Maternal sensitivity and the empathic brain: Influences of early life maltreatment

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ABSTRACT

One of the most striking characteristics of early life maltreatment (ELM) is the risk of transmission across generations, which could be linked to differences in maternal behavior. Maternal sensitivity includes appropriate and positive affective exchanges between mother and child. Mothers with a history of ELM have been found to show a lower sensitivity representing a significant risk factor for maltreating their own children. 25 mothers with and 28 mothers without sexual and/or physical childhood maltreatment (as assessed with the Childhood Experience of Care and Abuse interview) and their children participated in a standardized mother—child interaction task. Videotaped interactions were rated by two independent trained raters based on the Emotional Availability Scales. In addition, empathic capabilities were assessed with the Interpersonal Reactivity Index. High resolution structural magnetic resonance brain images of the mothers were analyzed with unbiased voxel-based morphometry and correlated with maternal sensitivity. Results indicate that mothers with ELM were less sensitive in the standardized interaction with their own child. In non-maltreated control mothers, maternal sensitivity was positively related to anterior insular grey matter volume, a region which is crucially involved in emotional empathy, while there was a positive association between maternal sensitivity and grey matter volume in parts of the cognitive empathy network such as the superior temporal sulcus and temporal pole region in mothers with ELM. These results implicate that neurostructural alterations associated with poor maternal sensitivity might be a sequelae of ELM and that mothers with ELM may try to compensate deficits in emotional empathy by recruiting brain regions involved in cognitive empathy when interacting with their child. Thus, findings suggest possible coping strategies of mother with ELM to prevent an intergenerational transmission of abuse.

1. Introduction

One of the most striking characteristics of early life maltreatment (ELM) which is estimated to occur in 30% of children (Butchart and Mikton, 2014) is the risk of transmission across generations (Berlin et al., 2011; Bifulco et al., 2002; Widom, 1989). Studies in animals and humans suggest, that the intergenerational transmission may be linked to behavioral (McFarlane et al., 2014; Weisman et al., 2013), hormonal (Champagne et al., 2001; Weisman et al., 2012) and epigenetic mechanisms (Yehuda et al., 2014). However, the exact mechanisms have not been fully elucidated, up to now. Research findings show that women with ELM are less sensitive when interacting with their child, which puts them at risk for abusive behavior (Fuchs et al., 2015; Möhler et al., 2001, 2009). Despite the widely recognized importance of sensitive maternal behavior for the child's well-being, only little is known about the neurobiological correlates of maternal sensitivity which is defined as a mother's capability to respond to her child in ways that are contingent to the child's needs (Ainsworth et al., 1978).

Parenting challenges two abilities, i. to appropriately perceive, experience and sympathize with the child's emotions (related to emotional empathy), and ii. to cognitively mentalize the needs of

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the child (related to cognitive empathy). This differentiation is based on imaging studies of the parenting brain indicating a phylogenetically ancient network of emotion processing which subsumes paralimbic insula-cingulate structures that impart infant's cues salience and enables parents to intuitively resonate with the child's emotions. This emotion processing network is complemented by a cortical mentalizing network underlying parents' ability to infer mental states from the behavior of their child and thereby to predict infant's needs including the medial prefrontal cortex (mPFC), the superior temporal sulcus (STS), and temporal poles as well as the temporo-parietal junction (Feldman, 2015). Interestingly, mothers' parenting behavior is particularly driven by the emotion processing network while fathers exhibit activity in the emotion and in the mentalizing network (Abraham et al., 2014).

These circuits within the parenting brain correspond with the brain circuits that have been found to be involved in cognitive and emotional empathy (Leigh et al., 2013; Paulus et al., 2015; Reniers et al., 2014; Shamay-Tsoory, 2014). For cognitive empathy, this network consists of the superior temporal sulcus, the temporal poles, the temporo-parietal junction, the precuneus, and the medial prefrontal cortex (Koster-Hale and Saxe, 2013; Schurz et al., 2014). For emotional empathy, the neurological core network is formed by the anterior insula and the anterior cingulate cortex (Singer and Lamm, 2009).

