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Maternal Behavior Affects Child's Attachment-Related Cortisol Stress Response

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Abstract

Background: Mothers with a history of childhood maltreatment (CM) are likely to transmit their own experiences to the next generation. This is highly influenced by the quality of maternal behavior that enables to buffer infant's hypothalamic-pituitary-adrenal (HPA) axis response to stress. From a transgenerational perspective the research question is, if infant's cortisol stress response is influenced by maternal CM experiences or rather by the behavioral pathways during the first year of life.

Methods: 53 mother-child-dyads were measured at 12 months of infant's age in a laboratory visit assessing the maternal quality of interactive behavior using the Atypical Maternal Behavior Instrument for Assessment and Classification (AMBIANCE) measured during the strange situation procedure (SSP). Maltreatment experiences were assessed using the childhood trauma questionnaire (CTQ). Salivary cortisol of mother and infant were collected prior to and directly, 15 and 30 minutes after the SSP.

Results: Infants of disruptive mothers showed a significant increase in cortisol ($F(3; 147) = 2.897$, $p = 0.048$) after the SSP compared to infants of mothers with sensitive caregiving. Maternal CM did not influence the infant's cortisol stress response due to the SSP. However maternal cortisol response was altered by trend due to CM ($F(1.392; 71.008) = 3.157$, $p = 0.066$).

Conclusions: Our data indicate that infant's cortisol stress reactivity is influenced by the quality of maternal behavior and not by the transgenerational transmission of maternal CM experiences per se. These findings implicate that helping mothers to improve their caregiving behavior may help to improve stress-reactivity of their infant.

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Introduction

Childhood maltreatment (CM) is considered as a significant risk factor for detrimental development, in particular when it occurs early in life [1,2]. Individuals with experiences of CM are at higher risk for long-term serious health consequences on [1] psychological level (e.g. elevated risk for psychiatric disorders [3], increased sensitivity for everyday stressors [4] and perception of stress [4] and [2] physical level (e.g. more medical diagnoses [5] and lower expectancy of life [6]. CM has been shown to be transmitted to the next generation via behavioral (e.g., quality of parenting) [7] and presumably via biological pathways [8,9,10].

Dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis has been widely shown in the context of CM. The HPA axis, considered as the body's major glandotrop stress system, is associated with increased vulnerability to psychological and physical diseases [11]. Stress is regulated via the HPA axis, which exerts an adaptive stress response of the organism. The stress response initiates a biochemical cascade where corticotropin-releasing hormone (CRH) is delivered from the hypothalamus. The delivery of CRH triggers the flow of the adrenocorticotropin-releasing hormone (ACTH) produced by the anterior pituitary, which, on the other hand, activates the release of glucocorticoids from the adrenal cortex [1,12]. During upcoming stress, the HPA axis increases the production of cortisol to offer the capacity to mobilize energy or priming the body for similar stressors in the future [13]. Cortisol increase reaches a peak between 20 to 40 minutes after a stressor and falls back to the baseline when the stressful situation is resolved [14], with peak levels of infant´s cortisol within 20 to 40 minutes after a stressor [15]. Functional stability of the HPA axis is not definitively developed at birth but infant´s cortisol baseline secretion and peak percentage increases week by week until the age of 1 year. In 1 year old infant, the HPA axis has become socially regulated which protect infant´s development from detrimental effects of excessive exposure to glucocorticoids [16,17].

CM and HPA Reactivity

Specifically, the stress of experiencing CM has been linked to HPA dysregulation during the period of maltreatment as well as until adulthood [17]. Ongoing stress and stress of which the individual is not able to effectively cope with may change the sensitivity of the glucocorticoid receptors, resulting in alterations in cortisol delivery and affects other brain structures such as the hippocampus [18]. Several studies have examined the effect of CM showing that individuals with CM experiences demonstrate dysregulated cortisol levels measured in urine, blood and saliva [19,20]. Morris and colleagues (2012) showed that adults, who were maltreated as children, tend to exhibit lower levels of cortisol in the evening [21] and blunted responsiveness to psychosocial challenges [22]. In contrast, Heim et al. identified increased cortisol responsiveness to challenge in context of CM [23]. Especially in maltreated children, the research findings are less clear [24] revealing increased, decreased or similar patterns of cortisol reactivity compared to a non-maltreated control group [17]. In detail, Cicchetti and Rogosch (2001) and Bruce and colleagues (2009) detected that physically abused children showed lower salivary cortisol levels and flattened diurnal slope [25,26] indicating a down-regulation of the HPA axis in response to initial cortisol increasing the context of CM [18]. Both, boys and girls with CM experiences showed attenuated cortisol stress responses in stressful situations [24,27,28]. In addition, studies of toddlers living in Russia and Romania showed decreased morning cortisol levels and no diurnal salivary cortisol decrease throughout the day [29]. This has also been shown to be apparent among preschoolers in foster care, of which 35% showed blunted cortisol diurnal rhythm [30]. In contrast to these findings, De Bellis et al. (1999) showed that children with experiences of CM and a consecutive posttraumatic stress disorder had increased cortisol levels [19]. Furthermore, it has been shown that cortisol levels increased with the severity and duration of CM [12]. Longitudinal studies of HPA axis regulation in maltreated individuals are rare [24]. Nevertheless, one study realized a longitudinal HPA axis follow-up from childhood over adolescence to adulthood in maltreated girls. They reported high cortisol levels in childhood, attenuated cortisol in adolescence and exhibited low cortisol levels in adulthood [31], which suggest a shift from hypocortisolism in childhood to receptor down-regulation in adulthood in response to chronic stress [28].

