Oxytocin Increases Gaze to the Eye Region of Human Faces

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Background: In nonhuman mammals, oxytocin has a critical role in peer recognition and social approach behavior. In humans, oxytocin has been found to enhance trust and the ability to interpret the emotions of others. It has been suggested that oxytocin may enhance facial processing by increasing focus on the eye region of human faces.

Methods: In a double-blind, randomized, placebo-controlled, between-subject design, we tracked the eye movements of 52 healthy male volunteers who were presented with 24 neutral human faces after intranasal administration of 24 IU oxytocin or placebo.

Results: Participants given oxytocin showed an increased number of fixations and total gaze time toward the eye region compared with placebo participants.

Conclusions: Oxytocin increases gaze specifically toward the eye region of human faces. This may be one mechanism by which oxytocin enhances emotion recognition, interpersonal communication, and social approach behavior in humans. Findings suggest a possible role for oxytocin in the treatment of disorders characterized by eye-gaze avoidance and facial processing deficits.

Key Words: Emotion, face recognition, oxytocin, peptide, social cognition

The capacity to develop social attachments is fundamental to the healthy development of individuals and communities, as is evident across parent-child attachments, intimate couples, peer friendships, and professional partnerships (1). Alternatively, abnormalities in the processing of social information and the regulation of close attachments are associated with virtually every form of human psychopathology (2). Animal research has identified a role for the neuropeptide oxytocin (OT) in enhancing social recognition and approach behavior, while also decreasing social avoidance and aggression (3). These findings have led some (2) to suggest that OT may have a role in the enhancement and treatment of relationships (i.e., parent-child bonds, couple distress), and the amelioration of disorders characterized by social deficits (i.e., autism, schizophrenia).

Few studies have examined the effect of OT administration on social-cognitive processes in humans. Initial research has shown that OT nasal administration (24–27 IU) enhances trust (4), identification of emotions from the eyes of others (5), the benefits of social support during social stress tasks (6), and reduced responsiveness to social threat stimuli (7). In Domes *et al.* (5), for example, 30 male subjects received OT (24 IU) or a placebo before tests of one's ability to read subtle facial cues of internal emotion states. The OT participants were better able to infer the emotion state of the actors, and effects were stronger for faces rated difficult to read. Domes *et al.* (5) argued one possible mechanism underlying this effect was OT enhancement of eye gaze during face perception.

Face perception is a basic process in interpersonal communication (8). Critical information is taken from the eyes and, to a lesser extent, the mouth, where individuals assess the degree of interest, threat, and emotion of another (5,8). In fact, amount of eye gaze has been found to be predictive of one's ability to interpret the intentions of others and the meaning of social situations (9–12). We tested the hypothesis that OT enhances eye gaze to facial stimuli. It was hypothesized that participants assigned to receive OT would gaze longer and more frequently toward the eye region of faces compared with participants assigned to receive placebo. It was also predicted that OT would enhance gaze to the nose-mouth region, given its secondary role in face perception. Finally, it was predicted that OT would not enhance gaze to peripheral regions less involved in face perception, such as the cheeks and forehead.

Methods and Materials

Fifty-two healthy young adult men aged 18–28 years (M = 19.80, SD = 2.63) were recruited from the student population of the University of New South Wales and randomly assigned in a double-blind manner to receive either 24 intranasal units (IU) of OT (n = 25; Novartis; three puffs per nostril, each with four IU OT) (4,6); or an identical placebo (n = 27) developed by a compounding chemist containing all ingredients except the active OT. Exclusion criteria included a diagnosis of major depression, bipolar, panic, and psychotic disorders; substance dependence; or epilepsy. Women were excluded to avoid sex differences in OT response (5–7). Participants were instructed to abstain from alcohol and caffeine on the day of testing and from food and drink, except water, for 2 hours before drug administration. After a description of the study, written consent was obtained. Ethical approval was provided by the University of New South Wales Ethics Committee (06074).

The Positive and Negative Affect Scale (PANAS; 13) was used to track mood changes in positive and negative affect states. Twenty-four human male and female black and white neutral faces were selected from the Psychological Image Collection at Stirling (14) and presented for 2 sec each on a 1750-Tobii binocular eye tracker with 17-inch display, maximum resolution of 1280 × 1024 pixels, .5 degrees accuracy, and a sampling rate of 50 Hz (15). Three hotspot regions were created on each face stimulus blind to subject data consisting of the eye region, the nose and mouth region, and the forehead and both cheeks. Region size varied according to the actor's face. Measures included eye-gaze duration (total milliseconds spent fixating on

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a hotspot) and fixation count (number of gaze fixations toward a hotspot; 15). To begin, the PANAS and a brief diagnostic screen was conducted. Participants then received the nasal spray. Forty-five minutes later (5–7), participants completed the PANAS and viewed faces on the eye-tracker. Participants were told that we were interested in how OT influenced reactions to social information and asked to view faces as they appeared on the monitor. Participants returned the following day to complete the PANAS and side-effect reports.

Results

Data from four participants were removed because of equipment malfunction, leaving 24 participants assigned to each drug condition. A one-way analysis of variance (ANOVA) showed there was no difference between groups in age [$F(1,47) = 1.50$, $p = .23$]. To evaluate the effect of OT on mood, *t* tests were run on scores at each time point; there were no differences between groups at the three time points on positive or negative affect (largest $t = 1.80$, $p = .18$). To check for drug awareness and safety, chi-square analysis was run on whether side effects were reported or what drug participants believed they had received. No differences were found between drug conditions ($p > .7$). Side effects reported by OT participants included relaxation ($n = 2$), irritability ($n = 2$), stomach cramps ($n = 1$), and sensitivity to smells ($n = 1$).

