Psychoneuroendocrinology 85 (2017) 115–122

Contents lists available at ScienceDirect

Psychoneuroendocrinology

journal homepage: www.elsevier.com/locate/psyneuen

Emotional maltreatment is associated with atypical responding to stimulation of endogenous oxytocin release through mechanically-delivered massage in males☆

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ARTICLE INFO

Keywords:
Oxytocin
Massage
Affectionate touch
Massage seat cover
Emotional maltreatment
Infant signals

ABSTRACT

The neuropeptide oxytocin plays an important role in social behavior, parenting, and affectionate touch and there is some evidence that oxytocin release can be stimulated by massage or affectionate touch. We examined the effects of massage applied by a massage seat cover on salivary oxytocin levels in two exploratory studies using within-subject designs. In Study 1 massage effects on oxytocin levels were examined in a sample of N = 20 healthy female participants. Effects of a 15-min massage session were compared to a control condition during which participants sat on a comfortable chair without a massage seat cover. Salivary oxytocin levels were measured at baseline and up to three hours after the session. We found that massage attenuated oxytocin decreases over time, indicating that massage stimulates oxytocin release. In Study 2, we examined whether effects of massage in N = 46 healthy male participants depend on experiences of emotional maltreatment. In addition, we examined whether enhanced oxytocin levels after massage affect the use of excessive handgrip force in response to infant crying and laughter as measured with a handgrip dynamometer. Our findings show that massage results in elevated oxytocin levels compared to a control condition, but that the effects of massage are dependent on experiences of emotional maltreatment. Men with experiences of emotional maltreatment showed lower oxytocin levels, which did not increase after massage. Furthermore, we found that high oxytocin levels after massage were related to reduced handgrip force during exposure to infant crying and laughter, indicating that massage stimulates a sensitive response to infant signals by stimulating oxytocin release. Although massage did not affect oxytocin levels in individuals with experiences of maltreatment, it reduced the use of handgrip force in response to infant crying and laughter in these individuals. Our findings indicate that emotional maltreatment is associated with atypical responding to stimulation of endogenous oxytocin release.

1. Introduction

The neuropeptide oxytocin is well known for its role in social affiliation, parenting, and other forms of social behavior (Carter, 1998; Feldman, 2012; Feldman and Bakermans-Kranenburg, 2017). Research has shown that it is involved in initiating the "touch circuitry" between parents and infants (Gordon et al., 2010). For example, maternal oxytocin levels increased after infant contact in mothers who provided high levels of affectionate touch (Feldman et al., 2010). Maternal oxytocin has also been shown to be enhanced when newborns perform massage-like hand movements to the mothers' breast in preparation for the first breastfeeding (Matthiesen et al., 2001).

Other studies point to oxytocin enhancing effects of massage in adults. Holt-Lunstad et al. (2008) found that married couples who received a 4-week intervention to increase support through warm touch (touching their partner's neck, shoulders, and hands) showed increased

☆ MJB-K and MHvIJ were supported by research grants from the Netherlands Organization for Scientific Research; the Gravitation program of the Dutch Ministry of Education, Culture, and Science; and the European Research Council (MHvIJ: NWO SPINOZA prize; MJBK: VICI grant no. 453-09-003; AdG 669249).
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http://dx.doi.org/10.1016/j.psyneuen.2017.08.017
Received 15 May 2017; Received in revised form 14 August 2017; Accepted 14 August 2017

salivary oxytocin levels compared to a control group. In line with these findings, Morhenn et al. (2012) found that massage increases plasma oxytocin and reduces adreonocorticotropin hormone compared to a control group, possibly indicating that massage has stress-reducing and anxiolytic effects. These studies seem to indicate that massage stimulates endogenous oxytocin release. However, previous studies examining endocrine effects of massage report inconsistent findings and massage effects on cortisol are generally small (Moyer et al., 2011). It is, therefore, still uncertain whether massage stimulates oxytocin production and release. One explanation for previously reported inconsistent findings on endocrine effects of massage is that there may be individual differences in the response to massage or affectionate touch. Effects of massage may be different for men and women because of sex differences in the oxytocin system (Taylor, 2006); men have been shown to have higher plasma oxytocin levels than women (Weisman et al., 2013) and respond differently to exogenous intranasal oxytocin administration (Rilling et al., 2014).

Another individual difference factor that may influence the endogenous oxytocin release is childhood caregiving experiences. Childhood caregiving experiences play an important role in shaping the oxytocin system (Feldman, 2015) and influence oxytocin release in response to stress (Pierrehumbert et al., 2010). In addition, childhood caregiving experiences have been shown to affect sensitivity to intranasal oxytocin in multiple studies. For example, we found that intranasal oxytocin administration decreased the use of excessive handgrip force in response to infant crying, but only in individuals who reported positive childhood experiences and not in individuals who reported harsh caregiving experiences (Bakermans-Kranenburg et al., 2012). Negative childhood experiences also moderate oxytocin effects at the neural level: oxytocin effects on resting-state functional connectivity were only found in individuals who reported a supportive family background (Riem et al., 2013). In a similar vein, Meinlschmidt and Heim (2007) showed that individuals with experiences of early parental separation exhibited attenuated cortisol decreases after intranasal oxytocin administration (versus placebo) compared with control subjects without experiences of early separation. Furthermore, individuals with negative childhood experiences show lower oxytocin levels in cerebrospinal fluid (Heim et al., 2009) and plasma (Opacka-Juffry and Mohiyeddini, 2012), indicating that adverse childhood experiences may lead to a dysregulation of the oxytocin system. Individuals with negative childhood experiences may therefore also show abnormal responding to stimulation of endogenous oxytocin release through massage.