Recently, a growing research interest has been focused on the biological correlates of trans-generational transmission of CM showing that maternal child abuse results in disturbances in the HPA axis in their offspring. Brand and colleagues (2010) detected that children of mothers with CM showed lower baseline cortisol compared to children of mothers without CM. Additionally, children of mothers of a combination of both, a history of early maternal abuse and comorbid post-traumatic stress disorder, were associated with greater increases in child's cortisol levels [32]. Fisher et al. (2007) observed in a 25 - year longitudinal study lower morning cortisol and modified cortisol release during the day in children of mothers´ with experiences of CM compared to children without CM experiences of their mothers [33].

The transmission of HPA axis dysregulation due to CM into the next generation was confirmed by Yehuda and colleagues (2005) who reported, that offspring of mothers with traumatic experiences in adulthood and PTSD showed significantly lower cortisol levels in saliva and blood compared to a control group [34].

Quality of Caregiving and HPA Axis Reactivity

In childhood sensitive, warm and responsive caregiving plays an equivalent role in successful child's behavioral and physiological regulation outcomes [35]. High quality of caregiving is critical in reducing young infants´ distress in situations of emotional arousal and may buffer infant´s HPA axis response during stress [18]. Extensive evidence of research findings indicates that excessive or prolonged activation of stress response in the first years of infants' life predicts later psychophysiological healing. It is particularly important to differ between types of stress: positive stress, tolerable stress and toxic stress. Infants could cope with both types of stress like positive stress as well as tolerable stress with moderate, short-lived stress responses respectively stress with potential to negatively affect but over limited time periods. Especially toxic stress in childhood revealed correlations with emotional behavior, health across lifespan and promotes damaging effects on learning [36,37]. Recently, physiological parameters have been used to confirm behavioral observations and to enable a more basal understanding of the relation between behavioral and physiological systems. The HPA axis stress response has been used to study physiological stress responsiveness to arousing or stressful situations in humans and animals [38,39]. The adrenocortical system seems to be particularly responsive to aversive or stressful situations that convey novelty or uncertainty accompanied by negative emotions [48]. The earliest years in infants´ life are well known to be a critical window for disturbances in stress regulation processes. Both, sensitive and intrusive maternal interacting behaviors in free play and stressful situations have been associated with alterations of infants´ stress regulation outcomes [39]. Especially the daily quality of caregiving may affect the development of infant's stress regulatory capacities [17,40,53]. Gunnar et al. (1992) found associations between the quality of caregiving and the adrenocortical response of the infant during a paradigm of separation of mother and infant. Their findings suggested that caregiving might buffer the adrenocortical response of the infant in stressful situations [41]. These findings were replicated by Enlow et al. (2014), who found that higher maternal insensitivity was associated with higher cortisol release during a stressful laboratory paradigm [42]. This was confirmed by Haley et al. 2003 who reported that infants of more responsive parents showed greater regulation like lower peaks of cortisol in stress situations in their HPA stress response than infants of less responsive parents [43]. In contrast Nachmias et al. (1996) showed no cortisol increase during an experimental setting of live clown in children of more sensitive parents compared to lower sensitive caregiving [44]. On the other hand a high quality of caregiving is supposed enhance secure attachment between child and caregiver [55], and children who are securely attached showed no anomalous elevation of cortisol reaction when the attachment figure was present [46; 47,48]. Cicchetti et al. suggested sensitive caregiving to play a major role on infants´ HPA axis regulation [49]. However, there are only few comparative studies focusing on both, maternal behavior and maltreatment and their effects on infants´ HPA axis reactivity during stressful situations [50]. For example Martinez-Torteya (2014) evaluated the effect of maternal parenting on infant's biobehavioral regulation among maternal CM [51]. They found no direct influence of infants´ physiological or behavioral responses but positive associations between maternal

interaction quality and infant´s cortisol reactivity to stressors [51]. Our investigations may shed light on the influence of maternal CM and the quality of caregiving on infants´ stress response one year after birth. Especially, the question of a transgenerational transmission of CM on behavior level should be clarified. Therefore, we aimed to differentiate maternal CM and caregiving on child's cortisol stress reactivity and measured salivary cortisol in the mothers-child-dyad during the SSP. We hypothesized 1. that maternal cortisol response during SSP differs between mothers´ with and without CM and 2. that the cortisol response of the child will be transmitted by interacting behavior of the mothers´ in the first year of life and not by the history of maternal CM.

