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Maternal Overreactive Sympathetic Nervous System Responses to Repeated Infant Crying Predicts Risk for Impulsive Harsh Discipline of Infants

Katharina J. Joosen[1], Judi Mesman[1], Marian J. Bakermans-Kranenburg[1,2], and Marinus H. van IJzendoorn[1,2]

Abstract

Physiological reactivity to repeated infant crying was examined as a predictor of risk for harsh discipline use with 12-month-olds in a longitudinal study with 48 low-income mother–infant dyads. Physiological reactivity was measured while mothers listened to three blocks of infant cry sounds in a standard cry paradigm when their infants were 3 months old. Signs of harsh discipline use were observed during two tasks during a home visit when the infants were 12 months old. Mothers showing signs of harsh discipline ($n = 10$) with their 12-month-olds were compared to mothers who did not ($n = 38$) on their sympathetic (skin conductance levels [SCL]) and parasympathetic (respiratory sinus arrhythmia) reactivity to the cry sounds. Results showed a significant interaction effect for sympathetic reactivity only. Mean SCL of harsh-risk mothers showed a significant different response pattern from baseline to crying and onward into the recovery, suggesting that mean SCL of mothers who showed signs of harsh discipline continued to rise across the repeated bouts of cry sounds while, after an initial increase, mean SCL level of the other mothers showed a steady decline. We suggest that harsh parenting is reflected in physiological overreactivity to negative infant signals and discuss our findings from a polyvagal perspective.

Keywords

harsh discipline, physiological reactivity, infant crying, polyvagal theory

Parental harsh discipline plays an important role in the development of problem behavior in childhood and adolescence as evidenced by studies showing that parental use of harsh discipline is related to higher levels of behavior and mental health problems in childhood (e.g., Bender et al., 2007; Fine, Trentacosta, Izard, Mostow, & Campbell, 2004; Gershoff, 2002; Miner & Clark-Stewart, 2008; Prinzie, Onghena, & Hellinckx, 2006). In the current study, we attempt to identify maternal physiological predictors of a risk for impulsive harsh discipline of infants. Harsh parenting can be seen as an overreactive strategy used by parents with negative, blame-oriented, and child-centered attributions about their children's behavior (Bugental & Happaney, 2004; Bugental, Lewis, Lin, Lyon, & Kopeikin, 1999). On a biological level, harsh parenting has been related to physiological hyperreactivity to (negative) infant signals (for a review, see McCanne & Hagstrom, 1996). More specifically, studies have shown a stronger activation of the sympathetic nervous system (SNS) in response to infant crying among harsh or abusive parents when compared to control groups (Crowe & Zeskind, 1992; Disbrow, Doerr, & Caulfield, 1977; Frodi & Lamb, 1980; Out, Bakermans-Kranenburg, Van Pelt, & Van IJzendoorn, 2012), which may indicate that harsh parents perceive their children's behavior as more threatening (Martorell & Bugental, 2006). Porges' (2001, 2011) polyvagal theory suggests that the perception of negative infant signals as threatening could lead harsh parents to rely more on physiological defensive strategies supported by the phylogenetically older SNS than on the functioning of the vagal brake supported by the parasympathetic nervous system (PNS). Previous studies that found significant relations between harsh or abusive parenting and physiological hyperreactivity mainly used questionnaires or interviews to measure harsh or abusive parenting (e.g., Crowe & Zeskind, 1992; Lansford et al., 2011). The few studies that did incorporate direct observations of harsh discipline used laboratory settings and cross-sectional designs

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(e.g., Lorber & O'Leary, 2005). We add to this literature by examining sympathetic and parasympathetic activation in response to infant crying in relation to parental risk for impulsive harsh discipline as observed in the home, using a longitudinal study design. Because the study is based on an at-risk sample that has not been definitively identified as including mothers who show significant harsh discipline or child maltreatment, the current investigation should be seen as preliminary.

Defining Harsh Discipline

Definitions of harsh discipline can encompass subtle forms, such as grabbing hard, forms of corporal punishment, or more extreme forms of physical punishment, such as beating, kicking, or even burning. A broader concept of overreactive discipline including parenting behaviors such as yelling, threatening, commanding, and name-calling, has also been used in various studies (e.g., Bugental & Happaney, 2004; Fine et al., 2004; Straus & Stewart, 1999). Such overreactive parenting behaviors are also central to Patterson's (1982) coercion theory, which describes how parents respond with escalating coercive discipline strategies such as physical and verbal harshness when faced with challenging child behavior. Harsh parenting of course cannot be automatically equated to maltreatment. In this light, an important distinction can be made between instrumental versus impulsive harsh discipline. Instrumental harsh discipline is executed in a controlled and deliberate manner without strong, negative parental emotions. Impulsive harsh discipline on the other hand is related to parental feelings of anger and being out of control (Holden & Miller, 1997). Following this distinction, especially impulsive harsh discipline is likely to be related to child maltreatment, because the impulsive nature of the parental response increases the risk for escalation into abusive parenting. Indeed, in a study on correlates of substantiation of maltreatment, it was found that parental impulse control and the use of harsh discipline distinguished substantiated cases from other cases (Scannapieco & Connell-Carrick, 2005). Others have also concluded that based on the empirical literature, harsh discipline strategies such as corporal punishment are a major risk factor for maltreatment (e.g., Straus, 2000). Furthermore, compared to instrumental harsh discipline, impulsive harsh parenting is more likely to result from information processing deficits also found among abusive parents, such as negative attribution biases (e.g., Milner, 2003; Smith & O'Leary, 1995).

