Physiological reactivity to infant crying in maltreating and non-maltreating mothers

Sophie Reijman
0991791

First reader:
Prof. dr. L. R. A. Alink

Second readers:
Prof. dr. M. J. Bakermans-Kranenburg,
Prof. dr. M. H. van IJzendoorn

Acknowledgements

I wish to thank Lenneke Alink for her expertise, prompt feedback, and dedicated and warm supervision; Marian Bakermans-Kranenburg and Rien van IJzendoorn for their inspiring work, for graciously admitting me to the research team, and their continuing help; Laura Compier-de Block, for bringing the required structure and an always friendly collaboration; Claudia Werner for getting me up to speed, and the research assistants for all the work they have done. Finally, I am grateful to all the mothers who kindly participated in the study.

Abstract

The relationship between child maltreatment and physiological reactivity to infant crying was evaluated using measures of heart rate (HR) in a sample of 30 maltreating and 24 non-maltreating mothers. For the maltreating group, child maltreatment had been substantiated. During a standardized cry paradigm, mothers listened to nine cry sounds of three different pitches. Each fundamental frequency was presented three times, over three blocks. Mothers rated the urgency of each sound and indicated what their caregiving responses would be. Maltreating mothers showed a lower HR reactivity than non-maltreating mothers to the first and second block of cry sounds as compared to baseline. A lack of functional physiological reactivity when required may explain their impaired ability to respond adequately to their children.

Introduction

Child maltreatment is the outcome of multiple pathways with different interacting risk factors, including parent and child characteristics (Brown, Cohen, Johnson, & Salzinger, 1998). Deviant child behavior and infant crying are examples of child characteristics capable of evoking abusive responses from caregivers (Ammerman, 1990; Frodi, 1981). A partial explanation for abusive responses of some parents but not others has long since been suggested to lie in physiological reactivity to infant stimuli such as crying (Disbrow, Doerr, & Caulfield, 1977; Friedrich, Tyler, & Clark, 1985). Overall, abusive parenting has been found to be associated with increased physiological reactivity to infant crying, but findings have been inconsistent (see McCanne & Hagstrom, 1996, for a review). McCanne and Hagstrom (1996) point out that this may be due to methodological differences, such as the type (visual versus auditory) and length of experimental stimuli, and the type of comparison stimuli (infant versus nonsocial). Therefore, the current study aims at evaluating heart rate (HR) reactivity to infant crying in maltreating mothers as compared to non-maltreating mothers using a standardized cry paradigm.

The possible negative outcomes for children who are or have been victims of abuse and neglect range from poor social functioning to impaired stress regulation and psychopathology (Alink, Cicchetti, Kim, & Rogosch, 2012; Cicchetti & Toth, 2005; Spinhoven et al., 2010). Thus, understanding the underlying mechanisms of child abuse and neglect is necessary for the development of effective prevention and intervention programs (Ammerman, 1990). One such important mechanism may be parents' physiological responses to infant crying. On the one hand, through crying infants communicate their distress and effectuate parental proximity and nurturance

(Ainsworth, 1969). For the formation of a secure attachment bond during the first year of life it is important that caregivers adequately provide care when so solicited by their children (De Wolff & Van IJzendoorn, 1997). On the other hand, infant cries can be perceived as aversive and as such may evoke harsh parenting responses (Frodi, 1981). The contrast between these effects of infant crying, ensuring survival by eliciting caregiving responses yet forming a risk factor for child abuse and even death, has been amply highlighted (Frodi, 1985; LaGasse, Neal, & Lester, 2005; Zeskind & Shingler, 1991).

One factor that has been identified as influencing the perception of and response to infant crying is the cry sound's fundamental frequency (Crowe & Zeskind, 1992; LaGasse, Neal, & Lester, 2005). Cry sounds that are higher in pitch are perceived as more urgent and may release more sensitive caregiving responses (Zeskind, 1980). This finding is congruent with the conceptualization of crying as a graded signal, which varies in intensity reflecting the urgency of the underlying motivation (Murray, 1979). It also supports the notion of differential responsiveness (Hubbard & Van IJzendoorn, 1991), according to which only vocalizations of severe distress require a prompt response. Deviant cry acoustics, such as extremely high fundamental frequency, are indeed associated with high infant vulnerability like prematurity, perinatal problems, and medical or neurological conditions (Frodi et al., 1978; Soltis, 2004). However, high-pitched sounds have also been associated with more intended harsh responses (Out, Pieper, Bakermans-Kranenburg, Zeskind, & Van IJzendoorn, 2010). This suggests that besides acoustic characteristics, contributing factors to differential perception and behavioral responses may also lie within caregivers, which is consistent with the interactive nature of child maltreatment.