Material and Methods

Participants and Study Design

TRANS-GEN is an interdisciplinary study consortium investigating in a prospective approach the pathways leading to resilience or vulnerability in the transgenerational transmission of childhood maltreatment (CM) by focusing psychological, biological and social factors.

The study was funded by the Federal Ministry of Education and Research and was approved by the Ethics Committee of Ulm University. After recruiting in the maternity unit of the Ulm University Hospital all mother-infant dyads were followed up twice: 3 months (t1) and 12 months (t2) after birth.

Participants

Since October 2013, 533 mother-infant-dyads were being recruited in the women's hospital of the University Hospital of Ulm 1-6 days after parturition and were willing to complete the screening interview (t0). Inclusion criteria were age >18, over 37 weeks of pregnancy, sufficient knowledge of the German language, no complications during parturition or health problems of mother and/or infant as well as no current drug consumption or a history of severe psychiatric disorders or current infections. 240 mother-infant-dyads could be invited for a follow-up 3 months (t1) after birth in both laboratory as well as in home visit and 158 mother-infant-dyads participated in a further laboratory and home visit around 12 months of infant's age (t2).

All mother-child-dyads were asked to collect salvia of 4 measurement points. The sample for the following analyses included 53 mother-infant-dyads. Missing data sets were due to the lack of agreement for collecting biological samples of 1 cases of mothers-child-dyads. In addition, 104 of mothers´ and 106 of infant´s collected salvia had no or insufficient amount of saliva for each data point, before (baseline before SSP), directly after (+1 min.) 15 minutes (+15 min.) and 30 minutes (+30 min.) the SSP. For final analysis, we included only mothers and their infants with a complete data set of 4 measurements. Cortisol levels of two infants could not be analyzed due to low amount of saliva. Therefore, we considered complete data sets of 53 mothers and 51 infants for final analyses (complete data sets means no missing of any of each 4 measurement points).

Mothers' age at time of measurement (t2) was between 21 and 43 years (mean 33.72 years [SD 4.47 years]). Maternal body mass index (BMI) was between 17.26 and 31.83 (mean 24.35 [SD 3.82]. 79.2% of the mothers reported to be married or living in a partnership and 88.7% of all mothers had German citizenship. Mother's level of education at t2 in comparison to the educational background of the German population showed, that 56.6% had a grammar school degree, 11.3% a secondary school degree, 22.6% a basic secondary school degree and 7.5 % no school diploma. Furthermore, 20.8% of the mothers had medical risk factors e.g. chronic disease, high blood pressure or allergies. 30 male and 21 female infants were investigated in laboratory visit. All mother-infant-dyads were invited around 12 months of infant´s age (12.0 ± 0.1 months) (mean 12.43 years [SD 0.80 years]) (Table 1).

Procedure

Mothers were screened for CM using the CTQ [52]. Experiences of emotional abuse, physical abuse, emotional neglect, physical neglect and sexual abuse are assessed with five items each rated on a five-point Likert scale. The CTQ subscale scores range from 5 to 25 and the total scores from 25 to 125. The sum score over all 25 items was calculated as a cumulative measure from "none" maltreatment experiences (25 points) up to "minimal" till "extreme" maltreatment load [53]. All ratings were summed up to a sum score. Mothers´ with a higher sum score than 25 were classified as CM+.

All mother infant-dyads were invited for a

laboratory visit at 12 months of infant's age (t2). Due to circadian rhythm of cortisol levels, all mother-child-dyads were assessed from 10.00 am to 1.00 pm. After a short introduction explaining the procedure of the investigation, mothers and infants were asked to have a resting phase of 15-20 minutes before sampling of the first saliva probes (baseline before SSP) prior to the beginning of the SSP. Further saliva samples were collected directly (+1 min. after SSP), 15 minutes (+15 min. after SSP) and 30 minutes (+30 min. after SSP) after the SSP while mothers were asked to play with their infant and relax by using toys. The implementation of the SSP was based on the standardized SSP protocol including 7: (e1) mother and infant were alone in the room with the infant exploring the room and the mother sitting on a chair, (e2) first encounter and interaction with the stranger, (e3) mother went out of the room (first separation), (e4) mother came back after a time period ranging from 30 seconds and 3 minutes dependent on child´s irritation and reaction of being separated from the mother (stranger left the room while reunion), [5] mother left the room for the second time while infant is alone in the room (second separation), (e6) the stranger came back instead of the mother, (e7) the mother came into the room (second reunion) while the stranger went out of the room [54].

