possibility that on an everyday level, abusive parents do not necessarily respond more punitively or harshly to children's negative signals than other parents, but do fail to provide constructive and consistent discipline strategies as well as positive affect. The cry paradigm we used presents mothers with a mild child-related stressor of an intensity that mothers are likely to encounter on a daily basis. It is conceivable that in quotidian contexts, such as that of short infant cry bouts, abusive mothers too show a lack of engagement with their child, rather than instant hyperirritability.

Evaluating whether different patterns of dysfunctional autonomic reactivity to more extreme stressors are associated with different types of child maltreatment remains useful. Future studies would continue to benefit from an operationalized distinction between emotional and physical abuse and neglect. A challenge in this regard is that different types of maltreatment often co-occur, as they did in our sample (Euser et al., 2013; Manly, Cicchetti, & Barnett, 1994). Large sample sizes are therefore needed to link differential risk factors to subtypes of maltreatment.

Our findings appear to be in contrast with McCanne and Hagstrom's (1996) conclusion that more studies provided evidence for a relation between physiological *hyper*reactivity and abusive parenting. However, they pointed out that results were inconsistent among studies, which is possibly due to methodological differences such as the characteristics of

experimental stimuli. For that reason, we used a standardized cry paradigm that has been proven effective in other studies (Joosen et al., 2013a, 2013b; Out et al., 2010; Riem et al., 2012) and makes results among studies more easily comparable. Using the same cry paradigm, autonomic hyperreactivity was found to predict maternal harsh disciplining 9 months later (Joosen et al., 2013b), but harsh discipline might be reflective of maternal over-involvement rather than disengagement. It may therefore be fundamentally different from maltreatment in our sample, of which severe child neglect was a dominant trait. This demonstrates that results are difficult to compare when different operationalizations of parenting are used. Our results support the basic notion that ANS arousal is a requirement for sensitive parenting, for which promptness of response is a main condition (Joosen et al., 2013a). Congruently, in a sample of mothers where normative, hyper-, and hypoarousal patterns of the ANS were distinguished during the Strange Situation, mothers showing autonomic hypoarousal scored highest on observed insensitive parenting behavior (Sturge-Apple et al., 2011). There may be an optimal level of arousal that promotes sensitive parenting, but based on the current state of the research in this area, no definite conclusions can be drawn yet.

Furthermore, we found that significant positive correlations between HR and sAA for non-maltreating mothers differed significantly from non-significant correlations between HR and sAA for maltreating mothers. Asymmetry *between* the hypothalamic–pituitary–adrenal (HPA) axis and sympathetic adrenomedullary (SAM) system has been identified as a correlate of maltreatment experiences and aggression in adolescents (Gordis, Granger, Susman, & Trickett, 2006; Gordis, Granger, Susman, & Trickett, 2008). The importance of studying the systems' interaction has already been emphasized (Bauer, Quas, & Boyce, 2002). Although it has been recognized that measures *within* the ANS generally do not correlate well (Bosch et al., 2011; Folkow, 2000), it is the pattern of significant differences between correlations in our sample that is striking and suggests that future study of within-system dissociations might be worthwhile as well.

We turn to some of the methodological aspects of this study. The disadvantage of presenting standardized cry sounds in an experimental setting is not knowing to what extent the results can be generalized to mothers' natural caregiving context. However, mothers were tested in an environment familiar to them. Standardized paradigms also make results more easily comparable among studies.

A second limitation is that the maltreating and non-maltreating groups differed on several aspects: maltreating mothers and their children were younger, had a somewhat lower educational level, had smoked more (despite our request not to do so) and exercised less previous to the research appointment. This profile in itself might be telling in terms of the stressors maltreating mothers face and the control they have over their lives. It is consistent with the findings that parental low educational level is a risk factor for child maltreatment (Euser et al., 2013) and low parental age is (modestly) associated with risk for abusive and neglect (Stith et al., 2009). Regarding the effect of these variables on autonomic (re)activity, we tested their potential confounding effect. Smoking and maternal age were significant as a covariate on certain contrasts in the analyses. By including smoking and maternal age as covariates (among others) we precluded their confounding influence on the results. Finally, we did not measure salivary flow rate. sAA levels are affected by saliva flow which may depend on methodological factors such as collection material and sampling duration (Bosch et al., 2011). However, saliva collection was standardized in the current study (participants kept the swab under their tongue for 90 s), in which case sAA activity (U/ml) and sAA output (U/min) are highly correlated.

In conclusion, maltreating mothers showed lower sAA levels and an attenuated sAA reactivity pattern in response to infant crying. This might reflect maltreating mothers' disengagement from mildly stressful child signals, such as they encounter on a daily basis. Autonomic hypo(re)activity may partly underlie their impaired ability to adequately respond to their children on a behavioral level. It has been suggested that children who show physiological hyper- or hyporeactivity may require different types of intervention, and low physiological responsiveness in particular might be associated with low responsiveness to intervention (for a review see Gunnar & Fisher, 2006). Similarly, our findings provide a broader understanding of the biological and experiential profile of maltreating mothers and might therefore be useful for the development of prevention and intervention programs from which they can optimally profit.

Summary

We wanted to evaluate whether maltreating mothers differ from non-maltreating mothers in their autonomic reactivity to infant crying. We tentatively expected autonomic hyperreactivity in abusive mothers, and hyporeactivity in mothers who neglected their children. 44 maltreating

and 42 non-maltreating mothers participated in the study. Maltreatment was substantiated by coding the families' records from CPS and the child care office. All mothers were found to have neglected their children, while 52 % was additionally abusive. During a standardized cry paradigm, mothers listened to nine infant cry sounds that varied in pitch. Saliva was collected at baseline, after each cry sound, and after a recovery episode. sAA was assayed from saliva samples and used as a measure of ANS activity. Maltreating mothers showed lower overall sAA levels and a flat reactivity pattern to infant crying as compared to non-maltreating mothers. We found no effect of type of maltreatment (neglect only vs neglect and abuse), which may be explained by the fact that all mothers in the sample were neglectful, impeding a clear distinction between maltreatment subtypes. Furthermore, positive correla-tions between sAA and HR for non-maltreating mothers differed significantly from non-significant correlations between sAA and HR for maltreating mothers. This may indicate anomalous asynchrony between different components of the ANS in maltreating mothers. Results are interpreted in light of the functional sharing of autonomic arousal between mother and child, which might be reflective of maternal empathy for her child's distress. The lack of functional autonomic (re)activity can thus be seen as a risk factor contributing to child maltreatment.

CHAPTER 4

ATTACHMENT REPRESENTATIONS AND AUTONOMIC REGULATION IN MALTREATING AND NON-MALTREATING MOTHERS

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Abstract

This study assessed attachment representation and attachment-related autonomic regulation in a sample of 38 maltreating and 35 non-maltreating mothers. Mothers' state of mind regarding attachment was measured using the Adult Attachment Interview (AAI). They further watched an attachment-based comfort paradigm, during which we measured skin conductance (SCL) and vagal tone (RMSSD). More maltreating mothers (42%) than non-maltreating mothers (17%) had an *unresolved/disoriented* (U) AAI classification. Coherence of mind was significantly lower in the maltreating group. Attachment representation was related to physiology during the comfort paradigm: Unresolved attachment, total U score, a non-autonomous classification, and low coherence of mind were associated with a decrease in SCL during the comfort paradigm, specifically during the responsive caregiver scenario. However, physiology did not differ between maltreating and non-maltreating mothers. The decrease in SCL of unresolved mothers during the comfort paradigm might be indicative of a deactivating response, which is congruent with the dissociative nature of the unresolved state of mind. Results point to the potential utility of interventions focused on attachment representations for maltreating mothers.

Key words: child maltreatment, attachment, autonomic regulation

Introduction

Adult attachment representation has been recognized as an important predictor of parenting behavior (Main, Kaplan, & Cassidy, 1985; Van IJzendoorn, 1995). Mothers with an unresolved state of mind toward attachment-related trauma show more anomalous behavior in interaction with their children than other mothers (Main & Hesse, 1990; Madigan et al., 2006). Findings from a limited number of studies suggest that unresolved attachment is also overrepresented in maltreating parents (e.g., Adshead & Bluglass, 2005), but additional evidence from case-control studies with a comprehensive operationalization of child maltreatment is needed. Therefore, in this study we assessed attachment representation in a sample of maltreating mothers for whom emotional and physical neglect and abuse were substantiated and a comparison group of non-maltreating mothers. Attachment-related autonomic regulation has been associated with both attachment representations (Roisman, Tsai, & Chiang, 2004) and parenting behavior (Sturge-Apple, Skibo, Rogosch, Ignjatovic, & Heinzelman, 2011). We examined whether autonomic regulation during a comfort paradigm differed according to mothers' attachment representation and according to their maltreatment status.

State of Mind toward Attachment

Child maltreatment has a wide variety of etiological risk factors, including low SES, single parenthood, parental psychopathology, low social support, and parents' negative experiences with caregivers in their own childhood (Cicchetti & Valentino, 2006; Euser et al., 2013; Stith et al., 2009). In addition to actual childhood caregiving experiences, a possibly more proximal factor to be considered in the etiology of child maltreatment is parents' mental *representations* of childhood experiences (Morton & Browne, 1998). The foremost instrument to assess adult attachment representations is the Adult Attachment Interview (AAI; George, Kaplan, & Main, 1985; Hesse, 2008), a semi-structured interview in which individuals are asked to describe their early and ongoing relationship with their caregivers. Their narrative is coded using classifications of state of mind with respect to attachment (Main, Goldwyn, & Hesse, 2003). Typically, one out of three possible main classifications is assigned to the state of mind most prominent throughout the interview as a whole: secure-autonomous (F), insecure-dismissing (Ds), or insecure-preoccupied (E), of which F is considered the most beneficial (see the method section for further details).

Furthermore, when present, discussions of experiences of loss, abuse or other potential trauma are scored for disorientation in reasoning or discourse, and when sufficiently marked may lead to a primary classification of an unresolved/disoriented state of mind (U/d; henceforth U). In such a case a secondary (organized) classification of F, Ds, or E is assigned for the remaining narrative. Finally, interviews in which a singular organized state of mind cannot be identified (for instance, because marked indications of several states of mind are present) are coded as unclassifiable ("cannot classify"; CC). U and CC classifications are overrepresented in clinical samples (Bakermans-Kranenburg & Van IJzendoorn, 2009; Van IJzendoorn & Bakermans-Kranenburg, 1996).

Unresolved Attachment and Dissociative Parenting

A clinical phenomenon associated with unresolved and unclassifiable states of mind regarding attachment is dissociation (e.g., Harari et al., 2009; Riggs et al., 2007; Steele, 2003; Thomson & Jaque, 2014). In a non-clinical, low-risk sample unresolved state of mind was associated with absorption tendencies (Hesse & Van IJzendoorn, 1999), which is not pathological per se, but constitutes a core component of dissociation (Carlson & Putnam, 1993). Generically speaking, dissociation involves a lack of integration of psychological processes such as memory, consciousness, and perception, characterized by intrusive, uncontrolled disruptions and experiential disengagement (Cardeña & Carlson, 2011; Spiegel et al., 2011). Conceptually, this is similar to what may occur during the AAI for people with an unresolved state of mind. During discussion of loss or trauma, they may display anomalous ideation (e.g., speaking of a dead person as if they were alive) or disoriented discourse (e.g., visual-sensory images intrude the discourse while an episode of childhood abuse is recounted), both unremarked upon by the interviewee. This suggests a lack of integration of specific memories with the current sense of self, and absorption in the event under discussion, since speech is no longer successfully monitored.

It has been suggested that if parents display such lapses of a dissociative nature during the AAI, similar behavior is likely to intrude their parenting behavior during interactions with their children (Hesse & Main, 2006). A U classification on the AAI was found to be related to various expressions of anomalous parenting behavior (labeled *frightened/frightening* or FR behaviors; Main & Hesse, 1990; Schuengel, Bakermans-Kranenburg, & Van IJzendoorn, 1999). FR behaviors include several categories, of which one (*entrance into a dissociative state*) is

explicitly dissociative, while others (*threatening behavior* and *frightened behavior*) contain dissociative elements in that they suggest an alteration in psychological state disconnected from current interactive context (Hesse & Main, 2006). This set of anomalous parenting behaviors was expanded by Lyons-Ruth, Bronfman, and Parsons (1999) in the Atypical Maternal Behavior Instrument for Assessment and Classification (AMBIANCE) and examined by Out, Bakermans-Kranenburg, and Van IJzendoorn (2009) using the Disconnected and extremely Insensitive Parenting measure (DIP) which also includes more subtle forms of disrupted parenting. A meta-analysis has shown an association between a U classification on the AAI and both FR and disrupted parenting behavior (Madigan et al., 2006).

From Anomalous Parenting to Child Maltreatment

The boundaries between FR behaviors, disrupted parenting, and child maltreatment seem nebulous. Although the former two may occur in non-maltreating parents (see Hesse & Main, 1999; Schuengel et al., 1999), higher levels of affective errors and negative behaviors have been observed in maltreating mothers (Skowron, Cipriano-Essel, Benjamin, Pincus, & Van Ryzin, 2013; Skowron et al., 2011). Beyond their correlation, pervasive forms of intrusive/negative behavior and withdrawal could *themselves* be conceived as child emotional abuse and neglect, respectively (Barnett, Manly, & Cicchetti, 1993). A small, heterogeneous body of research seems to further point to a link between an AAI U classification and substantiated perpetration of child maltreatment. In a sample of mothers clinically referred for Münchausen syndrome by proxy, 60% were assigned a U classification on the AAI (Adshead & Bluglass, 2005), while 18% is the normative rate in non-clinical mothers (Bakermans-Kranenburg & Van IJzendoorn, 2009). In a subgroup of mothers under surveillance from the public social services for the protection of juveniles, average continuous U scores were significantly higher than in a comparison group of mothers living in poverty and a low-risk control group (Frigerio, Costantino, Ceppi, & Barone, 2013). On an extreme level, more mothers who had killed their children had a U classification (61%) than both mentally ill mothers and mothers from the normative population (Barone, Bramante, Lionetti, & Pastore, 2014). However, no elevated prevalence of U (12%) was found in mothers with substantiated child neglect (Lindhiem, Bernard, & Dozier, 2011). So far, studies on AAI classifications of maltreating parents are relatively scarce and results have not been unequivocal.

Attachment and Autonomic Regulation

Adult attachment dimensions have been related to different responses of the autonomic nervous system (ANS) during the AAI. The ANS is part of the peripheral nervous system, which connects the central nervous system (i.e., the brain and spinal cord) with the rest of the body (Kiernan & Rajakumar, 2014). The ANS innervates the internal organs through the sympathetic and parasympathetic subsystems (Larsen, Schneiderman, & DeCarlo Pasin, 1986). Generally, the sympathetic branch mobilizes the body to deal with environmental demands, while the parasympathetic system restores energy during rest. Skin conductance levels (SCL; electrodermal activity of the skin) and vagal tone (heart rate variability associated with respiration; Porges, 1991) are examples of frequently used autonomic parameters (Kreibig, 2010). Integrated with its role in behavioral preparation, the interest in ANS response patterns as reflective of emotion has increased over recent decades (see Kreibig, 2010, for an overview). For instance, stress or anxiety has been quite unequivocally associated with increases in SCL and a decrease in parasympathetic indices such as vagal tone.

During the AAI, individuals using a deactivating strategy toward attachment memories (associated with a dismissing state of mind) showed increased SCL reactivity to attachment-related questions as compared to hyperactivating interviewees (pertinent mostly to preoccupied classifications; Dozier & Kobak, 1992). This validated the notion that a person with a dismissing state of mind copes by suppression of negative emotions. The finding was replicated in a study that further suggested the association to be unique to electrodermal activity, since no effects were found for cardiovascular measures (Roisman et al., 2004). Preoccupied individuals showed no change in SCL during the interview, which seems incongruent with the "involving/preoccupying anger" inferred from their answers (i.e., abundant, apparently angry discussions of negative experiences with caregivers, indicative of current mental entanglement with caregiving experiences; the most common subtype of AAI preoccupation). Studies that have examined autonomic regulation in relation to an unresolved state of mind are lacking, probably in part because the rate of U classifications in community samples is such that substantial subgroup sizes are hard to obtain. One study that did test the association with an unresolved state of mind found no differential autonomic regulation during the AAI for adopted adolescents (Beijersbergen, Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2008), which, as the authors noted, may have been partly due to their focus on ANS arousal during

questions regarding loss or trauma. U indices may occur outside of the context of these questions, and furthermore tend to be brief. It may therefore be worthwhile to measure autonomic regulation associated with unresolved attachment outside of the direct AAI context.

Although it remains unclear to what extent the potentially traumatic experiences discussed during the AAI are the direct causes of the unresolved state of mind (Lyons-Ruth, Yellin, Melnick, & Atwood, 2003), early experiences of maltreatment have commonly been associated with unresolved attachment, either directly (Bailey, Moran, & Pederson, 2007), or, as postulated by Riggs and Jacobvitz (2002), indirectly by heightening vulnerability to subsequent adversity. Early trauma such as childhood abuse and neglect has mainly been associated with subsequent increased ANS reactivity (e.g., Heim et al., 2000; Oosterman, De Schipper, Fisher, Dozier, & Schuengel, 2010). However, differential autonomic response patterns may be discerned according to *state of mind* toward the trauma. For instance, traumatized individuals with a dissociative coping strategy may show a dampened autonomic response during trauma-related confrontation (Griffin, Resick, & Mechanic, 1997). A neurobiological model was proposed in which certain manifestations of dissociation were associated with inhibition of the amygdala by the medial prefrontal cortex, resulting in dampened autonomic output and emotional experience (Sierra & Berrios, 1998). More recently, evidence was presented for a dissociative subtype of PTSD, following a similar model of excessive prefrontal inhibition of limbic regions (Lanius et al., 2010). Consistent with this line of findings, PTSD and an unresolved state of mind towards attachment were highly associated in a sample of war veterans, probably due to their commonality of an inherently dissociative lack of integration (Harari et al., 2009). Indirect evidence thus suggests that individuals with an unresolved state of mind, through their dissociative features, may show autonomic hyporeactivity to trauma-related stimuli.

Autonomic Regulation and Parenting

Maternal autonomic dysregulation within attachment-related settings has also been related to inappropriate parenting behavior. Mothers with ANS hyperarousal during the Strange Situation Procedure (SSP) displayed more harsh/intrusive caregiving behavior, while mothers with an autonomic hypoarousal pattern scored highest on maternal insensitivity, disengaged *and* intrusive parenting as compared to a normative group (Sturge-Apple et al., 2011). Several studies have looked at decreases in vagal tone (labeled vagal withdrawal and taken as a sign

of active and flexible emotion regulation) in relation to parenting. Mothers of infants with an avoidant attachment strategy showed less vagal withdrawal than mothers of securely attached infants during the final reunion episode of the SSP (Hill-Soderlund et al., 2008). Mothers of avoidant dyads have been characterized by, inter alia, consistently low responsiveness to negative child signals (Ainsworth, Blehar, Waters, & Wall, 1978; Belsky, Rovine, & Taylor, 1984; Raval et al., 2001). Also in mothers of avoidant children, low vagal withdrawal predicted decreased maternal sensitivity during episodes of child negative affect (Mills-Koonce et al., 2007). Low vagal withdrawal in combination with high cortisol was associated with maternal negative intrusiveness during the reunion of the Still Face Paradigm (Mills-Koonce et al., 2009). Finally, *more* vagal withdrawal was associated with episodes of increased positive parenting in abusive and neglectful mothers during a joint teaching task with their children (Skowron et al., 2013). Combined, these results point to an association between diminished autonomic regulation and less optimal caregiving.

The Current Study

In the current study we assessed state of mind with regard to attachment in a sample of maltreating and demographically matched non-maltreating mothers. For the maltreating group physical and emotional child abuse and neglect were substantiated, which provides an important addition to the existing literature. We evaluated the association between the three constructs outlined above: between attachment and child maltreatment perpetration; between attachment and autonomic regulation; and between autonomic regulation and child maltreatment. With an exploratory aim, we tested whether autonomic regulation mediated the relationship between attachment and child maltreatment. SCL and vagal tone (RMSSD; root mean square of successive differences) were measured during standardized attachment-based video clips. The clips displayed a separation between abstract animated representations of a caregiver and infant, followed by a *responsive caregiver* and an *unresponsive caregiver* outcome scenario, shown alternately (Johnson, Dweck, & Chen, 2007).

First, we hypothesized that more maltreating mothers than non-maltreating mothers would have an unresolved state of mind towards attachment, and more maltreating mothers would be assigned an insecure (Ds, E, or U/CC) classification. Second, we expected that maltreating mothers as well as mothers with unresolved and insecure

attachment representations would show autonomic dysregulation during the attachment-based videos.

Method

Participants

We recruited 45 maltreating and 45 non-maltreating mothers from a mental health clinic. Mothers in the maltreating group received therapy that revolved around their parenting problems and received a brochure about the study from their therapists at the beginning of their treatment. The clinic kept family records for all mothers, which included CPS referrals and life histories of family members. We coded these records to substantiate recent or ongoing abuse and neglect perpetrated by the mother using the Maltreatment Classification System (MCS; Barnett et al., 1993). When records were inconclusive, we interviewed the mother's psychiatrist about her parenting problems using a semi-standardized interview. For three mothers, neither their records nor their psychiatrists provided proof of maternal maltreatment. In these cases, we conducted a Dutch adaptation of the Maternal Maltreatment Classification Interview (MMCI; Cicchetti, Toth, & Manly, 2003) which verified absence of maltreatment in two mothers. We considered them as non-maltreating in the analyses. One mother could not be reached for a follow-up MMCI and was excluded from analyses because of her inconclusive current maltreatment status.

Non-maltreating mothers were recruited by research assistants in a clinical subdivision of the facility, where their child was in therapy for developmental or learning problems. Because having a child with these types of problems may constitute a specific challenge for caregiving, we also coded the family files of maltreating mothers for their children's clinical diagnoses to ensure the two groups were comparable in this respect. To verify the absence of maltreatment in the non-maltreating group, the MMCI (Cicchetti et al., 2003) was used. For three mothers incidents of maltreatment were coded from the interview. All of these incidents had taken place less than five years ago, so that the recency of the problems matched these mothers to the maltreating group. Therefore they were excluded from the non-maltreating group and transferred to the maltreating group. For 16 participants physiological and/or AAI data were missing due to technical problems or because the participant's psychiatrist had advised against conducting the AAI. Additionally, one interview could not be scored because of the participant's language difficulties. The final sample consisted therefore of 38 maltreating

mothers and 35 non-maltreating mothers. The 17 excluded mothers did not differ on maltreatment status from the mothers with complete data (p = .55). Excluded mothers and those included in the final sample were also similar on number of children, maternal mean age, children's mean age, and education (ps > .18). They differed on ethnicity (p = .01): 96% of included mothers were of Caucasian ethnicity, compared to 77% (n = 13) in the excluded group.

In the final sample, 45% had completed secondary school, and 34% had finished elementary school or a short track of secondary school. The mean age of the mothers was 41.32 years (SD = 7.15) and on average they had 2.41 children (SD = 1.19).

The study was approved by the Medical Ethics Review Committee for Mental Health Care (METiGG). All mothers gave informed consent for participation and, in the maltreating group, for researchers' access to the family files. As a compensation for participation, mothers received 40 Euros and travelling expenses.

Procedure

Two individual appointments took place at the facility, on average no more than about a week apart. All mothers were tested by young, female research assistants who had memorized a structured script to standardize the procedure as much as possible. The first session took place in the morning to prevent the influence of diurnal fluctuations in ANS activity. Mothers completed three computer tasks, including a comfort paradigm (Johnson et al., 2007), during which electrocardiogram (ECG) and impedance cardiogram (ICG) signals were recorded. Afterwards, mothers completed a questionnaire on health-related issues, such as smoking and exercising prior to the session, and on their family situation, including educational level, number of children, and children's ages. Furthermore, we administered the MMCI to the non-maltreating group. During the second appointment we conducted the Adult Attachment Interview (George et al., 1985).

Measures

Maltreatment Classification System. We used the Maltreatment Classification System (MCS; Barnett et al., 1993), which has been found a reliable and valid system to code incidents of maltreatment (e.g., English et al., 2005). The MCS may be applied to all available documents from families' Department of Human Services (DHS) records, thereby maintaining independent criteria that comprehend more than legally recognized cases of maltreatment (Cicchetti, Rogosch, Gunnar, & Toth,

2010). In accordance with operational definitions, we coded abuse (physical and emotional) and neglect (again, physical and emotional). The fact that certain types of maltreatment were recorded in the files suggests them to be of a chronic rather than incidental nature. Only incidents of *maternal* maltreatment were considered. Coding was done by trained research assistants. Inter-rater reliability for maltreatment type on 15 files was excellent, with $\kappa = .82$ for abuse and $\kappa = 1.00$ for neglect. For the presence versus absence of maltreatment there was full agreement ($\kappa = 1.00$). Subsequently, all records were coded by two different research assistants and discrepancies were resolved through discussion. We found that all mothers in the maltreatment group had been neglectful towards their children, either physically or emotionally, and 55% ($n = 21$) of the maltreating mothers had also abused their child(ren) physically or emotionally.

Maternal Maltreatment Classification Interview. The MMCI (Cicchetti et al., 2003) is a semi-structured interview that evaluates whether the mother has maltreated any of her children recently and during their lifetime. Mothers are asked about incidents of physical and emotional abuse and neglect, as well as sexual abuse, and about any contact the family may have had with CPS. We translated the interview into Dutch for this study. Coding was done by trained research assistants. Inter-rater reliability on 12 interviews was excellent, with full agreement for the presence versus absence of maltreatment, incidents of neglect versus abuse, and severity of the incidents (for all $\kappa = 1.00$). Interviews were coded by two different research assistants and discrepancies were resolved through discussion.