In the current studies, we examine whether massage stimulates endogenous oxytocin release in men and women and whether enhanced oxytocin levels after massage affect responses to infant crying and laughter. In a previous study, we found that intranasal oxytocin modulates neural responses to infant crying: oxytocin increased reactivity in empathy-related brain regions and decreased amygdala reactivity to crying (Riem et al., 2011). Similarly, reduced amygdala activity after intranasal oxytocin administration was also found during exposure to infant laughter (Riem et al., 2012). Reduced amygdala activity may be the mechanism underlying the anxiolytic and stress-reducing effects of oxytocin, which promote a sensitive caregiving response to an infant signal. This is particularly important during exposure to infant crying, as crying can elicit negative feelings of aversion and anger (Soltis, 2004) and excessive infant crying can even elicit harsh caregiving responses in some parents (Barr et al., 2006; Reijneveld et al., 2004). It is however unknown whether stimulation of endogenous oxytocin release influences responding to infant crying and laughter.

The current study is the first to examine whether massage stimulates endogenous oxytocin release through mechanically-delivered massage in a standardized setting. First, we examine whether massage applied by a massage seat cover influences salivary oxytocin levels in a pilot study with N = 20 healthy female participants (Study 1). We expected that massage stimulates endogenous oxytocin release and results in increased oxytocin levels. In Study 2, we examine whether effects of massage in N = 46 healthy male participants depend on experiences of emotional maltreatment. In addition, we examine whether enhanced oxytocin levels after massage affect the use of excessive handgrip force in response to infant crying and laughter as measured with a handgrip dynamometer. We expected that enhanced oxytocin levels after massage are related to decreased handgrip force in response to infant signals, but that oxytocin-releasing effects of massage are influenced by emotional maltreatment.

2. Study 1

2.1. Methods

2.1.1. Participants

Participants were 20 female students and employees from Leiden University, The Netherlands, who volunteered to participate in a pilot study. The mean age of the participants was 27.50 years (*SD* = 6.53, range 22–46). The majority (60%) used oral contraceptives and did not have children of their own (90%). Participants were invited for the study in the luteal phase of their menstrual cycle in order to control for hormonal influences due to the menstrual cycle. For one participant it was not possible to determine menstrual phase because of use of intrauterine device. Exclusion criteria were arm, neck, and back injuries, pregnancy, breastfeeding, and use of medications other than oral contraceptives. All participants were non-smokers.

2.1.2. Procedure

A within-subject design was used to examine the effects of mechanically-delivered massage. Participants were invited for lab sessions on two successive days. The order of massage and control conditions was counterbalanced. They were instructed to abstain from alcohol and excessive physical activity during the 24 h before the start of study, and from caffeine on the data collection days. The sessions started at 9:00 a.m. with saliva collection to assess baseline oxytocin levels. Afterwards, participants completed questionnaires on food and drink intake, physical exercise, mood, and stress. Participants were then instructed to sit either on a chair with the electric massage seat cover (massage condition) or on the same chair without the seat cover (control condition) for 15 min while looking at photographs of landscapes. Neck, shoulders, and back were massaged by the seat cover (type: Medisana 88930). A vibration massage was applied in the seat of the cover. The seat cover did not provide heat and has not been used in previous research. Mechanically delivered massage was examined because of practical reasons and because the use of the massage seat cover enabled the study of the effects of massage in a standardized setting. After the massage or control session, saliva was collected at 9:15, 10:00, 11:00 a.m., and 12:00 p.m. and the mood questionnaire was completed again at 9.15 a.m. and 12.00 p.m. Participants left the laboratory after the second saliva collection but were asked to stay around in order to provide saliva samples at 10:00, 11:00, a.m. and 12:00 p.m. Participants remained seated during the period of saliva collection and were requested not to engage in abnormal physical activity.

2.1.3. Questionnaires

Current mood was measured with the Positive Affect Negative Affect questionnaire (PANAS; Watson et al., 1988). These items include 10 items for positive affect (e.g., alert, enthusiastic, determined) and 10 items for negative affect (e.g., upset, irritable, nervous). Each item was rated on a 5-point scale ranging from 1 = not at all to 5 = a lot. We used the Positive Affect scale ($\alpha > 0.85$), indicating positive mood before and after sitting on the (massage) chair. In addition, participants rated on two 10-point rating scales how much stress they experienced at home and at work on the day of the lab session. We used work-related stress as covariate, because oxytocin levels were measured during working hours.