Physiological reactivity to infant crying, such as measured by heart rate (HR), can be considered one of those contributing factors. It has been suggested that children's arousal as expressed by crying leads to autonomic arousal in the caregiver, which consequently triggers caregiving behavior (Zeskind, Sale, Maio, Huntington, & Weiseman, 1985). Incoherently, increased HR reactivity to infant crying has been associated with promptness of response (Del Vecchio, Walter, & O'Leary, 2009), which is a necessary condition for parental sensitivity, yet has also been related to child abuse (Frodi & Lamb, 1980). Recently, Joosen and colleagues (2012) found that increased HR reactivity was related to highly sensitive caregiving as observed in free play and bathing sessions. They interpreted their results in line with the autonomic subsystems of Porges' (2007) polyvagal theory. In accordance with this theory, high HR can result from activation of the sympathetic nervous system (SNS), which is associated with the perception of threat and a corresponding preparation for a 'fight or flight' response. An alternative option is that it stems from underlying activity of the parasympathetic nervous system (PNS). In that case efficient vagal brake functioning regulates behavior and emotion, thus promoting engagement and disengagement with an unthreatening environment. The findings by Joosen and colleagues (2012) supported this alternative, since high HR in sensitive mothers was accompanied by high respiratory sinus arrhythmia (RSA) withdrawal. Thus, highly sensitive parents may be prepared for social communication by increased physiological reactivity to infant crying, as seen in high HR accompanied by high RSA withdrawal. Conversely, (potentially) abusive parents may perceive the sounds as threatening and show increased HR through underlying SNS activation.

So far, little research has been done on HR reactivity to infant crying with mothers whose maltreatment of their children had been substantiated. The current

study adds to the literature by evaluating physiological reactivity and intended caregiving responses in a group of maltreating mothers as compared to non-maltreating mothers. In accordance with recommendations by McCanne and Hagstrom (1996), infant cry sounds were standardized and varying in pitch. Since both more sensitive and least sensitive (i.e., neglectful and abusive) mothers have been known to show increased HR reactivity to infant crying, no clear hypothesis can be formed concerning HR reactivity to cry sounds for the current sample. As for the urgency the mothers ascribe to the cry sounds and their intended caregiving responses, the notion of underlying SNS activation in maltreating mothers, and their perception of threat, suggests that maltreating mothers might rate cry sounds as more urgent than non-maltreating mothers, and perhaps intend to respond more harshly. Zeskind and Shingler (1991) however, found that abusive parents rated hyperphonated cries as sounding less urgent than did comparison parents. Therefore, these analyses may be considered exploratory.

Method

Participants

The sample consisted of 30 maltreating and 24 non-maltreating mothers who were recruited at a mental health facility. The maltreating mothers received family treatment, either as outpatients or as inpatients, whereas the non-maltreating mothers were recruited in a clinical subdivision concerning developmental or learning problems for at least one of their children. The maltreating mothers were informed about the study by their therapists. Child Protection Services (CPS) records were coded to substantiate recent or ongoing maltreatment using the Maltreatment Classification System (MCS; Barnett, Manly, & Cicchetti, 1993). When records were

inconclusive, the mother's psychiatrist was interviewed using a semi-standardized interview about the mother's parenting problems. The non-maltreating mothers were approached by research assistants who travelled to one of the facility's locations for personal recruitment. To verify the absence of maltreatment, a Dutch adaptation of the Maternal Maltreatment Classification Interview (MMCI; Cicchetti, Toth & Manly, 2003) was used.

The mean age of maltreating mothers was 37.60 years (*SD* = 7.75). All were of Caucasian ethnicity, except for one mother, who was of African descent. Of the maltreating mothers, 45% had completed elementary school or a short track of secondary school, 39% had an advanced secondary school or vocational school diploma, and 13% had finished college or university. They had an average of 2.39 (*SD* = 1.23) children with a mean age of 9.24 years (*SD* = 5.23). The mean age of the non-maltreating mothers was 43.21 years (*SD* = 4.88). In this group, all mothers were of Caucasian ethnicity. The majority (58%) had an advanced secondary school or vocational school diploma, while 25% had finished elementary school or a short track of secondary school, and 8% held a college or university degree. They had an average of 2.46 (*SD* = 1.02) children with a mean age of 12.72 (*SD* = 3.34).