Comfort Paradigm. The comfort paradigm (Johnson et al., 2007) consists of two different video clips showing two animated ellipses, one larger (the "caregiver") and one smaller (the "child"). Both started with a 10-sec introductory clip in which caregiver and child enter the scene together. When the ground slopes upward, the caregiver continues unto a mid-slope plateau, whereas the child is held back and starts to cry. This is conveyed using the sound of a human infant cry, visually emphasized by the pulsation and change of color of the child ellipse (see Figures 1a and b). In the 8-sec *responsive* caregiver outcome clip, the caregiver then returns to the child, as the infant cry sound continues but diminishes towards the end (Figure 1c). In the other outcome, the 8-sec *unresponsive* caregiver clip, the caregiver ellipse continues higher up the slope, leaving the child behind (Figure 1d). The crying sound continues but eventually fades just as in the responsive clip.

The paradigm has previously been used with infants (Biro, Alink, Van IJzendoorn, & Bakermans-Kranenburg, 2014; Johnson et al., 2007; Johnson et al., 2010). Based on the infant working model of attachment, the authors of the paradigm hypothesized that infants with secure attachment would spend more time looking at the *un*responsive caregiver scenario (contrary to their expectation), while insecurely attached infants would look longer at the responsive caregiver outcome, and this was indeed the case (Johnson et al., 2007; Johnson et al., 2010). This shows that people may respond differently to the paradigm's caregiving outcomes according to their mental representation of attachment. This is the first study to use the paradigm with adult participants.

The comfort paradigm was presented on a laptop with E-prime software. We started the task with a 4-min baseline of neutral images. We then showed the introductory clip, immediately followed by either the responsive or the unresponsive clip (counterbalanced). The same combination of introductory and outcome clip was repeated 4 times. A second baseline of neutral images lasting 2 minutes was shown, after which we presented the introductory clip combined with the *other* outcome scenario (responsive when the first series were unresponsive, or unresponsive when the first series were responsive), 4 times in a row. The order of the responsive and unresponsive clips was counterbalanced. The task was finalized with a 2-min recovery segment of neutral images.

Skin Conductance Level (SCL) and Vagal Tone (RMSSD). During the cry paradigm, SCL, an electrocardiogram (ECG), and an impedance cardiogram (ICG) were measured using an ambulatory monitoring system (VU-AMS5fs; TD-FPP, Vrije Universiteit, Amsterdam, the Netherlands). Before the assessment of SCL mothers washed their hands with a mild soap. Then two Ag-AGCI electrodes, filled with isotonic GEL101 electrode paste, were placed on the middle and index finger of mothers' non-dominant hand. For the ECG, three disposable pre-gelled Ag-AgCI electrodes (ConMed, New York, USA) were placed slightly below the right collar bone 4 cm to the right of the sternum, between the two lower ribs on the right side, and under the left breast (4 cm under the nipple). For the ICG, four electrodes were attached at the top end of the sternum between the tips of the collarbones, on the spine (at least 3 cm above the previous one), at the low end of the sternum where the ribs meet, and again on the spine (at least 3 cm under the previous one). E-prime had been programmed so that markers were sent to the ECG and

SCL recording during baseline, the display of each video clip, and recovery. We labeled the data according to these markers.

Out of the various autonomic measures assessed during the paradigm, we focused on SCL and vagal tone (RMSSD) in our analyses to reduce the number of statistical tests. These two measures were selected over other indices for several reasons. First of all, they allowed us to separately evaluate both sympathetic (SCL) and parasympathetic (RMSSD) nervous system activity (whereas heart rate, for instance, is a mixed index). Second, in previous studies on autonomic functioning in an attachment-related context SCL and vagal tone have each been used as singular measures of the ANS (e.g., respectively Dozier & Kobak, 1992; Mills-Koonce et al., 2007). In other studies, SCL was measured in addition to salivary alpha-amylase, and vagal tone in addition to cardiovascular measures such as inter-beat intervals, and effects were found only for SCL and vagal tone, respectively (Hill-Soderlund et al., 2008; Roisman et al., 2004). Average SCL and RMSSD were derived per labeled segment, after which the mean over the segments was calculated per clip content (introductory, responsive, unresponsive) in SPSS. We checked for outliers (using standardized scores of -3.29 and 3.29 as cut-off) per labeled segment as well as per aggregated episode. For SCL two participants and for RMSSD six participants showed outliers for individual segments, which were winsorized (Tabachnik & Fidell, 2001), so that the least extreme outlier was replaced with a value .10 above the highest non-outlying score, and for the next more extreme outlier .10 was added to the preceding value, thus preserving the original order. For RMSSD the combined episodes further showed four outliers, which were winsorized as well. Combined episodes showed no further outliers.

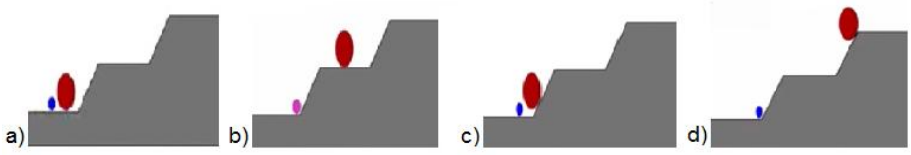

Figure 1. Stills from the comfort paradigm. a) and b) display the introductory clip of the comfort paradigm, in which a) "caregiver" oval and "child" oval enter the scene and, b) the caregiver mounts the slope, leaving the child behind, who starts to cry; c) displays the responsive clip, in which the caregiver returns to the crying child; d) shows the unresponsive clip, in which the caregiver leaves the crying child behind (Johnson, Dweck, & Chen, 2007). Participants watched c) and d) in counterbalanced order.

Adult Attachment Interview (AAI). The AAI (George et al., 1985) is a semi-structured interview aimed at assessing the interviewee's state of mind regarding attachment. The protocol includes questions about participants' relationship with their parents in childhood, important losses during their lifetime, and other potentially traumatic experiences, as well as how each of these affects their current functioning (see Hesse, 2008, for a detailed discussion of the AAI). Each interview was transcribed verbatim by a trained research assistant, after which the transcript was checked by another trained research assistant.

Attachment classifications are coded based on discourse *coherence* (rather than on content), and a continuous score for *coherence of mind* is assigned. Three organized or resolved (i.e., "definitive and singular," Hesse, 2008, p. 563) classifications are distinguished. Generally, the *secure-autonomous* (F) classification is assigned when the interviewee openly values attachment, yet discusses relationships with certain objectivity, and is associated with high coherence of mind; the *dismissing* classification reflects a dismissal or devaluing of attachment; *preoccupied* speakers appear overly involved with attachment experiences. The latter two correspond to low coherence of mind scores. Apart from the three organized classifications, the *unresolved/disoriented* (U/d; henceforth U) classification may be primarily assigned when during discussion of loss or a potentially traumatic experience, the speaker displays a clear lapse in the monitoring of discourse or reasoning (e.g., talking about a dead person as if they were still alive, or expressing the belief of having caused one's own childhood abuse). This lapse is indicative of a disoriented state of mind with regard to the event under discussion, and when sufficiently unequivocal results in a high continuous U score and a pertinent primary U classification. Finally, *cannot classify* is a rare, unorganized classification that mostly involves clear indications of two contradictory representations for different stretches of the same interview. U and CC share the lack of a single, organized attachment representation and in research have been pragmatically combined to form one category (e.g., Harari et al., 2009). AAI classifications were dichotomized into U/CC vs non-U (Ds, F, or E) as well as F vs non-F (Ds, E, U/CC) groups. Transcripts contained no identifying information and were coded by two certified coders using the standard AAI classification system (Main et al., 2003). The coders were unaware of the participants' maltreatment status or physiological data. Inter-rater reliability (n = 16) was satisfactory for the three-way classification Ds, F, E 75% , for the four-way classification Ds, F, E, U 69%, for F vs non-F 88% , for U vs non-

U 75%. In the case of disagreement, the scores of the expert coder (MJBK) were used.

Data Analysis

For the preliminary analyses, we performed *t*-tests to compare Ds and E mothers on their autonomic levels, in order to assess whether they could be grouped into one insecure category. Once attachment groupings were established, we performed Pearson's chi-square tests to compare maltreating vs non-maltreating, U vs NonU (Ds, F, E), and F vs NonF (Ds, E, U/CC) mothers on ethnicity, educational level, medication, hearing problems, exercise, and smoking, and whether their children had a clinical diagnosis. *T*-tests were done to check for differences in maternal age, children's mean age, and number of children. We calculated Pearson's correlation coefficients for the relation between the continuous background variables and baseline levels of the autonomic measures. We performed *t*-tests to evaluate whether exercise and smoking had an effect on baseline levels of the physiological variables. Univariate ANCOVAs, with maternal age as covariate (see below), were done to compare maltreating and non-maltreating mothers on baseline levels of SCL and RMSSD.

Next, we tested the associations between attachment, autonomic regulation, and child maltreatment perpetration with a series of regression analyses. The association between state of mind toward attachment and child maltreatment was tested using logistic regression. Four attachment constructs were entered as predictor variable in separate regressions: (1) Unresolved vs resolved attachment (dichotomous), (2) Insecure (Ds, E, or U/CC) vs autonomous attachment (dichotomous), (3) total U score (continuous), and (4) coherence of mind (continuous). Next, we tested whether attachment representation was associated with autonomic regulation during the comfort paradigm with a series of hierarchical multiple regressions. Again, the four attachment constructs mentioned above were entered as predictor variable in separate regressions with SCL and RMSSD during the responsive and unresponsive outcome scenario of the comfort paradigm as dependent variables. To test whether autonomic regulation during the comfort paradigm predicted maltreatment status, we performed separate logistic regressions with child maltreatment as dichotomous dependent variable and SCL and RMSSD during the responsive and unresponsive clips as predictor variable, respectively. Finally, we did exploratory analyses to test whether autonomic regulation mediated the association between

state of mind toward attachment and child maltreatment, using the Preacher and Hayes' (2008) SPSS macro for indirect effects.

Covariates

For the logistic regression predicting child maltreatment from attachment, demographics on which the maltreating and non-maltreating group differed (i.e., maternal age and children's mean age) were initially entered as covariates in the first block. Neither was significant, so they were excluded.

For the association between attachment and autonomic regulation, hierarchical multiple regressions were initially done to identify significant covariates. In the first block we entered: (1) demographics on which maltreating and non-maltreating mothers differed (i.e., maternal age and children's mean age; (2) circumstantial factors / habits (i.e., whether mothers smoked, whether they had exercise in the week prior to participation); (3) testing characteristics (i.e., the order in which responsive/unresponsive clips were presented, autonomic baseline levels). A second block was created for the predictor variable of interest (i.e., attachment representation). Smoking, order of clip presentation, and autonomic baseline levels emerged as significant covariates. The results presented below are therefore based on hierarchical multiple regressions with smoking, clip presentation order, and autonomic baseline levels in the first block, and attachment in the second block.

For the logistic regressions predicting child maltreatment from autonomic regulation, we repeated the procedure described above. Smoking and exercise emerged as significant covariates, and were therefore retained in the first block of the logistic regression, with autonomic regulation added in the second block.

Finally, for the mediation analyses, maternal age, children's mean age, smoking, exercise, order of clip presentation, and autonomic baseline levels were initially defined as covariates in the SPSS macro. Smoking and exercise were significant and retained in the analyses.

Results

Preliminary analyses

Ds and E mothers did not differ on SCL and vagal tone values at baseline, nor during the responsive and unresponsive clips of the paradigms ($ps \geq 0.10$), and could therefore be jointly compared to U and F mothers. With regard to demographics and background information, maltreating and non-maltreating mothers did not differ on ethnicity,

educational level, medication affecting heart rate, number of children, or whether their children had been clinically diagnosed (*p*s > .14). However, mothers and children in the maltreating group were significantly younger (38.16 years, *SD* = 7.36 and 9.52 years, *SD* = 5.21) than their counterparts in the non-maltreating group (44.74 years, *SD* = 5.11 and 14.04 years, *SD* = 3.73), $t(66.17) = 4.47$, $p < .001$ and $t(67.04) = 4.28$, $p < .001$, respectively. Furthermore, fewer maltreating mothers than non-maltreating mothers had exercised in the week prior to the research appointment, χ^2 (1, $N = 73$) = 5.51, $p = .02$, and more maltreating mothers than non-maltreating mothers had smoked on the morning of the assessment, χ^2 (1, $N = 73$) = 8.02, $p = .01$. There were no other significant group differences (*p*s > .06)

Maternal age and children's mean age were negatively correlated with baseline SCL ($r = -.27$, $p = .02$ and $r = -.30$, $p = .01$, respectively) and maternal age also correlated with baseline RMSSD ($r = -.26$, $p = .03$). There were no significant associations between having exercised or smoked and baseline levels of SCL or RMSSD (*p*s > .06). For the maltreating group, the number of days in therapy before participating in the study was not related to baseline levels of the autonomic measures or to mothers' attachment representation (*p*s ≥ .32). No differences were found between maltreating and non-maltreating mothers for baseline levels of any of the physiological variables, when controlling for maternal and children's age (*p*s > .83).

Attachment Representation and Child Maltreatment

Dichotomous attachment variables. AAI classifications and scores for maltreating and non-maltreating mothers are displayed in Table 1. The U/CC classification significantly increased the likelihood of being classified as a maltreating mother, χ^2 (1, $N = 73$) = 5.56, $p = .02$. For one non-maltreating mother her U classification was based on a recent loss. Excluding her from the analyses did not affect the reported results. Autonomous attachment did not significantly decrease the odds of being classified as a maltreating mother, χ^2 (1, $N = 73$) = 2.42, $p = .12$.

Continuous attachment variables. Total U score was not significantly associated with the likelihood of being classified as a maltreating or non-maltreating mother, χ^2 (1, $N = 73$) = 2.56, $p = .11$. However, coherence of mind lowered the odds of being classified as a maltreating mother, χ^2 (1, $N = 73$) = 7.08, $p = .01$.

In sum, we found that unresolved attachment significantly predicted child maltreatment perpetration, and that coherence of mind was negatively associated with being a maltreating mother (see Figure 2).

Attachment Representation and Autonomic Regulation

Dichotomous attachment variables. SCL and RMSSD values during baseline, and the responsive and unresponsive clips are displayed in Table 1. We found that having a U/CC classification was associated with lower SCL during the responsive outcome scenario of the comfort paradigm, significantly adding to the predictive value of the covariates, F change (1, 68) = 6.76, p = .01 (see Figure 3). In the same direction, an autonomous attachment representation significantly predicted *higher* SCL during the responsive clip, F change (1, 68) = 5.48, p = .02. Neither U/CC nor F status predicted SCL during the unresponsive clips or vagal regulation during the comfort paradigm (ps ≥ .16).

Continuous attachment variables. In line with findings for dichotomous predictors, total U score was associated with lower SCL during the responsive caregiver scene (F change [1, 68] = 6.80, p = .01), while coherence of mind predicted higher SCL during the responsive clip (F change [1, 68] = 5.33, p = .02). Again, neither total U score nor coherence of mind predicted SCL regulation during the unresponsive clip or vagal regulation during either outcome scenario (ps ≥ .15).

In sum, unresolved attachment and continuous U scores were associated with lower SCL during the responsive clip, while an autonomous representation and coherence of mind predicted higher SCL during the responsive caregiver scenario. No relation was found between attachment and SCL during the unresponsive scene or attachment and vagal tone (see Figure 2).

Autonomic Regulation and Maltreatment Status

Neither SCL nor RMSSD during either outcome scenario of the comfort paradigm were related to maltreatment status (ps ≥ .27).

Table 1

AAI Outcomes and Autonomic Levels for Maltreating and Non-maltreating Mothers

		Maltreating (n = 38)		Non-maltreating (n = 35)		Statistics	
						χ^2	p
AAI U/CC		42%		17%		5.56	.02*
AAI F		45%		63%		2.42	.12
		M	*SD*	*M*	*SD*	χ^2	p
AAI U/d score		4.18	2.13	3.33	1.91	2.56	.11
AAI CM score		4.64	1.85	5.76	1.65	7.08	.01*
		M	*SD*	*M*	*SD*	t	p
SCL	baseline	5.34	2.36	4.57	2.60	-1.34	.19
	responsive	5.21	2.46	4.55	2.74	-1.10	.28
	unresponsive	5.27	2.35	4.46	2.73	-1.37	.18
RMSSD	baseline	38.32	21.17	34.58	19.49	-0.78	.44
	responsive	35.13	19.26	31.37	15.49	-0.91	.36
	unresponsive	34.36	16.76	31.35	15.88	-0.79	.43

Note: [a] and [b] were significantly different, $p < .05$.

AAI U/CC = Unresolved or Cannot Classify classification; AAI F = secure-autonomous classification; AAI U/d score = Unresolved/disoriented continuous score; AAI CM score = Coherence of mind continuous score; SCL = skin conductance level; RMSSD = root mean square of successive differences (vagal tone).

Mediation

Preacher and Hayes (2004) have argued that the separate testing of the *c*, *a*, and *b* paths may be compromised by low statistical power, and that the only a priori condition for testing a mediation effect should be the association between the independent and the dependent variable. For significant *c* paths (i.e., the total effects of U attachment and coherence of mind on child maltreatment) we therefore tested with an exploratory aim whether autonomic regulation during the comfort paradigm mediated the association between attachment and child maltreatment. The *c'* paths (i.e., direct effect of attachment on child maltreatment, after controlling for autonomic regulation) were significant (*p*s < .05). The 95% confidence intervals for the indirect effect of attachment on child maltreatment, the *ab* paths, all contained zero. In sum, no mediating effects were found.

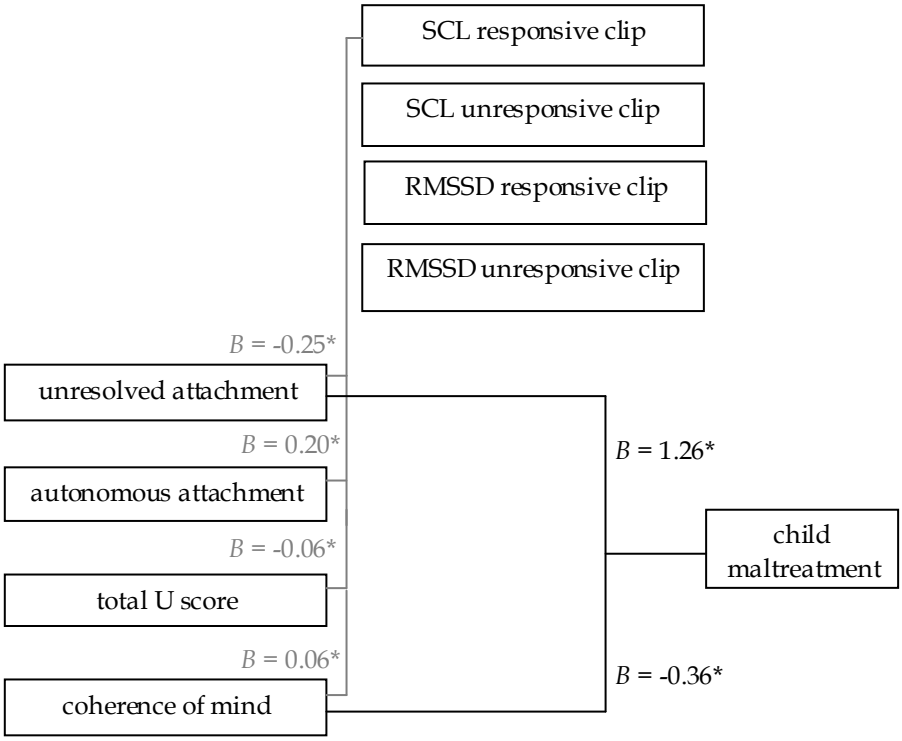

Figure 2. Summary of results. U = Unresolved / disoriented; SCL = skin conductance levels; RMSSD = root mean square of successive differences (an index of vagal tone). Absence of a drawn pathway means regression analyses were not significant (*p*s > .05). * $p < .05$

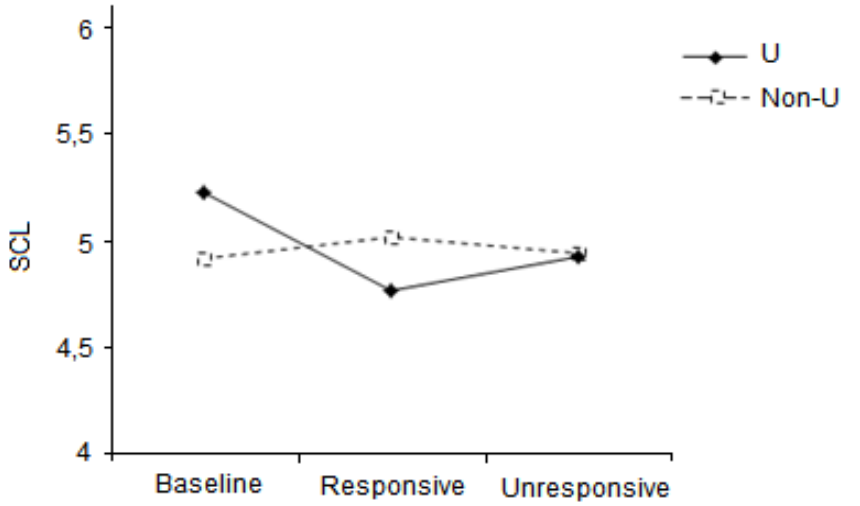

Figure 3. SCL response per AAI status. SCL regulation from baseline to the responsive clip differed between U/CC mothers and mothers with a resolved attachment representation.

Discussion

An unresolved state of mind toward attachment and low coherence of mind were associated with child maltreatment perpetration. This was in line with our expectations. Although a robust link between an unresolved state of mind and anomalous parenting behavior had already been established (Madigan et al., 2006), our finding is an important addition to the small body of research that has identified an unresolved state of mind in maltreating parents (e.g., Adshead & Bluglass, 2005; Barone et al., 2014). Whereas some of the these studies were marked by homogeneity in (relatively rare) maltreatment types (Münchausen by proxy in Adshead & Bluglass, 2005; filicide in Barone et al., 2014), for the mothers in our sample a wide range of maltreatment incidents were substantiated, including emotional and physical child abuse and neglect, which renders them more representative of the population of maltreating mothers. Considering the difference in unresolved loss or trauma, it may seem surprising that maltreating and non-maltreating mothers did not differ on continuous U scores. A possible explanation is that the non-maltreating group is a high-risk control group, which is, save for the perpetration of maltreatment, in many relevant aspects similar to the maltreating group, such as with respect to their educational level and

having clinically diagnosed children. Their U scores hovered under the cut-off value, rendering the difference between continuous scores non-significant. Such low-to-moderate U scores may be assigned to indices of mild disorientation in discourse during discussions of trauma, such as unfinished sentences. These carry less weight than marked signs of absorption or anomalous ideation (Main et al., 2003). The dichotomous distinction between unresolved and resolved classifications may therefore be clinically more relevant than a comparison of average U scores.

Contrary to our expectations, maltreating and non-maltreating mothers did not differ on the distinction between autonomous and insecure states of mind. This seems in contrast with studies that have associated insecure states of mind with less optimal caregiving (Van IJzendoorn, 1995). Our non-significant result may be due to insufficient statistical power, since we did find the expected difference on the continuous dimension of attachment security: Maltreating mothers showed lower coherence of mind than non-maltreating mothers. This supports the pragmatic use of both continuous and categorical indicators of attachment representation (Van IJzendoorn & Bakermans-Kranenburg, 2014). Narrative coherence has been said to reflect "the core of attachment state of mind" (Bernier & Dozier, 2003). It has been related to, for example, maternal sensitivity (Coppola, Vaughn, Cassibba, & Costantini, 2006) and, inversely, with inappropriate maternal attributions of her child's mental state (Bernier & Dozier, 2003). The current results are congruent with this line of findings by linking low coherence of mind to child abuse and neglect.

The Unresolved state of mind and U scores, as well as non-autonomous attachment and low coherence of mind were associated with decreased SCLs during the comfort paradigm, particularly during the reunion between "caregiver" and "child". It may be that for these mothers watching a reunion episode is especially poignant because of the contrast with their own attachment experiences. Indeed, an overview of the literature on autonomic responses and their relation to emotions has shown that SCL decreases are relatively uniquely indicative of a deactivating response of (non-crying) sadness (Kreibig, 2010). We tentatively suggest that mothers' deactivating, rather than activating, response may indicate a passive, disengaging coping strategy, which seems congruent particularly with the dissociative nature of the unresolved state of mind. It may seem surprising that the reunion clip evoked such a response, but relevant studies (on parenting quality and children's attachment) have also found autonomic distinctions between

mothers solely during the reunion episodes of the Strange Situation Paradigm and the Still Face Paradigm (respectively, Hill-Soderlund et al., 2008; Mills-Koonce et al., 2009), suggesting its emotional salience. No associations with AAI state of mind were found for RMSSD. On the one hand this is congruent with research that has found attachment-related regulation for electrodermal but not for cardiovascular measures (Roisman et al., 2004). On the other hand, it may be due to our stimulus; the comfort paradigm may have been too mild to evoke a more complete autonomic response. However, the results suggest that incoherent and unresolved mothers were more affected by the comfort paradigm than organized mothers were. Thereby they highlight how even short and subtle attachment-related stimuli are able to evoke an autonomic response that distinguished unresolved from organized mothers, also out of the direct AAI context. This makes attachment-related autonomic regulation a promising area for future research, considering that stimuli of a longer duration and with real-life verisimilitude may reveal more clearly the differences in autonomic regulation inherent to attachment representation that our findings touched upon.

