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Reading the mind in the infant eyes: Paradoxical effects of oxytocin on neural activity and emotion recognition in watching pictures of infant faces

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ABSTRACT

The neuropeptide oxytocin facilitates parental caregiving and is involved in the processing of infant vocal cues. In this randomized-controlled trial with functional magnetic resonance imaging we examined the influence of intranasally administered oxytocin on neural activity during emotion recognition in infant faces. Blood oxygenation level dependent (BOLD) responses during emotion recognition were measured in 50 women who were administered 16 IU of oxytocin or a placebo. Participants performed an adapted version of the Infant Facial Expressions of Emotions from Looking at Pictures (IFEEL pictures), a task that has been developed to assess the perception and interpretation of infants' facial expressions. Experimentally induced oxytocin levels increased activation in the inferior frontal gyrus (IFG), the middle temporal gyrus (MTG) and the superior temporal gyrus (STG). However, oxytocin decreased performance on the IFEEL picture task. Our findings suggest that oxytocin enhances processing of facial cues of the emotional state of infants on a neural level, but at the same time it may decrease the correct interpretation of infants' facial expressions on a behavior level.

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1. Introduction

Before the onset of speech infants have vocalizations and facial expressions at their disposal to communicate with the caregiver. The correct interpretation of these infant signals is essential for the caregiver in order to respond appropriately. Previous studies have shown that oxytocin, a neuropeptide that is involved in social affiliation (Carter, 1998), is also involved in the processing of infant vocal cues (Riem et al., 2011, 2012b). Moreover, oxytocin has been shown to facilitate mental state reasoning, defined as the ability to infer others' mental states, thought, feelings and intentions (Domes et al., 2007b; Riem et al., submitted for publication). However, the aforementioned studies focus on infant *vocal* expressions and *adult* facial expressions. It is not yet clear whether oxytocin plays a role in the interpretation of *infant facial* expressions.

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The current study is the first randomized controlled trial examining the influence of intranasally administered oxytocin on the neural mechanisms underlying emotion recognition in infant faces. We examined the neural response to infants' facial emotions with functional magnetic resonance imaging (fMRI).

Infant facial expressions provide important cues about an infant's emotional state and are used by parents in concert with infant vocalizations and contextual information to interpret the needs of their infant. The "Infant Facial Expressions of Emotions from Looking at Pictures" (IFEEL Pictures; Emde et al., 1993) have been developed to assess the perception and interpretation of infants' facial expressions (e.g., Siddiqui et al., 2000). It consists of 30 pictures of infant faces and requires participants to describe in one word the emotional expression of the infant. Several studies have shown that the test can be used to study individual differences in the interpretation of infant emotions. For example, research using the IFEEL pictures has shown that abusive fathers perceive infant emotions in a more negative light than non-abusive fathers (Francis and Wolfe, 2008) and that neglecting mothers are more inaccurate in labeling infant emotions (Hildyard and Wolfe, 2007).

Oxytocin is a neuropeptide that plays an important role in sensitive parenting. Previous research has shown that higher levels of maternal oxytocin across pregnancy predict higher quality of postpartum maternal behavior (Feldman et al., 2007) and that oxytocin has stress-reducing effects in breastfeeding mothers (Heinrichs et al., 2001, 2002). In addition, intranasal administration of oxytocin stimulates a range of social behaviors (for a meta-analysis, see Van IJzendoorn and Bakermans-Kranenburg, 2012), such as trust (Kosfeld et al., 2005) and empathy (Bartz et al., 2010). Domes et al. (2007b) showed that intranasal oxytocin also facilitates mindreading, assessed with the Reading the Mind in the Eyes Task (RMET; Baron-Cohen et al., 1997), a test that requires individuals to infer mental states by looking at photographs of the eye region of adult faces. This is in line with other studies showing that oxytocin stimulates emotion recognition in adult faces (Bartz et al., 2010; Marsh et al., 2010), possibly by enhancing activation in empathy-related brain regions (Riem et al., submitted for publication).