There were no significant differences between the groups regarding ethnicity, educational level, and number of children (*p*s > .27). Mothers in the maltreating group and their children were significantly younger than mothers and children in the non-maltreating group, $t(49.54) = -3.24$, $p < .01$ and $t(49.60) = -2.85$, $p < .01$, respectively. However, since neither maternal nor children's mean age were related to the outcome measure, they were not considered for further analysis.

The study was approved by the Ethics Review Board of the Leiden University Medical Center. All mothers signed an informed consent form for participation and, in

the maltreating group, for researchers' access to the family files. As a compensation for completed participation they received 40 Euros as well as travelling expenses.

Procedure

Mothers were contacted for two individual appointments, which took place at a facility's location that was familiar to them. During the first visit, they completed three computer tasks, of which the Cry Paradigm (Zeskind & Shingler, 1991) reported on here was the first, and during which an electrocardiogram (ECG) signal was recorded. Afterwards, mothers filled out two questionnaires: one concerning health-related practices prior to the session, such as drinking coffee, smoking, and exercising, and a second one assessing background information of their family situation, such as educational level, marital status, and children's ages. Furthermore, for the non-maltreating group the session ended with the MMCI. The Adult Attachment Interview (George, Kaplan & Main, 1985) took place during the second visit. These data will be presented elsewhere.

Measures

Maltreatment Classification System. The Maltreatment Classification System (MCS; Barnett et al., 1993) was used to code all incidents of maltreatment reported in the clinic's records from Child Protective Services (CPS) and the child care office. For this purpose it has been proven to be a reliable and valid system (Cicchetti, Rogosch, Gunnar, & Toth, 2010). Only incidents involving maternal maltreatment were considered for coding. In accordance with operational definitions of the MCS, different subtypes of maltreatment were coded: physical abuse, physical neglect, emotional abuse, and emotional neglect (no mother was found to have sexually

abused any of her children). A distinction was made between abuse, which included physical and emotional abuse, and neglect, consisting of physical and emotional neglect. Coding was done by trained research assistants. Interrater reliability on 15 files was good with $\kappa = .82$ for abuse and $\kappa = 1.00$ for neglect. For the presence vs absence of maltreatment there was full agreement, with $\kappa = 1.00$. Subsequently, all records were coded by two different research assistants and discrepancies were resolved through discussion.

All mothers in the maltreatment group were found to have been neglectful towards their children, either physically or emotionally. Furthermore, for 50% of the mothers incidents of abuse, again either physical or emotional, were coded.

Cry Paradigm. The cry paradigm was presented on a laptop with E-prime software. A six-minute baseline of neutral images was followed by three blocks with three cry sounds each. Within blocks, sounds differed in fundamental frequency; the three cries of 500, 700, and 900 Hz were presented in a random order. All sounds had a duration of 10 seconds, containing seven cry expirations, and were presented through Sennheiser HD202 headphones at a constant volume. The paradigm ended with another four-minute baseline of neutral images. After each cry sound mothers were presented with four questions, two of which concerned the characteristics of the sound (i.e., its perceived urgency and the baby's perceived health) and the other two assessed mothers' arousal and aversion to the sound. Subsequently, they were presented with seven more questions about their intended caregiving response to the baby. All questions were answered on a 5-point rating scale and mothers were given a minimum of one minute and a half to do so before the start of the next sound, during which their saliva was collected to assess levels of alpha amylase. These results will

be presented elsewhere. To get acquainted with a cry sound and the questions, between the first baseline period and the three blocks they practiced with the cry of 500 Hz.

The sounds were obtained by recording the spontaneous crying of a healthy, 2-day-old, full birth weight, and full-term baby girl, of which a 10-second period was then selected. The seven cry expirations within sounds had a mean duration of 1055 msec (range, 545 to 1899 msec). The original cry with a mean fundamental frequency peak of F_0 = 452.6 Hz (range, 425.2 to 515.6 Hz; 500 Hz Cry) was digitally increased with approximately 200 and 400 Hz, while temporal and other spectral aspects of the cry were held constant. This resulted in two new cry sounds with an overall peak of F_0 = 714.5 Hz (700 Hz Cry) and F_0 = 895.8 Hz (900 Hz Cry), respectively.

The cry paradigm has been used in previous studies on physiological reactivity to infant crying (Joosen et al., 2012; Out et al., 2010).

Heart Rate. During the computer paradigms an electrocardiogram (ECG) was measured using an ambulatory monitoring system (VU-AMS5fs; TD-FPP, Vrije Universiteit, Amsterdam, the Netherlands). 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). E-prime had been programmed so that markers were sent to the ECG 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. Each ECG recording was inspected, manually corrected when necessary, and labeled according to the markers

sent by E-prime. The software package then derived the mean HR for baseline, each cry sound, and recovery from the mean IBI per labeled segment. Finally, the mean HR per block as well as per pitch was calculated in SPSS.