Maltreating and non-maltreating mothers did not differ in their autonomic responsiveness to the comfort paradigm, and no mediating effect of autonomic regulation was found. The lack of differential autonomic regulation may be due to the high level of comparability between the maltreating and non-maltreating group, particularly in terms of the caregiving challenges they faced having clinically diagnosed children. Interestingly, previous findings for the current sample have shown that another paradigm of infant cry sounds did elicit different autonomic responses for maltreating and non-maltreating mothers (Reijman et al., 2014), so the lack of autonomic differences may also be task-related. In the comfort paradigm, the visual presentation of the dyad gave meaning to the "child's" cry sounds, which may have evoked attachment-related emotions in mothers. In the previously used cry paradigm, cry sounds of different pitches were presented without any visual accompaniment, leaving the interpretation of the cries open, which may have resulted in a stronger activation of mothers' *caregiving* system. Our findings converge with those of Riem and colleagues (2012), who found no mediating role for amygdala reactivity in the association between attachment security and participants' behavioral responses to infant cry sounds, as measured by force used when squeezing a handgrip dynamometer. However, as indicated by the authors, their sample was small and consisted of women without children of their own. The absence of neurobiological mediation found so far may then

have methodological explanations, which future studies could try to rule out before firm conclusions are drawn.

Our study had several limitations. The sample was small, which may have led to insufficient statistical power to detect differences in attachment representations between maltreating and non-maltreating mothers. It also precluded the comparison of neglectful versus neglectful and abusive mothers. As mentioned, the comfort paradigm may have been too mild to evoke a pronounced pattern of autonomic regulation. Furthermore, as with any standardized task, it challenges the external validity of the findings, which need to be replicated in more natural settings. Although the arguably high-risk status of our non-maltreating group may have limited the differences found between maltreating and non-maltreating mothers, we ultimately consider this a strong point: it means that the differences we did find can be plausibly attributed to mothers' maltreatment status. Studies using more than one comparison group may shed light on attachment representation and autonomic regulation associated with different levels of caregiving quality. Finally, the unresolved state of mind toward attachment is only one way in which disorientation toward traumatic experiences may manifest. As described in previous sections, it is coded in the presence of narrations of loss or childhood abuse. Expanding on the U/d scale, the Helpless-Hostile scale was developed to code additional indications of an unintegrated state of mind throughout the AAI (Lyons-Ruth et al., 2003; Lyons-Ruth, Yellin, Melnick, & Atwood, 2005). Such indications include, for example, the devaluation of a caregiver in combination with unconscious identification with same caregiver, and they have been associated with maternal disrupted communication as coded by the AMBIANCE system (Lyons-Ruth et al., 1999; Lyons-Ruth et al., 2005). Future studies might assess the Helpless-Hostile state of mind as an additional potential risk factor for child maltreatment.

Our finding of incoherence and an unresolved state of mind in maltreating mothers supports the possible utility of attachment-based interventions. Although short, maternal behavior-focused interventions have overall been most effective (when sensitive parenting or infant attachment was the outcome measure; Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2003), intervention effectiveness may diminish with at-risk parents (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2005). Promisingly, a short-term parenting-focused intervention improved parental sensitivity and child attachment quality in a sample of maltreating parents (Moss et al., 2011). However, in a systematic comparison of a behavior-focused program and an attachment-informed

psychotherapeutic intervention in maltreating mothers and their preschool children, the latter was found more effective (at improving children's self and other representations; Toth, Maughan, Manly, Spagnola, & Cicchetti, 2002). Although both types of intervention programs were equally effective in maltreating families with younger infants (Cicchetti, Rogosch, & Toth, 2006), a 12-month follow-up showed that the beneficial effects of the psychotherapeutic intervention on child attachment security held up better than those of the parenting-focused program (Pickreign Stronach, Toth, Rogosch, & Cicchetti, 2013). Furthermore, unresolved attachment in parents may sometimes impede the effectiveness of brief, behavior-focused interventions, as in an intervention study with adolescent mothers, especially when it obstructs fruitful dyadic interactions (Moran, Pederson, & Krupka, 2005). Trauma processing focused on integrating traumatic experiences within one organized state of mind toward attachment may therefore be a prerequisite for effective interaction-focused intervention with unresolved maltreating mothers. The inclusion of ANS measurements pre- and post-intervention could further show whether a shift from an unresolved to an organized state of mind entails changes in attachment-related autonomic regulation.

CHAPTER 5

STRESS REACTIVITY IN MALTREATING PARENTS AND AT-RISK ADULTS: REVIEW AND META-ANALYSES

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Abstract

We reviewed and meta-analyzed 11 studies (N = 524) that examined the association between (risk for) child maltreatment perpetration and basal autonomic activity and 11 studies (N = 503) that examined the association between (risk for) child maltreatment and autonomic stress reactivity. We hypothesized that higher basal levels of autonomic activity and increased stress reactivity would be found in maltreating parents and participants at risk for being abusive. The narrative review showed that evidence from significance testing within and across studies was mixed. Results of the first meta-analysis revealed that (risk for) child maltreatment was associated with higher levels of baseline autonomic nervous system (ANS) activity (g = 0.24) when measures included indices influenced by both the sympathetic and the parasympathetic branches (such as heart rate and blood pressure). The second meta-analysis yielded no differences in ANS stress reactivity between maltreating/at-risk participants and non-maltreating/low-risk comparison groups. Power analyses showed that most studies reviewed were underpowered. Results are discussed within the framework of allostatic load, and future directions for research are suggested.

Key words: child maltreatment, review, autonomic nervous system, stress, meta-analysis

Introduction

The possibility that dysregulated psychophysiology may serve as a risk factor for child maltreatment has been the topic of long-standing (albeit intermittent) research interest, particularly with respect to the activity of the autonomic nervous system (ANS). The ANS may be considered an endophenotype with relevance for the etiology of child maltreatment because of its role in emotion regulation and behavioral responsiveness (Stemmler, 2004; Sturge-Apple, Skibo, Rogosch, Ignjatovic, & Heinzelman, 2011). Autonomic stress reactivity may provide real-time insight into the nature of maltreating parents' responses to their children. Prior research has suggested increased ANS (re)activity in maltreating parents and individuals at risk for perpetrating child maltreatment; however, inconsistent findings across as well as within studies have been noted (McCanne & Hagstrom, 1996). Furthermore, the last review of the literature on this topic was conducted approximately 20 years ago (McCanne & Hagstrom, 1996), and effect size estimates for the association between physiological (re)activity and (risk for) child maltreatment have not been assessed using meta-analytic methods. To address this gap in the literature, we reviewed the literature and conducted two meta-analyses: one examining the association between (risk for) child maltreatment and baseline ANS activity levels, and another examining the association between (risk for) child maltreatment and ANS stress reactivity.

The ANS is a component of the biological stress system (Stratakis & Chrousos, 1995). It regulates the visceral organs and consists of the parasympathetic and the sympathetic branches whose functions, generally speaking, lead to opposite effects. The parasympathetic division slows down heart rate and stimulates digestion, promoting the conservation and recuperation of energy (i.e., anabolic processes). The sympathetic nervous system increases heart rate and inhibits digestion, mobilizing the body in response to, or in anticipation of, environmental challenges (i.e., catabolic processes; Viamontes & Nemeroff, 2009). In response to stress, parasympathetic influences are typically inhibited, while the sympathetic nervous system is activated. ANS activation helps individuals adapt to changing circumstances and maintain stability through change, a process called allostasis (McEwen & Seeman, 1999). When stressful environmental demands are chronic or too frequent, physiological responses may become dysregulated and have detrimental consequences, a condition referred to as allostatic load (Beckie, 2012; Sterling & Eyer, 1988). Autonomic dysregulation may underlie

maladaptive behavior, including inadequate parenting (Sturge-Apple et al., 2011).

Autonomic stress reactivity as a correlate of child maltreatment was first examined in the 1970s (Disbrow, Doerr, & Caulfield, 1977). In their seminal study, Frodi and Lamb (1980) measured heart rate, blood pressure, and skin conductance in abusive and nonabusive mothers as they viewed videos of a crying/smiling infant. The Frodi and Lamb findings sparked additional interest in the role of autonomic stress reactivity and (risk for) child maltreatment, leading to other studies on this topic (e.g., Casanova, Domanic, McCanne, & Milner, 1992; Crowe & Zeskind, 1992; Friedrich, Tyler, & Clark, 1985; Pruitt, & Erickson, 1985; Stasiewicz & Lisman, 1989); Wolfe, Fairbank, Kelly, & Bradlyn, 1983). A narrative review summarizing the findings of these early studies concluded that maltreating/at-risk participants appeared to exhibit increased autonomic reactivity to stressors compared to their nonmaltreating/low-risk counterparts (McCanne & Hagstrom, 1996). This was consistent with the aggressive nature of child physical abuse (Lorber, 2004), the maltreatment subtype on which most of the reviewed studies focused. On the other hand, findings were notably mixed, possibly because studies have varied with respect to sample characteristics (e.g., ranging from maltreating parents to nonparents at risk for child maltreatment), standardized stressors (e.g., ranging from recordings of infant cry sounds to nonchild-related tasks such as solving anagrams), and autonomic measures assessed (e.g., skin conductance, heart rate). Two recent studies found that maltreating and at-risk parents may respond with *less* autonomic arousal to stress than their respective comparison groups (Crouch et al., 2015; Reijman et al., 2014, 2015).

Considering the differences in methodology and findings across studies, and the long lapse since the last review (McCanne & Hagstrom, 1996), the present study was designed to provide an updated narrative review of the literature with a focus on the following research questions: (1) Is (risk for) child maltreatment associated with increased ANS baseline activity? (2) Is (risk for) child maltreatment associated with increased ANS stress reactivity? The qualitative approach of the narrative review offers a descriptive synthesis of the evidence, and allows for an in-depth and critical analysis of methodological discrepancies across studies (Petticrew & Roberts, 2006). On the other hand, narrative reviews cannot quantitatively assess the *combined* effect size over studies. A single study may lack statistical power to detect significant differences between groups, and meta-analysis is a tool to assess overall effects across studies. Therefore, we also conducted two

meta-analyses to estimate overall effect sizes for (1) the relationship between (risk for) child maltreatment and autonomic baseline activity, and (2) the association between (risk for) child maltreatment and autonomic stress reactivity. In both meta-analyses, we distinguished between mixed indices of the ANS (i.e., under both sympathetic and parasympathetic influence, e.g., heart rate, respiration rate), sympathetic indices (e.g., skin conductance), and parasympathetic indices (e.g., respiratory sinus arrhythmia).

Based on conclusions from the above mentioned review (McCanne & Hagstrom, 1996), we hypothesized that maltreating and at-risk individuals (compared to nonmaltreating/low-risk individuals) would show (1) greater (generic) ANS and SNS baseline arousal and greater stress reactivity (defined as increase of arousal in response to stress), and (2) lower PNS baseline levels and lower levels of PNS stress reactivity. Furthermore, we examined variables that might explain differences in effect sizes across studies. Identification of moderators may explain divergent results and provide valuable directions for future research. Specifically, we looked at the following variables as potential moderators: (a) parenting status (whether participants were parents or not); (b) maltreatment status (whether participants had been substantiated for maltreatment or had been identified as at risk); (c) maltreatment type (physical abuse only vs inclusion of neglect); (d) presentation of stimulus (auditory, visual, or real-life); (e) the percentage of women in the sample; (f) sample size; and (g) year of publication. Power analyses were performed to evaluate the adequacy of the sample sizes of individual studies.

Method

Literature search and inclusion criteria

We used four search methods in order to retrieve relevant studies. Specifically, we searched the databases Embase, PsycInfo, PubMed, and Web of Science using the following search terms: "*child maltreatment*" *OR* "*child abuse*" *OR* "*child neglect*" *OR* "*physical abuse*" *OR* "*physical neglect*" *OR* "*emotional abuse*" *OR* "*emotional neglect*") *AND (parent* OR mother* OR father* OR caregiv* OR risk) AND (autonomic OR physiolog* OR cardiovascular OR HR OR* "*blood pressure*" *OR DBP OR SBP OR respirat* OR RR OR HRV OR amylase OR sAA OR sympathetic OR electrodermal OR* "*skin conductance*" *OR SCL OR SCR OR parasympathetic OR vagal OR*

RSA.[1] Second, these same terms were used to assess potentially eligible dissertations and conference proceedings. Third, we searched Web of Science for references to pioneering articles (i.e., Frodi & Lamb, 1980; McCanne & Hagstrom, 1996). Finally, the reference sections of eligible articles and dissertations were checked for additional potentially eligible papers. Eligibility was based on three main inclusion criteria: (1) The sample consisted of parents with substantiated child maltreatment, or participants (parents or nonparents) at high risk for child maltreatment as assessed by a validated instrument (e.g., Child Abuse Potential [CAP] Inventory) or defined as such by the authors based on a substantial number of risk factors; (2) at least one index of the ANS was measured; (3) the physiological measurement included ANS baseline activity and/or stress reactivity. The stress-invoking stimulus could be child-related (e.g., video of a crying infant) or nonchild-related (e.g., having to complete a series of anagrams).

From the 1142 studies obtained through the search of electronic databases, a sample of 150 abstracts was randomly selected in order to establish intercoder reliability with respect to decisions about inclusion in the narrative review and meta-analyses. Two of the authors (RH and SR) independently coded the 150 abstracts as either *not eligible* or *eligible* (i.e., selected for inclusion). When abstracts were potentially eligible but did not provide sufficient information to determine eligibility, the full text articles were retrieved and coded. The two authors reached 100% consensus on studies coded as eligible. Having established adequate intercoder reliability, the remaining abstracts obtained from the literature search were divided between RH and SR for independent coding with respect to inclusion or exclusion. In the case of multiple eligible publications reporting (partly) on the same sample, only the publication with the most available physiological data was included. This ensured that every participant was represented just once in each meta-analysis performed in the present study. For instance, Reijman et al. published two papers on autonomic (re)activity in a largely overlapping sample of maltreating mothers (2014; 2015). The latter included one autonomic measure, namely salivary alpha-amylase, while the former included four, i.e. heart rate, vagal tone, pre-ejection period,

[1] Our initial intent was to include studies on the association between perpetration of child maltreatment and hypothalamic-pituitary-adrenal axis (re)activity, and relevant terms were part of the literature search, but this did not render a sufficient number of studies to be separately meta-analyzed.

and skin conductance, and was therefore selected for inclusion in the meta-analyses. Twelve studies published or submitted for publication between 1977 and 2015 were identified as eligible for inclusion in the present study: 11 included ANS baseline measures and 11 included ANS stress reactivity (10 studies reported both ANS baseline measures and ANS stress reactivity and thus were included in both meta-analyses). Narrative reviews of these 12 studies are provided below (see also Table 1).

When participants were exposed to multiple stressors/stimuli (Casanova et al., 1992; Friedrich et al., 1985; Frodi & Lamb, 1980; Pruitt & Erickson, 1985), we selected one stressor from each study for inclusion in the meta-analyses. This was done for several reasons. First, it ensured that each participant would be represented only once in each meta-analysis. Including multiple effect sizes for samples exposed to multiple stressors would have given more weight to those samples than to others. Alternatively, we could have calculated one combined effect size for the multiple stressors, but this strategy would have made studies less comparable and it would also have made moderator analyses for *presentation of stimulus* impossible. The hierarchy of criteria used to select a single stressor from studies that presented multiple stressors was as follows: a) psychosocial stimuli such as cry sounds were preferred over physiological tasks such as immersing a foot in ice-cold water; b) child-related stimuli were considered more relevant than nonchild-related stimuli; and c) stress-invoking stimuli were selected over nonstress-invoking stimuli. These eligibility criteria led to the inclusion of the stressful film task in the Casanova et al. (1992) study, the audiotaped infant crying in the Friedrich et al. (1985) study, and the video of the crying infant in the Frodi and Lamb (1980) and Pruitt and Erickson (1985) studies.

Narrative review

Parents with substantiated child maltreatment. Six studies included parents who had been substantiated for abuse and/or neglect of their children. Creaven, Skowron, Hughes, Howard, and Loken (2014) recruited 52 mother-child dyads in which the mother had been a perpetrator of child abuse or neglect. Child Protective Services (CPS) records were coded using the Maltreatment Classification System (MCS; Barnett, Manly, & Cicchetti, 1993). The group was compared to 52 mother-child dyads without previous CPS records. Maltreating and nonmaltreating mothers did not differ on age, employment status, child age, or child sex, but maltreating mothers were less educated and had

lower household incomes. For a baseline assessment in the lab, dyads were seated together on a couch under dim lights and watched a low-action animation film for five minutes. Heart rate (HR) and respiratory sinus arrhythmia (RSA) were measured in both mother and child. Maltreating mothers showed significantly higher HR and lower RSA at baseline than nonmaltreating mothers. Although dyads' HR and RSA were measured during a joint task, the study did not assess autonomic *stress* reactivity.

The remaining five studies included measurements of autonomic responses to stressful child-related stimuli. Disbrow et al. (1977) recruited 22 physically abusive and 24 neglectful parents via CPS. Of the total sample 63% were mothers. Maltreating parents were matched to a nonmaltreating comparison group on age, education, ethnicity, relationship status (single vs in a couple), and children's age. The comparison group was screened to verify they had not been previously reported to CPS. In the lab, parents watched a videotape of interactions between a mother, father, and child of the same race as themselves. The tape included pleasant and stressful interactions. For the baseline assessment, neutral colors were presented before the start of the tape, as well as in between interaction scenes. No information was reported on whether groups differed in autonomic arousal during baseline. Information on differential reactivity from baseline to the stressful interaction scenes was reported only for HR. The change in HR from baseline to the stressful interaction scenes did not differ significantly for maltreating and comparison parents.

Frodi and Lamb (1980) included 14 physically abusive and 14 comparison mothers. Abusive mothers were recruited through Parents Anonymous and all admitted to having abused at least one of their children. The comparison group was individually matched to the abuse group on age, marital status, social class, number of children, and children's age. Participants watched two videotapes with three 2-min segments each (also used by Pruitt & Erickson, 1985, see below). The first and last segment of each tape showed an infant quiescent but alert. The middle segment of one tape showed the same infant smiling and cooing, while the middle segment of the other tape showed the infant crying. The order of presentation of the two tapes was counterbalanced. HR, skin conductance (SC), and diastolic blood pressure (DBP) were measured during a 2-min rest period and the first and last 30 seconds of each video segment. For reactivity analyses, the last 30 seconds of the first segment showing the infant quiescent were used as a baseline from which change scores were calculated. Abusive and nonabusive mothers

did not differ on baseline levels for any of the autonomic measures. However, abusive mothers showed greater HR and SC increases, but smaller DBP increases than nonabusive mothers in response to the crying infant.

Wolfe et al. (1983) also made use of the presentation of videotapes. A group of seven mothers who had been referred to a treatment program by the local child welfare agency after verification of child abuse and seven comparison mothers participated. The groups were individually matched on education, income, number of children, children's age, and parent-reported child behavior problems. After a 5-min resting baseline, mothers watched a 3-min videotape with 12 scenes of mother-child interactions. Some interaction scenes were stressful (e.g., dyadic conflicts) whereas others were not (e.g., mother and child playing together). After that, a 5-min post-task baseline was recorded. HR, respiration rate (RR), and SC responses were measured during baseline and while viewing the interaction scenes. Eight scenes, of which the level of stressfulness was agreed on by more than 65% of mothers, were included in analyses. Although means and standard deviations for autonomic values at baseline and during the stressful scenes were displayed for both abusive and nonabusive mothers, whether the groups differed significantly on autonomic arousal at baseline was not reported. Using baseline levels as a covariate, abusive mothers showed higher SC and RR during the stressful scenes than nonabusive mothers. There were no effects for HR.

Friedrich et al. (1985) and Reijman et al. (2014) used infant cry sounds as a stressor. Friedrich et al. (1985) had a sample of abusive (n = 14), neglectful (n = 13), and comparison mothers (n = 15). Maltreating mothers had been substantiated for abuse or neglect within the past year. The comparison group received financial aid from the county welfare office and during the time they were receiving the assistance no reports of abuse or neglect were filed against them. The three groups did not differ on age, education, income, marital status, or children's age, although abusive and neglectful mothers on average had more children than comparison mothers. Mothers listened to a 9-min audiotape on which 1-min sounds of white noise, a tone, and infant crying were alternated. Results for the cry sound were selected for this review and the meta-analyses (see inclusionary criteria described above). The order of presentation of the segments was counterbalanced, but the cry sound was always preceded by the nonstressful white noise. HR, finger blood volume (FBV), and SC were measured during a 7-min baseline and throughout the presentation of the audiotape. There were no differences

between the groups on any of the measures at baseline. For HR and FBV, reactivity to the cry sound was analyzed as the difference between mean values at baseline and during the cry. There were no significant differences among the maltreatment groups for HR reactivity or FBV reactivity. For SC, reactivity was analyzed in two ways: as the increase from the last 10 seconds of white noise to the first 10 seconds of the cry (deflections), and as the total number of seconds SC was higher during the cry than during baseline. There were no differences between groups in their SC deflections, but there was a difference between groups on the number of seconds above baseline. Particularly during the second cry segment, both the abusive and neglectful groups showed more sustained SC increase from baseline as compared to the comparison group.

Reijman et al. (2014) recruited a sample of maltreating mothers through a mental health clinic, where mothers received therapy focusing on their parenting problems. Incidents of abuse and neglect were coded from CPS records. All mothers were found to be neglectful, while about half were also abusive. Nonmaltreating mothers were recruited from a different subdivision of the same mental health clinic, where their children were in therapy for a developmental or learning disorder. In this group, the Maternal Maltreatment Classification Interview (Cicchetti, Toth, & Manly, 2003) was conducted to verify the absence of maltreatment incidents. Physiological data were available for 42 maltreating and 38 nonmaltreating mothers. The groups did not differ on ethnicity, education, medication intake, number of children, or whether children were clinically diagnosed, but maltreating mothers and their children were significantly younger, more maltreating mothers smoked, and fewer exercised as compared to the nonmaltreating group. These variables (age, smoking, and exercise habits) were controlled for in the analyses. After watching neutral images during a 5-min baseline assessment, they listened to nine 10-sec infant cries of varying pitches. HR, pre-ejection period (PEP), vagal tone (RMSSD), and SC were measured throughout. No differences were found between the groups for any of the autonomic variables at baseline. From baseline to the cry sounds, maltreating and nonmaltreating mothers showed similar HR and RMSSD responses, but there was an effect of maltreatment status on PEP reactivity, with maltreating mothers showing a nonsignificant PEP decrease, while the comparison group showed a nonsignificant PEP increase. Finally, maltreating mothers showed less SC reactivity than nonmaltreating mothers.

Summary. Of these six studies with maltreating parents, one provided evidence supporting the association between child maltreatment and

higher levels of baseline autonomic arousal, with lower parasympathetic activation (Creaven et al., 2014). Information on autonomic differences at baseline was not reported by Disbrow et al. (1977) or Wolfe et al. (1983). The three remaining studies found no significant associations between child maltreatment status and baseline levels of autonomic arousal (Friedrich et al., 1985; Frodi & Lamb, 1980; Reijman et al., 2014).

Regarding the association between child maltreatment status and reactivity to stressful stimuli, evidence was mixed as well. In the Frodi and Lamb (1980) and in the Wolfe et al. (1983) studies, effects for two out of three autonomic measures supported the link between child maltreatment and increased stress reactivity. Friedrich et al. (1985) found that abusive and neglectful mothers showed more sustained increases in SC than comparison mothers during a cry sound as compared to baseline, but there were no differences between groups in SC deflections, HR reactivity, or FBV reactivity. In Reijman et al. (2014), only the differential direction of PEP responses to infant crying suggested slightly more sympathetic reactivity in maltreating mothers. However, maltreating mothers showed weaker SC responses than nonmaltreating mothers, indicating less sympathetic reactivity, while there were no significant effects for HR or RMSSD. Finally, autonomic stress reactivity did not distinguish abusive from comparison parents in Disbrow et al. (1977).

Parents and nonparents at risk for child abuse. Six studies assessed the risk for committing child abuse in parents and nonparents. Five of the six studies used a validated instrument designed to assess risk for child physical abuse, namely the Child Abuse Potential Inventory (CAP Inventory; Milner, 1986; Milner & Wimberley, 1979). The CAP Inventory is a self-report questionnaire that consists of 160 statements to which respondents are asked to indicate whether they agree or disagree. It consists of an abuse potential scale (77 items), six factor scales (e.g., distress, rigidity, unhappiness, various interpersonal problems), and three validity scales to detect if respondents answered randomly, faked good (i.e., denied problems), or faked bad (i.e., exaggerated problems). Adequate construct validity, internal consistency, and stability over time have been demonstrated across numerous samples (see Milner, 2004, for a review, but see Voorthuis et al., 2014).

Casanova et al. (1992) recruited 151 parents from day-care and social service agencies. All were screened with the CAP Inventory. Respondents with valid answers were included in the high-risk group if they scored 166 or higher (the signal detection cut-off score), while those who scored below the median norm abuse score of 66 were considered

low risk. Fifteen high-risk mothers were individually matched with 15 low-risk mothers on ethnicity, age, marital status, number of children, and children's age. The two groups of mothers were exposed to a series of nonchild-related stimuli, namely a cold pressor task, a stressful film, unsolvable anagrams, and car horn sounds. For each task, HR and SC were measured the minute prior to stimulus onset (baseline), the minute of stimulus presentation, and the minute after stimulus completion. Results for the stressful film were selected for inclusion in this review and the meta-analyses (see inclusion criteria described above). The stressful 1-min film displayed two industrial accidents. There were no differences in HR during baseline, while no information was reported on significant differences between groups for SC baseline levels. The stressful film evoked a stress response on both ANS measures, but no significant differences between high- and low-risk mothers in HR reactivity and SC reactivity (from baseline to film exposure) were found.

