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SHORT COMMUNICATION

Oxytocin differentially modulates eye gaze to naturalistic social signals of happiness and anger

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Summary A number of previous studies has shown that oxytocin (OT) promotes facial emotion recognition and enhances eye gaze to facial stimuli in humans. Other studies report valence-specific effects of OT, supporting the proposed prosocial role of OT in social interactions. In the present study, we tested the hypothesis whether OT might selectively enhance eye gaze to positive, approach-related, but not to negative, threat-related social cues. In a placebo-controlled, double-blind, between-subject design, we assessed the effects of intranasal OT administration (24 IU) in 62 healthy male volunteers on eye gaze toward the eyes of neutral, positive (happy) and negative (angry) facial expressions compared with placebo. In order to capture the dynamics of facial expressions, we used video sequences showing neutral faces gradually displaying a specific emotion. In line with previous studies, OT increased eye gaze toward neutral facial expressions. Moreover, under OT treatment, eye gaze remained increased when the face showed a happy facial expression, but in contrast decreased when the face displayed an angry expression. These results support the notion that OT differentially modulates visual attention toward social signals of positive approach and threat and thereby contributes to the modulation of non-verbal interpersonal communication.

1. Introduction

The ability to infer the emotions of others from their facial expressions is critical for functional reciprocal social interactions in humans (Adolphs, 2002). Face perception and facial emotion recognition depends on visual attention to relevant facial features. Eyetracking studies have revealed that healthy adults devote the majority of their overt attention to the eye region during face processing (e.g. Sullivan et al., 2007). Thus, time spent looking at the eyes might indicate social approach and social information processing, depending on how unambiguous the emotional expression appears. Eye gaze to ambiguous faces is initiated to extract social information from the most informative part of the face. As the emotional facial expression becomes more and more obvious, eye gaze might have a different function, regulating the social interaction in terms of approach and avoidance.

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Numerous animal studies have shown that the neuropeptide oxytocin (OT) is involved in the regulation of complex social behavior. OT receptors are distributed in various brain regions including the amygdala, hippocampus, and paraventricular nucleus of the hypothalamus, regions associated with the central regulation of social behaviors (Carter, 1998; Donaldson and Young, 2008). Recent studies report similar effects of OT on human social behavior including interpersonal trust, positive communication, social support, and attachment (Heinrichs et al., 2009). OT improves the ability to infer the mental states of others from subtle social cues (Domes et al., 2007; Schulze et al., 2011) and dynamic facial expressions (Lischke et al., 2012) and increases gaze toward the eyes of neutral faces (Guastella et al., 2008) and briefly presented emotional faces (Gamer et al., 2010). OT modulates brain activity in areas associated with social cognition and thus appears to be an important neuromodulator for interpersonal perception and communication in humans (for reviews, see Ebstein et al., 2010; Meyer-Lindenberg et al., 2011).

In addition, there is some evidence for selectively prosocial effects of OT, since OT specifically enhances the processing of positive social information such as the recognition of happy faces (Di Simplicio et al., 2009; Marsh et al., 2010; Schulze et al., 2011). Since previous studies have demonstrated that visual attention is sensitive to OT treatment, these prosocial effects could be due to specific modulations of visual attention toward positive social cues. However, in a recent study we were not able to demonstrate OT effects on visual scanning to morphed emotional faces (Lischke et al., 2012), a finding probably related to the low ecological validity of the stimuli.

In the present study, we aimed to investigate how OT might modulate visual attention during the viewing of naturalistic dynamic human faces expressing different emotions. We hypothesized that OT given intranasally would enhance visual attention toward the eyes of neutral facial stimuli. In response to obvious emotional stimuli, we expected OT to promote eye gaze to happy faces and decrease eye gaze to angry faces, which would be in accordance to the social regulation hypothesis introduced above.

2. Materials and methods

2.1. Participants

Sixty-two healthy male volunteers (age, mean ± SD: 24.0 ± 2.5 years) participated in the present study and were divided in two groups which did not differ in age (mean ± s.d.: OT: 23.9 ± 0.4; PL: 24.4 ± 0.5; $t_{60} = 0.47$; $p = .50$). Exclusion criteria were medical or psychiatric illness, use of medication, substance abuse, and smoking. Psychology students were also excluded. All participants had normal or corrected to normal vision. The study protocol was approved by the institutional review board and all subjects gave written informed consent and were paid for participation.

2.2. Experimental protocol

In a double-blind, placebo-controlled study design, subjects were randomly assigned either to receive 24 IU of OT ($n = 30$, 6 puffs of Syntocinon-Spray; Novartis, Basel, Switzerland) or placebo ($n = 32$) intranasally 40 min before beginning the Dynamic Affect Recognition Evaluation, with the placebo including all ingredients except for the neuropeptide.

2.3. Dynamic Affect Recognition Evaluation (DARE)

The original version of the Dynamic Affect Recognition Evaluation (DARE), which was developed to serve as a naturalistic yet standardized tool for assessing facial emotion recognition (Porges et al., 2007) uses the Cohn—Kanade database of facial expressions (Cohn et al., 1999; Kanade et al., 2000). The original DARE is described in detail elsewhere (Bal et al., 2010). The version employed in the present study consisted of 12 video sequences presenting facial expressions of different male and female actors. Each trial began with a neutral facial expression that slowly changed into one of two basic emotions (happiness or anger) over time. Trial duration ranged from 16 to 34 s. Participants were asked to detect the emotion of the particular face presented as soon as possible. The percentage of correct answers and the response latency for each emotion were calculated.

2.4. Eye movement recordings and analysis

To assess visual attention, we recorded eye movements with a remote infra-red eyetracker (iView X^{TM} RED, SensoMotoric Instruments, Teltow, Germany). Eye movements were recorded at 50 Hz sampling rate with a spatial resolution of $<0.1^{\circ}$ for tracking resolution and $<0.5^{\circ}$ for gaze position accuracy. The DARE stimuli (640 × 480 pixels) were presented on a 17 in. screen (resolution: 1280 × 1024 pixels) with a viewing distance of 60 cm. Fixations were coded for a minimum gaze duration of 80 ms within a sphere of approx. 1° visual angle (approx. 28 pixels). The mean number of fixations and the mean fixation time were calculated for the whole face and the eye region of the facial stimuli using stimulus-specific templates. In order to test for specific effects induced by the emotional expression, we divided the whole trial into an early exploratory phase showing the neutral expression (the first 2 s of a trial), and the late emotion recognition phase before a decision about the emotion displayed was made (the last 2 s before button press of a trial). For each individual trial presented, the relative fixation duration for the eye region compared to the whole face for each processing phase was calculated.

2.5. Statistical analyses

In order to explicitly test for the proposed interaction effects, eyetracking data were analyzed using a three-way ANOVA [substance (OT, PL) × emotion (happy, angry) × phase (early, late)] and subsequent two-way ANOVAs for each phase (early and late) for both the percentage of time and the number of fixations spent on the eye region relative to the whole face.

Performance in recognizing angry and happy facial expressions was tested using MANOVA for the number of correct responses and the response latency, i.e. the percentage of time elapsed before the button was pressed relative to the