A one–way multiple ANOVA test of drug (OT or placebo) was run on gaze duration and fixation counts toward the eye, nose-mouth, and cheek-forehead regions. Results and effect sizes are presented in Figure 1. There was a main effect of face region [$F(4,43) = 63.19$, $p < .05$]. Participants gazed longer and fixated more frequently toward the eyes, followed by the nose-mouth, and then finally the forehead and cheek region. A main effect of drug, [$F(1,46) = 15.50$, $p < .001$], was qualified by an interaction between face-region and drug [$F(2,45) = 6.25$, $p < .001$]. Follow-up ANOVA tests for drug within each face region showed that OT participants gazed longer [$F(1,46) = 11.24$, $p = .002$] and fixated more frequently [$F(1,46) = 14.77$, $p < .001$] toward the eyes compared with participants who received placebo. There was no difference between drug groups in gaze duration [$F(1,46) = 1.44$, $p = .23$] or fixations [$F(1,46) = 2.12$, $p = .14$] toward the nose-mouth region. A trend indicated that OT participants may have gazed less [$F(1,46) = 3.55$, $p = .06$] and fixated fewer times [$F(1,46) = 3.06$, $p = .09$] at the forehead and cheek regions compared with placebo-administered patients.

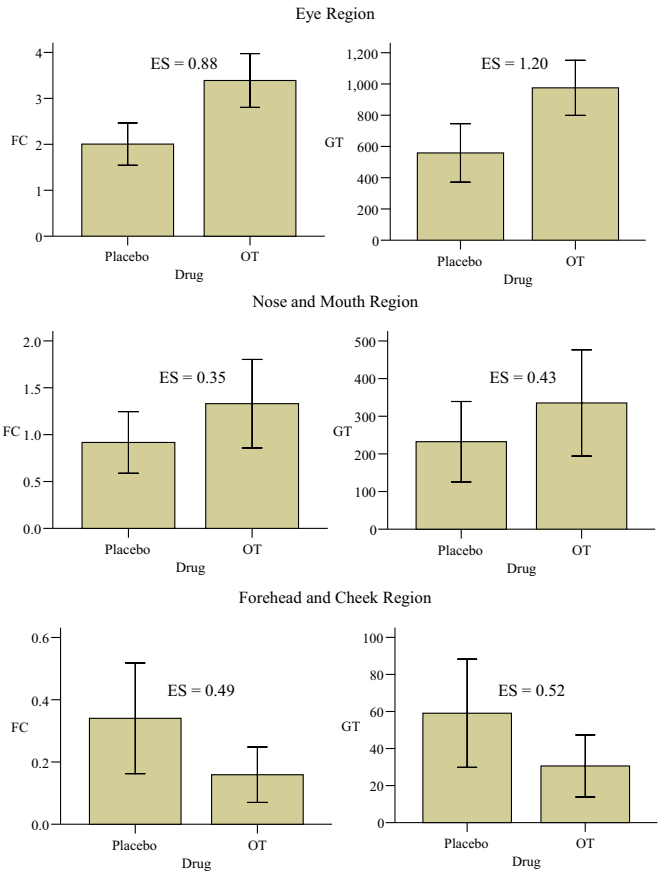

Figure 1. Mean gaze duration and fixations to each face region. FC = Fixation Count; GT = Gaze Time; OT = Oxytocin. Gaze time is reported in milliseconds and error bars represent standard error. ES = Cohen's D effect size.

Discussion

This report shows that men administered a single dose of intranasal OT gazed longer and fixated more frequently toward the regions of neutral human faces critical for interpersonal communication. In particular, OT was shown to produce large and powerful effects of gaze enhancement to the eye region of human faces (16). The eyes represent the communication focal points of the face and are the primary source for detection of interpersonal interest, threat, and emotion in others (8,9). The OT group also showed longer and more frequent gaze to the nose and mouth and decreased gaze to peripheral regions of the face; however, these effects were not statistically significant in this sample size. Findings suggest that eye-gaze enhancement may be one of the mechanisms underlying the positive effects of OT on face perception and interpersonal communication in humans (2,5).

In regard to biological mechanisms, a number of brain regions are involved in face perception, including the lateral fusiform gyrus, the lateral inferior occipital gyri, the posterior superior temporal sulcus, and the amygdala (17). The only study to evaluate OT administration on brain activation during face perception (7) assessed amygdala activation upon presentation of social threat (fear faces) and nonsocial threat stimuli. Oxytocin reduced amygdala activation, particularly on presentation of social threat stimulus, leading the researchers to argue that OT reduces social threat perception and helps individuals to feel more at ease when viewing faces (7,8). Our findings could be explained by a reduction in amygdala activation from OT. Neutral faces activate the amygdala (17), albeit to a lesser extent than threatening faces. This is particularly true when neutral faces are unfamiliar (18) and involve direct eye gaze (19). Oxytocin may have reduced amygdala activation upon presentation of neutral faces, thereby assisting participants to feel more at ease and less guarded and resulting in more frequent direct eye contact. Further research is required, however, to evaluate the effect of intranasal OT on other brain regions important for face perception.

Studies indicate that OT enhances the ability to detect emotion in others (5). Our study suggests that eye-gaze enhancement is one mechanism that may be associated with improved face perception and interpersonal communication from OT administration. Disorders characterized by deficits in communication and emotion perception, such as autism (9,10,20,21), schizophrenia (22), and fragile X syndrome (12), are associated with deficits in

face perception and eye gaze. Oxytocin may have therapeutic value in the treatment of these disorders. Interestingly, the direction to focus attention toward the eyes in disordered populations ameliorates some emotion perception deficits (23). Research is now needed to evaluate the durability of the effect of OT on eye-gaze enhancement during facial processing in psychiatric disorders. Such results may lead to the use of OT in interventions aimed at alleviating social communication deficits.

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