Crouch et al. (2015) studied a sample of 48 parents, of which 28 were women. Parents with valid response patterns on the CAP Inventory were classified as high-risk if their CAP abuse score was at or above the signal detection cut-off score of 166, while those with a score below 166 were considered low-risk. The two groups did not differ significantly on age, gender, education, annual household income, marital status, or number of children, but more high-risk parents were African American. Race/ethnicity was not associated with any of the outcome measures. All parents completed a computer task which required them to solve as many anagrams as possible in three minutes. Participants were randomly assigned to either a difficult anagram condition or an easy anagram condition. HR and RSA were measured during a 3-min baseline and during the anagram task. At baseline, high-risk parents showed higher HR and lower RSA than low-risk parents. In response to the anagram task, HR and RSA of high-risk parents did not change, while low-risk parents showed an increase in HR and a decrease in RSA. Difficulty of the anagram task did not moderate patterns of change in HR or RSA over time.

The four remaining studies sampled nonparents and used child-related stimuli. Pruitt and Erickson (1985) recruited 61 nonparents who were 30 years of age or younger. Based on the CAP Inventory, placement in the high- versus low-risk groups was determined by taking the upper and lower 33% of nonweighted abuse scores. Twenty-two participants (14 women) were classified as high-risk (nonweighted abuse score > 9.1) and 22 participants (16 women) were classified as low-risk (nonweighted abuse score $\leq$ 4). No matching of the groups on demographics was

reported. Participants were shown two videotapes that were 6 min each. One video showed a 5-month old female infant first quiescent but alert (2 min), smiling and cooing (2 min), then again quiescent (2 min), while the other video showed the same infant quiescent (2 min), crying (2 min), and quiescent (2 min). The same videotapes had been used by Frodi and Lamb (1980; see above). Whether the video with the smiling or the crying infant was shown first was counterbalanced within women/men in the low/high risk groups. HR and SC responses were measured 2 min before and throughout the videotapes. Results were reported in peak HR and peak SC rather than mean levels. Autonomic patterns across the set of videotapes were analyzed, so that baseline activity and reactivity to the crying infant specifically were not included. The authors reported that overall, high-risk participants had significantly higher peak HR and marginally lower peak SC, and showed lower HR variability in response to the videos. There were no significant differences between the low-risk and high-risk groups with respect to SC reactivity in response to the videotapes.

Crowe and Zeskind (1992) screened 284 introductory psychology students for child physical abuse risk using the CAP Inventory. After excluding students whose responses on the CAP Inventory were invalid or incomplete, 30 participants were selected with either high CAP scores (upper 28th percentile of scores; M = 283, SD = 40.7) or low CAP scores (lower 28th percentile of scores; M = 53, SD = 50.4). Both groups consisted of eight men and seven women, and did not differ on age, ethnicity, income, or reported history of abuse. Participants listened to two audio recordings, one with four 10-sec phonated infant cry sounds and one with four 10-sec hyperphonated infant cry sounds. The first tape, containing either phonated or hyperphonated cries, was repeated twice. After a 10-min rest, the remaining tape of phonated/hyperphonated infant cry sounds was played twice. Order of presentation of the phonated/hyperphonated cries was counterbalanced within men/women in the low/high CAP groups. HR and SC were assessed two minutes before stimulus onset and throughout the presentation of the cry sounds. No significant differences at baseline between the high- and low-CAP groups were reported for HR or SC. In response to the cry sounds, the high-CAP group showed marginally greater HR changes than the low-CAP group, but in a negative direction, so that the HR of those at risk for child abuse tended to decrease, while that of the low-CAP group did not. The authors also reported a marginally significant interaction effect of CAP risk status and cry type (phonated vs hyperphonated) on SC responses, such that the high-CAP group showed

somewhat higher SC responses to the phonated sounds than the low-CAP group. There were no risk group differences in SC reactivity to the hyperphonated cry sounds.

Laud (1997) also used the infant cry sound as a stress-evoking stimulus. Participants were randomly chosen from a larger pool (N = 199) of unmarried, nonparent, female psychology students that were screened for health (including cardiovascular) and hearing concerns. Based on CAP Inventory abuse scores, 38 respondents were classified as high risk (CAP abuse score ≥ 166) and 34 respondents were classified as low risk (CAP abuse scores ≤ 63). The high-risk and low-risk groups did not differ on ethnicity, age, or education. After a 4-min resting baseline, participants listened to an infant cry sound that lasted eight minutes. HR was recorded throughout the baseline and the cry sound presentations, and systolic and diastolic blood pressures were measured every two minutes. CAP risk groups did not differ on any of the baseline autonomic measures or in their autonomic response from baseline to the cry sounds.

Stasiewicz and Lisman (1989) used the Adult-Adolescent Parenting Inventory (AAPI; Bavolek, Kline, McLaughlin, & Publicover, 1979) to assess child abuse risk in a sample of male, unmarried, nonparent undergraduate students. Participants who obtained scores in the upper 30% of the AAPI distribution of scores were classified as high-risk (n = 16) and those with scores in the lower 38% of the distribution of AAPI scores were classified as low-risk (n = 16). No information on whether the risk groups were demographically matched was reported. After a 6-min resting baseline participants were either exposed to an audio recording of the cry sounds of a medically at-risk infant or the sound of a smoke alarm. Results were reported for the two stressors combined, so that examination of data specific to the infant cry sounds was not possible. The volumes required to evoke similar levels of aversiveness in response to the infant cry sound and the smoke alarm sound had been determined in a pilot study. Infant cries and the smoke alarm sounds were presented for three minutes each and were repeated three times with 2-min breaks between presentations. DBP was assessed as an index of ANS activation. High-risk and low-risk participants did not differ with respect to baseline DBP nor in their DBP response to the infant cry/smoke alarm sounds.

Summary. Results of significance testing in most of the studies with at-risk samples found no significant evidence for a link between risk for child abuse and autonomic activity at baseline (Casanova et al., 1992; Crowe & Zeskind, 1992; Laud, 1997; Stasiewicz & Lisman, 1989), or

autonomic reactivity to stressful child- or nonchild-related stimuli (Casanova et al., 1992; Laud, 1997; Stasiewicz & Lisman, 1989). Information on autonomic baseline differences was partially or not explicitly reported in Casanova et al. (1992) and Pruitt and Erickson (1985). Crouch et al. (2015) found that high-risk parents showed higher HR and lower RSA at baseline, although the high-risk group showed less autonomic reactivity to a stressful task than the low-risk group. Crowe and Zeskind (1992) found greater HR reactivity to cry sounds in the high-risk group, but the reactivity constituted a decrease rather than an increase in arousal. In Pruitt and Erickson (1989), high-risk participants showed no HR change in response to a video of a crying infant, while the low-risk group showed a HR decline. There were no other risk group differences in autonomic reactivity to the stressors used in the reviewed studies.

Table 1
Summaries of reviewed studies

Study	*Sample size*	*Parent status*	*Malt status*	*Cut-off scores*	*Malt subtype*	*Autonomic measures*	*Stressor*	*Relevant findings*	
Disbrow et al., 1977	83	parents	substantiated	N/A	abuse and neglect	HR, SC	videos of stressful dyadic interactions	*B*	N/I
								R	N.s.
Frodi & Lamb, 1980	28	parents	substantiated	N/A	abuse	HR, DBP, SC	video crying infant	*B*	N.s.
								R	↑ HR, SC; ↓ DBP
Wolfe et al., 1983	14[a]	parents	substantiated	N/A	abuse	HR, RR, SC	videos of parent-child conflict situations	*B*	N/I
								R	↑ RR, SC; n.s. for HR
Friedrich et al., 1985	42	parents	substantiated	N/A	abuse and neglect	HR, FBV, SC	infant cry sound	*B*	N.s.
								R	N.s. for HR, FBV; ↑ SC sec above baseline

Pruitt & Erickson, 1985	44	nonparents	high-risk (CAPI)	upper 33% (≥ 9.1) lower 33% (≤ 4.0)	physical abuse	HR, SC	video crying infant	*B*	N/I
								R	↓ HR; SC $p > .05$
Stasiewicz & Lisman, 1989	32	nonparents	high-risk (AAPI)	upper 30% lower 30%	abuse	DBP	infant cry sound and smoke alarm	*B*	N.s.
								R	N.s.
Casanova et al., 1992	30	parents	high-risk (CAPI)	> 166 < 66	physical abuse	HR, SC	stressful film	*B*	N.s. for HR; N/I for SC
								R	N.s.
Crowe & Zeskind, 1992	30	nonparents	high-risk (CAPI)	upper 28% (*M*=283, *SD*=40.7) lower 28% (*M*=53, *SD*=50.4)	physical abuse	HR, SC	infant cry sounds	*B*	N.s.
								R	↑ HR (decrease); ↑ SC to phonated sounds
Laud, 1997	72	nonparents	high-risk (CAPI)	≥ 166 ≤ 63	physical abuse	HR, DBP, SBP	infant cry sound	*B*	N.s.
								R	N.s

Creaven et al., 2014	104	parents	substantiated	N/A	abuse and neglect	HR, RSA	N/A	*B*	↑ HR; ↓ RSA
								R	N/A
Reijman et al., 2014	80[b]	parents	substantiated	N/A	abuse and neglect	HR, RMSSD, PEP, SCL	infant cry sounds	*B*	N.s.
								R	↓ SC; ↑ PEP; HR, RMSSD *p*s > .05
Crouch et al., 2015	48	parents	high-risk (CAPI)	> 166 < 166	physical abuse	HR, RSA	anagrams	*B*	↑ HR, ↓ RSA
								R	↓ HR, RSA

[a] For SC results in Wolfe et al., *N* = 10

[b] For PEP results in Reijman et al., *N* = 77

Note. Malt = maltreatment; CAPI = Child Abuse Potential Inventory; AAPI = Adult-Adolescent Parenting Inventory; HR = heart rate; SC = skin conductance; RSA = respiratory sinus arrhythmia; FBV = finger blood volume; DBP = diastolic blood pressure; SBP = systolic blood pressure; RMSSD = root mean square of successive differences; PEP= pre-ejection period; RR = respiration rate; B = Baseline; R= Reactivity; N.s. = Not significant; N/A = does not apply; N/I = no information reported. Relevant findings are reported for maltreating or at-risk populations relative to nonmaltreating or low-risk control groups, at $p < .05$.

Conclusion. Across both sets of studies on parents with substantiated maltreatment and individuals at risk for abuse, only two studies provided evidence (based on significance testing) supporting heightened autonomic activity and lower parasympathetic activation at baseline among maltreating/at-risk individuals (Creaven et al., 2014; Crouch et al., 2015, respectively). These two studies (as well as the seven studies that did not find ANS baseline differences) varied in their sample characteristics (substantiated maltreatment vs at-risk status), maltreatment type (abuse and neglect vs risk for physical abuse), gender ratio (mothers only vs mothers and fathers), sample size (N = 104 vs N = 48), and baseline procedure (watching a video in the presence of their child vs resting in solitude). This state of affairs makes it hard to identify variables that may explain differences in results across studies. Both Creaven et al. and Crouch et al. measured HR and RSA, but studies that did *not* find group differences on ANS baseline activity also included HR and RSA as outcome measures (e.g., Reijman et al., 2014). Synthesis of the findings is further complicated by the fact that several studies did not statistically test (or report) whether the maltreating/at-risk groups differed from their comparison groups on ANS baseline values, despite reporting the respective values. Group differences could not be reviewed in those cases (although effect sizes could potentially be calculated and included in a meta-analysis; see below).

Regarding ANS stress reactivity as a risk factor for child maltreatment, the least equivocal findings were presented by Frodi and Lamb (1980) and Wolfe et al. (1983). Both samples consisted of physically abusive parents, all mothers, who were presented with stress-invoking, child-related videotapes. Common autonomic measures were HR and SC, and abusive mothers showed heightened SC stress reactivity in both studies. Frodi and Lamb (1980) additionally found greater HR reactivity in the abusive group while Wolfe et al. (1983) did not. The remaining three studies with maltreating samples (which included neglectful parents) and none of the studies with at-risk samples showed differential stress reactivity. This tentatively suggests that increased sympathetic reactivity is a risk factor specific to substantiated physical abuse. Operational variation was also present in the set of studies using the CAP Inventory, with cut-off scores being criterion-referenced (i.e., signal detection score of 166) in some studies and norm-referenced (e.g., upper vs lower 33 percentile of sampled scores) in others. Such differences in methodology may help explain the variability of findings observed across studies.

Moreover, small sample sizes may have contributed to instability of results across the studies reviewed (e.g., exaggerated effect sizes, low positive predictive power, increased risk of either Type I or Type II errors; for a discussion of these issues see Button et al., 2013). Use of small samples makes it difficult to draw conclusions from individual studies based on significance testing. A systematic review of effect sizes across studies is needed to determine which (if any) of these issues associated with small effect sizes might be operating in this literature.

Meta-analytic Procedures

Although the narrative review conveys the similarities and differences of the methods and the results of significance testing across studies, it does not quantitatively analyze the strength of the effects observed. Results of the narrative review revealed seemingly contradictory findings (based on significance testing) among as well as within studies (e.g., Frodi & Lamb, 1980; Reijman et al., 2014), an observation that is consistent with that of an earlier review (McCanne & Hagstrom, 1996). Meta-analysis is thus warranted to assess the overall effects for the relation between (risk for) child maltreatment and autonomic baseline activity as well as stress reactivity, and to test whether effects may be moderated by sample or study characteristics.

Moderators

For the meta-analyses, we coded two types of moderators: sample-related and procedure-related. Sample-related moderators were *maltreatment status* (categorical: substantiated maltreatment vs risk for physical abuse) and *percentage of women* in the sample (continuous). Procedural characteristics were *presentation of stressor* (categorical: auditory vs visual vs real-life stimuli), *publication year* (continuous), and *sample size* (continuous). The potential moderators *parenting status* (whether participants were parents or not) and *maltreatment type* (studies that focused on [risk for] physical abuse vs studies that included neglect) were excluded because of their high overlap (83% in both cases) with *maltreatment status* in the current set of studies. Interrater reliability of the coding of moderators was good, with intraclass correlations for continuous moderators ranging from .96 – 1, and kappas for categorical moderators ranging from .85 – 1.

Statistical analyses

We performed meta-analyses on two overall outcomes: the association between (risk for) child maltreatment and ANS baseline

activity, and the association between (risk for) child maltreatment and ANS stress reactivity. Within each of these two sets of studies, we conducted several meta-analyses: one for mixed ANS measures (i.e., a combination of mixed indices of both the sympathetic and parasympathetic branches, such as HR, blood pressure, RR); one for the sympathetic nervous system (measured relatively purely as SC or PEP); one for the parasympathetic nervous system (as indicated by RSA/RMSSD); and one for HR alone, since it was included in the large majority of studies. Study outcomes were entered in Comprehensive Meta-Analysis (CMA; Borenstein, Rothstein, & Cohen, 2005). In the case of mean values being reported without standard deviations, we estimated the latter based on the *SD*s for the corresponding autonomic measure in Reijman et al. (2014). *SD*s of SC levels in Pruitt and Erickson (1985) were estimated based on Casanova et al. (1992) because SC was reported in micromhos x 10^6 in both papers. CMA transformed the outcomes into Hedges' *g* effect sizes, which is appropriate for smaller sample sizes such as ours (Cumming, 2012; Lakens, 2013). In line with our hypothesis that (risk for) child maltreatment would be associated with higher levels of (re)activity, effects in that direction were marked positive, while effects in the opposite direction were identified as negative. Reactivity was defined as *increases* in arousal in response to stress, i.e., ANS and SNS increases and PNS decreases. In the case of findings indicated as nonsignificant but without further statistical details, we assigned a zero effect size at $p = .50$ (Mullen, 1989). These cases are marked with an asterisk in Figure 1. Confidence intervals (CIs) of 95% around the point estimate of every effect size are reported.

Almost all studies had more than one ANS outcome measure. For our analyses on the ANS subsystems (SNS, PNS, mixed ANS), combined effect sizes were calculated for measures belonging to the same subsystem. For instance, for Reijman et al. (2014), a combined effect size for the sympathetic branch was calculated from the measures of SC and PEP. Similarly, for Wolfe et al. (1983), a combined effect size was calculated from HR and RR, which are both mixed indices of the sympathetic as well as the parasympathetic branch and may be considered markers of generic ANS arousal.

Statistics for the combined effect sizes (with 95% CIs) and moderator analyses were drawn from random effect models. Random effect models are based on the assumption that studies differ in their characteristics, and since meta-analytical results are calculated from this assumption, they may be generalized to studies not sampled in the meta-analysis, but belonging to the same population (Hedges & Vevea, 1998). We tested the

homogeneity of different sets of effect sizes and moderating effects of categorical variables with the *Q* statistic (Borenstein et al., 2005). Contrast analyses for categorical moderators were conducted only when there were at least two groups with $k \geq 4$ (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2003). Continuous moderators were tested in univariate as well as multivariate regression models, since *year of publication* and *sample size* were correlated ($r = .56$, $p = .04$). We also performed a series of cumulative meta-analyses according to *year of publication*, in which the combined effect size with the addition of each new study is calculated, to further inspect time-related trends.

In the case of significant combined effect sizes, funnel plots were inspected for potential publication bias, i.e., the tendency for small studies with nonsignificant or unexpected results to remain unpublished, which would be visually represented by the funnel plot's asymmetrical base. We calculated a fail-safe number to reflect the number of studies with null results necessary to reduce the effect size to a nonsignificant effect. Finally, we conducted power analyses for individual studies based on the combined effect sizes in the program G-Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2007), to calculate (1) the sample size required to detect the combined effect size, with $\alpha = .05$ and a power of .80, and (2) the power of each study to detect the combined effect size, given their sample size and $\alpha = .05$.

No outliers were found for any of the continuous moderators (standardized *z*-scores < -3.29 or > 3.29; Tabachnik & Fidell, 2001). Checks for outliers in effect sizes were done at the level of analysis, i.e., for sympathetic, parasympathetic, and generic autonomic measures separately, and revealed no outliers.

Results

Child maltreatment and ANS baseline activity

Point estimates and respective CIs of the effect sizes for the outcome measures of each study included in the meta-analysis examining the link between (risk for) child maltreatment and autonomic baseline activity are presented in Figure 1. For the association between (risk for) child maltreatment and baseline activity of the ANS subsystems, we grouped mixed indices of (a) the sympathetic and parasympathetic branches to assess nonspecific ANS activity (i.e., HR, blood pressure, and RR), (b) indices of sympathetic activity only (i.e., SC, PEP), and (c) indices of parasympathetic activity only (i.e., RSA/RMSSD).

For mixed ANS basal activity, the combined effect size was significant, g = 0.24, 95% CI [0.05, 0.43], p < .05 in a homogeneous set of studies (k = 11, N = 524; Q = 11.33, p > .05). The funnel plot was symmetrical, showing no evidence for publication bias. The fail-safe number was 6, indicating that six null results would be necessary to reduce this meta-analytic finding to a nonsignificant effect. Our power analyses showed that a sample size of N = 432 would be required to detect the combined effect size g = 0.24. The power of the individual studies to detect this effect size ranged from .11 for the study with the smallest sample size to .33 for the largest sample size. The combined effect sizes for the sets of studies examining the association between (risk for) child maltreatment and sympathetic nervous system activity at baseline (k = 6, N = 234), and parasympathetic baseline activity (k = 3, N = 232) were not significant (g = 0.003 and g = 0.30, respectively; see Table 2 for statistical details).

For baseline HR, the set of studies (k = 10, N = 492) was homogeneous, Q = 11.81, p > .05. The combined effect size was significant (g = 0.24, 95% CI [0.03, 0.45], p < .05), indicating that (risk for) perpetration of child maltreatment was associated with higher HR levels at baseline.

There were no moderating effects of *maltreatment status* (p > .05). For the association between (risk for) child maltreatment and mixed ANS baseline activity, effect size estimates were significant for parents with substantiated maltreatment, but not for participants at risk (see Table 2). It bears mentioning that maltreatment status was significantly associated with parenting status, such that participants at risk (as opposed to substantiated) for maltreatment were more often non-parents (e.g., undergraduate students). Regression analyses showed no moderating effects for the percentage of female participants, year of publication, or sample size (ps > .05). Cumulative meta-analyses showed no time-related change in effect sizes.

Child maltreatment and ANS stress reactivity

Point estimates and respective CIs for all outcome measures included in the meta-analysis on the link between (risk for) child maltreatment and autonomic stress reactivity are displayed in Figure 1. The meta-analytical results are summarized in Table 3. The combined effect size for the sets of studies examining the association between (risk for) child maltreatment and mixed ANS stress reactivity (k = 11, N = 503) was not significant, g = -0.12 (see Table 3).

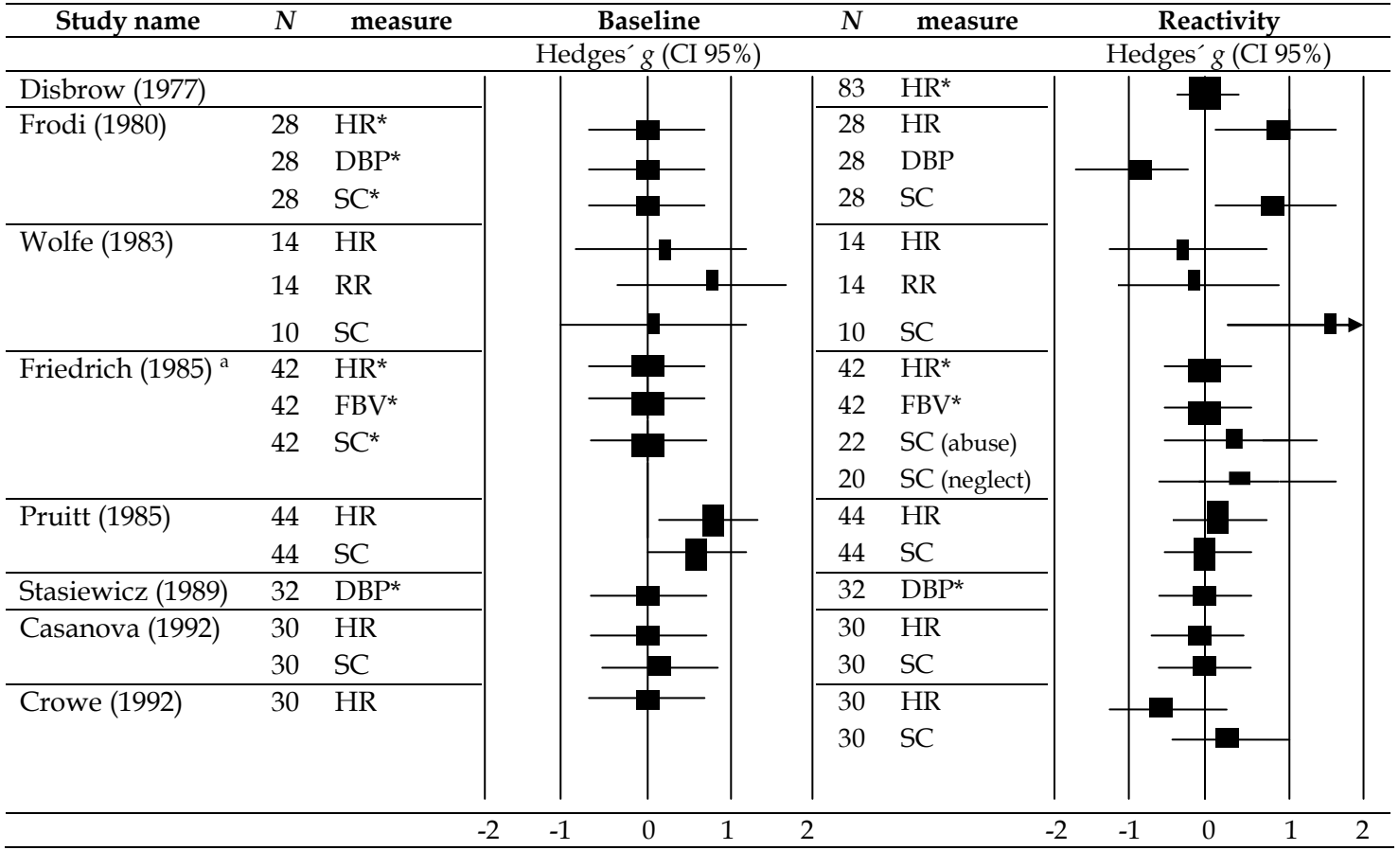
The combined effect size estimating the association between (risk for) child maltreatment and sympathetic reactivity to stressors (k = 8, N = 264) was not significant either, g = 0.27, 95% CI [-0.04, 0.58], p = .09. Finally, there was no effect for parasympathetic reactivity (g = -0.26 for k = 2, N = 128) or HR (g = -0.10 for k = 10, N = 471; see Table 3).

We found no moderating effect of *maltreatment status* or *presentation of stimulus* and there were no significant effect sizes for any of the subgroups (ps > .05). In a multivariate model, only *year of publication* predicted the effect sizes for (risk for) child maltreatment and mixed ANS reactivity, later publications being associated with negative effect sizes (p = .02). No moderating effects could be tested for the combined effect sizes on parasympathetic reactivity due to the low number of studies. In a multivariate model, *year of publication* and *gender ratio* (% women in the sample) predicted effect sizes for the association between (risk for) child maltreatment and HR reactivity (ps < .01). The regression line for *year of publication* showed a change from positive effect sizes to negative effect sizes over the years. This seems mainly due to an early study that found a large positive effect (Frodi & Lamb, 1980) and a recent study that yielded a strong negative effect (Crouch et al., 2015). The regression line for *gender ratio* showed that samples with lower percentages of women were associated with negative effect sizes, while higher percentages of women were associated with smaller negative, null, or positive effects. There were no other moderating effects. However, cumulative meta-analyses showed that for SNS stress reactivity, with each aggregated study after Frodi & Lamb (1980) and Wolfe et al. (1983) the combined effect size further approached a null effect, which is displayed in Figure 2.