Three participants who had missing HR data due to failure of the ECG recording or because E-prime had failed to send markers were not viable for analysis, resulting in the final sample of 30 maltreating and 24 non-maltreating mothers. They did not differ from included participants on any of the background variables (*p*s > .17). There were no other missing data. A check for mean HR per labeled segment revealed that there were no outliers.

Perceived urgency. After each cry sound, participants answered four questions. On a 5-point rating scale they indicated to what extent they perceived the sound as urgent, as aversive, the child as sick, and themselves as aroused, with 1 representing the answer ‘very little’ and 5 referring to ‘very much’ (Zeskind & Lester, 1978; Zeskind & Marshall, 1988). Each fundamental frequency was presented three times, resulting in twelve ratings per fundamental frequency. Following Out et al. (2010), who found one component underlying these twelve ratings, the averages were aggregated to form the overall perceived urgency. Cronbach’s alpha ranged from .88 to .89. They were calculated per block as well as per pitch.

Intended caregiving. After answering the four questions regarding perceived urgency, mothers were asked about their intended caregiving towards the baby. On a 5-point rating scale they indicated the likeliness with which they would respond with each of seven options, i.e., picking it up, cuddling it, focusing on something else, feeding it, firm handling, waiting, and giving it a pacifier, with 1 corresponding to

'unlikely' and 5 meaning 'likely' (Out et al., 2010; Zeskind, 1980). Following Out et al. (2010), two clusters of caregiving were distinguished. The cluster of sensitive caregiving included picking the baby up, cuddling it, feeding it, focusing on something else (reversed), and waiting (reversed), while the cluster of harsh parenting was equivalent to the item of firm handling. Cronbach's alpha ranged between .79 and .91. The averages of these clusters were, again, calculated per block as well as per pitch.

Results

Preliminary analyses

Chi square analyses showed that maltreating mothers did not significantly differ from non-maltreating mothers on physical exercise in the week prior to testing, χ^2 (1, N = 54) = 3.19, p = .07. However, significantly more maltreating mothers had smoked on the day of the research appointment as opposed to non-maltreating mothers, χ^2 (1, N = 54) = 9.75, p < .01. Independent t-tests showed that physical exercise was not significantly related to heart rate during the cry paradigm, t(52) = -.43, p = .67, but that smoking was, with mothers who had smoked showing an increased heart rate during the paradigm, t(52) = -2.34, p < .05. However, neither of these variables were significant as covariates in the repeated measures analyses, therefore they were not included further in the analyses reported here.

Correlations

Pearson's correlation coefficients between mean HR, perceived urgency, intended sensitive response, and intended harsh response were calculated per block (see Table 1). Where a significant correlation between two variables was found for one group,

while for the other group the correlation between the same variables was not significant, these correlations never differed significantly (*p*s > .25).

Table 1

Correlations for Maltreating Mothers and Non-Maltreating Mothers per Block

	Mean HR	Perceived Urgency	Intended sensitivity	Intended harshness
Block 1				
Mean HR	___	-.01	-.11	-.15
Perceived urgency	-.17	___	.30	.39*
Intended sensitivity	.00	.42*	___	.05
Intended harshness	-.04	.25	.09	___
Block 2				
Mean HR	___	.01	-.10	-.19
Perceived urgency	-.07	___	.16	.29
Intended sensitivity	.32	-.21	___	.10
Intended harshness	-.20	.18	-.30	___
Block 3				
Mean HR	___	.14	-.21	.09
Perceived urgency	-.06	___	.23	.24
Intended sensitivity	.16	.15	___	-.20
Intended harshness	-.40*	.27	-.31	___

Note: Correlations for the maltreating group are displayed above the diagonal series of dashes, $N = 30$. Correlations for the non-maltreating group are shown below the diagonal series of dashes, $N = 24$.

* $p < .05$

Heart rate

Table 2 displays means and standard deviations of HR for both groups during the five episodes of the cry paradigm. An independent *t*-test showed that maltreating mothers had higher heart rates (HR) during baseline than non-maltreating mothers and that this

difference approached significance, $t(53) = 1.87$, $p = .07$. There were no significant differences between the maltreating and non-maltreating mothers for blocks 1, 2, 3, and recovery.