FMRI studies measuring brain activity by detecting associated changes in blood flow have shown that intranasal oxytocin facilitates sensitive responding to infant vocalizations by decreasing activation in the amygdala (Riem et al., 2012a), a brain region implicated in the experience of fear and disgust (LeDoux, 2000), and by increasing activation in the insula and inferior frontal gyrus (IFG) (Riem et al., 2011), brain regions involved in empathy, emotion recognition, and the processing of facial emotional expressions (Bernhardt and Singer, 2012; Carr et al., 2003; Keuken et al., 2011; Liakakis et al., 2011). Other studies also found activation in the anterior insula and IFG during the presentation of pictures of infant faces (for a review see Rilling, 2013). Insula and IFG activation may allow parents to internally simulate what a child is feeling. Indeed, in a previous study we found that intranasal oxytocin enhances activation in the insula during the Reading the Mind in the Eyes Task, thereby facilitating the interpretation of adults' emotions (Riem et al., submitted for publication).

The orbitofrontal cortex (OFC) has also been shown to be activated during the observation of infant faces (Rilling, 2013). The OFC shows a very specific, rapid response to infant faces, and it has been suggested that this may be the potential brain basis for the "innate releasing mechanisms" for nurturing of infants as described by Lorenz (Kringelbach et al., 2008). Intranasal oxytocin has been shown to reduce activation and connectivity of the globus pallidus with reward- and attachment-related brain areas in fathers who were exposed to pictures of their own child (Wittfoth-Schardt et al., 2012). It is as yet unknown how oxytocin influences neural responses to infant faces in women. Moreover, it is unclear whether intranasal oxytocin facilitates the ability to interpret infant facial expressions.

In this study, we examined the influence of intranasally administered oxytocin on neural activation during the IFEEL pictures task with fMRI in female adults. To our knowledge, this study is the first randomized controlled trial examining the influence of intranasally administered oxytocin on the neural mechanisms underlying emotion recognition in infant faces. We were especially interested in effects of oxytocin on the anterior insula, the inferior frontal gyrus pars opercularis (IFG), and the orbitofrontal cortex (OFC), since previous studies have shown that these regions play an important role in the perception of infant stimuli and can be affected by intranasal oxytocin (Riem et al., 2011, 2012b; Strathearn et al., 2009; Wittfoth-Schardt et al., 2012). In addition, we examined effects of intranasal oxytocin on the anterior superior temporal gyrus (STG) and the middle temporal gyrus temporo occipital part (MTG), because these regions have been shown to be activated during emotion recognition in adult faces (Adams et al., 2009; Pincus et al., 2010; Riem et al., submitted for publication). Furthermore, since previous studies have found moderation of oxytocin effects by early caregiving experiences (Bakermans-Kranenburg and Van IJzendoorn, 2013), we examined the potential moderating influence of experienced parenting on the effects of oxytocin. Finally, we expected that intranasal oxytocin would increase performance on the IFEEL picture task.

2. Results

In order to identify brain regions involved in reasoning about the emotional state of infants, we contrasted the emotional state condition with the gender condition. The whole brain analysis revealed three clusters in the placebo group with peak voxels in the left middle temporal gyrus and in the bilateral inferior frontal gyrus (see Table 1). The pattern of activation included the bilateral paracingulate gyrus, the temporal poles, the occipital poles, the bilateral occipital cortex, the left putamen, the left insula, the right orbitofrontal cortex, the bilateral fusiform gyri and the left thalamus (see Fig. 1).

To examine whether oxytocin affected brain activity during emotional state reasoning we contrasted the oxytocin group with the placebo group (Oxytocin $^{\text{Emotion}>\text{Gender}}$ > Placebo $^{\text{Emotion}>\text{Gender}}$ and Oxytocin $^{\text{Emotion}>\text{Gender}}$ < Placebo $^{\text{Emotion}>\text{Gender}}$). In the whole brain analysis no significant differences in brain activity were found between the