Ambiance Measure

For measuring the quality of maternal interactive behavior we videotaped mother-infant interactions during the SSP analyzed by the "Atypical Maternal Behavior Instrument for Assessment and Classification (AMBIANCE)" (AMBIANCE;55). The AMBIANCE is based on the theory of Main and Hesse (1990) and has been developed by Lyons-Ruth and colleagues and assesses anomalous parental behavior of mothers´ during interactions with their infant [55,56,57].

Additionally to the concepts of frightened and frightening behaviors and dissociated parental states described by Main and Hesse [56] AMBIANCE considers profound disruptions in mother – infant interaction as well as behaviors that are physically or emotionally withdrawn [58]. To assess the quality of interacting behavior AMBIANCE codes disrupted maternal behaviors on five dimensions: affective communication errors, role/ boundary confusion, disorganized/ disoriented behaviors, negative/intrusive behavior, and withdrawal. Each dimension is coded on a 7-point scale as well as an overall score of the level of disruption. The frequency and intensity of all disrupted behaviors mothers´ displayed in the course of the interaction with their infant resulted in the level of maternal disrupted communication. Maternal disrupted communication coded up to 4 has been considered "not-disrupted" whereas a level from 5 to 7 is considered "disrupted". Therefore, mothers with maternal communication below 5 were coded as "not-disrupted" whereas mothers coded from 5 till 7 were coded as "disrupted" mothers. All videotaped play sessions were scored by a single coder, who was blind to all other data of the mother-infant-dyads. This coder was trained by and reliable with the original developers of the AMBIANCE [55].

Saliva Sampling

For saliva sampling, SalivaBio's Children's Swabs (SCS) (Salimetrics, State College, USA) were used by following the standard procedures. Therefore, SCS were placed into the infant's and mothers´ mouths for about 30 seconds. Thereafter, swabs were stored in storage tubes on ice at -20°C. Upon completion of t4, tubes were centrifugalized at 4°C/ rpm and aliquots were stored at -80° C. Cortisol levels (µg/dL) were analyzed by C. Kirschbaum (Technical University of Dresden, Germany). The salivary concentrations were measured using chemiluminescence immunoassay with high sensitivity (IBL International, Hamburg, Germany). The intra and interassay coefficients for cortisol were below 8%.

Statistical Analyses

We conducted statistical analyses using Statistical Package for the Social Sciences version 23.0 (SSP Inc., Chicago, IL). Statistically significant was set at $p<.05$. Normal distribution of data was tested by non-parametric Kolmogorov-Smirnov test. Since data were normally distributed, data were analyzed as follows: ANCOVA for repeated measures was calculated for each of the cortisol values between subject (group: "CM-" / "CM+"; "not-disrupted" / "disrupted" maternal behavior; mother, infant) and within subjects (for episode "baseline before SSP" to "+30 min."). Greenhouse-Geisser as well as Sphericity assumed correction for repeated measures were applied. To test differences between the groups within each

measurement we used unpaired t-tests. Infant sex, age of the mother at birth as well as the body mass index of the mother were controlled as covariates (Table 1).

Results

Descriptive Analyses

Descriptive statistics are shown in Table 1. Twenty-eight of 53 mothers were grouped as CM+ and 21 showed "disrupted" maternal behavior (Table 2 and 3). No significant differences were detected between the CM- and CM+ mothers as well as "non-disrupted" and the "disrupted" maternal behavior group concerning infant's sex, mother's age at birth and body mass indexes and thus were not considered for further analyses. There were also no significant differences for maternal interacting behavior focusing maternal education as well as their current marriage status.

Maternal Experiences of CM and Cortisol Reactivity in Mothers and their Infant

Focusing maternal HPA axis reactivity during SSP by using ANCOVA for repeated measures, neither main time (F (1.392; 71.008) = 0.579, p= 0.503), nor group effects (F (1; 207.539) = 1.052, p= 0.310) were detectable for CM+ compared to CM-. The values showed marginal, but no significant differences for group-by-time effects (F (1.392; 71.008) = 3.157, p= 0.066) (figure 1a).

For infant´s HPA axis time effects (F (2.226; 109.096) = 14.277, p= 0.000) could be shown. For infant's main group-by-time (F (2.226; 109.096) = 0.595, p= 0.571) or group effects (F (1; 49) = 0.740, p= 0.394), no significant results were detectable (figure 1b).

T-test analyses comparing two independent samples revealed no differences focusing maternal and infant´s cortisol values and CM for each of the measurements (baseline before SSP - +30 min.).