Biological Mechanisms Underlying Harsh Parenting

Individual differences in parental physiological reactivity to negative infant stimuli have been related to differences in harsh or abusive parenting. For example, greater heart rate (HR) reactivity to infant crying has been shown to distinguish parents at risk for abuse from controls (for a review, see McCanne & Hagstrom, 1996). Furthermore, there is empirical support for a direct relation between HR reactivity and overreactive discipline, as shown by findings that greater maternal HR reactivity is related to the degree and frequency of maternal anger or irritation through vocal or nonvocal channels during frustration tasks (Lorber & O'Leary, 2005). However, greater HR reactivity in response to infant crying has also been found in highly sensitive mothers (Joosen et al., 2012) and in mothers with a prompt response to infant crying (Del Vecchio, Walter, & O'Leary, 2009). The finding that greater HR reactivity seems to be related to both harsh and sensitive parenting may be due to the fact that activation of both the sympathetic and the parasympathetic branch of the autonomic nervous system can lead to increases in HR (see Berntson, Cacioppo, Quigley, & Fabro, 1994). These dual mechanisms influencing HR create a problem for the interpretation of HR reactivity.

To examine the underlying mechanisms of physiological reactivity, Porges' (1995, 2001, 2007, 2011) polyvagal theory describes three subsystems of the autonomic nervous system, namely (1) the social communication circuit which involves the myelinated vagus and the PNS; (2) the mobilization circuit involving the SNS and fight-or-flight behaviors; and (3) the most primitive circuit of immobilization involving the unmyelinated vagus and, for example, feigning death or freezing behaviors. These three subsystems developed in three phylogenetic stages and are therefore hierarchically activated when responding to external stressors. The activation of a specific subsystem also depends on the perception of the environment as either safe or threatening. In a safe environment, the PNS circuit for social communications is activated to promote survival by facilitating social interactions and social bonds. The PNS depends on the functioning of an active vagal brake, which in a safe environment suppresses the HR in order to maintain homeostasis (Porges, 2001, 2007). However, when the environment is perceived as dangerous or threatening, the autonomic system switches to the more primitive circuits and activates the SNS to regulate defensive strategies through a fight-or-flight response.

PNS and SNS Subsystems in Relation to Parental Responses to Negative Infant Signals

The degree of cardiac control by the vagal brake can be quantified by the amplitude of respiratory sinus arrhythmia (RSA). RSA indicates the change in HR that co-occurs with one's breathing cycles. During inspiration, the vagal brake is slightly released causing a subtle HR acceleration, while during expiration, the vagal brake is reactivated and HR decelerates (Porges, 1995). Furthermore, efficient release of the vagal brake (i.e., RSA withdrawal) seems to be associated with increased behavioral and emotional control, which enables rapid mobilization as well as calm and self-soothing behavioral states in response to environmental demands (Porges, 1996). Concerning parenting behavior both higher resting levels of RSA (Musser, Ablow, & Measelle, 2012) and a stronger RSA withdrawal in response to infant crying (Joosen et al., 2012) have been associated with higher levels of maternal sensitivity. In other words, an efficiently functioning PNS and accompanying vagal brake point to physiological flexibility when reacting to environmental demands.

Activation of the SNS can be measured by an individual's electrodermal activity operationalized as changes in skin conductance level (SCL). Whereas HR is influenced by both branches of the autonomic nervous system, electrodermal activity is exclusively regulated by the SNS (Boucsein, 1992). When the SNS is activated, sweat in the eccrine sweat glands accumulates, causing rising sweat levels in the sweat ducts (of the palmar surfaces), resulting in higher levels of skin conductance (Boucsein, 1992; Dawson, Schell, & Filion, 2000). The relation between harsh or even abusive parenting and an overreactivity of the SNS has been shown by several empirical studies. An early study of maternal physiological reactivity to infant signals by Frodi and Lamb (1980) indeed showed a greater increase in SCL for abusive mothers compared to control mothers in response to infant crying. Another study including both males and females with high and low scores on the child abuse potential inventory confirmed this finding by showing greater SCL reactivity among the high child abuse potential group for phonated cry sounds specifically (Crowe & Zeskind, 1992).

In addition, one study among high-risk mothers showed that mothers with low perceived power used more harsh discipline with infants and toddlers with a difficult temperament. This relationship was mediated by higher levels of cortisol (Martorell & Bugental, 2006). Cortisol levels, indicating activity of the hypothalamic–pituitary–adrenal axis, can be interpreted as a correlate of SNS activity because both systems are involved in stress management (e.g., El-Sheikh, Erath, Buckhalt, Granger, & Mize, 2008). Because harsh parents have been shown to hold negative and child-blaming attributions, they are likely to operate from a threat perspective rather than a safety perspective. It could thus be hypothesized that they would show physiological overreactivity of especially the SNS in response to infant crying. Furthermore, following Porges' notion that the autonomic subsystems are hierarchically organized and activated, the SNS overreactivity of harsh or abusive parents in response to negative infant signals could be the result of a poorly functioning vagal brake (Porges, 2001, 2011). For example, a recent study on children's vagal regulatory capacity showed that low vagal regulatory capacity predicted stronger sympathetic responses to stressful tasks even when these were administered in a supportive research setting (Wolff, Wadsworth, Wilhelm, & Mauss, 2012). It may be that children with a low vagal regulatory capacity misinterpret the supportive context as threatening and experience stronger SNS reactivity across a greater variety of situations. Translated into our study, this would mean that the difference between parents using harsh discipline and those who do not would be the combination of an overreactive SNS with an unresponsive PNS.

Study Aim and Hypotheses

Most studies that have focused on physiological reactivity to infant or child signals among harsh or abusive parents have not incorporated measures on PNS reactivity. To address this gap in the current literature, sympathetic *and* parasympathetic activation in reaction to stressors such as infant crying should be measured simultaneously to unravel the unique effects of the two branches and to identify meaningful differences between them. Furthermore, most studies linking physiological overreactivity to harsh discipline have used a cross-sectional design, and in some cases, physiological responses were measured in the same setting as used for the measurement of harsh discipline (Lorber & O'Leary, 2005). In the current longitudinal study, we tested the hypothesis that parents with a stronger activation of the SNS in response to standardized infant cry sounds (measured when their second-born infants were 3 months old with a cry paradigm) would be more likely to show signs of harsh discipline with their second-born infants at 12 months. At the age of 12 months, infants lack the cognitive capacity to show premeditated deliberate noncompliance to maternal demands. Being prone to using harsh discipline with an infant at this age may therefore be a particularly salient indicator of possible negative and child-blaming attributional biases and the risk for impulsive harsh discipline we investigated.