Table 2

Heart Rate during the Cry Paradigm for Maltreating and Non-Maltreating Mothers

	Maltreating group[a]		Non-maltreating group[b]			
	M	*SD*	*M*	*SD*	*t*	*p*
Baseline	78.15	9.96	73.24	9.09	1.87	.07
Block 1	81.14	11.43	78.50	10.50	0.87	.39
Block 2	81.49	10.81	78.81	10.23	0.93	.36
Block 3	81.63	11.08	77.71	9.80	1.36	.18
Recovery	75.12	9.35	72.26	8.36	1.17	.25

Note: [a] $N = 30$, [b] $N = 24$

A repeated measures ANOVA with episode (baseline, the three blocks of cry sounds, and recovery) as within-subjects factor and group (maltreating vs. non-maltreating) as between-subjects factor showed that there was an overall main effect of episode, with increased HR during the cry sounds as opposed to both baseline and recovery, $F(4, 49) = 49.43$, $p < .01$, partial $\eta^2 = .80$. No main effect of group was found, $F(1, 52) = 1.57$, $p = .22$, partial $\eta^2 = .03$. However, an interaction effect between episode and group was found, $F(4, 49) = 4.16$, $p < .01$, partial $\eta^2 = .25$ (Figure 1). Contrast analyses showed that this interaction effect was significant for the change in HR between baseline and block 1 ($F[1, 52] = 6.21$, $p < .05$, partial $\eta^2 = .11$), baseline and block 2 ($F[1, 52] = 5.80$, $p < .05$, partial $\eta^2 = .10$), and baseline and recovery ($F[1, 52] = 5.96$, $p < .05$, partial $\eta^2 = .10$). Maltreating mothers showed less increase in HR than

non-maltreating mothers from baseline to blocks 1 and 2 and HR decreased more from baseline to recovery for the maltreating group than the non-maltreating group.

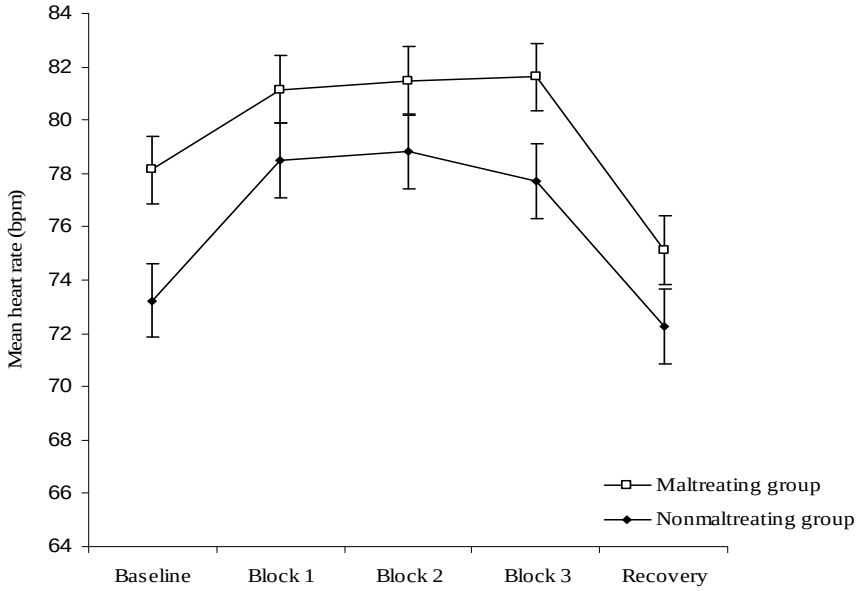

Figure 1. Heart rate reactivity to infant crying (*M, SE*) in maltreating and non-maltreating mothers.

Perceived urgency and intended caregiving responses

Means and standard deviations of perceived urgency, intended sensitive response, and intended harsh response are displayed in Table 3. For these three variables, repeated measures ANOVAs with pitch (500, 700, and 900 Hz) as within-subjects factor and group (maltreating vs. non-maltreating) as between-subjects factor were carried out. The same analyses were done with episode (baseline, the three blocks of infant crying, and recovery) as within-subjects factor and again group (maltreating vs. non-maltreating) as between-subjects factor. In no analysis was there a main effect of group (*p*s > .19) or of episode (*p*s > .16). There were no significant interaction effects of group with episode (*p*s > .10) or of group with pitch (*p*s > .63) on perceived urgency of the cry sounds or on either of the intended caregiving responses. Thus,

there were no differences between maltreating and non-maltreating mothers (overall and depending on episode or pitch) in how they perceived the sounds or intended to respond to them.