Maternal interacting quality and cortisol reactivity in mothers and their infant

Using ANCOVA for repeated measures the saliva cortisol in mothers relative to maternal interacting behavior showed neither main time (F (1.398; 71.305) = 0.663, p= 0.466), group-by-time (F (1.398; 71.305) = 1.097, p= 0.320) nor group effects (F (1; 51) = 0.053, p= 0.819) (figure 2a).

Saliva cortisol in their infants, however, showed significant time (F (3; 147) = 16.472, p= 0.000) as well as significant main group-by-time effects (F (3; 147) = 2.897, p= 0.048). For main group effects no significant differences could be shown (F (1; 49) = 1.664, p= 0.203) (figure 2b).

T-test analyses comparing two independent samples showed no differences for maternal cortisol levels focusing maternal interacting behavior. For infants cortisol values differences could be shown for the measurement 15 minutes after SSP (+15 min.) (t(49) = -2.108, p = 0.040). Infants of mothers with lower sensitive caregiving showed significant higher cortisol values (M = 6.46, SD = 3.525) than infants of mothers with a higher sensitive interacting behavior (M = 9.613, SD = 7.051).

Behavior and Infants´ Cortisol Reactivity

Correlation Between CM and the Quality of Maternal Caregiving

Pearson correlation analyses between the CTQ sum score of maternal maltreatment and interacting behavior measured by the AMBIANCE global score revealed no significant associations (r(53)=.080, p=0.567) (Table 4).

Discussion

Our findings reveal differences in the cortisol

Table 1. Descriptive analyses of covariates

	N	Min	Max	Mean	SD
Mother's age at birth	53	21	43	33.72	4.47
Body mass indexes	53	17.26	31.83	24.35	3.82
Infants´ age	53	11	14	12.43	0.80

Table 2. Allocation of the AMBIANCE overall score

	N	Range	Min.	Max.	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
AMBIANCE overall score	53	5	1	6	3,96	,166	1,208	1,460
Valid N (listwise)	53							

		Frequency	Percent	Valid Percent	Cumulative Percent
AMBIANCE overall score	´non-disruptive´	32	60,4	60,4	60,4
	´disruptive´	31	39,6	39,6	100,0
	total	53	100,0	100,0	

Table 3. Allocation of the maternal child maltreatment

	N	Range	Min.	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Maternal CM	53	70	1	36,53	2,043	14,871
Valid N (listwise)	53					

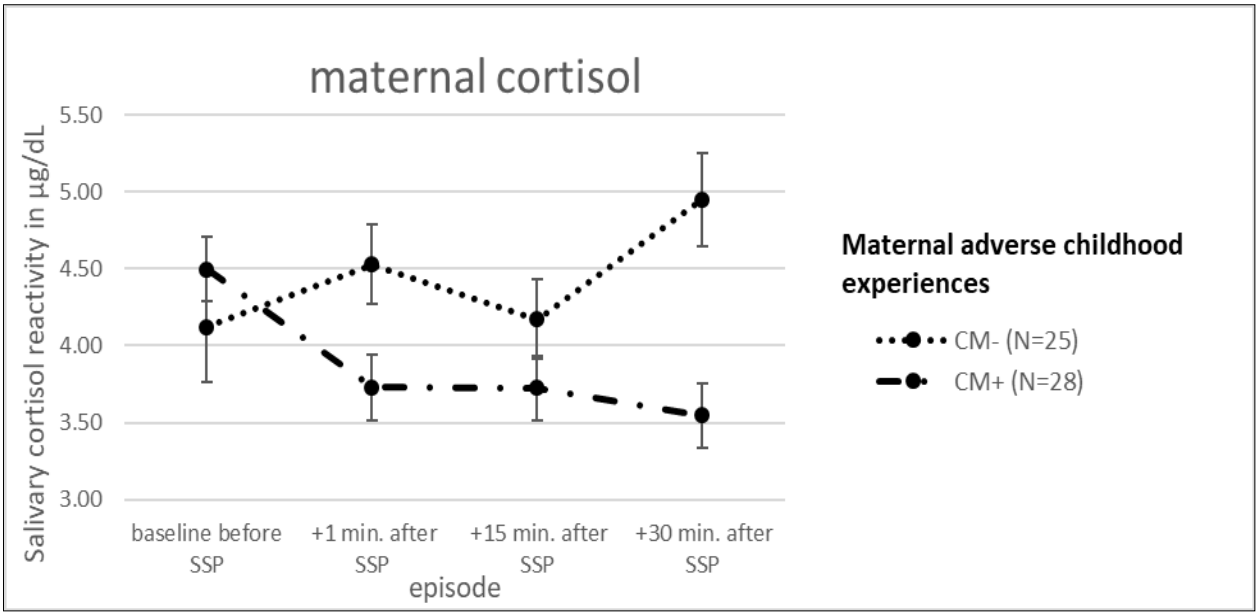
		Frequency	Valid Percent
Maternal CM	CM-	25	47,2
	CM+	28	52,8
	total	53	100,0