We selected low-socioeconomic status (SES) mothers of first-born children who scored low or high on externalizing problems. Both low SES and high externalizing behavior levels are risk factors for family violence (Cyr, Euser, Bakermans-Kranenburg, & Van IJzendoorn, 2010; Euser, Van IJzendoorn, Prinzie, & Bakermans-Kranenburg, 2010). Specifically, we expected that mothers showing signs of harsh discipline compared to other mothers would have had an overreactivity of the SNS as shown by a greater increase in SCL in response to infant cry sounds. Concerning PNS reactivity to infant cry sounds, we expected that mothers showing signs of harsh discipline would have had a less efficient PNS as indicated by significantly less RSA withdrawal than the other mothers in response to the cry sounds. Furthermore, we examined the risk for harsh discipline controlling for maternal sensitivity because of earlier found relations with both parasympathetic functioning (Joosen, Mesman, Bakermans-Kranenburg, & Van IJzendoorn, 2012; Musser et al., 2012) and harsh discipline (Engfer & Gavranidou, 1987; Joosen et al., 2012). Even though this study is preliminary, given the absence of evidence for clear harsh or maltreating parenting, it adds to previous work by exploring the possible early prediction of a risk for harsh discipline by physiological indicators within a longitudinal design, while simultaneously controlling for possible confounding behavioral influences.

Method

Sample and Procedure

Participants were recruited via the Regional Coordination Programs of the Dutch National Institute for Public Health and Environment (NIPHE). Inclusion criteria were (1) both parents were low to middle educated; (2) the first-born child was younger than 6 years; (3) the second-born child was neither premature nor handicapped; (4) both children and parents lived together in one household; (5) both parents were Caucasian; and (6) the first-born child scored either low or high on externalizing behavior on the Child Behavior Checklist (CBCL/1½–5; Achenbach & Rescorla, 2000; cutoffs based on Van Zeijl et al., 2006). We added the final criterion in order to increase the chance of including mother–infant dyads at both low and high risk for harsh discipline without relying solely on more distal risk factors such as parental education level. This approach is based on the evidence that child externalizing problems are related to parental use of harsh discipline (e.g., Bender et al., 2007; Fine et al., 2004; Gershoff, Lansford, Sexton, Davis-Kean, & Sameroff, 2012) and that parental discipline strategies toward siblings show significant consistency (e.g., Holden & Miller, 1999; Lysenko, Barker, & Jaffee, 2013).

Because the focus of the recruitment was to approach families from the lower socioeconomic strata, we preselected postal codes of areas in which more than 30% of inhabitants had a low income (less than €14,200 per year; as defined by the Dutch Central Bureau of Statistics). Families with a newborn infant living in these areas received a letter from the NIPHE with information about the study. Interested mothers of a second newborn infant were requested to fill out a card with their details and were then contacted by phone to find out the educational level of both parents (1 = *elementary school*, 2 = *first 4 years of Dutch high school*, 3 = *vocational education or 5 or 6 years of high school*, 4 = *higher professional education*, and 5 = *university*). When both parents had a low (Level 1 or 2) educational level or no more than one of the parents scored Level 3, a home visit was planned to complete the CBCL about the first child. All mothers who completed the CBCL received a coupon with a value of €10.

A total of 53 families met our criteria (26 with a "high externalizing" first child), of whom 48 families were included in this article (3 families dropped out during the first 12 months and 2 mothers had unreliable electrocardiogram [ECG] data). Within the final sample, 13% of mothers finished elementary school, 60% finished the first 4 years of Dutch high school, and 27% obtained a degree in vocational education or finished 5 or 6 years of high school. Maternal mean age at time of birth of their second-born child was 29.65 years (standard deviation [*SD*] 4.93; range 19–39 years). The mean age of the first-born children at the time of selection was 35.42 months (*SD* 12.65; range 18–70). Of the first-born children, 54% were boys; and of the second-born children, 35% were boys.

The current study presents part of the results from a larger longitudinal study in which 103 two-children families were followed along various domains during the first 2 years after the birth of the second child (see also Joosen et al., 2012; Joosen, Mesman, et al., 2012). All families participated in a total of six home visits after the birth of the second child. Home visits were scheduled when the second-born child was 3, 6, 9, 12, 18, and 24 months old. For the current study, we used the assessments at 3 and 12 months of the subsample of lower educated families. At the 3-month home visit, mothers participated in a 20-min cry paradigm (Out, Pieper, Bakermans-Kranenburg, & Van IJzendoorn, 2010; Zeskind & Lester, 1978) during which an ECG signal as well as the SCL were recorded. Prior to the cry paradigm, mothers were asked to fill out a short questionnaire concerning possible smoking habits and their frequency of physical exercise. At the 12-month home visit, mothers were observed with both children simultaneously during two discipline tasks. The higher educated families could not be included for these analyses since the cry paradigm was not administered with these families at the 3-month home visit.

In all participating families, both parents signed informed consent forms. To limit loss of participants through attrition, families were given gift coupons and small presents for the children after each home visit. Procedures and measures used in this study were reviewed and approved by the ethical committee of the Institute of Education and Child Studies at Leiden University.

Measures

Externalizing Behavior. The CBCL for ages 1½–5 (Achenbach & Rescorla, 2000; Van Zeijl et al., 2006) was used in the screening phase to assess externalizing behaviors of the first-born child and was obtained from mothers during the selection home visit. Mothers indicated whether their child displayed any of the 100 behavioral descriptions in the last 2 months on a 3-point scale (0 = *not true*, 1 = *somewhat or sometimes true*, and 2 = *very or often true*). The distribution of CBCL Externalizing Problem scores reported by Van Zeijl et al. (2006) was used to determine cutoff scores in identifying low versus high levels of externalizing behaviors. Families were selected for the low externalizing group when scores on externalizing behavior of the oldest child did not exceed the lowest 50% of scores in the norm group of the same age. Families were placed in the high externalizing group when scores were within the highest 25% of scores in the norm group of the same age.

