SHORT COMMUNICATION

Oxytocin enhances the experience of attachment security

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Summary Repeated interactions between infant and caregiver result in either secure or insecure relationship attachment patterns, and insecure attachment may affect individual emotion-regulation and health. Given that oxytocin enhances social approach behavior in animals and humans, we hypothesized that oxytocin might also promote the subjective experience of attachment security in humans. Within a 3-week interval, 26 healthy male students classified with an insecure attachment pattern were invited twice to an experimental session. At the beginning of each experiment, a single dose of oxytocin or placebo was administered intranasally, using a double-blind, placebo-controlled within-subject design. In both conditions, subjects completed an attachment task based on the Adult Attachment Projective Picture System (AAP). Thirty-two AAP picture system presentations depicted attachment-related events (e.g. illness, solitude, separation, and loss), and were each accompanied by four prototypical phrases representing one secure and three insecure attachment categories. In the oxytocin condition, a significant proportion of these insecure subjects ($N = 18$; 69%) increased in their rankings of the AAP prototypical "secure attachment" phrases and decreased in overall ranking of the "insecure attachment" phrases. In particular, there was a significant decrease in the number of subjects ranking the pictures with "insecure-preoccupied" phrases from the placebo to the oxytocin condition. We find that a single dose of intranasally administered oxytocin is sufficient to induce a significant increase in the experience of attachment security in insecurely attached adults.
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1. Introduction

The fundamental ability to form attachment is essential for human social relationships. During repeated interactions with a supportive and sensitive caregiver, a child develops a stable cognitive-emotional schema of the caregiver's availability for reducing stress and providing comfort and protection in potentially threatening situations (Bowlby, 1969). Based on these assumptions, infants and adults are classified either as secure or insecure with regard to attachment using standardized measures designed to activate the individual's attachment system (Westen et al., 2006). Notably, attachment insecurity contributes to a wide spectrum of mental disorders (Maunder and Hunter, 2001).

In non-human mammals, receptors for the neuropeptide oxytocin are distributed in various brain regions that are associated with the ability to form normal social attachments and affiliation, including parental care, pair bonding, and social memory (Carter, 1998; Uvnas-Moberg, 1998; Young and Wang, 2004). Intranasal oxytocin administration in humans has been found to reduce endocrine and psychological responses to social stress (Heinrichs et al., 2003), to increase trust (Kosfeld et al., 2005), the ability to infer the mental state of another person ('mind-reading') (Domes et al., 2007a), social memory (Heinrichs et al., 2004; Guastella et al., 2008b), and gaze toward the eye region of human faces (Guastella et al., 2008a). Given that oxytocin seems to promote social approach behavior (Heinrichs and Domes, 2008), we hypothesized that oxytocin might also promote the experience of secure attachment in humans. In particular, intranasal oxytocin administration was expected to enhance the subjective perception of attachment security in insecurely attached individuals.

2. Methods and materials

In the present study, we recruited 26 healthy male students, aged 21—33 years, at the Technical University Munich (March to August, 2006) who were classified with an *insecure* attachment pattern using a standardized and validated adult attachment measure based on analyzing individual stories to attachment related pictures (Adult Attachment Projective Picture System—AAP; George and West, 2001). The AAP picture drawings depict attachment-related events (e.g. illness, solitude, separation, loss, and abuse). The psychometric properties of the AAP were established in an independent validity study with 144 non-patient subjects (George and West, 2001). This study found strong psychometric validity, including high inter-rater reliability, test—retest reliability (after three, six and twelve months), discriminant validity, and convergent construct validity with the Adult Attachment Interview. The feasibility of using the AAP in a neurobiological context has successfully been demonstrated in a recent neuroimaging study (Buchheim et al., 2008).

To enable statistical comparisons in the experimental procedure (oxytocin vs. placebo) in the present study, we adapted the attachment task in the following way: the eight pictures (drawings) from the AAP were presented four times in the same order. Each of the 32 picture presentations was accompanied by four prototypical phrases, each phrase representing one of the four established attachment categories: one *secure* and three insecure categories (*insecure-dismissing, insecure-preoccupied,* and *unresolved with respect to loss or trauma*[1]). Subjects were presented in these 32 pictures in the attachment task in the two experimental conditions (oxytocin and placebo, see below). Following the AAP classification scheme, phrases were designed as follows: *Secure* individuals demonstrate the ability to draw upon attachment resources (thinking, seeking for help) to remedy distress. *Dismissing* individuals avoid or minimize direct expressions of attachment related distress and often take care of situations on their own. *Preoccupied* individuals are uncertain if an attachment figure might be available to remedy distress. Individuals, classified as *unresolved with respect to loss or trauma* are not able to integrate attachment related fears related to death, attack, abuse or disaster.