No experiences of CM (CM-)

Experiences of CM (CM+)

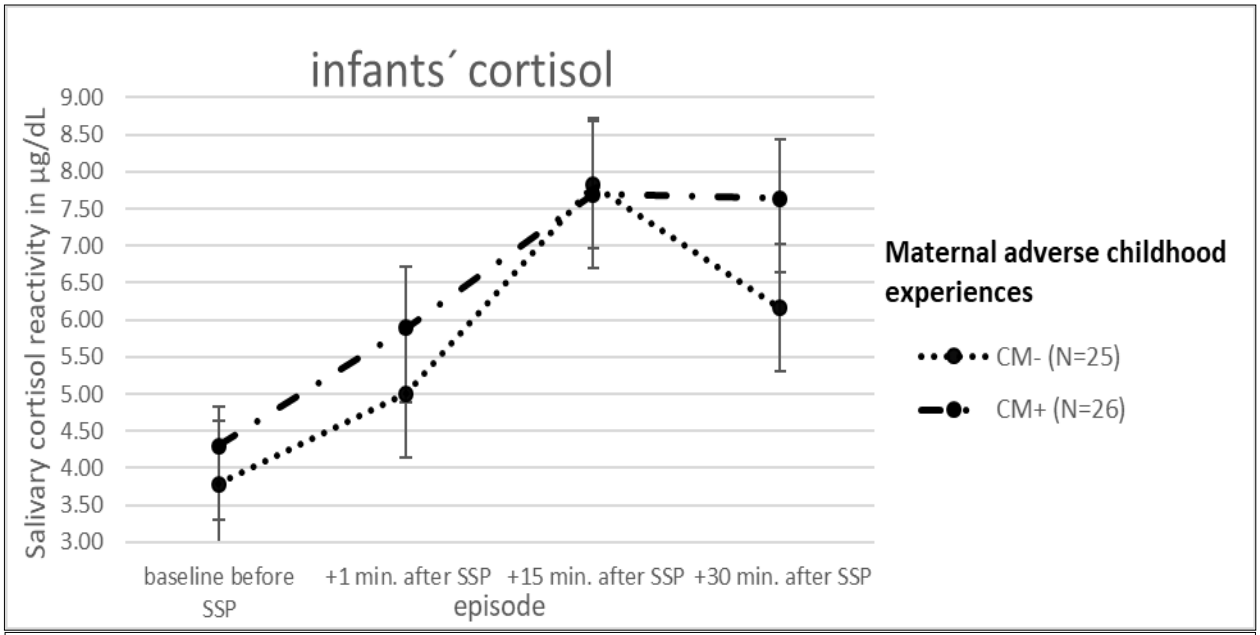
Table 4. Pearson Correlations between AMBIANCE overall score and CTQ overall score

		AMBIANCE overall score	CTQ overall score
AMBIANCE overall score	Pearson Correlation	1	,131
	Sig. (2-tailed)		,348
	N	53	53
CTQ overall score	Pearson Correlation	,131	1
	Sig. (2-tailed)	,348	
	N	53	53



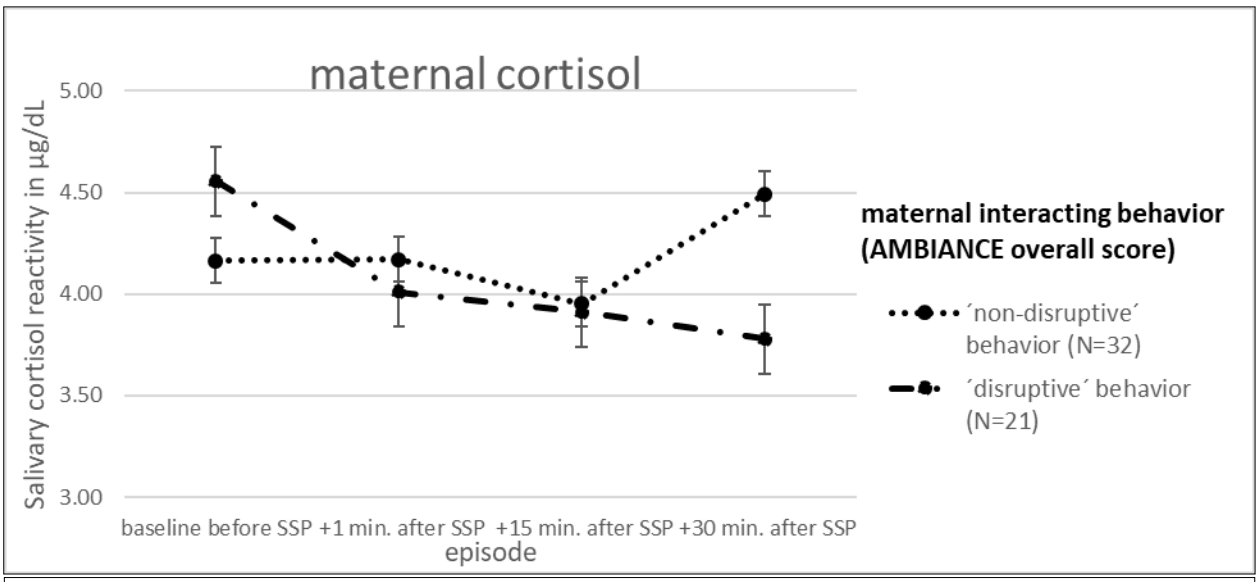
Strange situation procedure (SSP); No experiences of CM (CM-); Experiences of CM (CM+)