Cry Paradigm. To determine physiological reactivity to negative infant signals, a cry paradigm was administered. The cry perception stimuli and paradigm (Out et al., 2010) were administered using a laptop with E-prime software. Mothers listened to three blocks of each three cry sounds that varied in fundamental frequency within each block. Cry stimuli were derived from the spontaneous crying of a healthy 2-day-old, full birth weight and full-term female infant and were recorded midway between scheduled feedings.

To provide cry stimuli with different fundamental frequencies, the original cry (averaging approximately 500 Hz) was digitally increased by approximately 200 and 400 Hz, respectively, while holding temporal and other spectral aspects of the cry constant (see Out et al., 2010). Each of the three blocks of cry sounds contained each of the three cry sounds (i.e., 500 Hz, 700 Hz, and 900 Hz) presented in a random order. The cry stimuli were presented at a constant volume through Sennheiser HD202 headphones. Following a 4-min baseline period and a practice trial in which the 500-Hz cry was presented, mothers listened to the three blocks of three cry sounds each. The paradigm was concluded with a 2-min recovery period. During the entire cry paradigm, mothers' ECG and SCL signals were recorded continuously.

RSA. RSA was measured as an indicator of vagal brake reactivity. To extract RSA values, the ECG signals were measured with an ambulatory monitoring system (VU University Ambulatory Monitoring System [VU-AMS] 5fs Manual, 2011; TD-FPP, Vrije Universiteit, Amsterdam, the Netherlands). For the ECG signal, three disposable pre-gelled silver–silver chloride (Ag-AgCl) electrodes (ConMed, New York) were used, which were placed below the right collar bone 4 cm to the right of the sternum, 4 cm under the left nipple, and at the lateral right side. The full ECG signal was stored at a 16-bit sampling rate. The physiological responses were synchronized to the cry sounds using a marker button on the AMS device. The experimenter pushed the button 2 s before the stimulus was presented, leaving markers that allowed for accurate labeling of each cry sound.

For the measurement of RSA, the ECG signal was used to derive interbeat interval (IBI) time series by visual peak detection of the R-wave through accompanying VU-AMS 5fs software packages. Each recorded ECG complex was inspected and corrected by hand when necessary. RSA was measured through calculation of the root mean square of successive differences (RMSSD) of IBIs for each of the labeled segments (baseline, recovery, and each of the cry presentations). RMSSD has been shown to highly correlate with other time and frequency domain measures of RSA across various ambulatory conditions (Goedhart, Van der Sluis, Houtveen, Willemsen, & de Geus, 2007). For mean RMSSD, missing values for two participants of the nonharsh group were replaced with the mean scores for each labeled segment. Outliers were detected for mean RMSSD and were winsorized for three participants of the nonharsh group to values corresponding to a standardized value of 3.29, while preserving the participant's response pattern. To investigate RSA response patterns during the cry paradigm, mean RMSSD levels were aggregated within each of the three blocks (i.e., average of three consecutive episodes of 10 s).

SCL. To indicate SNS activity, SCL signals were measured with the same ambulatory monitoring system used for ECG registration (VU-AMS 5fs; TD-FPP). SCL has been a long established valid measure of SNS activity (Dawson et al., 2000). SCL was measured with two Ag-AgCl electrodes, which were filled with Biopac isotonic paste. After washing both hands with a mild soap solution, the electrodes were attached to the volar surfaces of the medial phalanges of the middle and index finger of the nondominant hand. The SCL signal was stored on the VU-AMS 5fs at 10 samples/s (10 Hz). The physiological responses were synchronized to the cry sounds using a marker button on the AMS device. The experimenter pushed the button 2 s before the stimulus was presented, leaving markers that allowed for accurate labeling of each cry sound. Mean SCL was calculated for each of the labeled segments (baseline, recovery, and each of the cry presentations). For mean SCL, missing values for four participants (three in the nonharsh-risk group) were replaced with the mean scores for each labeled segment. No outliers were detected for SCL. To investigate the SCL response patterns during the cry paradigm, SCL levels were aggregated within each of the three blocks (i.e., average of three consecutive episodes of 10 s).

Smoking and Physical Exercise. Mothers were asked to fill out a short questionnaire prior to the cry paradigm in which they answered whether they had smoked, and how many, cigarettes prior to the home visit that day (0 = *no*, 1 = *yes one or two*, and 2 = *more than two*), and how often they had engaged in physical exercise in the week prior to the home visit (0 = *no*, 1 = *yes once or twice*, and 2 = *more than twice*) to control for any influence on the ECG data (De Geus, Boomsma, & Snieder, 2003; Farrington, 1997; Vander, Sherman, & Luciano, 2001). For both smoking and physical exercise, scores were dichotomized creating a smoking (scores of 1 and 2) and a nonsmoking (score of 0) group as well as an exercise and nonexercise group. Missing values for one participant (2%) were replaced with the modus for both variables.

Maternal Sensitivity. Maternal sensitivity was assessed with the Ainsworth Sensitivity rating scale (Ainsworth, Bell, & Stayton, 1974) during free play on the mother's lap without toys (5 min) and during bathing (10–20 min). Observations took place during the 3-month home visit and only involved the mother with her second-born infant. Arrangements were made to ensure that the firstborns were not at home or would play with a research assistant in a separate room. All observations were rated independently by two trained coders, but bath and lap sessions were rated by the same coder. Intercoder reliabilities (intraclass correlation, single rater, and absolute agreement) for each pair of the six coders ranged from .75 to .92. When the scores of the two independent coders differed by two or more points (on the 9-point scale), tapes were discussed and a consensus score was assigned. For smaller differences, the average of both scores was used. One missing value was replaced with the overall mean of the group and one outlying value was winsorized to a value corresponding to a standardized value of −3.29.