Only main effects for pitch were found. For perceived urgency, there was a significant effect of pitch, $F(2, 51) = 38.95$, $p < .01$, partial $\eta^2 = .60$. Contrast analyses indicated a significant increase in perceived urgency from 500 to 700 Hz ($F[1, 52] = 56.34$, $p < .01$, partial $\eta^2 = .52$), from 500 to 900 Hz ($F[1, 52] = 69.57$, $p < .01$, partial $\eta^2 = .57$), as well as from 700 to 900 Hz ($F[1, 52] = 6.59$, $p < .05$, partial $\eta^2 = .11$; Table 3).

For intended sensitive response, the effect of pitch was significant as well, $F(2, 51) = 14.40$, $p < .01$, partial $\eta^2 = .36$. Contrast analyses showed that the intended response increased in sensitivity for the 700 Hz as opposed to the 500 Hz sound ($F[1, 52] = 29.34$, $p < .01$, partial $\eta^2 = .36$, as well as for the 900 Hz when compared to the 500 Hz sound, $F(1, 52) = 16.89$, $p < .01$, partial $\eta^2 = .25$, but not for the contrast between 700 and 900 Hz, $F(1, 52) = 0.16$, $p = .69$, partial $\eta^2 = .003$ (see Table 3).

Finally, for intended harsh response, analyses revealed no effect of pitch ($F[2, 50] = 0.60$, $p = .56$, partial $\eta^2 = .02$).

Table 3

Perceived Urgency and Intended Responses per Pitch

	Maltreating group		Non-maltreating group	
	M	*SD*	*M*	*SD*
Perceived urgency				
500 Hz[a]	1.65	0.51	1.69	0.68
700 Hz[a]	2.37	0.78	2.36	0.68
900 Hz[a]	2.54	0.92	2.66	0.83
Intended sensitive response				
500 Hz[b c]	3.02	0.75	3.10	0.91
700 Hz[b]	3.59	0.68	3.83	0.68
900 Hz[c]	3.55	0.73	3.79	0.63
Intended harsh response				
500 Hz	1.21	0.58	1.08	0.25
700 Hz	1.24	0.62	1.11	0.36
900 Hz	1.30	0.75	1.07	0.25

Note: Main effects of pitch on perception and intended sensitive response were found (see text).
[a], [b], and [c] indicate significant contrasts between fundamental frequencies.

Discussion

The aim of this study was to evaluate whether listening to infant crying led to a stronger or weaker increase in heart rate in maltreating mothers as compared to a non-maltreating group. Results showed that maltreating mothers had lower HR reactivity to the cry sounds than non-maltreating mothers. This extends the existing literature by showing this HR reactivity pattern to standardized cry sounds in a clinical sample of mothers whose maltreatment of their children had been substantiated.

Frodi and Lamb (1980) found that abusive parenting was associated with increased HR reactivity to infant stimuli, although they presented their participants

with videos of infants. However, high HR reactivity has also been related to promptness of response to infant crying (Del Vecchio, Walter, & O'Leary, 2009) and to highly sensitive caregiving (Joosen et al., 2012). This apparent discrepancy in findings may be explained by underlying ANS activity. On the one hand, increased HR reactivity stems from SNS activation, connected to perception of threat, while on the other hand it can result from PNS activity, which is associated with preparation for (dis)engagement with a nonthreatening environment (Joosen et al., 2012). Our finding of lower HR reactivity in maltreating mothers seems to be in line with studies linking higher HR reactivity to more sensitive caregiving and therefore possibly to underlying PNS activity rather than SNS activation. More evidence for this hypothesis is needed through measurements of sympathetic and parasympathetic reactivity, such as vagal tone, skin conductance, and alpha-amylase in parents with different caregiving characteristics. More conclusive evidence on physiological reactivity to infant stimuli is required before this component can be integrated in intervention programs for maltreating mothers.

The observed low HR reactivity in the maltreating group may also have to do with the latter's marginally higher HR baseline levels. Congruent with the "law of initial values", higher baseline levels might restrict the magnitude of physiological response. However, this does not change the implication that maltreating mothers are significantly less aroused by infant crying than non-maltreating mothers. In accordance with Porges (1995), higher baseline levels may indicate increased sympathetic tone in the absence of external challenge. The combination with lower reactivity when cry sounds were presented suggests that maltreating mothers show an impaired regulation of functional responsiveness to environmental demands. Non-maltreating mothers, on the other hand, showing lower HR baseline levels yet higher

HR reactivity to cry sounds, are likely to adequately regulate their responsiveness to internal and external cues.