Table 2
Combined effect sizes for autonomic baseline activity

	K	*N*	*g*	*95 % CI*	Q^h	Q^c
ANS	11	524	0.24*	0.05, 0.43	11.33	
Maltreatment status						0.37
Substantiated	5	268	0.30*	0.02, 0.59	2.46	
At-risk	6	256	0.18	-0.10, 0.46	8.19	
SNS	6	204	-0.003	-0.27, 0.26	0.29	
Maltreatment status						
Substantiated	4	160	-0.01	-0.33, 0.31	0.04	
At-risk	2	74	0.02	-0.44, 0.47	0.24	
PNS	3	232	0.30	-0.14, 0.75	5.50	
Maltreatment status						
Substantiated	2	184	0.17	-0.38, 0.71	3.43	
At-risk	1	48	0.67	-0.20, 1.54		
HR	10	492	0.24*	0.03, 0.45	11.81	
Maltreatment status						0.13
Substantiated	5	268	0.28	-0.03, 0.59	2.49	
At-risk	5	224	0.20	-0.13, 0.52	8.82	

Note. k = number of studies; N = number of participants; g = Hedges' g effect size; CI = confidence interval; Q^h = homogeneity index; Q^c = contrast index; ANS = autonomic nervous system; SNS = sympathetic nervous system; PNS = parasympathetic nervous system; HR = heart rate. Contrasts were tested for subgroups with $k \geq 4$. * $p < .05$


Study name
N
measure
Baseline
Hedges´ g (CI 95%)
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measure
Reactivity
Hedges´ g (CI 95%)
Disbrow (1977)
83 HR*
Frodi (1980)
28 HR*
28 DBP*
28 SC*
28 HR
28 DBP
28 SC
Wolfe (1983)
14 HR
14 RR
10 SC
14 HR
14 RR
10 SC
Friedrich (1985) a
42 HR*
42 FBV*
42 SC*
42 HR*
42 FBV*
22 SC (abuse)
20 SC (neglect)
Pruitt (1985)
44 HR
44 SC
44 HR
44 SC
Stasiewicz (1989)
32 DBP*
32 DBP*
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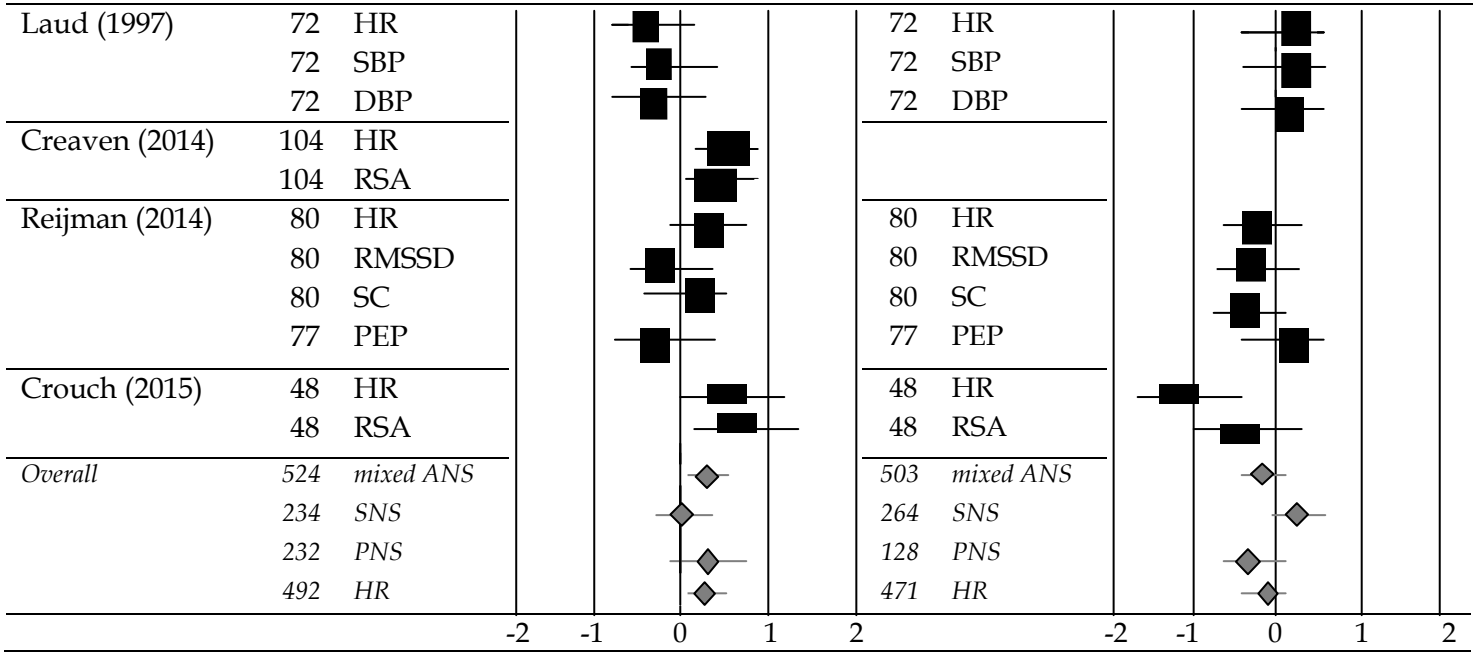

Figure 1. Effect sizes for baseline and reactivity levels for the individual studies. *Note.* HR = heart rate; RSA = respiratory sinus arrhythmia; FBV = finger blood volume; SC = skin conductance; DBP = diastolic blood pressure; SBP = systolic blood pressure; RMSSD = root mean square of successive differences (measure of vagal tone); PEP = pre-ejection period; RR = respiration rate. * Asterisks indicate that effect sizes were based on $p = .50$ due to lack of statistical details. [a] The sample of Friedrich et al. (1985) consisted of abusive, neglectful, and control mothers. For SC, results for the abusive and neglectful groups were reported separately, so we divided the control group's *n* by two in order to avoid double representation of participants.

Table 3
Combined effect sizes for autonomic stress reactivity

	K	*N*	*g*	*95% CI*	Q^h	Q^c
ANS	11	503	-0.12	-0.32, 0.09	12.61	
Maltreatment status						0.73
Substantiated	5	247	-0.03	-0.28, 0.23	0.94	
At-risk	6	256	-0.22	-0.60, 0.15	10.91	
Presentation of stimulus						0.07
Auditory	5	256	-0.05	-0.30, 0.20	3.29	
Visual	5	199	0.00	-0.28, 029	0.23	
Real-life	1	48	-1.07	-1.72, -0.42		
SNS	8	264	0.27	-0.04, 0.58	9.96	
Maltreatment status						
Substantiated	5	160	0.50	-0.03, 1.02	8.59	
At-risk	3	104	0.07	-0.31, 0.45	0.40	
Presentation of stimulus						0.89
Auditory	4	152	0.13	-0.20, 0.46	1.35	
Visual	4	112	0.47	-0.17, 1.11	7.95	
Real-life	0					
PNS	2	128	-0.26	-0.61, 0.10	0.26	
Maltreatment status						
Substantiated	1	80	-0.19	-0.63, 0.25		
At-risk	1	48	-0.38	-0.98, 0.21		
Presentation of stimulus						
Auditory	1	80	-0.19	-0.63, 0.25		
Visual	0					
Real-life	1	48	-0.38	-0.98, 0.21		
HR	10	471	-0.10	-0.36, 0.16	17.03*	
Maltreatment status						1.16
Substantiated	5	247	0.03	-0.26, 0.31	4.83	
At-risk	5	224	-0.26	-0.71, 0.19	10.84*	
Presentation of stimulus						0.83
Auditory	4	224	-0.09	-0.35, 0.17	2.65	
Visual	5	199	0.09	-0.19, 0.37	4.13	
Real-life	1	48	-1.07	-1.72, -0.42		

Note. k = number of studies; N = number of participants; g = Hedges' g effect size; CI = confidence interval; Q^h= homogeneity index; Q^c= contrast index; ANS = autonomic nervous system; SNS = sympathetic nervous system; PNS = parasympathetic nervous system; HR = heart rate. Contrasts were tested for subgroups with $k \geq 4$. * $p < .05$

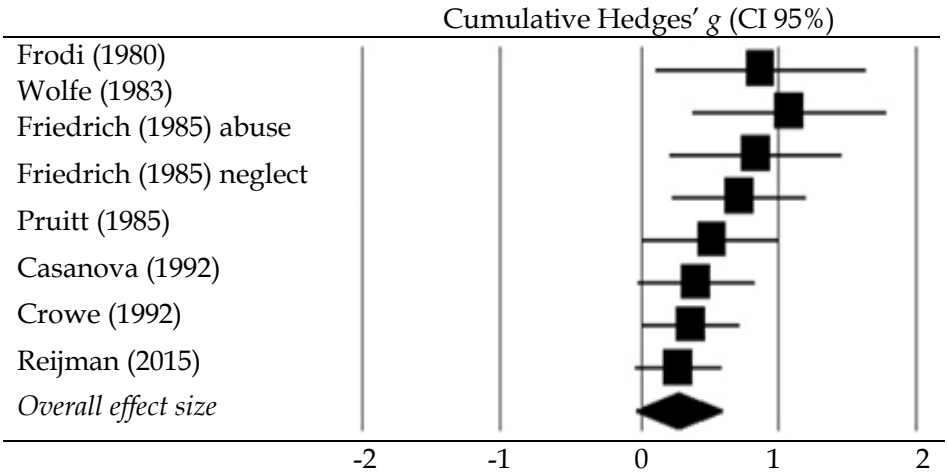

Figure 2. Cumulative effect sizes for sympathetic nervous system reactivity
The sample of Friedrich et al. (1985) consisted of abusive, neglectful, and control mothers. For sympathetic reactivity, results for the abusive and neglectful groups were reported separately, so we divided the control group's *n* by two in order to avoid double representation of participants.

Discussion

Our meta-analyses showed that maltreating parents and participants at risk for child maltreatment exhibited greater autonomic activity at rest (g = 0.24) than their respective comparison groups. This is in line with our first hypothesis and with conclusions from an earlier review (McCanne & Hagstrom, 1996). Greater autonomic activity at baseline, as observed in mixed ANS indices (e.g., HR, blood pressure, RR), suggests a chronic state of arousal in maltreating and at-risk participants, even in the absence of stressors. Because these findings are based on mixed ANS indices, it is impossible to say whether they represent impaired parasympathetic vagal regulation, sympathetic influences, or both.

In any case, the ANS responds to the environment, and cardiovascular measures are particularly sensitive to it (McEwen, 1998). Sustained cardiovascular arousal may be a sign of allostatic load, which could be caused by an environment that is continuously (perceived as) overly demanding or challenging, or by a dysregulated ANS unable to decrease activity in the absence of challenges (Friedman, Karlamangla, Gruenewald, Koretz, & Seeman, 2015; Juster, McEwen, & Lupien, 2010; McEwen, 1998). The notion of allostatic load as applied to child

maltreatment is consistent with literature identifying (early) life adversities as risk factors for child abuse and neglect, such as having experienced abuse in childhood, unemployment, single parenthood, and low social support (Stith et al., 2009). Maltreating or at-risk individuals may live in circumstances that are generally more challenging or unpredictable and such circumstances may take a toll on the regulatory function of the ANS. We found no significant effects of (risk for) child maltreatment on pure measures of sympathetic or parasympathetic baseline activity, but only a few studies have included pertinent indices (k = 5 and k = 3, respectively). Contrary to our expectations, we did not find meta-analytical evidence for increased autonomic stress responsiveness as a risk factor contributing to child maltreatment. First of all, this may have to do with the low number of studies included in the meta-analyses. For SNS reactivity, confidence intervals of the effect size (g = 0.27) bordered on zero, indicating that there may have been insufficient power for the effect to reach statistical significance. This seems compelling especially considering the SNS's prominent role in stress reactivity. On the other hand, as revealed by our narrative review, only two early studies (Frodi & Lamb, 1980; Wolfe et al., 1983) found that abusive mothers responded with higher SNS increases to a stressor. The cumulative meta-analyses showed that each aggregated study since then has approximated the overall effect to a null effect. This suggests that the hypothesized association between (risk for) child maltreatment and SNS reactivity may have been subject to the *winner's curse* (Button et al., 2013; Molendijk et al., 2012). In line with the suggestion made in our narrative review, it may be that the large effects found for sympathetic reactivity in early studies with small sample sizes were inflated and hard to replicate. Additional studies might then further reduce the effect, rather than increase the required statistical power to detect significant differences. Figure 1 suggests that research on the physiology of maltreating parents / at-risk adults has shifted from sympathetic to parasympathetic reactivity, with only one study from the last 20 years including sympathetic measures, and all studies including parasympathetic measures dating from the past few years. We emphasize the relevance of including both sympathetic and parasympathetic indices in future studies to clarify the matters discussed above.

The lack of differential autonomic stress reactivity we found seems in contrast with the review by McCanne and Hagstrom (1996). In their definition of autonomic hyperreactivity they included both increased and prolonged autonomic activation during any circumstance, including

resting/relaxation (i.e. baseline) and the presentation of stimuli. However, we distinguished between autonomic activation at baseline specifically, and strictly defined autonomic reactivity as the change in ANS activity from baseline to stress. This may at least partly explain the discrepancy in supporting evidence for ANS hyperreactivity as a risk factor for child maltreatment. We chose to focus on these two outcomes because they were most commonly assessed, but some valuable results not represented in our meta-analyses bear mentioning. For instance, parents at risk for child abuse showed possible sensitization to a persistent infant cry sound, as seen by a renewed increase in autonomic arousal after several minutes, whereas low-risk parents did not show signs of sensitization (Laud, 1997). Several studies found that maltreating parents showed similar autonomic responses to child signals of a negative and a positive valence, while nonmaltreating parents distinguished between the two different kinds of stimuli (Disbrow et al., 1977; Frodi & Lamb, 1980). Finally, (risk for) child maltreatment was associated with *overall* higher HR in Disbrow et al. (1977) and Crouch et al. (2015) and higher peak HR in Pruitt & Erickson (1985), i.e., independent of condition (baseline vs stress). Chronic arousal in maltreating parents or at-risk participants suggests there may be a ceiling effect, i.e., high levels of HR activity beyond which they show no further increases in response to stress (Crouch et al., 2015).

We found no evidence for moderating effects of the categorical variables in either meta-analysis, such as whether maltreatment was substantiated or risk for physical abuse was assessed with the CAP Inventory. Combined effect sizes were predominantly homogeneous, suggesting that effects may be similar according to maltreatment status and stimulus presentation, but the small cell sizes preclude any firm conclusions. Multivariate regressions showed that year of publication predicted the effect size for mixed ANS reactivity, and year of publication as well as the percentage of women in the sample predicted the HR reactivity effect size. Later publications and samples with lower percentages of women were associated with a directional change toward negative effect sizes. Again, these findings should be interpreted with caution as strong effects may tilt the regression line disproportionately with this small number of included studies. Notably, the moderating effect of several potentially relevant variables could not be tested, either because the cell size for one of the categories was small even after dichotomization ($k < 4$; e.g., socioeconomic status, whether the stressor was child-related or nonchild-related) or because data were not consistently reported (e.g., ethnicity, participants' age).

The small number of included studies is one of the limitations of our meta-analyses, and for this reason our findings should be considered exploratory. Homogeneity tests and moderator analyses of small sets of studies might easily lead to type 2 errors. The meta-analytical evidence must therefore be considered with caution. A second limitation is that the two meta-analyses were done on almost the same set of studies, so our findings for ANS baseline activation and ANS stress reactivity were not independent. The fact that these two results were found in almost the same set of studies is consistent with the the notion that the underlying process of allostatic load may result in both chronic autonomic activation and increased reactivity to stressors, as discussed above.

The studies included in our meta-analyses were not without methodological shortcomings. Our narrative review showed a predominant lack of supporting evidence (based on significance testing) for the hyperreactivity hypothesis, which may be due to studies' small samples. As discussed above, small samples may lead to insufficient statistical power for small effects to reach statistical significance, while in other cases it may lead to exaggerated significant effects. Another important shortcoming is that in quasi-experimental designs groups are not equivalent from the onset. When we want to ascribe observed differences in autonomic (re)activity to whether participants are maltreating/at-risk or not, insufficient comparability of groups on potential confounding variables is a threat to internal validity (Cook & Campbell, 1986; Shadish, Cook, & Campbell, 2002). Not all of the reviewed studies matched their groups on variables such as socio-economic status or educational level. Furthermore, when groups differed on a potential confounding variable, this was not always controlled for in analyses. Almost none of the studies controlled for maltreatment experienced by participants in their own youth, a factor that is related to child maltreatment perpetration (e.g., Pears & Capaldi, 2001) as well as autonomic responsiveness (Casanova et al., 1994; Heim et al., 2000). Alternative explanations for observed correlations are thus not ruled out. Finally, all of the studies included in our meta-analyses used a case-control design, precluding causal inferences about the association between autonomic (re)activity and child maltreatment.

Nonetheless, the studies reviewed herein may serve as an impetus to the field, and we hope future research will build on and expand their scope. Although this line of research experienced a 15-year gap in activity after the initial wave of studies, the recent resurgence of studies examining ANS activity in at-risk/maltreating individuals suggests a renewed interest. Recent advances in technology allow for noninvasive

assessment of autonomic (re)activity unconfined to laboratory settings. Future research may make use of ambulatory assessments of parents' functioning in their home environment, potentially increasing the ecological validity of findings (De Geus & Van Doornen, 1996; Kupper et al., 2005). More complex operationalizations of child maltreatment would also help advance research in this area. For instance, an expansion of the focus on physical abuse to other types of maltreatment such as emotional abuse and neglect could address relevant questions such as whether different subtypes (or combinations of subtypes) of maltreatment are associated with different autonomic response patterns. Inclusion of degrees of maltreatment severity would allow for a shift from a dichotomous to a more dynamic approach. Finally, randomized experiments using biofeedback or other experimental manipulations of ANS functioning could provide insight into the possible causal role of autonomic activity in perpetration of child maltreatment.

Such additions to the field could further support previous suggestions that maltreating parents may benefit from physiology-based stress regulation (e.g., Casanova et al., 1992; Crouch et al., 2015), but currently the field lacks randomized controlled trials on the effectiveness of such intervention components in maltreating or at-risk populations. A more interactive approach that has been found to be effective is an attachment-based, short-term intervention using video feedback, such as the Video-feedback Intervention to promote Positive Parenting (VIPP; Juffer, Bakermans-Kranenburg, & Van IJzendoorn, 2007). A randomized controlled trial with 67 dyads under surveillance for child maltreatment showed that such an intervention was effective in increasing parental sensitivity (i.e., adequate responding to children's distress; Moss et al., 2011). Future studies could examine whether the effectiveness of similar intervention programs is enhanced by including elements such as biofeedback to improve maltreating parents' stress regulation.

CHAPTER 6

EPILOGUE

Epilogue

The studies in this dissertation focused on two parental risk factors for child maltreatment: autonomic nervous system (re)activity and attachment representation. Neglectful and abusive mothers were compared to a non-maltreating control group on their autonomic reactivity to infant crying using a standardized cry paradigm (Zeskind & Shingler, 1991) and on their state of mind toward attachment as measured by the AAI (George, Kaplan, & Main, 1985). The results described in Chapters 2 and 3 were not unequivocal, but overall suggested that maltreating mothers mainly showed less sympathetic reactivity to infant crying than non-maltreating mothers. Furthermore, as reported in Chapter 4, more maltreating than non-maltreating mothers had an unresolved state of mind regarding attachment, and they had lower coherence of mind.

Empirical study in context of meta-analysis

The association between child maltreatment perpetration and blunted autonomic (re)activity we found in our empirical study seemed in contrast with earlier literature (McCanne & Hagstrom, 1996). Therefore we conducted a meta-analysis including all available studies on this topic (k = 12). As reported in Chapter 5, maltreating parents and at-risk adults had higher ANS activity at baseline, but did not show significantly different autonomic reactivity to stressful stimuli. In light of these meta-analytic findings, are we to reconsider our earlier conclusion that maltreating mothers appeared to show sympathetic *hypo*reactivity? As can be seen in Figure 1 of Chapter 5, the point estimate for skin conductance (SCL) reactivity in our empirical study (g = -0.24) lies outside the confidence intervals of the overall combined effect size for sympathetic reactivity (which almost solely consisted of SCL measures) in our meta-analysis (g = 0.27, CI 95% [-0.04, 0.58]). This means that the finding for SCL reactivity in our empirical study differed significantly from the meta-analytic result for sympathetic reactivity. In a random effects model, as we used in the meta-analyses, the sample of studies k is considered a random sample from a population of studies (e.g., including those that have been done but are not represented, and those that have not yet been done), and the point estimate may be generalized to that population (Hedges & Vevea, 1998). The fact that the point estimate for SCL in our empirical study lies outside the CIs of the meta-analysis' combined effect size indicates that our empirical study may not belong to the same population from which k was sampled. This could be

due to the fact that child neglect perpetration characterized our sample, which was not the case for any of the other studies included in the meta-analysis. We also controlled for relevant potential confounders, such as maltreatment experienced by parents in their own childhood, where other studies had not. Hyporeactivity may therefore be a risk factor for child maltreatment even within the context of our meta-analytical findings. Our findings, and the contrast with those of previous studies, point to the need for future research to continue to aim for the distinction between neglectful and abusive parents in order to test whether autonomic hyporeactivity is associated with child neglect specifically.

Attachment

On the cognitive-affective level, an unresolved/disoriented (U/d) state of mind toward attachment was significantly more prevalent among maltreating than non-maltreating mothers. While discussing potentially traumatic experiences such as abuse or loss, U/d mothers displayed lapses of reasoning or discourse and did not remark upon those lapses. This state of mind therefore has distinct dissociative qualities, as conveyed in Chapter 4, i.e. the display of disrupted consciousness in the face of traumatic memories. However, not just the U/d state of mind but low coherence of mind in general is associated with disintegrated cognitive-affective processes. The narratives that receive low scores on coherence have been proposed to reflect multiple models of attachment (Main, 1991). For instance, an idealizing speaker displays a positive image of his/her attachment history on a semantic level, while actual experiences appear to have been negative. Speakers with preoccupied tendencies may talk compassionately about a caregiver one moment while displaying apparent anger the next, and often show remarkable oscillations in their evaluation of attachment experiences throughout the interview, without reaching one coherent narrative. Coherence of mind and attachment classifications may therefore be considered indicators of interviewees' internal working model of attachment, which has its root in infancy (Bretherton & Munholland, 2008). Consistent with this notion, we reported in Chapter 4 how a comfort paradigm based on infants' internal working model of attachment (Johnson, Dweck, & Chen, 2007) generated an autonomic response that distinguished unresolved and non-autonomous from resolved and autonomous mothers, respectively. Unresolved and non-autonomous attachment (as well as continuous U scores and low coherence of mind) were associated with a SCL decrease during an animated scene of a responsive caregiver-ellipse comforting a crying

infant-ellipse. This may reflect an emotional response of non-crying sadness (Kreibig, 2010) to the representation of an experience in contrast with their own.

Causality

The findings presented in this dissertation are correlational, precluding causal inferences. Etiological research on child maltreatment is characterized by the case-control design, since experimental manipulations to evoke maltreating behavior are not ethical (in humans). A well-designed twin study has evaluated the extent to which children evoke their own maltreatment, e.g., through the display of (inherited) antisocial behavior (Jaffee et al., 2004). Based on the fact that monozygotic (MZ) twin children share 100% of their early environment and genetic makeup, while dizygotic (DZ) twins share 100% of their environment but on average 50% of their genes, a higher concordance of child maltreatment within MZ pairs as compared to DZ twin pairs would indicate a (genetically mediated) child effect on maltreatment. They found that the within-twin pair co-occurrence of child maltreatment was similar for MZ and DZ twins, suggesting a negligible child effect on maltreatment.

The plausibility of a causal role of parental factors in child maltreatment may be inferred from relevant animal studies with experimental designs. For instance, rat dams naturally differ in the extent to which they lick, groom, and nurse their pups from an arched-back position (licking, grooming, arched-back nursing; LG-ABN). Low levels of LG-ABN behavior may be considered the rat equivalent of child neglect. The adult offspring of low LG-ABN mothers show increased physiological stress reactivity (Liu et al., 1997) and become low LG-ABN mothers themselves (Francis, Diorio, Liu, & Meaney, 1999). Cross-fostering experiments showed that both stress responses and maternal care were behaviorally rather than genetically transmitted across generations, since it was the rearing (not the biological) mother's behavior that was associated with pups' subsequent fearfulness and LG-ABN levels (Francis et al., 1999). Natural variations in maternal care can also be further manipulated, such as by regularly handling rat pups for short amounts of time, which increases levels of LG-ABN behavior (see Meaney, 2001, for a review). Handling of pups not only increased maternal care in naturally low LG-ABN rat dams (generation F1), but the effects extended to the maternal care of the handled, adult offspring (F2), and even to their non-manipulated offspring (F3), who showed normative levels of behavioral stress reactivity (Francis et al., 1999).

These experiments point to a causal role of parental factors in child maltreatment, and further show the close link between stress responses and parenting behavior through their parallel mechanism of transmission.