Signs of Harsh Discipline. Maternal discipline was observed during the home visit at 12 months. Observations consisted of two tasks, a don't-touch task and a cleanup task. In the don't-touch task, mothers were presented with a bag full of attractive toys. They were instructed to take the toys out of the bag, place them in front of the children, and to make sure neither child would touch the toys. After 2 min, the children were allowed to play only with the least attractive toy: a simple stuffed animal. After another 2 min, the children were allowed to play with all the attractive toys as well as a bag of extra toys. Following 15 min of free play with all toys (not coded for this study), mothers received an empty bag with the instruction that all toys had to be cleaned up by both children. She could help and encourage the children as she would normally do but was told that it was important that the children would do as much of the cleaning up as possible. The cleanup session ended when all toys were back in the bag or when ended by the experimenter after 10 min.

The observations were coded with an adapted version of the discipline rating scales used by Verschueren et al. (2006). Adaptations included a further division of the harsh discipline scale in a physical and a verbal subscale. Discipline strategies were rated as indicators of a *risk for harsh physical discipline* when mothers used unnecessary physical force, either when preventing their child from touching a forbidden object or when forcing the child to clean up (i.e., slapping, grabbing the child, pulling an arm too hard, grabbing toys from the child, pinching an arm, or grabbing/holding the face of the child). The action also had to cause a noticeable physical impact on the child (e.g., body movement, facial or vocal expression of shock or discomfort). Scores for harsh physical discipline were rated on a 5-point rating scale. Because harsh physical discipline in relatively short episodes is rare, the scale was defined in a way that would allow more subtle as well as blatant harsh acts to be included: 1 = *no physically harsh acts*, 2 = *a hint of harshness, but not severe or unclear impact on child*, 3 = *at least one harsh act but not physical punishment and not used to emphasize a verbal command*, 4 = *either more than one harsh act or a single act of physical punishment (e.g., slapping) or emphasizing a command (e.g., grabbing child's face)*, and 5 = *more than one harsh act of which at least one act of physical punishment; mother has clearly lost control*. Harsh verbal discipline was defined as irritation and anger in the tone of voice (i.e., impatient, irritated, angry voice, yelling, and screaming,). Scores for harsh verbal discipline were defined on a 5-point scale as follows: 1 = *no harsh verbal discipline*, 2 = *mild irritation*, 3 = *irritation and anger*, 4 = *obvious irritation and or anger on more than one occasion*, and 5 = *almost constant irritation and/or anger*. However, *harsh verbal discipline* scores showed too little variance at 12 months to include in further analyses, thus only *harsh physical discipline* scores are included in the final analyses.

At the 12-month home visit, both children participated simultaneously with their mother in the discipline tasks. Discipline strategies of the mother directed to each child were scored independently. In the current analyses, only the mother's harsh discipline score toward her second child was used. Intercoder reliabilities of six coders ranged from .76 to 1.00 on *risk for harsh physical discipline*. The highest score of the two situations observed (either of the don't-touch task or of the cleanup task) was used as indicator of the severity of maternal harsh physical discipline. Using this score, we created two groups based on a cutoff score of 3. This cutoff distinguished mothers who performed at least one act of clear physical harsh discipline ($n = 10$) from mothers who did not ($n = 38$). The highest obtained score for harsh discipline in the harsh group was 3.5 (range 3–3.5). Because we designed the discipline task to be too challenging for the second children, noncompliance to the task by the 12-month-old was expected. In general, second-time mothers would also be expected to anticipate the noncompliance of their 12-month-old child. Therefore, *any* act of harshness in response to the second child's noncompliance should be seen as a form of impulsive harsh discipline stemming from possibly biased attributions of the child's behavior and therefore as at-risk behavior for maltreatment.

Data Analysis

To control for any group differences, Pearson's χ^2 tests were conducted to compare mothers showing a risk for harsh discipline to mothers who do not on smoking and physical exercise. In addition, *t*-tests were performed to examine differences in age and baseline RSA and SCL between the two groups of mothers and to check for the influence of smoking and physical exercise on RSA baseline values. Pearson's correlation coefficients were calculated for the relation between maternal age and RSA baseline values.

To test the main hypotheses, two repeated measures analyses of variance (ANOVAs) were conducted to examine the association between harsh discipline and the development of SCL and RSA reactivity across the cry paradigm, with SCL or RSA as the outcome measures, episode (baseline, three blocks of cry sounds, and recovery) as the within-subject factor, and discipline (harsh-risk vs. no-harsh-risk) as the between-subject factor. Repeated measures ANOVA was chosen as the most suitable analytic method because of the repeated physiological measures obtained for each participant during the cry paradigm and to allow for comparisons of reactivity patterns over time between and within groups (Field, 2009). It should be noted that the use of repeated measures ANOVA seems to assume that harsh parenting is the predictor of reactivity. However, because of the temporal sequence of the assessments, SCL and RSA reactivity clearly have to be considered predictive of harsh parenting 9 months later. Repeated measures ANOVA enabled us to account for the temporal structure of reactivity to the cry sounds. Statistically, repeated measures ANOVA is indifferent to the role of variables in a substantive sense, and at a basic statistical level ANOVA methods can be translated into regression techniques without assumptions about cause and effect, or predictor and outcome (Kerlinger & Pedhazur, 1973). Greenhouse–Geisser ε was used to correct for violation of sphericity (determined by the Mauds-ley's test) in all repeated measures analyses. The more liberal Huynh–Feldt correction did not yield different results.

Additional analyses were conducted to examine harsh discipline risk group differences in mean SCL and RSA values per block to give more insight into between-group differences concerning physiological levels per block. Therefore, separate analyses of covariance (ANCOVAs) for each cry block and the recovery were run, in which baseline values for, respectively, SCL and RSA were entered as covariates. Furthermore, maternal sensitivity was included as a covariate in the latter two repeated measures ANOVAs to control for a previously found cross-sectional relation for the same sample of mothers between high levels of maternal sensitivity and increased RSA withdrawal in response to infant crying (Joosen et al., 2012). Furthermore, a direct negative relation was found between

Table 1. Background Data of Mothers at Risk for Harsh Discipline and Mothers Not at Risk for Harsh Discipline.