Another relevant factor in the interpretation of HR reactivity in maltreating mothers is the operationalization of maltreatment. Previous research has mainly included physically abusive parents (see McCanne & Hagstrom, 1996). In the current study, however, neglect was coded as well. For half of maltreating mothers incidents of neglect, but not of abuse, were found. The other mothers in this group both abused and neglected their children. It might be that the lower HR reactivity seen in the maltreating group can be accounted for by the neglectfulness found in all mothers, or those who were neglectful but not abusive. Their behavioral lack of activity might correspond to underlying hyporeactivity of the autonomous nervous system. Other studies with bigger sample sizes could focus on the different physiological reactivity patterns in abusive versus neglectful parents.

Since earlier research on the perceived urgency of cry sounds had been inconclusive, no clear hypothesis could be formed on how maltreating mothers would perceive the sounds as compared to non-maltreating mothers. We found that in both groups sounds of a higher pitch were perceived as more urgent. This suggests that maltreating mothers are capable of distinguishing sounds differing in fundamental frequency, as is consistent with previous research (Zeskind & Shingler, 1991), and can rate them correctly. Our finding is in accordance with Joosen and colleagues (2012), who did not find a difference in perceived urgency of cry sounds comparing highly sensitive to less sensitive mothers.

For intended sensitive response, a pattern similar to that of perceived urgency was found, with both groups generally intending to respond more sensitively as fundamental frequency increased. For intended harsh response no effects were found,

with all mothers rating low across all episodes and pitches. This may be because the cluster of intended harsh response consisted of a single item, namely ‘firm handling’, which, although of a general meaning, explicitly and unequivocally refers to harsh parenting behaviors. However, mothers reliably rated the item several times. Furthermore, effects of pitch on intended harsh response using the same task have previously been found in a twin sample (Out et al., 2010). Therefore, it may also simply be that maltreating mothers do not intend to be particularly harsh to their children or deem harsh parenting practices most appropriate. This notion is consistent with research showing that abusive episodes can be impulsive in nature (Dietrich, Berkowitz, Kadushin, & McGloin, 1990) and that stressful situations compromise caregiving behavior (Schellenbach, Monroe, & Merluzzi, 1991).

Even so it was found that maltreating mothers intended to respond more harshly as they perceived the cry sound to be more urgent during the first block of the paradigm. This pattern differed from that of non-maltreating mothers, who intended to respond more sensitively as their perceived urgency increased during the same block. This is consistent with research showing that parents’ perceptions of their children’s behavior is more strongly related than other assessments of child behavior (Stith et al., 2009). It may indicate a difference of inclination and suggests that high perceived urgency can be a risk factor for maltreating mothers’ harsh parenting responses. Maltreating mothers indeed showed more variation in their intended harsh responses than non-maltreating mothers. However, caution is warranted, since no averaged intended harsh responses were found to be high and most of them were very low. This same caution is required for the observed negative relationship between HR and intended harsh response for non-maltreating mothers at the end of the paradigm. For them, averaged intentions of harsh response were even lower.

To control an effect of therapy on the results we asked the maltreating mothers to participate at the start of their family treatment. Unfortunately, this was not feasible for all mothers and a possible therapy effect can therefore be considered a limitation of our study. It might be, for example, that mothers who had already received treatment were well aware of their own problematic parenting behavior and therefore purposefully scored low on this explicitly harsh response option.

Furthermore it should be noted that the experimental setting, out of the mothers' family context, and the presentation of standardized cry sounds of short duration may have led to an underestimation of mothers' physiological and intended responses. Indeed, the risk of abuse has been known to increase for infant crying excessive in duration (Reijneveld, Van der Wal, Brugman, Hira Sing, & Verloove-Vanhorick, 2004). On the other hand, the use of a standardized cry paradigm is at the same time a methodological strength, recommended by McCanne and Hagstrom (1996), to make results among studies more easily comparable.

A second notable strength is the composition of our sample, which included two groups of mothers whose children showed very similar characteristics (i.e., they were all diagnosed with at least one developmental disorder). This increases the likelihood that a maternal factor, such as a lower HR reactivity to cry sounds, and not the characteristics of their children per se, partly explains the presence of maltreatment.

In conclusion, maltreating mothers correctly distinguished between cry sounds, perceiving sounds of a higher pitch to be more urgent. Their intended caregiving responses suggest that they had no less intention to respond sensitively, and had no more intention to respond harshly to infants, than non-maltreating mothers. Yet still they showed a weaker increase in their HR reactivity pattern when

listening to infant crying than non-maltreating mothers. Thus, perhaps unconsciously, maltreating mothers seem to be affected differently by infant crying than non-maltreating mothers. Their lack of functional arousal may account for an impaired ability to respond adequately to their children.