As an alternative to the definition of a cause as both necessary and sufficient for its effect, the philosopher J. L. Mackie (1965) proposed the INUS condition, positing that a causal factor is an *insufficient* but *non-redundant* part of a condition that is itself *unnecessary* but *sufficient* (INUS) for the result. Applied to child maltreatment, this means that for a particular group of people, the INUS condition under which maltreatment occurs refers to a constellation of risk factors that is unnecessary (i.e., a different constellation of risk factors might lead to child maltreatment for other people) but sufficient (i.e., it leads to child maltreatment), and each risk factor in the constellation is insufficient (i.e., does not singularly cause child maltreatment) but non-redundant (i.e., without it, child maltreatment would not occur in these people) (Munro, Taylor, & Bradbury-Jones, 2013). This is consistent with the ecological/transactional model of multicausal pathways to child maltreatment, as outlined in previous chapters (Cicchetti & Valentino, 2006). The alternative definition does not imply that we can now ascribe a causal role to the risk factors we found in our study and meta-analysis, but it suggests that causality does not require them to be necessary or sufficient for child maltreatment to occur. According to these views, autonomic dysregulation as well as unresolved attachment and incoherence of mind may be considered part of the cumulative condition under which certain parents maltreat their children.

Conclusion

This dissertation has shown that dysregulation of the ANS may constitute a risk factor for child maltreatment in three different ways: through blunted reactivity to infant crying and anomalous disconnections between ANS components (empirical study; Chapters 2 and 3), and higher ANS baseline activity (meta-analysis: Chapter 5). The latter may indicate a state of chronic arousal in maltreating/at-risk parents, possibly reflective of the relatively stressful circumstances in which they live. The results of our empirical study (Chapters 2, 3, and 4) remarkably pointed to dissociative coping tendencies on different levels of functioning. First of all, the pattern of blunted ANS responsiveness to infant crying seems in line with mothers' behavioral disengagement. The maltreating mothers in our sample were predominantly neglectful, the inability, to an extreme extent, to offer their child(ren) affection, security,

and stability characterizing their problems in many cases. On the cognitive-affective level, the U/d state of mind also suggests dissociative coping with traumatic experiences. Overall, this pattern of dissociative coping provides an important addition to the traditional aggressive model of child abuse (Knutson, 1978) and broadens our understanding of the nature of child maltreatment.

The multiple pathways that mark the etiology of child maltreatment provide the clinician with many potential intervention targets. Increased ANS baseline activity, blunted ANS reactivity to child signals, and attachment representation may be among those targets. Over the course of the dissertation we have made suggestions for intervention programs based on our findings. Maltreating mothers with a U/d state of mind may require trauma processing before an attachment-based, maternal behavior-focused program like the Video-feedback Intervention to promote Positive Parenting (VIPP; Juffer, Bakermans-Kranenburg, & Van IJzendoorn, 2007) can be effective (Moran, Pederson, & Krupka, 2005). It is currently not known whether interventions aiming at maltreating parents' physiological stress regulation can lead to reduced child maltreatment perpetration, and caution is warranted in suggesting practical implications of our findings. The multiple associations between ANS functioning and child maltreatment in our empirical study and meta-analysis, however, identify it as a focus point of interest. Therefore, a new dimension for randomized controlled trials would be the addition of an ANS regulation component to existing intervention programs to assess if it increases their effectiveness. This would provide not only more theoretical insight into the causal role of ANS functioning in child maltreatment but may also improve clinical prospects.

References[1]

Achenbach, T.M., & Rescorla, L.A. (2003). Manual for the ASEBA Adult forms and profiles. University of Vermont, Research Center for Children, Youth, and Families, Burlington, VT.

Adshead, G., & Bluglass, K. (2005). Attachment representations in mothers with abnormal illness behaviour by proxy. *British Journal of Psychiatry, 187*, 328-333. doi:10.1192/bjp.187.4.328

Ainsworth, M.D.S., Blehar, M.C., Waters, E., & Wall, S. (1978). *Patterns of attachment: A psychological study of the strange situation.* Hillsdale, NJ: Erlbaum.

Alink, L.R.A., Cicchetti, D., Kim, J., & Rogosch, F.A. (2012). Longitudinal associations among child maltreatment, social functioning, and cortisol regulation. *Developmental Psychology, 48*, 224–236. doi:10.1037/ a0024892

Allwood, M.A., Handwerger, K., Kivlighan, K.T., Granger, D.A., & Stroud, L.R. (2011). Direct and moderating links of salivary alpha-amylase and cortisol stress-reactivity to youth behavioral and emotional adjustment. *Biological Psychology, 88,* 57–64. doi:10.1016/ j.biopsycho. 2011.06.008

Arnold, E. H., & O'Leary, S. G. (1995). The effect of child negative affect on maternal discipline behavior. *Journal of Abnormal Child Psychology, 23*, 585-595. doi:10.1007/BF01447663

Bailey, H. N., Moran, G., & Pederson, D. R. (2007). Childhood maltreatment, complex trauma symptoms, and unresolved attachment in an at-risk sample of adolescent mothers. *Attachment & Human Development, 9*, 139-161. doi:10.1080/14616730701349721

Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2009). The first 10,000 Adult Attachment Interviews: Distributions of adult attachment representations in clinical and non-clinical groups. *Attachment & Human Development, 11*, 223-263. doi:10.1080/ 14616730902814762

Bakermans-Kranenburg, M. J., Van IJzendoorn, M. H., & Juffer, F. (2003). Less is more: Meta-analyses of sensitivity and attachment interventions in early childhood. *Psychological Bulletin, 129*, 195-215. doi:10.1037/ 0033-2909.129.2.195

[1]Publications marked with an asterisk were included in our meta-analyses (Chapter 5)

Bakermans-Kranenburg, M. J., Van IJzendoorn, M. H., & Juffer, F. (2005). Disorganized infant attachment and preventive interventions: A review and meta-analysis. *Infant Mental Health Journal, 26,* 191–216. doi: 10.1002/ imhj.20046

Barnett, D., Manly, J. T., & Cicchetti, D. (1993). Defining child maltreatment: the interface between policy and research. In D. Cicchetti & S. L. Toth (Eds.), *Child abuse, child development, and social policy* (pp. 7–73). Norwood, NJ: Ablex.

Barone, L., Bramante, A., Lionetti, F., & Pastore, M. (2014). Mothers who murdered their child: An attachment-based study on filicide. *Child Abuse & Neglect*, doi:10.1016/j.chiabu.2014.04.014

Barr, R. G. (1990). The early crying paradox: A modest proposal. *Human Nature, 1*, 355–389. doi: 10.1007/BF02734051

Bauer, A.M., Quas, J.A., & Boyce, W.T. (2002). Associations between physiological reactivity and children's behavior: advantages of a multisystem approach. *Journal of Developmental Behavioral Pediatrics, 23*, 102–113.

Baum, B.J. (1993). Principles of saliva secretion. *Annals of the New York Academy of Sciences, 694*, 17–23. doi:10.1111/j.1749-6632.1993.tb 18338.x

Bavolek, S. J., Kline, D.F., McLaughlin, J.A., & Publicover, P.R. (1979). Primary prevention of child abuse: Identification of high risk adolescents. *Child Abuse & Neglect, 3*, 1071-1080. doi:10.1016/0145-2134(79)90152-2

Beckie, T.M. (2012). A systematic review of allostatic load, health, and health disparities. *Biological Research for Nursing, 14*, 311-346. doi:10.1177/ 1099800412455688

Beijersbergen, M. D., Bakermans-Kranenburg, M. J., Van IJzendoorn, M. H., & Juffer, F. (2008). Stress regulation in adolescents: Physiological reactivity during the Adult Attachment Interview and conflict interaction. *Child Development, 79*, 1707-1720. doi:10.1111/j.1467-8624.2008.01220.x

Belsky, J. (1980). Child maltreatment: An ecological integration. *American Psychologist, 35,* 320-335. doi: 10.1037/0003-066X.35.4.320

Belsky, J. (1993). Etiology of child maltreatment: A developmental-ecological analysis. *Psychological Bulletin, 114*, 413-434. doi:10.1177/10998004 12455688

Belsky, J., Rovine, M., & Taylor, D.G. (1984). The Pennsylvania Infant and Family Development Project, III: The origins of individual differences in infant-mothers attachment: Maternal and infant contributions. *Child Development, 55*, 718-728. doi:10.2307/1130124

Bernier, A., & Dozier, M. (2003). Bridging the attachment transmission gap: The role of maternal mind-mindedness. *International Journal of Behavioral Development, 27*, 355-365. doi:10.1080/0165025024400 0399

Bernier, A., Matte-Gagné, C., Bélanger, M.E., & Whipple, N. (2014). Taking stock of two decades of attachment transmission gap: Broadening the assessment of maternal behavior. *Child Development, 85*, 1852-1865. doi: 10.1037/0003-066X.35.4.320

Bernstein, D. P., & Fink, L. (1998). Childhood trauma questionnaire: A retrospective self-report manual. San Antonio, TX: The Psychological Corporation.

Bernstein, D. P., Fink, L., Handelsman, L., Foote, J., Lovejoy, M., Wenzel, K., Sapareto, E., . . . Ruggiero, J. (1994). Initial reliability and validity of a new retrospective measure of child abuse and neglect. *American Journal of Psychiatry, 151*, 1132–1136.

Bernstein, D. P., Stein, J. A., Newcomb, M. D.,Walker, E., Pogge, D., Ahluvalia, T., . . . Zule, W. (2003). Development and validation of a brief screening version of the childhood trauma questionnaire. *Child Abuse & Neglect, 27*, 169–190. doi:10.1016/S0145-2134(02)00541-0

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psycho-physiological implications. *Psychophysiology, 30*, 183–196. doi:10.1111/ j.1469-8986.1993.tb01731.x

Biro, S., Alink, L. R. A., Van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2014). Infants' monitoring of social interactions: The effect of emotional cues. *Emotion, 14*, 263-271. doi: 10.1037/a0035589

Borenstein, M., Rothstein, D., & Cohen, J. (2005). *Comprehensive meta analysis: A computer program for research synthesis.* Englewood, NJ: Biostat.

Bosch, J.A., De Geus, E.J., Veerman, E.C., Hoogstraten, J., & Nieuw Amerongen, A.V. (2003). Innate secretory immunity in response to laboratory stressors that evoke distinct patterns of cardiac autonomic activity. *Psychosomatic Medicine, 65*, 245–258. doi:10.1097/01.PSY. 0000058376.50240.2D

Bosch, J.A., Veerman, E.C., De Geus, E.J., & Proctor, G.B. (2011). a-Amylase as a reliable and convenient measure of sympathetic activity: Don't start salivating just yet! *Psychoneuroendocrinology, 36*, 449–453. doi:10.1016/ j.psyneuen. 2010.12.019

Bousha, D. M., & Twentyman, C. T. (1984). Mother-child interactional style in abuse, neglect, and control groups: Naturalistic observations in the home. *Journal of Abnormal Psychology, 93*, 106–114. doi: 10.1037/0021-843X.93.1.106

Bretherton, I., & Munholland, K. A. (2008). Internal working models in attachment relationships: Elaborating a central construct in attachment theory. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (pp. 102-127). New York: The Guilford Press.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist, 32,* 513-531. doi: 10.1037/0003-066X.32.7.513

Button, K.S., Ioannidis, J.P.A., Mokrysz, C., Nosek, B.A., Flint, J., Robinson, E.S.J., & Munafò, M.R. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience, 14*, 365-376. doi:10.1038/nrn3475

Cacioppo, J. T. (1994). Social neuroscience: Autonomic, neuroendocrine, and immune responses to stress. *Psychophysiology, 31*, 113–128. doi:10.1111/ j.1469-8986.1994.tb01032.x

Cardeña, E., & Carlson, E. (2011). Acute stress disorder revisited. *Annual Review of Clinical Psychology, 7,* 245-267. doi: 10.1146/annurev-clinpsy-032210-104502

Carlson, E. B., & Putnam, F. W. (1993). An update on the dissociative experiences scale. *Dissociation, 6*, 16-27.

Carney, R.M., Freedland, K.E, & Veith, R.C. (2005). Depression, the autonomic nervous system, and coronary heart disease. *Psychosomatic Medicine, 67*, 29–33. doi:10.1097/01.psy.0000162254.61556.d5

*Casanova, G. M., Domanic, J., McCanne, T. R., & Milner, J. S. (1992). Physiological responses to non-child-related stressors in mothers at risk for child abuse. *Child Abuse & Neglect, 16*, 31-44. doi:10.1016/0145-2134(92)90006-D

Casanova, G. M., Domanic, J., McCanne, T. R., & Milner, J. S. (1994). Physiological responses to child stimuli in mothers with and without a childhood history of physical abuse. *Child Abuse & Neglect, 18*, 995-1004. doi:10.1016/0145-2134(94)90124-4

Chatterton, R.T., Vogelsong, K.M., Lu, Y., Ellman, A.B., & Hudgens, G.A. (1996). Salivary a-amylase as a measure for endogenous adrenergic activity. *Clinical Physiology, 16,* 433–448. doi: 10.1111/j.1475-097X.1996.tb00731.x

Cicchetti, D., & Lynch, M. (1993). Toward an ecological/transactional model of community violence and child maltreatment: Consequences for children's development. *Psychiatry, 56*, 96–118. doi:10.1521/ 00332747.1993.11024624

Cicchetti, D., Rogosch, F. A., Gunnar, M. R., & Toth, S. L. (2010). The differential impacts of early physical and sexual abuse and internalizing problems on daytime cortisol rhythm in schoolaged children. *Child Development, 81*, 252–269. doi:10.1111/j.1467-8624.2009.01393.x

Cicchetti, D., Rogosch, F.A., & Toth, S.L. (2006). Fostering secure attachment in infants in maltreating families through preventive interventions. *Development and Psychopathology, 18,* 623-649. doi: 10.1017/S09545794 06060329

Cicchetti, D., & Toth, S.L. (2005). Child maltreatment. *Annual Review of Clinical Psychology, 1*, 409–438. doi:10.1146/annurev.clinpsy.1.102 803.144029

Cicchetti, D., Toth, S. L., & Manly, J. T. (2003). Maternal maltreatment classification interview. Rochester, NY: Unpublished measure.

Cicchetti, D., & Valentino, K. (2006). An ecological transactional perspective on child maltreatment: Failure of the average expectable environment and its influence upon child development. In D. Cicchetti & D. J. Cohen (Eds.), *Developmental psychopathology: Risk, disorder, and adaptation* (2nd ed, Vol. 3, pp. 129–201). New York, NY: Wiley.

Coatsworth, J. D., Duncan, L. G., Greenberg, M. T., & Nix, R. L. (2010). Changing parent's mindfulness, child management skills and relationship quality with their youth: Results from a randomized pilot intervention trial. *Journal of Child and Family Studies, 19*, 203-217. doi:10.1007/s10826-009-9304-8

Compier-de Block, L.H.C.G., Alink, L.R.A., Reijman, S., Werner, C.D., Maras, A., Rijnberk, C., Van IJzendoorn, M.H., & Bakermans-Kranenburg, M.J. (2015). Handgrip force of maltreating mothers in reaction to infant signals. *Child Abuse & Neglect, 40,* 124-131. doi: 10.1016/j.chiabu. 2014.03.006

Cook, T. D., & Campbell, D.T. (1986). The causal assumptions of quasi-experimental practice. *Synthese, 68*, 141-180. doi: 10.1007/BF00413970

Coppola, G., Vaughn, B. E., Cassibba, R., & Costantini, A. (2006). The attachment script representation procedure in an Italian sample: Associations with Adult Attachment Interview scales and with maternal sensitivity. *Attachment & Human Development, 8*, 209-219. doi:10.1080/ 14616730600856065

*Creaven, A. M., Skowron, E. A., Hughes, B. M., Howard, S., & Loken, E. (2014). Dyadic concordance in mother and preschooler resting cardiovascular function varies by risk status. *Developmental Psychobiology, 56,* 142-152. doi:10.1002/dev.21098

Crittenden, P.M. (1993) An information-processing perspective on the behavior of neglectful parents. Criminal Justice and Behavior, 20, 27–48. doi:10.1177/0093854893020001004

*Crouch, J. L., Hiraoka, R., McCanne, T. R., Reo, G., Wagner, M., Krauss, A., …Skowronski, J. J. (2015). *Heart rate and heart rate variability in parents at-risk for child physical abuse.* Manuscript submitted for publication.

*Crowe, H. P., & Zeskind, P. S. (1992). Psychophysiological and perceptual responses to infant cries varying in pitch: Comparisons of adults with low and high scores on the Child Abuse Potential Inventory. *Child Abuse & Neglect, 16,* 19-29. doi:10.1016/0145-2134(92)90005-C

Cumming, G. (2012). *Understanding the new statistics: Effect sizes, confidence intervals, and meta-analysis.* New York, NY: Routledge.

Cumming, G. (2014). The new statistics: Why and how. *Psychological Science, 25,* 7-29. doi:10.1177/0956797613504966

De Geus, E.J.C., & Van Doornen, L.J.P. (1996). Ambulatory assessment of parasympathetic/sympathetic balance by impedance cardiography. In J. Fahrenberg & M. Myrtek (Eds), *Ambulatory Assessment: Computer-assisted psychological and psychophysiological methods in monitoring and field studies* (pp. 141-163). Gottingen, Germany: Hogrefe & Huber.

Del Vecchio, T., Walter, A., & O'Leary, S.G. (2009). Affective and physiological factors predicting maternal response to infant crying. *Infant Behavior and Development, 32,* 117-122. doi:10.1016/j.infbeh.2008.10.005

De Veld, D.M.J., Riksen-Walraven, J.M., & De Weerth, C. (2012). The relation between emotion regulation strategies and physiological stress responses in middle childhood. *Psychoneuroendocrinology, 37*, 1309–1319. doi:10.1016/ j.psyneuen.2012.01.004

*Disbrow, M. A., Doerr, H., & Caulfield, C. (1977). Measuring the components of parents' potential for child abuse and neglect. *Child Abuse &Neglect, 1,* 279-296. doi:10.1016/0145-2134(77)90003-5

Dozier, M., & Kobak, R. R. (1992). Psychophysiology in attachment interviews: Converging evidence for deactivating strategies. *Child Development, 63*, 1473-1480. doi:10.1111/j.1467-8624.1992.tb01708.x

Dozier, M., Stovall-McClough, K. C., & Albus, K. E. (2008). Attachment and psychopathology in adulthood. In J. Cassidy & P. R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (2nd ed, pp. 718–744). New York, NY: The Guilford Press.

Ebisch, S. J., Aureli, T., Bafunno, D., Cardone, D., Romani, G. L., & Merla, A. (2012). Mother and child in synchrony: Thermal facial imprints of autonomic contagion. *Biological Psychology, 89*, 123–129. doi:10.1016/ j.biopsycho.2011. 09.018

Egeland, B., Jacobvitz, D., & Sroufe, L.A. (1988). Breaking the cycle of abuse. *Child Development, 59*, 1080-1088.

Egeland, B., & Susman-Stillman, A. (1996). Dissociation as a mediator of child abuse across generations. *Child Abuse & Neglect, 20,* 1123-1132.

El-Sheikh, M., Erath, S.A., Buckhalt, J.A., Granger, D.A., & Mize, J. (2008). Cortisol and children's adjustment: the moderating role of sympathetic nervous system activity. *Journal of Abnormal Child Psychology, 36*, 601–611. doi:10.1007/s10802-007-9204-6

El-Sheikh, M., Kouros, C. D., Erath, S., Cummings, E. M., Keller, P., & Staton, L. (2009). Marital conflict and children's externalizing behavior: Pathways involving interactions between parasympathetic and sympathetic nervous system activity. *Monographs of theSociety for Research in Child Development, 74*, 1–79. doi:10.1111/j.1540-5834.2009. 00501.x

English, D. J., Upadhyaya, M. P., Litrownik, A. J., Marshall, J. M., Runyan, D. K., Graham, J. C., & Dubowitz, H. (2005). Maltreatment's wake: The relationship of maltreatment dimensions to child outcomes. *Child Abuse & Neglect, 29*, 597-619. doi:10.1016/j.chiabu. 2004.12.008

Euser, S., Alink, L. R. A., Pannebakker, F., Vogels, T., Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2013). The prevalence of child maltreatment in the Netherlands across a 5-year period. *Child Abuse & Neglect, 37*, 841–851. doi:10.1016/j.chiabu.2013.07.004

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175-191. doi:10.3758/BF03193146

Folkow, B. (2000). Perspectives on the integrative functions of the sympatho- adrenomedullary system. *Autonomic Neuroscience, 83*, 101–115. doi:10.1016/ S1566-0702(00)00171-5

Fontana, V.J., Donovan, D., & Wong, R.J. (1963). The "maltreatment syndrome" in children. *The New England Journal of Medicine, 269*, 1389-1394. doi: 10.1056/NEJM196312262692601

Francis, D., Diorio, J., Liu, D., & Meaney, M. J. (1999). Nongenomic transmission across generations of maternal behavior and stress responses in the rat. *Science, 286,* 1155-1158. doi:10.1126/science. 286.5442.1155

Friedman, E. M., Karlamangla, A. S., Gruenewald, T. L., Koretz, B., & Seeman, T. E. (2015). Early life adversity and adult biological risk profiles. *Psychosomatic Medicine, 77*, 176-185. doi:10.1097/PSY.0000 000000000147

*Friedrich, W. N., Tyler, J. D., & Clark, J. A. (1985). Personality and psychophysiological variables in abusive, neglectful, and low-income control mothers. *Journal of Nervous and Mental Disease, 173,* 449-460. doi:10.1097/00005053-198508000-00001

Frigerio, A., Costantino, E., Ceppi, E., & Barone, L. (2013). Adult Attachment Interviews of women from low-risk, povery, and maltreatment risk samples: Comparisons between the hostile/helpless and traditional AAI coding systems. *Attachment & Human Development, 15,* 424-442. doi:10.1080/14616734. 2013.797266

*Frodi, A.M., & Lamb, M.E. (1980). Child abusers' responses to infant smiles and cries. *Child Development, 51*, 238–241. doi:10.2307/ 1129612

Frodi, A.M., Lamb, M.E., Leavitt, L.A., & Donovan, W.L. (1978). Fathers' and mothers' responses to infant smiles and cries. *Infant Behavior and Development, 1,* 187-198. doi:10.1016/S0163-6383(78)80029-0

George, C., Kaplan, N., & Main, M. (1985). Adult attachment interview. Unpublished manuscript, University of California, Berkeley.

Goedhart, A. D., Van der Sluis, S., Houtveen, J. H., Willemsen, G., & De Geus, E. J. C. (2007). Comparison of time and frequency domain measures of RSA in ambulatory recordings. *Psychophysiology, 44*, 203–215. doi:10.1111/ j.1469-8986.2006.00490.x

Goedhart, A. D., Willemsen, G., Houtveen, J. H., Boomsma, D. I., & De Geus, E. J. C. (2008). Comparing low frequency heart rate variability and preejection period: Two sides of a different coin. *Psychophysiology, 45*, 1086–1090. doi:10.1111/j.1469-8986.2008.00710.x

Goodman, J.S., & Blum, T.C. (1996). Assessing the non-random sampling effects of subject attrition in longitudinal research. *Journal of Management, 22*, 627- 652.

Gordis, E.B., Feres, N., Olezeski, C.L., Rabkin, A.N., & Trickett, P.K. (2010). Skin conductance reactivity and respiratory sinus arrhythmia among maltreated and comparison youth: Relations with aggressive behavior. *Journal of Pediatric Psychology, 35*, 547–558. doi: 10.1093/jpepsy/jsp113

Gordis, E.B., Granger, D.A., Susman, E.J., & Tricket, P.K. (2006). Asymmetry between salivary cortisol and α-amylase reactivity to stress: Relation to aggressive behavior in adolescents. *Psychoneuroendocrinology, 31*, 976–987. doi:10.1016/j.psyneuen.2006.05.010

Gordis, E.B., Granger, D.A., Susman, E.J., & Tricket, P.K. (2008). Salivary alpha amylase-cortisol asymmetry in maltreated youth. *Hormones and Behavior, 53*, 96–103. doi:10.1016/j.yhbeh.2007.09.002

Gordis, E. B., Margolin, G., Spies, L. A., Susman, E. J., & Granger, D. A. (2010). Interparental aggression and parent-adolescent salivary alpha amylase symmetry. *Physiology & Behavior, 100*, 225–233. doi:10.1016/j.physbeh. 2010.01.006

Granger, D.A., Kivlighan, K.T., El-Sheikh, M., Gordis, E.B., & Stroud, L.R. (2007). Salivary alpha-amylase in biobehavioral research. *Annals of the New York Academy of Sciences, 1098*, 122–144. doi:10.1196/annals.1384.008

Griffin, M. C., Resick, P. A., & Mechanic, M. B. (1997). Objective assessment of peritraumatic dissociation: Psychophysiological indicators. *American Journal of Psychiatry, 154,* 1081-1088. doi: 10.1176/ajp.154.8.1081

Gunnar, M.R., & Fisher, P.A. (2006). Bringing basic research on early experience and stress neurobiology to bear on preventive interventions for neglected and maltreated children. *Development & Psychopathology, 18*, 651–677. doi: 10.1017/S0954579406060330

Gunnar, M., & Quevedo, K. (2007). The neurobiology of stress and development. *Annual Review of Psychology, 58*, 145–173. doi:10.1146/annurev.psych.58.110405.085605

Gustafson, G. E.,Wood, R. M., & Green, J. A. (2000). Can we hear the causes of infant crying? In R. G. Barr, B. Hopkins & J. A. Green (Eds.), *Crying as a sign, a symptom, and a signal: Clinical, emotional and developmental aspects of infant and toddler crying* (pp. 8–22). London, England: Mac Keith Press.