To ensure construct validity of the prototypic classification group phrases, two independent certified AAP judges were given the 128 phrases in alphabetical order and asked to sort them into one of the four attachment categories. Agreement was achieved for 123 phrases (97%). The overall inter-rater reliability was $\kappa = .95$; high agreement was achieved in all four attachment categories—secure: $\kappa = .96$; dismissing: $\kappa = .94$; preoccupied: $\kappa = .96$; unresolved: $\kappa = .94$.

The study subjects were instructed to rank these phrases from the most to the least appropriate for each presentation (Fig. 1). The phrase chosen as most the appropriate (i.e., their first choice) was scored with a value of 3, the second choice with 2, the third choice with 1, and the last choice with 0. Thus, the summed scores for each attachment scale ("secure", "dismissing", "preoccupied", and "unresolved trauma") ranged from 0 to 96 with a midpoint at 48. Because of the item construction based on the ranking of four statements the sum of these four attachment scales is 192 (the sum $0 + 1 + 2 + 3 = 6$ points within each of 32 presentations) constantly by each measurement. The phrases were presented in a randomized balanced sequence in order to minimize simple memory effects across test sessions.

We used a double-blind, placebo-controlled within-subject design (AB-BA design). The participants were recruited on the basis of a pre-test screening using the AAP (George and West, 2001) of 43 healthy male students. 11 subjects with a secure attachment pattern were excluded from the study because our aim was to examine oxytocin-induced shifts from attachment insecurity towards attachment security. 6 subjects refused intranasal application of the substance. The remaining 26 participants were divided into two equally sized, randomly assigned sub-groups to receive the oxytocin or placebo condition first. Only the independent administrator masking and blinding the substance was not blind. A single dose of 24 IU oxytocin (Syntocinon spray, Novartis, Basel, Switzerland) or placebo was administered intranasally 50 min before the attachment task at both testing sessions (for details see Heinrichs and Domes, 2008). The placebo contained all inactive ingredients except for the neuropeptide. No undesired side-effects of the substance were observed. Subjects underwent both conditions within a 2—3-week period.

In order to control for nonspecific effects of arousal, wakefulness, and mood, we assessed these variables at three time

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[1] See detailed information about the definition of the AAP categories in Supplemental Material.
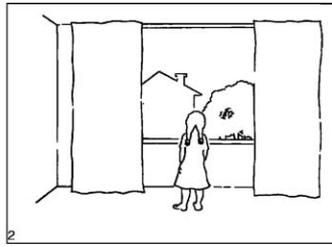
Which of the following statements characterize this picture most appropriately for you?

A. *The girl does not know what to do with her time and stares outside. She wants to play outside or be by herself.*

B. *A girl did something wrong and her mother punished her with house arrest. She goes into her room and distracts herself reading something.*

C. *A girl is looking out of the window. She is ill and has to stay inside and thinks about herself. Then her mother comes in and embraces her.*

D. *This girl seems somewhat desperate, maybe deserted by someone. She just wants to hide and to disappear from the world.*

Please only choose one letter in each line for your answer:

This is the most appropriate statement for me	A	B	C	D
This is the second appropriate statement for me	A	B	C	D
This is the third appropriate statement for me	A	B	C	D
This is the fourth appropriate statement for me	A	B	C	D

Figure 1 Example of the attachment task (1 of 32 presentations in total). *Note:* In the evaluation sentences represent the following attachment categories: (A) *insecure-preoccupied*; (B) *insecure-dismissing*; (C) *secure*; and (D) *unresolved*.

points (before applying the drugs, after 45 min, after the attachment task) by means of a suitable 12-item questionnaire (Multidimensional Mood Questionnaire; MMQ, Steyer et al., 1994). The MMQ is a short self-evaluative questionnaire that describes the current mood state of an individual on the three dimensions "good versus bad mood," "wakefulness versus sleepiness," and "calmness versus restlessness."