	Harsh-Risk Mothers		Nonharsh-Risk Mothers		Group Comparisons
Sample distribution: *n* (%)	10	(20.8)	38	(79.2)	
Smoking during day of home visit: *n* (%) yes	5	(10.4)	8	(16.7)	$\chi(1) = 3.60, p = .07$
Physical excercise in week before home visit: *n* (%) yes	4	(8.3)	24	(50.0)	$\chi(1) = 1.75, p = .19$
Maternal sensitivity at 3 months: *M* (*SD*)	6.23	(0.84)	6.51	(1.00)	$t(46) = 0.83, p = .41, r = .12$
Age in years: *M* (*SD*)	30.47	(5.54)	29.44	(4.81)	$t(46) = -0.58, p = .56, r = .09$

Note. M = mean; *SD* = standard deviation.

Table 2. Physiological Data of Mothers at Risk for Harsh Discipline and Mothers Not at Risk for Harsh Discipline.

	Harsh-Risk Mothers		Nonharsh-Risk Mothers		
	M	(*SD*)	*M*	(*SD*)	Group Comparisons
SCL					
Baseline	9.41	(3.11)	9.66	(3.07)	$t(46) = 0.23, p = .82, r = .03$
Block 1	11.11	(3.70)	10.85	(3.64)	$F(1, 45) = 1.50, p = .23$, partial $\eta^2 = .03$
Block 2	11.32	(4.10)	10.66	(3.67)	$F(1, 45) = 4.96, p < .05$, partial $\eta^2 = .10$
Block 3	11.39	(3.90)	10.57	(3.56)	$F(1, 45) = 5.70, p < .05$, partial $\eta^2 = .11$
Recovery	11.06	(3.73)	9.96	(3.10)	$F(1, 45) = 13.46, p < .01$, partial $\eta^2 = .23$
RMSSD					
Baseline	35.22	(14.98)	51.64	(25.73)	$t(46) = 1.93, p = .06, r = .27$
Block 1	35.96	(15.07)	45.50	(21.88)	$F(1, 45) = 0.14, p = .71$, partial $\eta^2 = .00$
Block 2	38.15	(16.40)	46.06	(20.23)	$F(1, 45) = 0.82, p = .37$, partial $\eta^2 = .02$
Block 3	34.28	(14.95)	45.91	(21.74)	$F(1, 45) = 0.02, p = .89$, partial $\eta^2 = .00$
Recovery	33.69	(18.31)	47.67	(23.01)	$F(1, 45) = 0.03, p = .87$, partial $\eta^2 = .00$

Note. M = mean; RMSSD = root mean square of successive differences; SCL = skin conductance levels; *SD* = standard deviation. Tests for group differences in Block 1 through recovery include the baseline value as a covariate.

maternal sensitivity in early infancy and harsh discipline in toddlerhood (Joosen, Mesman, et al., 2012).

Results

Preliminary Analyses

Sample distributions and descriptive statistics for the control variables are presented in Table 1. Mothers in the harsh discipline group did not differ significantly from the nonharsh-risk group of mothers on smoking, physical exercise, or age. Neither smoking, physical exercise, or maternal age had a significant influence on baseline levels of RSA nor were these variables significant covariates in any of the repeated measures ANOVAs for RSA. Therefore, analyses are reported without these variables. All repeated measures ANOVAs included a baseline value for SCL or RSA, respectively, as the reference point for reactivity.

SNS Reactivity

Mean SCL response patterns for both groups are presented in Table 2 and Figure 1. A repeated measures ANOVA showed a significant rise in mean SCL from baseline to the three cry sound blocks, $F(2.41, 111.04) = 23.57$, $p < .01$, partial $\eta^2 = .34$, as well as a significant decrease in mean SCL from Block 3 to recovery, $F(1, 46) = 10.29$, $p < .01$, partial $\eta^2 = .18$). A significant interaction effect between SCL reactivity over time and risk for harsh discipline was found, $F(2.41, 111.04) = 4.10$, $p < .05$, partial $\eta^2 = .08$. Mothers in the harsh-risk group showed a significantly different response pattern of SCL than the nonharsh-risk group from baseline to Block 3, $F(1, 46) = 5.22$, $p < .05$, partial $\eta^2 = .10$ and from baseline to the recovery, $F(1, 46) = 13.79$ $p < .01$, partial $\eta^2 = .23$). The mean SCL of the mothers in the nonharsh-risk group showed a less steep increase from baseline to Block 3 and to recovery than the increase of SCL in the harsh-risk mothers who continued to show elevated SCL until the end of the cry paradigm. This resulted in significantly different response patterns from baseline to Block 3 and similarly from baseline to recovery between the two groups. Maternal sensitivity at 3 months was not a significant covariate when added to the repeated measures ANOVAs; and when controlling for 3-month sensitivity, the interaction between SCL reactivity over time and harsh discipline remained significant, $F(2.38, 107.13) = 3.51$, $p < .05$, partial $\eta^2 = .07$. Follow-up tests did not reveal significant group differences for baseline SCL, but significantly higher mean SCL were found for the harsh-risk group of mothers compared to the nonharsh-risk group in Blocks 2, 3, and the recovery phase when corrected for baseline SCL values (test statistics presented in Table 2).