Harari, D., Bakermans-Kranenburg, M.J., De Kloet, C. S., Geuze, E., Vermetten, E., Westenberg, H.G.M., & Van IJzendoorn, M.H. (2009). Attachment representations in Dutch veterans with and without deployment-related PTSD. *Attachment & Human Development, 11,* 515-536. doi:10.1080/146167309032 82480

Hedges, L. V., & Vevea, J. L. (1998). Fixed- and random-effects models in meta-analysis. *Psychological Methods, 3,* 486-504. doi:10.1037/1082-989X.3.4.486

Heim, C., Newport, D. J., Heit, S., Graham, Y. P., Wilcox, M., Bonsall, R., Miller, A. H., . . . Nemeroff, C. B. (2000). Pituitary-adrenal and autonomic responses to stress in women after sexual and physical abuse in childhood. *Journal of the American Medical Association, 284*, 592–597. doi:10.1001/ jama.284.5.592.

Hesse, E. (2008). The Adult Attachtment Interview: Protocol, method of analysis, and empirical studies. In J. Cassidy & P.R. Shaver (Eds.), *Handbook of attachment: Theory, research, and clinical applications* (2nd ed., pp. 552-598). New York: Guilford Press.

Hesse, E., & Main, M. (1999). Second-generation effects of unresolved trauma in nonmaltreating parents: Dissociated, frightened, and threatening parental behavior. *Psychoanalytic Inquiry: A Topical Journal for Mental Health Professionals, 19*, 481-540. doi:10.1080/ 07351699909534265

Hesse, E., & Main, M. (2006). Frightened, threatening, and dissociative parental behavior in low-risk samples: Description, discussion, and interpretations. *Development and Psychopathology, 18,* 309-343. doi:10.1017/S09545794 06060172

Hesse, E., & Van IJzendoorn, M. H. (1999). Propensities towards absorption are related to lapses in the monitoring of reasoning or discourse during the Adult Attachment Interview. *Attachment & Human Development, 1*, 67-91. doi: 10.1080/14616739900134031

Hill-Soderlund, A. L., Mills-Koonce, W. R., Propper, C., Calkins, S. D., Granger, D. A., Moore, G. A., Garypie, J. L., . . . Cox, M. J. (2008). Parasympathetic and sympathetic responses to the strange situation in infants and mothers from avoidant and securely attached dyads. *Developmental Psychobiology, 50*, 361–376. doi:10.1002/dev.20302

Hillson, J.M.C., & Kuiper, N.A. (1994). A stress and coping model of child maltreatment. *Clinical Psychology Review, 14*, 261-285. doi:10.1016/ 0272-7358(94)90025-6

Ioannidis, J.P.A. (2005). Why most published research findings are false. *Chance, 18*, 40-47. doi:10.1080/09332480.2005.10722754

Jaffee, S. R., Caspi, A., Moffitt, T. E., Polo-Thomas, M., Price, T. S., & Taylor, A. (2004). The limits of child effects: Evidence for genetically mediated child effects on corporal punishment but not on physical maltreatment. *Developmental Psychology, 40*, 1047-1058. doi:10.1037/ 0012-1649.40.6.1047

Johnson, S. C., Dweck, C. S., & Chen, F. S. (2007). Evidence for infants' internal working models of attachment. *Psychological Science, 18*, 501-502. doi: 10.1111/j.1467-9280.2007.01929.x

Johnson, S. C., Dweck, D. S., Chen, F. S., Stern, H. L., Ok, S.J., & Barth, M. (2010). At the intersection of social and cognitive development: Internal working models of attachment in infancy. *Cognitive Science, 34*, 807-825. doi:10.1111/j.1551-6709.2010.01112.x

Joosen, K. J., Mesman, J., Bakermans-Kranenburg, M. J., Pieper, S., Zeskind, P. S., & Van IJzendoorn, M. H. (2013a). Physiological reactivity to infant crying and observed maternal sensitivity. *Infancy, 18*, 414–431. doi: 10.1111/j.1532-7078.2012.00122.x

Joosen, K. J., Mesman, J., Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2013b). Maternal overreactive sympathetic nervous system responses to repeated infant crying predicts risk for impulsive harsh discipline of infants. *Child Maltreatment, 18*, 252–263. doi: 10.1177/1077559513494762

Juffer, F., Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2007). *Promoting positive parenting: An attachment-based intervention.* Mahwah, NJ: Lawrence Erlbaum.

Juster, R. P., McEwen, B. S., & Lupien, S. J. (2010). Allostatic load biomarkers of chronic stress and impact on health and cognition. *Neuroscience and Biobehavioral Reviews, 35,* 2-16. doi:10.1016/ j.neubiorev.2009.10.002

Kempe, C.H., Silverman, F.N., Steele, B.F., Droegemueller, W., & Silver, H.K. (1962). The battered-child syndrome. *Journal of the American Medical Association, 181*, 17-24. doi: 10.1001/jama.1984.03340480070033.

Kibler, J. L. (2013). Posttraumatic stress and cardiovascular disease risk. *Journal of Trauma & Dissociation, 10*, 135–150. doi:10.1080/15299730802624577

Kiernan, J. A., & Rajakumar, N. (2014). *Barr's the human nervous system: An anatomical viewpoint* (10th ed.). Baltimore, MD: Lippincott Williams & Wilkins.

Knutson, J. F. (1978). Child abuse as an area of aggression research. *Journal of Pediatric Psychology, 3*, 20-27. doi:10.1093/jpepsy/3.1.20

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological Psychology, 84,* 394-421. doi:10.1016/j.biopsycho. 2010.03.010

Kupper, N., Willemsen, G., Riese, H., Posthuma, D., Boomsma, D. I., & De Geus, E. J. C. (2005). Heritability of daytime ambulatory blood pressure in an extended twin design. *Hypertension, 45,* 80-85. doi:10.1161/01.HYP. 0000149952.84391.54

LaGasse, L.L., Neal, R.A., & Lester, B.M. (2005). Assessment of infant cry: acoustic cry analysis and parental perception. *Mental Retardation and Developmental Disabilities Research Reviews, 11*, 83–93. doi:10.1002/mrdd.20050

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology, 4*, 863. doi:10.3389/fpsyg.2013.00863

Lanius, R. A., Vermetten, E., Loewenstein, R. J., Brand, B., Schmahl, C., Bremner, J. D., . . . Spiegel, D. (2010). Emotion modulation in PTSD: Clinical and neurobiological evidence for a dissociative subtype. *American Journal of Psychiatry, 167*, 640–647. doi:10.1176/appi.ajp.2009.09081168

Larsen, P. B., Schneiderman, N., & DeCarlo Pasin, R. (1986). Cardiovascular psychophysiology. In M. G. H. Coles, E. Donchin & S. W. Porges (Eds.), *Psychophysiology: Systems, processes, and applications* (pp. 125–129). New York, NY: Guilford Press.

*Laud, K. P. (1997). *The effects of infant crying on the heart rate, blood pressure, and distress levels of women high and low in physical child abuse potential* (Doctoral dissertation). Retrieved from ProQuest. (1997-95002-427).

Lim, C. L., Rennie, C., Barry, R. J., Bahramali, H., Lazzaro, I.,Manor, B., . . . Gordon, E. (1997). Decomposing skin conductance into tonic and phasic components. *International Journal of Psychophysiology, 25*, 97–109. doi:10.1016/S0167-8760(96)00713-1

Lindhiem, O., Bernard, K., & Dozier, M. (2011). Maternal sensitivity: Within-person variability and the utility of multiple assessments. *Child Maltreatment, 16,* 41-50. doi:10.1177/1077559510387662

Liu, D., Diorio, J., Tannenbaum, B., Caldji, C., Francis, D., Freedman, A., Sharma, S., Pearson, D., Plotsky, P. M., & Meaney, M. J. (1997). Maternal care, hippocampal glucocorticoid receptors, and hypothalamic-pituitary-adrenal responses to stress. *Science, 277,* 1659-1662. doi: 10.1126/ science.277.5332.1659

Lorber, M. F. (2004). Psychophysiology of aggression, psychopathy, and conduct problems: A meta-analysis. *Psychological Bulletin, 130,* 531-552. doi:10.1037/0033-2909.130.4.531

Lorber, M. F., & O'Leary, S. G. (2005). Mediated paths to overreactive discipline: Mothers' experienced emotion, appraisals, and physiological responses. *Journal of Consulting and Clinical Psychology, 73*, 972-981. doi:10.1037/0022-006X.73.5.972

Lorentz, K. (1999). IFCC methods for the measurement of catalytic concentrations of enzymes. Part 9. IFCC method for α-amylase (1-4-α-D-Glucan 4-Glucanohydrolase, EC 3.2.1.1). Indian Journal of Clinical Biochemistry, 12, 1-24. doi:10.1007/BF02867950

Lyons-Ruth, K., Bronfman, E., & Parsons, E. (1999). Maternal frightened, frightening, or atypical behavior and disorganized infant attachment patterns. *Monographs of the Society for Research in Child Development, 64*, 67–96.

Lyons-Ruth, K., Yellin, C., Melnick, S., & Atwood, G. (2003). Childhood experiences of trauma and loss have different relations to maternal unresolved and Hostile-Helpless states of mind on the AAI. *Attachment & Human Development, 5,* 330-352. doi:10.1080/14616730310001633410

Lyons-Ruth, K., Yellin, C., Melnick, S., & Atwood, G. (2005). Expanding the concept of unresolved mental states: Hostile / Helpless states of mind on the Adult Attachment Interview are dissociated with disrupted mother-infant communication and infant disorganization. *Development and Psychopathology, 17*, 1-23. doi:10.1017/S0954579405050017

Mackie, J.L. (1965). Causes and conditions. *American Philosophical Quarterly, 2,* 245-264.

Madigan, S., Bakermans-Kranenburg, M. J., Van IJzendoorn, M. H., Moran, G., Pederson, D. R., & Benoit, D. (2006). Unresolved states of mind, anomalous parental behavior, and disorganized attachment: A review and meta-analysis of a transmission gap. *Attachment & Human Development, 8,* 89-111. doi:10.1080/14616730600774458

Main, M. (1991). Metacognitive knowledge, metacognitive monitoring, and singular (coherent) vs. multiple (incoherent) models of attachment: Findings and directions for future research. In C. M. Parkes, J. Stevenson-Hinde, & P. Marris (Eds.), *Attachment across the life cycle* (pp. 127-159). London, UK: Routledge.

Main, M., Goldwyn, R., & Hesse, E. (2003). Adult attachment scoring and classification systems. Unpublished manuscript, University of California at Berkeley.

Main, M., & Hesse, E. (1990). Parents' unresolved traumatic experiences are related to infant disorganized attachment status: Is frightened and/or frightening parental behavior the linking mechanism? In M. T. Greenberg, D. Cicchetti, and E. M. Cummings (Eds.), *Attachment in the preschool years: Theory, research and intervention* (pp. 161-182). Chicago: University of Chicago Press.

Main, M., Kaplan, N., & Cassidy, J. (1985). Security in infancy, childhood and adulthood: A move to the level of representation. *Monographs of the Society for Research in Child Development, 50*, 66-106.

Manly, J. T., Cicchetti, D., & Barnett, D. (1994). The impact of subtype, frequency, chronicity, and severity of child maltreatment on social competence and behavior problems. *Development and Psychopathology, 6*, 121–143. doi:10.1017/S0954579400005915

Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition & Emotion, 23*, 209–237. doi:10.1080/02699930802204677

McCanne, T. R., & Hagstrom, A. H. (1996). Physiological hyperreactivity to stressors in physical child abusers and individuals at risk for being physically abusive. *Aggression and Violent Behavior, 1*, 345–358. doi: 10.1016/S1359-1789(96)00004-3

McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York Academy of Sciences, 840*, 33-44. doi:10.1111/j.1749-6632.1998.tb09546.x

McEwen, B. S., & Seeman, T. (1999). Protective and damaging effects of mediators of stress: Elaborating and testing the concepts of allostasis and allostatic load. *Annals of the New York Academy of Sciences, 896,* 30-47. doi:10.1111/j.1749-6632.1999.tb08103.x

Meaney, M. J. (2001). Maternal care, gene expression, and the transmission of individual differences in stress reactivity across generations. *Annual Review of Neuroscience, 24*, 1161-1192. doi: 10.1146/annurev.neuro. 24.1.1161

Michels, N., Sioen, I., Clays, E., De Buyzere, M., Ahrens, W., Huybrechts, I., Vanaelst, B., . . . De Henauw, S. (2013). Children's heart rate variability as stress indicator: Association with reported stress and cortisol. *Biological Psychology, 94*, 433–440. doi:10.1016/j.biopsycho. 2013.08.005

Mills-Koonce, W. R., Gariépy, J., Propper, C., Sutton, K., Calkins, S., Moore, G., & Cox, M. (2007). Infant and parent factors associated with early maternal sensitivity: A caregiver-attachment systems approach. *Infant Behavior & Development, 30*, 114-126. doi:10.1016/j.infbeh. 2006.11.010

Mills-Koonce, W. R., Propper, C., Gariépy, J., Barnett, M., Moore, G. A., Calkins, S., & Cox, M. J. (2009). Psychophysiological correlates of parenting behavior in mothers of young children. *Developmental Psychobiology, 51*, 650-661. doi:10.1002/dev.20400

Milner, J. S. (1986). *The Child Abuse Potential Inventory: Manual*. (2nd ed.). Webster, NC: Psytec.

Milner, J. S. (1993). Social information processing and child physical abuse. *Clinical Psychology Review, 13*, 275-294.

Milner, J. S. (2000). Social information processing and child physical abuse: Theory and research. In D. J. Hansen (Ed.), *Nebraska Symposium on Motivation* (Vol. 45, pp. 39–84). University of Nebraska Press.

Milner, J. S. (2004). The Child Abuse Potential (CAP) Inventory. In M. L. Hilsenroth & D. L. Segal (Eds.), *Comprehensive handbook of psychological assessment: Vol. 2. Personality assessment* (pp. 237-246). New York: John Wiley & Sons.

Milner, J. S., & Wimberley, R. C. (1979). An inventory for the identification of child abusers. *Journal of Clinical Psychology, 35*, 95-100.

Molendijk, M.L., Bus, B.A.A., Spinhoven, P., Kaimatzoglou, A., Oude Voshaar, R.C., Penninx, B.W.J.H., Van IJzendoorn, M.H., & Elzinga, B.M. (2012). A systematic review and meta-analysis on the association between BDNF val66met and hippocampal volume – A genuine effect or a winners curse? *American Journal of Medical Genetics. Part B, Neuropsychiatric Genetics, 159B*, 731-740. doi:10.1002/ajmg.b.32078

Moore, G. A., Hill-Soderlund, A. L., Propper, C. B., Calkins, S. D., Mills-Koonce, W. R., & Cox, M. J. (2009). Mother-infant vagal regulation in the face-to-face still-face paradigm is moderated by maternal sensitivity. *Child Development, 80*, 209–223. doi:10.1111/j.1467-8624.2008.01255.x

Moran, G., Pederson, D. R., & Krupka, A. (2005). Maternal unresolved attachment status impedes the effectiveness of interventions with adolescent mothers. *Infant Mental Health Journal, 26,* 231-249. doi: 10.1002/imhj.20045

Morton, N., & Browne, K. D. (1998). Theory and observation of attachment and its relation to child maltreatment: A review. *Child Abuse & Neglect, 22*, 1093-1104. doi:10.1016/S0145-2134(98)00088-X

Moss, E., Dubois-Comtois, K., Cyr, C., Tarabulsy, G. M., St-Laurent, D., & Bernier, A. (2011). Efficacy of a home-visiting intervention aimed at improving maternal sensitivity, child attachment, and behavioral outcomes for maltreated children: A randomized control trial. *Development and Psychopathology, 23,* 195-210. doi:10.1017/S0954 579410000738

Mullen, B. (1989). *Advanced basic meta-analysis*. Hillsdale, NJ: Erlbaum.

Munro, E., Taylor, J.S., & Bradbury-Jones, C. (2013). Understanding the causal pathways to child maltreatment: Implications for health and social care policy and practice. *Child Abuse Review, 23,* 61-74. doi: 10.1002/car.2266

Nater, U.M., & Rohleder, N. (2009). Salivary alpha-amylase as a noninvasive biomarker for the sympathetic nervous system: current state of research. *Psychoneuroendocrinology, 34,* 486–496. doi: 10.1016/j.psyneuen.2009.01.014

Newcomb, M.D., & Locke, T.F. (2001). Intergenerational cycle of maltreatment: A popular concept obscured by methodological limitations. *Child Abuse & Neglect, 25*, 1219–1240. doi:10.1016/S0145-2134(01)00267-8

Oosterman, M., De Schipper, J. C., Fisher, P., Dozier, M., & Schuengel, C. (2010). Autonomic reactivity in relation to attachment and early adversity among foster children. *Development and Psychopathology, 22*, 109–118. doi:10.1017/S0954579409990290

Opie, L. H. (2004). Introductory cardiovascular concepts. In L. H. Opie (Ed.), *Heart physiology (4th ed.): From cell to circulation* (pp. 3-15). Philadelphia, PA: Lippincott, Williams and Wilkins.

Out, D., Bakermans-Kranenburg, M.J., Granger, D.A., Cobbaert, C.M., & Van IJzendoorn, M.H. (2011). State and trait variance in salivary α-amylase: A behavioral genetic study. *Biological Psychology, 88*, 147–154. doi:10.1016/j.biopsycho.2011.07.008

Out, D., Bakermans-Kranenburg, M.J., & Van IJzendoorn, M.H. (2009). The role of disconnected and extremely insensitive parenting in the development of disorganized attachment: Validation of a new measure. *Attachment & Human Development, 11,* 419-443. doi:10.1080/14616730903132289

Out, D., Bakermans-Kranenburg, M. J., Van Pelt, J., & Van IJzendoorn, M. H. (2012). Salivary α-amylase and intended harsh caregiving in response to infant crying: Evidence for physiological hyperreactivity. *Child Maltreatment, 17*, 295–305. doi:10.1177/1077559512464427

Out, D., Pieper, S., Bakermans-Kranenburg, M. J., Zeskind, P. S., & Van IJzendoorn, M. H. (2010). Intended sensitive and harsh caregiving responses to infant crying: The role of cry pitch and perceived urgency in an adult twin sample. *Child Abuse & Neglect, 34*, 863–873. doi: 10.1016/j.chiabu.2010.05.003

Pears, K. C., & Capaldi, D. M. (2001). Intergenerational transmission of abuse: A two-generational prospective study of an at-risk sample. *Child Abuse & Neglect, 25*, 1439–1461. doi:10.1016/S0145-2134(01)00286-1

Petticrew M., & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide.* Oxford, UK: Blackwell Publishing.

Pickreign Stronach, E., Toth, S. L., Rogosch, F. A., & Cicchetti, D. (2013). Preventive interventions and sustained attachment security in maltreated children: A 12-month follow-up of a randomized controlled trial. *Development and Psychopathology, 26,* 919-930. doi:10.1017/S0954 579413000278

Porges, S. W. (1991). Vagal tone: An autonomic mediator of affect. In J. Garber & K. A. Dodge (Eds.), *The development of emotion regulation and dysregulation. Cambridge studies in social and emotional development* (pp. 111-128). New York, NY: Cambridge University Press.

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers, 36,* 717-731. doi: 10.3758/BF03206553

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40,* 879-891. doi:10.3758/BRM.40.3.879

*Pruitt, D. L., & Erickson, M. T. (1985). The Child Abuse Potential Inventory: A study of concurrent validity. *Journal of Clinical Psychology, 41*, 104-111. doi:10.1002/1097-4679(198501)41:1<104:: AID-JCLP2270 410119>3.0.CO;2-V

Raval, V., Goldberg, S., Atkinson, L., Benoit, D., Myhal, N., Poulton, L., . . . Zwiers, M. (2001). Maternal attachment, maternal responsiveness and infant attachment. *Infant Behavior & Development, 24*, 281–304. doi:10.1016/S0163-6383(01)00082-0

*Reijman, S., Alink, L. R. A., Compier-de Block, L. H. C. G., Werner, C. D., Maras, A., Rijnberk, C., . . . Bakermans-Kranenburg, M. J. (2014). Autonomic reactivity to infant crying in maltreating mothers, *Child Maltreatment, 19*, 101-112. doi:10.1177/1077559514538115

Reijman, S., Alink, L. R. A., Compier-de Block, L. H. C. G., Werner, C. D., Maras, A., Rijnberk, C., . . . Bakermans-Kranenburg, M. J. (2015). Salivary α-amylase reactivity to infant crying in maltreating mothers. *Child Psychiatry & Human Development, 46*, 589-599. doi:10.1007/ s10578-014-0499-6

Reijneveld, S. A., Van der Wal, M. F., Brugman, E., Hira Sing, R. A., & Verloove-Vanhorick, S. P. (2004). Infant crying and abuse. *The Lancet, 364*, 1340–1342. doi:10.1016/S0140-6736(04)17191-2

Riem, M.M.E., Bakermans-Kranenburg, M.J., Van IJzendoorn, M.H., Out, D., & Rombouts, S.A.R.B. (2012). Attachment in the brain: adult attachment representations predict amygdala and behavioral responses to infant crying. *Attachment & Human Development, 14,* 533–551. doi:10.1080/14616734.2012.727252

Riese, H., Groot, P. F. C., van den Berg, M., Kupper, N. H. M., Magnee, E. H. B., Rohaan, E. J., . . . De Geus, E. J. C. (2003). Large-scale ensemble averaging of ambulatory impedance cardiograms. *Behavior Research Methods, 35*, 467–477. doi:10.3758/BF03195525

Riggs, S. A., & Jacobvitz, D. (2002). Expectant parents' representations of early attachment relationships: Associations with mental health and family history. *Journal of Consulting and Clinical Psychology, 70,* 195-204. doi:10.1037/0022-006X.70.1.195

Riggs, S. A., Paulson, A., Tunnell, E., Sahl, G., Atkison, H., & Ross, C. A. (2007). Attachment, personality, and psychopathology among adult inpatients: Self-reported romantic attachment style versus Adult Attachment Interview states of mind. *Development and Psychopathology, 19,* 263-291. doi:10.1017/S0954579407070149

Roisman, G. I., Tsai, J. L., & Chiang, K. S. (2004). The emotional integration of childhood experiences: Physiological, facial expressive, and self-reported emotional response during the adult attachment interview. *Developmental Psychology, 40*, 776-789. doi:10.1037/0012-1649.40.5.776

Rosenthal, R., & DiMatteo, M.R. (2001). Meta-analysis: Recent developments in quantitative methods for literature reviews. *Annual Review of Psychology, 52*, 59-82.

Schuengel, C., Bakermans-Kranenburg, M.J., & Van IJzendoorn, M.H. (1999). Frightening maternal behavior linking unresolved loss and disorganized infant attachment. *Journal of Consulting and Clinical Psychology, 67*, 54-63. doi:10.1037/0022-006X.67.1.54

Sedlak, A.J., Mettenburg, J., Basena, M., Petta, I., McPherson, K., Green, A., & Li, S. (2010). Fourth National Incidence Study of child abuse and neglect (NIS-4): Report to Congress. U.S. Department of Health and Human Services, Administration for Children and Families, Washington, DC.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference.* Boston, NY: Houghton Mifflin Company.

Sierra, M., & Berrios, G. E. (1998). Depersonalization: Neurobiological perspectives. *Biological Psychiatry, 44*, 898–908. doi:10.1016/S0006-3223(98)00015-8

Skowron, E. A., Cipriano-Essel, E., Benjamin, L. S., Pincus, A. L., & Van Ryzin, M. J. (2013). Cardiac vagal tone and quality of parenting show concurrent and time-ordered associations that diverge in abusive, neglectful, and non-maltreating mothers. *Couple and Family Psychology: Research and Practice, 2*, 95–115. doi:10.1037/cfp 0000005

Skowron, E. A., Loken, E., Gatzke-Kopp, L. M., Cipriano-Essel, E. A., Woehrle, P. L., Van Epps, J. J., … Ammerman, R. T. (2011). Mapping cardiac physiology and parenting processes in maltreating mother-child dyads. *Journal of Family Psychology, 25*, 663-674. doi:10.1037/ a0024528

Soltis, J. (2004). The signal functions of early infant crying. Behavioral and Brain Sciences, 27, 443–490. doi:10.1017/S0140525X0400010X

Spangler, G., & Zimmermann, P. (1999). Attachment representation and emotion regulation in adolescents: A psychobiological perspective on internal working models. *Attachment & Human Development, 1*, 270-290. doi:10.1080/14616739900134151

Spiegel, D., Loewenstein, R. J., Lewis-Fernández, R., Sar, V., Simeon, D., Vermetten, E., …Dell, P. F. (2011). Dissociative disorders in DSM-5. *Depression and Anxiety, 28*, 824-852. doi:10.1002/da.20923

Spinhoven, P., Elzinga, B.M., Hovens, J.G.F.M., Roelofs, K., Zitman, F.G., Van Oppen, P., & Penninx, B.W.J.H. (2010). The specificity of childhood adversities and negative life events across the life span to anxiety and depressive disorders. *Journal of Affective Disorders, 126, 103–112*. doi:10.1016/j.jad.2010.02.132

*Stasiewicz, P. R., & Lisman, S. A. (1989). Effects of infant cries on alcohol consumption in college males at risk for child abuse. *Child Abuse & Neglect, 13*, 463-470. doi:10.1016/0145-2134(89)90050-1

Steele, H. (2003). Unrelenting catastrophic trauma within the family: When every secure base is abusive. *Attachment & Human Development, 5*, 353-366. doi:10.1080/14616730310001633438

Stemmler, G. (2004). Physiological processes during emotion. In P. Philippot & R. S. Feldman (Eds.), *The regulation of emotion* (pp. 33-70). Mahwah, NJ: Erlbaum.

Sterling, P. & Eyer, J. (1988). Allostasis: A new paradigm to explain arousal pathology. In S. Fisher & J. Reason (Eds.), *Handbook of life stress, cognition and health* (pp. 629-649). New York, NY: John Wiley & Sons.