References

Ainsworth, M. D. S. (1969). Object relations, dependency, and attachment: A theoretical review of the mother-infant relationship. *Child Development, 40,* 969-1025.

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.

Ammerman, R. T. (1990). Etiological models of child maltreatment: A behavioral perspective. *Behavior Modification, 14*, 230-254.

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.

Brown, J., Cohen, P., Johnson, J. G., & Salzinger, S. (1998). A longitudinal analysis of risk factors for child maltreatment: Findings of a 17-year prospective study of officially recorded and self-reported child abuse and neglect. *Child Abuse and Neglect, 22,* 1065-1078.

Cicchetti, D., & Toth, S. L. (2005). Child maltreatment. *Annual Review of Clinical Psychology, 1,* 409-438.

Cicchetti, D., Toth, S. L., & Manly, J. T. (2003). Maternal Maltreatment Classification Interview. Rochester, NY: Unpublished measure.

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

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.

De Wolff, M. S., & Van IJzendoorn, M. H. (1997). Sensitivity and attachment: A meta-analysis on parental antecedents of infant attachment. *Child Development, 68,* 571-591.

Dietrich, D., Berkowitz, L., Kadushin, A., & McGloin, J. (1990). *Child Abuse and Neglect, 14,* 337-345.

Disbrow, M. A., Doerr, H., & Caulfield, C. (1977). Measuring the components of parents' potential for child abuse and neglect. *Child Abuse and Neglect, 1,* 279-296.

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.

Frodi, A. (1981). Contributions of infant characteristics to child abuse. *American Journal of Mental Deficiency, 85,* 341-349.

Frodi, A. (1985). When empathy fails: Aversive infant crying and child abuse. In B.M. Lester & C.F.Z. Boukydis (Eds.), *Infant crying: Theoretical and research perspective.* New York: Plenum.

Frodi, A. M., & Lamb, M. E. (1980). Child abusers' responses to infant smiles and cries. *Child Development, 51,* 238-241.

Frodi, A. M., Lamb, M. E., Leavitt, L. A., Donovan, W. L., Neff, C., & Sherry, D. (1978). Fathers' and mothers' responses to the faces and cries of normal and premature infants. *Developmental Psychology, 14,* 490-498.

George, C., Kaplan, N., & Main, M. (1985). *Adult Attachment Interview.*

Unpublished manuscript, University of California, Berkeley.

Hubbard, F. O. A., & Van IJzendoorn, M. H. (1991). Maternal unresponsiveness and infant crying across the first 9 months: A naturalistic longitudinal study. *Infant Behavior and Development, 14,* 299-312.

Joosen, K. J., Mesman, J., Bakermans-Kranenburg, M. J., Pieper, S., Zeskind, P. S., & Van IJzendoorn, M. H. (2012). Physiological reactivity to infant crying and observed maternal sensitivity. *Infancy,* 1-18.

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.

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.

Murray, A. D. (1979). Infant crying as en elicitor of parental behavior: An examination of two models. *Psychological Bulletin, 86,* 191-215.

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 and Neglect, 34,* 863-873.

Porges, S. W. (1995). Cardiac vagal tone: A physiological index of stress. *Neuroscience and Biobehavioral Reviews, 19,* 225-233.

Porges, S. W. (2007). The polyvagal theory: Phylogenetic substrates of a social vervous system. *International Journal of Psychophysiology, 42,* 123-146.

Reijneveld, S. A., Van der Wal, M. F., Brugman, E., Hira Sing, R. A., & Verloove-Vanhorick, S. P. (2004). Infant crying and abuse.

Schellenbach, C. J., Monroe, L. D., & Merluzzi, T. V. (1991). The impact of stress on cognitive components of child abuse potential. *Journal of Family Violence, 6*, 61-80.

Soltis, J. (2004). The signal functions of early infant crying. *Behavioral and Brain Sciences, 27*, 443-490.

Spinhoven, P., Elzinga, B. M., Hovens, J. G. F. M., Roelofs, K., Zitman, F. G., Van Oppen, P., & Penninx, P. 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.

Stith, S. M., Ting Liu, L., Davies, C., Boykin, E. L., Alder, M. C., Harris, J. M., Som, A., McPherson, M., & 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.

Zeskind, P. S. (1980). Adult responses to cries of low and high risk infants. *Infant Behavior and Development, 3*, 167-177.

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.

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

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.

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.