PNS Reactivity Through the Vagal Brake

Mean RSA response patterns for both groups are presented in Table 2 and Figure 2. A repeated measures ANOVA for RSA

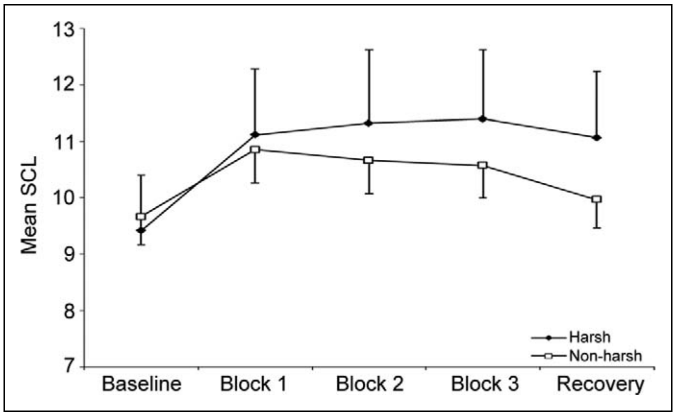

Figure 1. Skin conductance level reactivity to infant crying (*M*, *SE*) in harsh and nonharsh groups of mothers ($n = 48$). M = mean; SE = standard error.

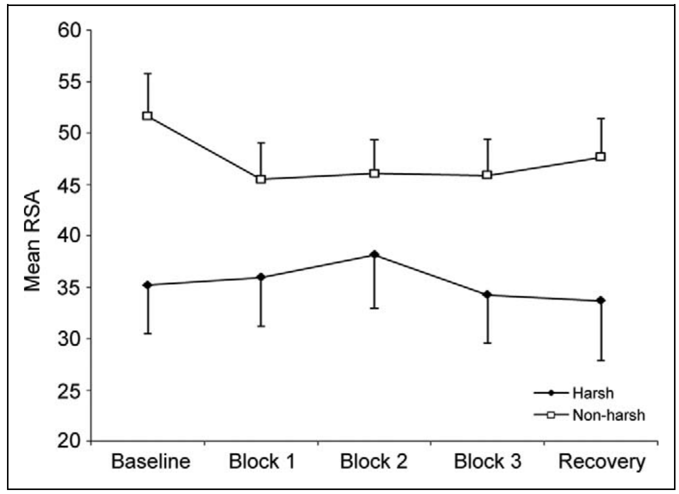

Figure 2. Respiratory sinus arrhythmia in response to infant crying (*M*, *SE*) in harsh and nonharsh groups of mothers ($n = 48$). M = mean; SE = standard error.

showed no significant main effect of RSA reactivity over time, $F(3.04, 139.68) = 0.87$, $p > .05$, partial $\eta^2 = .02$, nor an interaction effect between RSA reactivity over time and harsh discipline, $F(3.04,139.68) = 1.38$, $p > .05$, partial $\eta^2 = .03$. Thus, mothers in the harsh-risk group did not show a different RSA response pattern to the cry sounds compared to the other mothers. Maternal sensitivity at 3 months was not a significant covariate in the repeated measures ANOVA, $F(3.08, 138.51) = 1.27$, $p > .05$, partial $\eta^2 = .03$. Follow-up tests did not reveal significant differences in RSA between the harsh-risk and nonharsh-risk group during any of the assessment points when correcting for baselines values (test statistics are presented in Table 2).

Discussion

This preliminary study investigated differences in physiological reactivity to cry sounds between mothers observed to show signs of harsh discipline and mothers who were not. Specifically, we hypothesized that the mothers showing a risk for harsh discipline would have a stronger reactivity of the SNS in response to cry sounds compared to other mothers. Furthermore, we expected mothers showing a risk for harsh discipline to have a weaker RSA withdrawal compared to other mothers in response to cry sounds due to the absence of a well-functioning vagal brake (Porges, 2001). Our results confirmed that mothers in the harsh discipline risk group showed more reactivity of the SNS as shown by greater increases in SCL levels compared to mothers in the nonharsh-risk group, especially after repeated exposure to cry sounds across the paradigm. As the response patterns of the groups became significantly different from Block 3 onward, results suggest that mean SCL levels of mothers showing a risk for harsh discipline continued to be elevated across the cry paradigm compared to baseline, while the mean SCL level of mothers not showing a risk for harsh discipline showed a less steep increase during the cry presentations. Starting with the same mean SCL baseline levels between the two groups, mothers in the harsh-risk group continued to show increased SCL levels leading to significant mean level differences in the last part of the cry paradigm.

Nonetheless, *both* groups did show an initial activation of the SNS in response to the first block of cry sounds, shown by an increase in mean level SCL from baseline to Block 1 for all mothers. Furthermore, group differences in mean level SCL were not yet significant during the first block of cry presentations as shown by the ANCOVA for Block 1. It thus seems that it is not the immediate activation of the SNS in response to infant crying that differentiates between the two groups of mothers, but that only the enduring activation of the SNS in response to repeated cry sounds is linked to later observations of a risk for harsh parenting. This is in line with results from a study that found a later peak for shaken baby syndrome hospitalizations (10–13 weeks of age) than for the peak of the crying curve (5–6 weeks of age). This delay in peak for shaken baby syndrome hospitalization could be due to the stress that is caused for some (at-risk) parents, when they are confronted with persistent high crying levels that endure beyond the peak of the normal crying curve (Barr, Trent, & Cross, 2006). In other words, during the normal crying curve, most parents would be subjected to more persistent crying, but when this crying does not cease after 5–6 weeks after birth, it can cause dangerous stress levels for parents at risk for maltreatment. Thus, it seems that especially repeated exposure to crying is related to the experience of psychological stress in parents using harsh discipline, which in combination with negative, blame-oriented, and child-centered attributions (Bugental & Happaney, 2004; Bugental et al., 1999) leads to unremitting activation of their SNS. Longer cry samples might even have triggered the physiological response more intensively, and in future studies, the additional use of longer, more persistent crying is recommended.

Concerning our hypothesis on RSA withdrawal, results did not confirm a weaker RSA withdrawal in response to the cry sounds for the mothers showing a risk for harsh discipline compared to the mothers who did not. A possible explanation for this unexpected finding could be the use of RMSSD as a quantification of RSA. In the present study, very short segments were used for the calculation of RMSSD: Per block, we averaged three segments of 10 s (the duration of each cry sound), each divided by a resting period of 1 min. Unfortunately, RSA estimates in general have been found to be less reliable when measurement intervals are short (Berntson et al., 1997). Furthermore, RMSSD as a measure of RSA is known to have a large range of acceptable scores (see manual VU-AMS 5fs on http://www.vu-ams.nl/support/previous-ams-versions/manuals/amsgra), which in this study was shown by large *SD*s for the group averages per block. It is possible that these large *SD*s, in combination with the small group sizes (especially for the harsh group), were responsible for the lack of significant differences between the two groups of mothers on RMSSD levels.