Traumatic experiences have already been linked to deficits in empathy as there is evidence that PTSD patients, who experienced ELM, show impairments in empathic capabilities (Parlar et al., 2014), emotional awareness, emotion processing and emotion regulation when compared to healthy controls (Lanius et al., 2011). Interestingly, previous research revealed reduced grey matter volume in the emotional rather than the cognitive empathy network in individuals with ELM, in particular with regard to the anterior cingulate cortex (Carballedo et al., 2012; Frodl and O'Keane, 2013; McCrory et al., 2011) and the insula (Baker et al., 2013; Dannlowski et al., 2012; Edmiston et al., 2011). These alterations could at least partly explain the deficits in maternal sensitivity in women with experiences of ELM. Nevertheless, not all mothers who experienced ELM show reduced maternal sensitivity and recent results of our group indicate that some are highly sensitive when interacting with their child despite of their own history of ELM (Fuchs et al., 2015). This raises questions regarding neurobiological correlates of individual differences in maternal sensitivity among mothers with ELM.

In the current study, we therefore investigated associations between maternal sensitivity and grey matter volume in healthy mothers with and without ELM. Maternal sensitivity was assessed with Emotional Availability Scales in standardized mother—child interaction, compared between groups, and correlated with questionnaire measures for cognitive and emotional empathy as well as structural brain imaging data. In addition, grey matter volumes in core regions of the cognitive and emotional empathy networks were compared between the groups and correlated with maternal sensitivity in a hypothesis-driven region of interest approach.

Based on previous results, we hypothesized reduced maternal sensitivity in mothers with ELM compared to control mothers without ELM. In mothers with ELM we expected to find reduced grey matter volume of the emotional empathy network compared to non-traumatized control mothers and higher levels of maternal sensitivity to be associated with larger grey matter volume in the mentalizing brain circuit in the sense of a coping mechanism.

2. Methods and materials

2.1. Participants

30 mothers with experiences of physical or sexual childhood abuse (Early life maltreatment = ELM) and 29 mothers without any ELM (control) took part in the study. Due to movements during magnetic resonance imaging (MRI) four data sets had to be excluded from analysis. In addition, the data of two mothers who reported a current psychiatric disorder were excluded from the analysis. Therefore the final data set of the current study included 25 women with ELM (M_{age} = 38.8, SD = 6.7, range: 26—50 years) and 28 women without ELM (control; M_{age} = 39.1, SD = 4.5, range: 27—47 years). All women had at least one child aged five to twelve years with whom they were living together.

General exclusion criteria comprised: Any current axis I diagnosis including substance abuse or dependence in the last six months, dementia as well as any other neurological disorders, severe physical impairments, or any contraindications for MRI measurements (e.g. pregnancy or implants). An additional exclusion criterion for the control group was any lifetime axis I diagnosis. We also excluded women if they or their child had mental or physical disabilities that could interfere with the standardized mother—child interaction; we excluded children if they had an intelligence quotient of less than 70. Mothers with any evidence of child maltreatment had to be excluded for ethical reasons.

The study was part of a larger project in which effects of ELM on mother—child interaction are investigated (www.ubica.de). Mothers were recruited via advertisements in newspapers and internet, via flyers in pediatric and gynecologist practices, as well as letters sent to participants of a former population-based study on mother—child interaction (Möhler et al., 2009) and to randomly selected samples of local inhabitants. The study was performed in accordance to the ethical standards laid out by the Declaration of Helsinki and approved by the local ethics committee of the Medical Faculty of the University of Heidelberg. All participants gave written consent before their participation after the study procedures were fully explained to them and received a monetary compensation.

2.2. Measures

Qualified diagnosticians assessed ELM using the Childhood Experience of Care and Abuse Interview (CECA, Bifulco et al., 1994) as well as axis I and II comorbidities (SCID-I, Sheehan et al., 1999) and International Personality Disorder Examination (Bronisch and Mombour, 1994), respectively. The CECA can be regarded as the golden standard in the evaluation of childhood maltreatment (Thabrew et al., 2012).

Maternal sensitivity was assessed in a standardized mother—child interaction task consisting of a 15 min free play period and a 6 min problem-solving task conducted in a quiet room and recorded on video for later coding. In the free play period, children could use a variety of age-matched toys and mothers were instructed to play as usual. In the problem-solving task, children had to work on a very difficult puzzle (tangram) that required maternal help. Mothers were instructed to support their children, but to not solve the problem for them. Videos were rated by two independent, trained professional raters regarding maternal sensitivity with the Emotional Availability Scales (EA-Scales, Biringen et al., 1998), which measures maternal sensitivity from 1 "highly insensitive" to 7 "highly sensitive". According to the EA-Scales, a mother with high sensitivity withholds a positive, creative, authentic, and congruent communication throughout the whole observed period. Contrary to this, a highly insensitive mother shows no sign of positive