Stith, S. M., Ting Liu, L., Davies, C., Boykin, E. L., Alder, M. C., . . .Dees, J. E. M. E. G. (2009). Risk factors in child maltreatment: A meta-analytic review of the literature. *Aggression and Violent Behavior, 14*, 13–29. doi:10.1016/ j.avb.2006.03.006

Stoltenborgh, M., Bakermans-Kranenburg, M.J., Alink. L.R.A., & Van IJzendoorn, M.H. (2015). The prevalence of child maltreatment across the globe: Review of a series of meta-analyses. *Child Abuse Review, 24*, 37-50. doi:10.1002/car.2353

Stratakis, C. A., & Chrousos, G. P. (1995). Neuroendocrinology and pathophysiology of the stress system. *Annals of the New York Academy of Sciences, 771*, 1-18. doi:10.1111/j.1749-6632.1995.tb44666.x

Sturge-Apple, M. L., Skibo, M. A., Rogosch, F. A., Ignjatovic, Z., & Heinzelman, W. (2011). The impact of allostatic load on maternal sympathovagal functioning in stressful child contexts: Implications for problematic parenting. *Development and Psychopathology, 23*, 831–844. doi:10.1017/S0954579411000332

Tabachnik, B. G., & Fidell, L. S. (2001). Using multivariate statistics (4th ed.). Boston, MA: Allyn and Bacon.

Takai, N., Yamaguchi, M., Aragaki, T., Eto, K., Uchihashi, K., & Nishikawa, Y. (2004). Effect of psychological stress on the salivary cortisol and amylase levels in healthy young adults. *Archives of Oral Biology, 49*, 963–968. doi:10.1016/j.archoralbio.2004.06.007

Thombs, B. D., Bernstein, D. P., Lobbestael, J., & Arntz, A. (2009). A validation study of the Dutch childhood trauma questionnaire-short form: Factor structure, reliability, and known-groups validity. *Child Abuse & Neglect, 33*, 518–523. doi:10.1016/j.chiabu.2009.03.001

Thomson, P., & Jaque, S. V. (2014). Unresolved mourning, supernatural beliefs and dissociation: A mediation analysis. *Attachment & Human Development, 16*, 499-514. doi:10.1080/14616734.2014.926945

Toth, S.L., Maughan, A., Manly, J.T., Spagnola, M., & Cicchetti, D. (2002). The relative efficacy of two interventions in altering maltreated preschool children's representational models: Implications for attachment theory. *Development and Psychopathology, 14*, 877-908. doi:10.1017/S095457940200411X

Tsigos, C., & Chrousos, G. P. (2002). Hypothalamic-pituitary-adrenal axis, neuroendocrine factors and stress. *Journal of Psychosomatic Research, 53*, 865-871. doi:10.1016/S0022-3999(02)00429-4

Van IJzendoorn, M. H. (1995). Adult attachment representations, parental responsiveness, and infant attachment: A meta-analysis on the predictive validity of the Adult Attachment Interview. *Psychological Bulletin, 117*, 387-403. doi:10.1037/0033-2909.117.3.387

Van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (1996). Attachment representations in mothers, father, adolescents, and clinical groups: A meta-analytic search for normative data. *Journal of Consulting and Clinical Psychology, 64*, 8-21. doi:10.1037/0022-006X.64.1.8

Van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2014). Confined quest for continuity: The categorical versus continuous nature of attachment. *Monographs of the Society for Research in Child Development, 79,* 157-167. doi:10.1111/mono.12120

Van IJzendoorn, M. H. & Kroonenberg, P. M. (1988). Cross-cultural patterns of attachment: A meta-analysis of the Strange Situation. *Child Development, 59*, 147-156. doi:10.2307/1130396

Viamontes, G. I., & Nemeroff, C. B. (2009). Brain-body interactions: The physiological impact of mental processes–The neurobiology of the stress response. *Psychiatric Annals, 39*, 975–984. doi:10.3928/ 00485718-20091124-03

Voorthuis, A., Bhandari, R., Out, D., Van der Veen, R., Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2014). Childhood maltreatment experiences and child abuse potential: Temperamental sensitivity as moderator? *Journal of Family Violence, 29*, 749-756. doi:10.1007/s10896-014-9624-3

Wolfe, D.A. (1985). Child-abusive parents: an empirical review and analysis. *Psychological Bulletin, 97*, 462–482. doi:10.1037/0033-2909.97.3.462

*Wolfe, D. A., Fairbank, J. A., Kelly, J. A., & Bradlyn, A.S. (1983). Child abuse parents' physiological responses to stressful and non-stressful behavior in children. *Behavioral Assessment, 5*, 363-371.

World Health Organization. (1999). *Report of the consultation on child abuse prevention*. Geneva, Switzerland.

Yates, T. M. (2007). The developmental consequences of child emotional abuse: A neurodevelopmental perspective. *Journal of Emotional Abuse, 7*, 9–34. doi:10.1300/J135v07n02_02

Zeanah, C. H., Benoit, D., Hirshberg, L., Barton, M. L., & Regan, C. (1994). Mothers' representations of their infants are concordant with infant attachment classifications. *Developmental Issues in Psychiatry and Psychology, 1*, 9–18.

Zeskind, P. S., & Lester, B. M. (1978). Acoustic features and auditory perception of the cries of newborns with prenatal and perinatal complications. *Child Development, 49*, 580–589. doi:10.2307/1128224

Zeskind, P. S., & Marshall, T. R. (1988). The relation between variations in pitch and maternal perceptions of infant crying. *Child Development, 59*, 193–196. doi:10.2307/1130401

Zeskind, P.S., Sale, J., Maio, M.L., Huntington, L., & Weiseman, J.R. (1985). Adult perceptions of pain and hunger cries: A synchrony of arousal. Child Development, 56, 549–554. doi:10.2307/1129744

Zeskind, P. S., & Shingler, E. A. (1991). Child abusers' perceptual responses to newborn infant cries varying in pitch. *Infant Behavior and Development, 14*, 335–347. doi:10.1016/0163-6383(91)90026-O

Nederlandse samenvatting (Summary in Dutch)

Aan het begin van de zestiger jaren publiceerden kinderarts Henry Kempe en collega's een artikel over het Battered-childsyndroom, waarin hij de aandacht vestigde op kinderen die letsel hadden opgelopen door gewelddadig toedoen van hun ouder(s) (Kempe, Silverman, Steele, Droegemueller, & Silver, 1962). Deze publicatie speelde een belangrijke rol in het aanwakkeren van wetenschappelijke interesse in kindermishandeling, waartoe zowel fysieke en emotionele mishandeling en verwaarlozing als seksueel misbruik behoren (World Health Organization, 1999). Er ontstond een onderzoeksveld dat zich sindsdien heeft gericht op het identificeren van risicofactoren en consequenties. Ouderkenmerken die een risico vormen voor kindermishandeling zijn bijvoorbeeld lage SES, werkloosheid (Euser et al., 2013), de mishandeling die ouders in hun eigen jeugd zelf hebben meegemaakt (Pears & Capaldi, 2001), en psychopathologie (Stith et al., 2009). Met zulke kennis kunnen interventies worden opgezet met het doel het vóórkomen van kindermishandeling te verminderen. Twee potentiële risicofactoren waar relatief kleinschalig onderzoek naar is gedaan zijn de activiteit en stressreactiviteit van het autonoom zenuwstelsel en gehechtheid-representatie bij ouders. In dit proefschrift staan een empirische studie, een literatuuroverzicht, en een dubbele meta-analyse beschreven die deze factoren onder de loep nemen.

Activiteit en stress reactiviteit van het autonoom zenuwstelsel

Het autonoom zenuwstelsel (ANS) bestaat uit een sympathische en parasympathische tak; algemeen gesproken wordt bij stress de sympathische tak geactiveerd terwijl parasympathische activiteit daalt (Viamontes & Nemeroff, 2009). Dit uit zich bijvoorbeeld in een verhoogde hartslag en activiteit van de zweetklieren. Het lichaam wordt zo gemobiliseerd om te kunnen inspelen op behoeften vanuit de omgeving. In reactie op stresserende kindsignalen, waarvan het huilen van baby's een universeel voorbeeld is, laten ouders in het algemeen ook een stijging in fysiologische activiteit zien (Del Vecchio, Walter, & O'Leary, 2009; Frodi, Lamb, Leavitt, & Donovan, 1978). Dit wordt als functioneel beschouwd en is mogelijk zelfs een voorwaarde voor ouders om sensitief op hun kind te kunnen reageren (Joosen et al., 2012). Een hypothese is dat een afwijkende autonome stressrespons gedeeltelijk kan verklaren waarom sommige ouders te fel (e.g. mishandeling) of ontoereikend (e.g. verwaarlozing) op hun kinderen reageren. Ter ondersteuning van deze hypothese werd in een vroege studie gevonden

dat mishandelende moeders een sterkere stijging in hartslag en huidgeleiding lieten zien in reactie op huilgeluiden van baby's dan niet-mishandelende moeders (hoewel mishandelende moeders tegelijkertijd een *zwakkere* stijging in diastolische bloeddruk lieten zien; Frodi & Lamb, 1980). Deze resultaten suggereerden dat het autonoom zenuwstelsel van mishandelende moeders *hyper*reactief is, waardoor ze mogelijk hun gedrag minder goed in de hand hebben. Hoewel de bevindingen van studies in navolging van Frodi en Lamb (1980) tegenstrijdig genoemd kunnen worden, concludeerden de auteurs van een literatuuronderzoek dat de "hyperreactiviteit hypothese" overwegend ondersteuning leek te vinden (McCanne & Hagstrom, 1996). Sindsdien heeft onderzoek zich ruim vijftien jaar niet meer met deze vraag beziggehouden. Het is relevant op te merken dat vroege studies naar reactiviteit van het ANS als risicofactor voor kindermishandeling zich vooral richtten op fysieke mishandeling, met weinig tot geen systematische aandacht voor andere typen mishandeling, zoals verwaarlozing. Een recentere studie naar de relatie tussen moeders' autonome reacties op kindsignalen en hun opvoedingsstijl toonde aan dat autonome *hyper*reactiviteit gerelateerd was aan intrusief oudergedrag, terwijl autonome *hypo*reactiviteit (een gebrek aan respons van het ANS) samenhing met teruggetrokken / passief gedrag bij moeders (Sturge-Apple et al., 2011). Dit roept de vraag op of deze responspatronen van het ANS differentieel samenhangen met subtypen kindermishandeling, zodat hyperreactiviteit mogelijk geassocieerd is met actieve mishandeling, terwijl hyporeactiviteit samen zou gaan met de passiviteit van verwaarlozing.

Hoofdstuk 2 en 3 van dit proefschrift beschrijven een empirische studie naar reactiviteit van het ANS op huilgeluiden van baby's in een steekproef van mishandelende moeders en een vergelijkingsgroep van niet-mishandelende moeders. De mishandelende moeders waren in behandeling bij een kliniek voor geestelijke gezondheidszorg vanwege opvoedingsproblemen en tekortschietend ouderschap. Een subgroep woonde tijdelijk met kind(eren), en eventueel met de partner, in een wooncomplex onder toezicht van psychiaters, en ontving dagelijkse begeleiding. De overige moeders bezochten drie dagen per week met kind(eren), en eventueel met de partner, een gezinsdagbehandeling. Op basis van hun gezinsdossiers codeerden we incidenten van mishandeling die hadden plaatsgevonden en we maakten daarbij onderscheid tussen (emotionele en/of fysieke) mishandeling en verwaarlozing. Alle moeders uit de mishandelende groep hadden hun kind(eren) verwaarloosd, terwijl iets meer dan de helft aanvullend mishandeling had gepleegd. De controlegroep werd geworven via een andere

subdivisie van de kliniek waar hun kinderen werden behandeld voor een leerprobleem of ontwikkelingsstoornis. Tijdens de onderzoeksafspraak namen moeders deel aan het huilparadigma (Zeskind & Shingler, 1991), waarbij ze enkele minuten keken naar neutrale, rustgevende plaatjes en vervolgens luisterden naar negen huilgeluiden van baby's. De negen geluiden werden aangeboden in drie blokken; ieder blok bestond uit drie geluiden die wisselden in toonhoogte (500, 700, 900 Hz) in gerandomiseerde volgorde. Het paradigma werd afgesloten met weer een aantal plaatjes. Gedurende dit paradigma deden we verscheidene metingen van het autonoom zenuwstelsel, namelijk hartslag (onder invloed van zowel sympathische als parasympathische activiteit); respiratoire sinus aritmie (een parasympathische maat), pre-ejectie periode, en huidgeleiding (sympathische maten). De fysiologische gegevens van 42 mishandelende en 38 niet-mishandelende moeders waren bruikbaar. Uit speekselmonsters werd verder enzymatische alpha amylase geanalyseerd, waarvan de activiteit ook zowel door de sympathische als de parasympathische tak beïnvloed wordt (mishandelende groep n = 44; controlegroep n = 42). We vonden dat de huidgeleiding van mishandelende moeders minder steeg dan die van niet-mishandelende moeders. De resultaten voor pre-ejectie periode waren in de tegenovergestelde richting, en suggereerden iets meer sympathische reactiviteit in de mishandelende groep, maar dit effect was minder uitgesproken: voor de mishandelende groep noch de controlegroep was de verandering in pre-ejectie periode in reactie op de huilgeluiden significant. Er waren geen verschillen tussen de groepen in hartslag of respiratoire sinus aritmie respons. Mishandelende moeders hadden over het algemeen lagere alpha amylase activiteit, en lieten geen verandering in alpha amylase zien tijdens het paradigma, terwijl alpha amylase bij niet-mishandelende moeders steeg in reactie op de huilgeluiden. Hoewel deze bevindingen niet eenduidig zijn, wijzen ze overwegend op een zwakkere autonome stressreactiviteit in mishandelende moeders. Bovendien was er bij de mishandelende groep mogelijk een verstoorde coördinatie tussen de verschillende componenten van het ANS: waar in de controlegroep, overeenkomstig met verwachtingen, sprake was van negatieve correlaties tussen hartslag en pre-ejectie periode en positieve correlaties tussen hartslag en alpha amylase, was dit in de mishandelende groep *niet* het geval.

Onze resultaten leken te contrasteren met de bestaande literatuur. Daarom deden we een literatuuronderzoek en twee meta-analyses naar de basale activiteit en stressreactiviteit van het autonoom zenuwstelsel als risicofactor voor kindermishandeling, beschreven in hoofdstuk 5. We

vonden 12 empirische studies waarin autonome (re-)activiteit was gemeten bij mishandelende ouders of volwassenen met een verhoogd risico om kindermishandeling te plegen (inclusief onze eigen empirische studie hierboven beschreven). Het literatuuroverzicht liet zien dat de "hyperreactiviteit hypothese" strikt genomen weinig ondersteuning leek te vinden en dat steekproeven vaak erg klein waren. Statistische power-analyse bevestigde deze indruk; bijna alle studies hadden te weinig statistisch onderscheidingsvermogen. De meta-analyses wezen uit dat mishandelende ouders / hoge risicogroepen hogere basale autonome activiteit hadden in vergelijking met niet-mishandelende / lage risicogroepen (Hedges' g = 0.24). Voor de relatie tussen autonome stressreactiviteit en (hoog risico op) kindermishandeling vonden we een niet-significant positief effect (Hedges' g = 0.27). Cumulatieve meta-analyse op basis van chronologie liet zien dat voor *sympathische* stressreactiviteit sterke positieve effecten uit enkele vroege studies met iedere daaropvolgende studie verder tot nul werden gereduceerd.

De resultaten voor sympathische reactiviteit uit onze empirische studie, in het bijzonder die voor huidgeleiding, verschilden significant van de meta-analytische resultaten voor sympathische reactiviteit. Een mogelijke verklaring is dat onze steekproef gekarakteriseerd kan worden door de hoge prevalentie van verwaarlozing, terwijl in andere studies de nadruk lag op fysieke mishandeling. Bovendien controleerden we in onze studie voor potentieel vertekenende variabelen, zoals de mishandeling waar ouders vroeger zelf slachtoffer van waren geweest, terwijl dat in andere studies niet gebeurde. In de context van de meta-analyse verliest onze empirisch gebaseerde conclusie dat mishandelende moeders een zwakkere stressreactiviteit lieten zien daarom niet noodzakelijk aan validiteit.

Gehechtheidrepresentatie

De representatie die volwassenen hebben ten opzichte van gehechtheidrelaties kunnen de kwaliteit van het ouderschap beïnvloeden (Van IJzendoorn, 1995). De meest minutieuze methode voor de evaluatie van gehechtheidrepresentaties is het Gehechtheidsbiografisch Interview (GBI; George, Kaplan, & Main, 1985), waarin de geïnterviewde wordt gevraagd zowel de vroege als huidige relatie met de ouders/verzorgers te omschrijven. Een belangrijke component van het interview is de vraag om de vroege relatie met de primaire verzorgers (vaak de vader en moeder) in beknopte termen te definiëren en deze vervolgens te ondersteunen met concrete herinneringen. Op basis van de samenhang van het antwoordpatroon gedurende het interview wordt de

gehechtheidrepresentatie gecodeerd (Main, Goldwyn, & Hesse, 2003). De classificatie *veilig-autonoom* (F) wordt toegekend wanneer de samenhang tussen de abstract/semantische typering en de concrete herinneringen hoog is. Ongeacht of de ervaringen van de spreker overwegend positief of negatief waren, de geïnterviewde beschouwt ze met een zekere objectiviteit en hecht openlijk waarde aan persoonlijke relaties. In het geval van de *onveilig-gereserveerde* (Ds) representatie wordt de vroege relatie met de ouders getypeerd als positief, terwijl dit niet met concrete herinneringen onderbouwd wordt, of daardoor zelfs wordt tegengesproken. De sprekers geven vaak erg korte antwoorden en gaan niet of slechts oppervlakkig in op de vragen. Gehechtheidsgerelateerde herinneringen lijken zo te worden vermeden. *Onveilig-gepreoccupeerde* (E) sprekers geven lange, diffuse antwoorden waarin ze niet tot een samenhangend beeld van de relatie met hun ouders komen. De evaluatie van hun ervaringen oscilleert gedurende het interview, soms van het ene op het andere moment. Ze kunnen boosheid jegens een of beide ouders uiten in wijdlopige passages waarin ze de context van het interview uit het oog lijken te verliezen. Tot slot, als de spreker potentieel traumatische ervaringen benoemt (i.e., seksueel misbruik, fysieke of zware emotionele mishandeling, of dierbaren die overleden zijn) wordt aanvullend zijn/haar narratief rondom deze gebeurtenissen gecodeerd. Als er anomalieën zijn in het redeneren of praten over de ervaringen (bijvoorbeeld spreken over een overleden dierbare alsof degene nog leeft) zonder dat de spreker dit zelf opmerkt, dan kan de classificatie *onverwerkt/gedesoriënteerd* (U/d) toegekend worden. Naast de U/d classificatie wordt er ook altijd een secundaire F, Ds, of E classificatie gecodeerd. De U/d classificatie komt onevenredig veel voor in klinische populaties (Bakermans-Kranenburg & Van IJzendoorn, 2009) en hangt samen met afwijkend oudergedrag (Madigan et al., 2006). De relatie tussen een U/d classificatie en kindermishandeling is nog niet eerder onderzocht in steekproeven van zowel mishandelende als verwaarlozende ouders.

In dezelfde klinische steekproef als tevoren beschreven namen we het GBI af (mishandelende groep n = 38; niet-mishandelende groep n = 35). We vonden dat meer mishandelende moeders een U/d representatie hadden (42%) dan niet-mishandelende moeders (17%). Mishandelende moeders scoorden bovendien lager op *coherence of mind*; de consistentie van hun impliciete overtuigingen en denkpatronen ten aanzien van gehechtheid. Vervolgens hebben we getoetst of de associatie tussen gehechtheidrepresentatie en kindermishandeling gemedieerd werd door regulatie van het autonoom zenuwstelsel in gehechtheidsgerelateerde

context. We deden metingen van huidgeleiding en respiratoire sinus aritmie terwijl moeders keken naar het troostparadigma (Johnson, Dweck, & Chen, 2007). In korte videoclips komen een kleine geanimeerde ellips (het "kind") en een grotere geanimeerde ellips (de "verzorger" / "moeder") samen in beeld, maar raken van elkaar gescheiden. In één scenario laat de "moeder" het "kind" alleen achter, in een ander scenario komt "moeder" terug en worden de twee herenigd. De fysiologische respons van moeders tijdens het troostparadigma verschilde overeenkomstig met hun gehechtheidrepresentatie op basis van het GBI: moeders met een U/d classificatie of een hogere U/d score en moeders met een onveilige classificatie of lage *coherence of mind* score lieten een daling in huidgeleiding zien tijdens de hereniging tussen "moeder" en "kind". Een daling in huidgeleiding is in eerder onderzoek specifiek geassocieerd met een gevoel van lichte droefenis (Kreibig, 2010). Mishandelende en niet-mishandelende moeders verschilden niet in hun fysiologische respons tijdens het troostparadigma en we vonden geen mediërend effect.

Conclusie

De resultaten die in dit proefschrift beschreven zijn, wijzen erop dat een gebrek aan reactiviteit van het autonoom zenuwstelsel op stresserende kindsignalen mogelijk een risicofactor is voor kindermishandeling (hoofdstuk 2 en 3). Gezien het feit dat onze steekproef vooral gekenmerkt werd door verwaarlozing, is het denkbaar dat een gebrek aan reactie op gedragsniveau gepaard gaat met een gebrek aan reactie op fysiologisch niveau. Een meta-analyse (hoofdstuk 5) liet verder zien dat mishandelende ouders en volwassenen met verhoogd risico om te mishandelen hogere basale autonome activiteit hadden, in de afwezigheid van stresssignalen. Interventies om kindermishandeling te reduceren kunnen daarom baat hebben bij het toevoegen van een component die zich richt op fysiologische stressregulatie, maar momenteel ontbreken gerandomiseerde experimenten die dit testen.

Onze bevinding dat meer mishandelende moeders een U/d gehechtheidrepresentatie hadden heeft eveneens klinische implicaties. Hoewel een korte interventie die zich richtte op het opvoedingsgedrag van mishandelende ouders effectief was in het verhogen van sensitief ouderschap en daarom als veelbelovend kan worden beschouwd voor het terugdringen van kindermishandeling (Moss et al., 2011), was een gedragsgerichte interventie met tienermoeders minder effectief wanneer deelnemers een U/d representatie hadden (Moran, Pederson, & Krupka,

2005). In zulke gevallen kan traumaverwerking en het bijstellen van de representatie van menselijke relaties een noodzakelijke voorwaarde zijn voor het veranderen van oudergedrag.

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Curriculum Vitae

Sophie Reijman werd geboren op 14 oktober 1986 te 's-Gravenhage. In 2005 behaalde ze haar diploma aan het Gymnasium Haganum aldaar. Ze verhuisde naar Spanje en begon in 2006 met de studie psychologie aan de Universiteit van Valencia. Daar maakte ze kennis met gehechtheidstheorie en deed ze haar eerste onderzoekservaring op met de *Situación Extraña*, de Strange Situation Procedure. In 2010 keerde Sophie terug naar Nederland en sloot haar bachelor psychologie af aan de Universiteit Leiden. Aansluitend begon ze bij de afdeling Algemene en Gezinspedagogiek aan de research master Developmental Psychopathology in Education and Child Studies, die ze in 2012 afrondde. Tijdens haar masteropleiding werkte Sophie als akademie-assistent mee aan het onderzoeksproject over stressregulatie in mishandelende moeders, waarvan ze één van de coördinatoren werd; een functie die ze vanuit een aanstelling als promovenda vanaf 2012 vervolgde. Resultaten van dit project zijn in dit proefschrift beschreven. Daarnaast heeft Sophie college gegeven over de neurobiologische consequenties van kindermishandeling en is ze gecertificeerd codeur van het Gehechtheidsbiografisch Interview (Adult Attachment Interview; AAI). Vanaf januari 2016 is ze als postdoc verbonden aan de universiteit van Cambridge om onderzoek te doen naar gedesorganiseerde gehechtheid.

Publicaties (List of publications)

Reijman, S., Alink, L. R. A., Compier-de Block, L. H. C. G., Werner, C. D., Maras, A., Rijnberk, C., ... Bakermans-Kranenburg, M. J. (2015). Salivary α-amylase reactivity to infant crying in maltreating mothers. *Child Psychiatry & Human Development, 46*, 589-599. doi:10.1007/s10578-014-0499-6

Reijman, S., Alink, L. R. A., Compier-de Block, L. H. C. G., Werner, C. D., Maras, A., Rijnberk, C., ...Bakermans-Kranenburg, M. J. (2014). Autonomic reactivity to infant crying in maltreating mothers, *Child Maltreatment, 19*, 101-112. doi:10.1177/1077559514538115

Compier-de Block, L.H.C.G., Alink, L.R.A., Reijman, S., Werner, C.D., Maras, A., Rijnberk, C., Van IJzendoorn, M.H., & Bakermans-Kranenburg, M.J. (2015). Handgrip force of maltreating mothers in reaction to infant signals. *Child Abuse & Neglect, 40,* 124-131.

Ingediende manuscripten

Reijman, S., Alink, L. R. A., Compier-de Block, L. H. C. G., Werner, C. D., Maras, A., Rijnberk, C., ... Bakermans-Kranenburg, M. J. (2015). Attachment representations and autonomic regulation in maltreating and non-maltreating mothers. Manuscript under review.

Reijman, S., Bakermans-Kranenburg, M. J., Hiraoka, R., Crouch, J. L., Milner, J. S., Alink, L. R. A., & Van IJzendoorn, M. H. (2015). Baseline functioning and stress reactivity in maltreating parents and at-risk adults: Review and meta-analyses of autonomic nervous system studies. Manuscript under review.