It could also be that varying levels of sensitivity in the second year after birth have dampened the degree of RSA withdrawal in the nonharsh-risk group. Previous findings have shown stronger RSA withdrawal for highly sensitive mothers (Joosen et al., 2012) as well as a significant relation between low levels of early maternal sensitivity and the risk for using harsh discipline in toddlerhood (Joosen, Mesman, et al., 2012). Therefore, we also controlled for the level of early maternal sensitivity (at 3 months after birth) in the current study. Nonetheless, because we did not include later levels of maternal sensitivity (during the second year) when creating the two groups, it is possible that the nonharsh-risk group included highly sensitive mothers as well as mothers with medium or low levels of sensitivity. In a larger sample, distinctions between a highly sensitive and a moderately sensitive nonharsh-risk group could be made. We would predict that this would uncover significantly less RSA withdrawal in mothers showing a risk for harsh discipline compared to highly sensitive mothers who do not show a risk for harsh discipline. Therefore, a mix of mothers with various levels of sensitivity in our nonharsh group could have been the reason why we did not find the hypothesized stronger RSA withdrawal for the nonharsh-risk group in this study.

Some limitations of the current study should be mentioned. First, the small sample size may influence the replicability of the results. Results on RSA withdrawal may have been affected by the small sample in combination with the large *SD*s for RMSSD mean levels per segment. Second, we based our split between the groups of mothers on the more subtle signs for harsh discipline, which resulted in a total of 10 mothers in the harsh group. Because of this small subsample, the current study can be seen as preliminary and we emphasize the need for replications in larger samples. However, home observations of moderate to severe harsh discipline are not to be expected in a nonclinical population, because any mother would be at her best in front of a camera. Therefore, when using home observation cutoffs for harsh parenting can only be based on the milder and subtler signs of harsh discipline, therefore registering only the tip of the iceberg and referring to mothers at risk for showing harsh discipline rather than harsh discipline per se. Third, we did not have enough statistical power to test whether there was a significant interaction between SNS and PNS reactivity patterns across the cry paradigm and whether such an interaction would be different for both groups. Furthermore, we did not control for respiration rate in our estimation of RSA (Grossman & Taylor, 2007). In a comparative study between different quantification methods for RSA using data collected with a similar ambulatory device, RMSSD levels were proven to be a reliable and valid estimate of RSA (Goedhart et al., 2007). Because all participants were seated during the entire cry paradigm (including baseline measurement), and did not speak during cry presentations, changes in respiration rate due to physical activity or talking could only have had a minimal effect on our estimation of RSA. Finally, there is no conclusive evidence as to whether the same neurobiological processes are involved in a risk for harsh versus abusive parenting. Instrumentally, harsh discipline may be applied to control child noncompliance, whereas abusive parenting appears to be less related to child behavior (e.g., Jaffee et al., 2004), and the underlying causal mechanisms may differ as well. Future studies should compare physiological reactivity of abusive parents with that of parents using only harsh parenting behaviors—if such "pure" groups can indeed be found. Including measures of parental negative attributions related to threat perception and more extensive measures of verbal harsh discipline may also help to elucidate these issues.

Uncovering potential risk factors for harsh discipline is of great importance for mental health care professionals, because early identification of at-risk parents creates the opportunity for early intervention strategies in breaking an otherwise continuing pattern of maladaptive parenting. Physiological markers are valuable in providing a more thorough understanding of the biological underpinnings of ineffective and potentially harmful parenting behaviors. Especially the identification of patterns specific to impulsive rather than instrumental harsh discipline may inform prevention efforts aimed at mothers at risk for maltreatment. This distinction is also relevant to theoretical considerations regarding maltreatment risk, as it provides important information on mechanisms underlying different pathways from harsh discipline strategies to potentially maltreatment outcomes.

In a related avenue of research, infant dolls have been used that can be programmed according to the amount of time the doll cries during a 24-hr observation period. These dolls are also equipped with a device that registers various parenting behaviors (e.g., Bruning & McMahon, 2009; Roberts, Wolman, & Harris-Looby, 2004; Van Anders, Tolman, & Volling, 2012). Along these lines, we developed an ecologically valid but standardized setting using an infant simulator with interactive features, the Leiden Infant Simulator Sensitivity Assessment (LISSA; Voorthuis et al., In press). The doll resembles a real infant in appearance and it produces crying sounds that are lifelike, beginning with fussing and progressing to more intense crying. Sensitivity measured with the LISSA was related to an increase in positive affect during caretaking, and insensitivity was related to intended harsh caregiving response during the cry paradigm. With the existing ambulatory devices to record physiological reactivity continuously during longer periods, it might be possible to simultaneously measure physiological data during the 24 hr that study participants, for example, expectant parents, would take care of such a doll as a screen or pretest for preventive intervention. Additionally, future studies could use similar dolls programmed with either standardized cry sounds or their own infant cry sounds to compare their influence on both behavioral and physiological reactivity of parents showing harsh discipline.

In conclusion, the current study showed a significantly different response pattern to repeated cry sounds for mothers at risk for harsh discipline as compared to mothers who were not, which seemed to be due to the fact that mean SCL levels of mothers in the former group continued to rise across the repeated exposure to cry sounds, while after an initial increase the mean SCL level of the other mothers showed a steady decline. From a polyvagal perspective, the current results for SNS reactivity seem to confirm that repeated cry sounds are experienced as more psychologically stressful and possibly more threatening by mothers in the harsh-risk group than by the other mothers. Therefore, we suggest that a risk for harsh parenting reflects behavioral as well as physiological overreactivity to negative infant signals.

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