Figure 1a. ANCOVA for repeated measures for CM and maternal cortisol reactivity



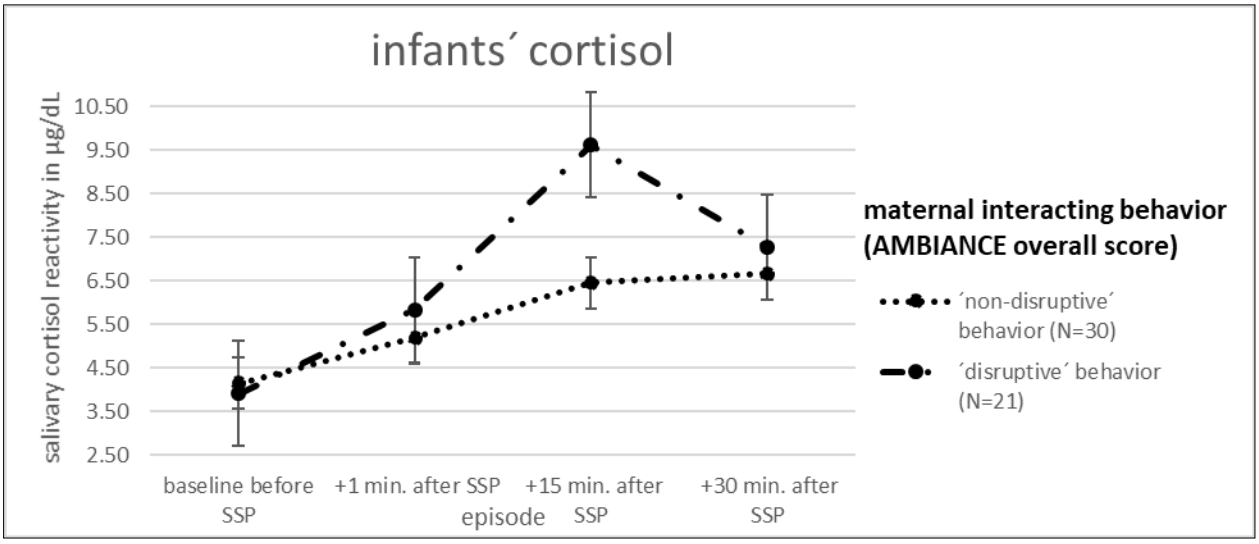
Strange situation procedure (SSP); No experiences of CM (CM-); Experiences of CM (CM+)

Figure 1b. ANCOVA for repeated measures for CM and infants´ cortisol reactivity



Strange situation procedure (SSP)

Figure 2a. ANCOVA for repeated measures for AMBIANCE overall score of "non-disruptive´ vs. ´disruptive´ behavior and maternal cortisol reactivity



Strange situation procedure (SSP)

Figure 2b. ANCOVA for repeated measures for AMBIANCE overall score of "non-disruptive´ vs. ´disruptive´ behavior and infants´ cortisol reactivity

stress responses of mothers and infants in relation to maternal CM and the quality of interacting behavior. Mothers with a history of CM showed no significant, but by trend differences in their cortisol stress response compared to mothers without CM. Transgenerational effects on cortisol stress reactivity in the child were only present when mothers showed disruptive maternal behavior towards the child, but not when mothers have reported maltreatment in their history

Infants Cortisol Reactivity Depending on Maternal CM and Interacting Quality

Focusing the infant's cortisol response in association to maternal CM we could not find any differences between both groups of infants with and without maternal CM. This is in line with Martinez-Torteya et al. (2014) who found no direct association between maternal CM and infant's cortisol reactivity after stressors [51]. However, two longitudinal studies of Fisher et al. (2007) and Brand et al. (2010) described differences in baseline cortisol levels as well as modified cortisol release during the day in infants of mothers´ with experiences of CM compared to infants without maternal CM [32,33]. The divergence between our results and that of Fisher et al. (2007) and Brand et al. (2010) may be explained by the low severity of maternal CM load in our sample. Fisher et al. (2007) and Brand et al. (2010) measured a sample with a range from low to high maltreatment. In contrast to that, our sample showed only low to moderate maltreatment load. We might consider that severity of maternal CM load affects the transmission of own experiences of CM into the next generation. This is in accordance with Alink et al. (2012) who showed that the risk of dysregulation in cortisol levels of mothers with CM increased in dependence to the severity and the duration of CM [12]. Therefore, we conclude that lower CM experiences in our sample may lead to a lower risk for transgenerational transmission of HPA axis dysregulations.

Interestingly, our data showed that maternal interacting quality seems to be a main factor that influence the infant´s cortisol stress regulation. Infants of mothers´ with disruptive interacting behavior showed a significant peak of cortisol level after 15 minutes compared to infants of mothers with sensitive interacting behavior. This indicates that enhanced sensitive caregiving resulted in lower infant's cortisol stress response. The results are in line with previous studies showing that a higher quality of caregiving resulted in a reduced infant's cortisol stress response [17,46,51]. Especially during the first years of life, infants need to manage the challenging transition from external regulation of affect and internal arousal to rising levels of psychobiological regulation [59]. In attachment as well as developmental theory it is suggested that the quality of parental interacting behavior as well as the relationship between infants and parents are an important factor for the development of infant's emotional and physiological regulatory strategies [47,59,].

The SSP is conceived as a stressful procedure in which the infant is stressed by two short separations from the caregiver. Several studies confirmed that the quality of maternal interacting behavior may buffer infants´ distress in situation of emotional arousal [60]. A stable and reliable relationship between mother and infant based on maternal sensitive interacting behavior might reduce infants´ distress due to the SSP and stabilize the infant at the time of the reunion with the caregiver. Lower sensitive and supportive parenting (e.g. like frightening and anxious interaction behavior) might constrain or reduce the ability of physiological regulation, reflected by a dysregulation of infants' cortisol stress response [40,61].

Maternal Cortisol Reactivity in Relation to CM and Their Interacting Quality

Mothers´ with a history of CM showed no significant but marginal differences in course of their cortisol levels compared to mothers without CM. However mothers with a history of CM started with a lower but not significant differences in cortisol baseline than mothers without CM. This was also found by Trickett et al., (2010) who showed in a longitudinal design that adults maltreated in childhood showed lower cortisol baselines than adults without CM [31]. Our findings show that the severity of experiencing CM may affect the regulation of the HPA axis until adulthood which is confirmed by data of Tarullo and Gunnar [17]. One potential reason might be the moderate to low severity of CM load in our sample. Looking at maternal interacting quality there were no significant differences in the cortisol responses between disruptive and non-disruptive mothers. It seems that focusing differences in maternal interacting behavior in detail may not alter the cortisol reaction in mothers [21].

In summary, we did not find any cortisol-related transmission effects of CM to the next generation, however, maternal behavior seemed to play a crucial role in this context. This is a particularly important and encouraging finding with regard to the cycle of maltreatment and the fact that many parents are concerned to transmit their own experiences to their infants. Especially for parents with CM, the former experience of maltreatment was not as crucial like maternal daily interactions and the relationship with their infant. Inadequate or anomalous maternal interacting behavior may aggravate infants´ stress regulatory strategies, which could be a risk for later stress-related mental and physical burden linked to increased stress vulnerability and impaired emotion regulation [62, 63]. Our results indicate that especially the daily experienced interacting quality by their mothers is relevant for the development of infant´s HPA stress regulation in the first year of life.

Therefore the findings of our analyses indicate both, protection and risk factors. On the one hand, maternal CM experience has been proven to affect cortisol stress response in adulthood. Especially mothers with CM experiences may be particularly vulnerable for dysregulated HPA axis. On the other hand, we were able to show that CM experience did not directly burden the next generation in terms of their stress regulation capacities. However, daily interactions between mother and infant contribute to the development of infants´ resilient stress responsiveness.

Limitations

Limitations of this study were saliva acquisition problems due to mothers´ and infants´ limited amounts. This resulted in the small sample size of complete data sets. Additionally, in contrast to other studies with high maltreatment load our study showed a rather low severity of CM experiences. This has to be taken into account when comparing our results with other studies with samples showing wider range of CM experiences. Demographic characteristics of our sample can be considered as one limitation since the level of maternal education was high compared to other samples with history of CM.

Conclusion

Mothers with a history of CM are likely to transmit their own experiences to the next generation. Our data show that not CM per se but the current quality of maternal caregiving plays a crucial role for the regulation of infant's cortisol stress reactivity. We may conclude that CM experiences are transmitted to the next generation via maternal behavior. This can be considered as an encouraging result, focusing the research findings of early life stress since improvement of maternal behavior is part of most preventions and interventions focusing on parent-infant relationships [64].

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