Drug and session effects were statistically tested by the sign test, a non-parametric paired test, comparing number of decreases and increases of the dependent variable between two experimental conditions. The same subjects were measured under the placebo and oxytocin conditions, with each person serving as his own control. The sign test was chosen for the following reasons. First, the instrument is based having subjects rank order phrases; this is best captured by non-parametrical methods. Second, most of the attachment scales (as well as differences of scales to be compared) did not achieve the normal distribution as measured by the Shapiro—Wilk test. Finally, in formulating the hypothesis of the present study, we expected small to moderate changes that are nonetheless observed by most subjects. The sign test is sensitive to changes of this kind. The study was approved by the local ethics committee at the Technical University of Munich and conducted according the Declaration of Helsinki. All procedures were carried out with the adequate understanding and written consent of the subjects.

3. Results

Our hypothesis that oxytocin increases the subjective perception of attachment security implies that the subjects in the oxytocin condition will show more selections of those phrases representing *secure attachment* than subjects in the placebo condition. This would be indicated by increasing the rank of their selection of the "secure" phrases and, consequently, decreasing the rank of "insecure" phrases as their preferred descriptor. The experience of attachment security was operationalized by the scale "*secure*"; the experience of attachment insecurity was formally operationalized by the sum of the three "insecure" scales "*dismissing + preoccupied + unresolved − 96*", which is mathematically equivalent to "96 − *secure*".

Oxytocin increased the rankings of attachment security and decreased the rankings of attachment insecurity (Fig. 2). Under placebo the value of the scale "*secure*" was 49.8 ($s = 15.5$) and under oxytocin mean values increased to 51.5 ($s = 12.7$). This change was observed by the majority of participants: 18 subjects (69%) out of 26 increased in rating "secure attachment", whereas only 8 subjects (31%) decreased ($p = .038$, one-tailed exact sign test). Consequently, opposite changes were observed by the global *insecurity* scale decreasing from 46.2 to 44.5 points (8 of 26 subjects, $p = .038$, one-tailed exact sign test).

A further analysis of the specific contribution of the three different insecure attachment styles on global insecurity decrease identified the scale "*preoccupied*" as the one that changed most due to oxytocin, whereas there were no significant changes in the remaining two attachment scales "*dismissing*" and "*unresolved*". The value of the "*preoccupied*" scale decreased from the mean 53.3 ($s = 9.2$) under the placebo to 50.7 ($s = 8.9$) under the oxytocin condition. A decrease was observed in 18 subjects, an increase by 7
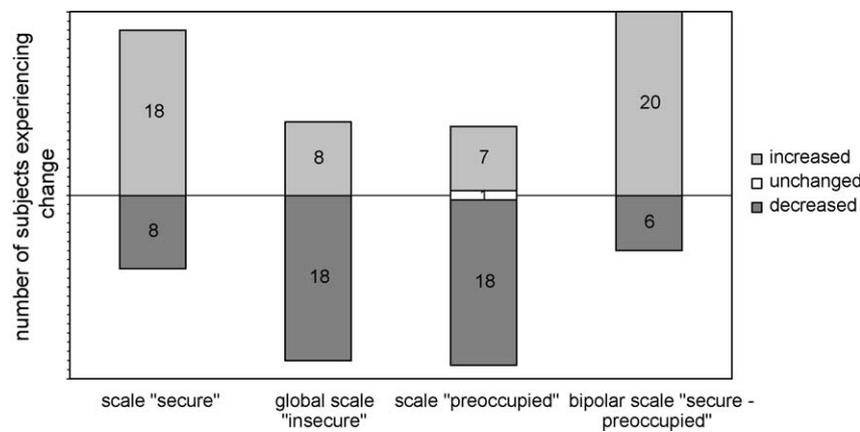
Figure 2 Effect of oxytocin versus placebo on attachment experience. One-tailed exact sign test: "secure" or "insecure" $p = .038$, "preoccupied" $p = .022$, "secure—preoccupied" $p = .005$.

subjects and 1 subject did not change ($p = .022$; one-tailed exact binomial test).

The post hoc analysis of the concurrent changes in the two significant scales ("secure" and "preoccupied") led to the following results. The majority of 14 out of 26 subjects changed to higher ranked security in both scales, 7 subjects improved in only one scale, and only 4 subjects worsened in both scales. Finally, we have integrated both scales into one bipolar scale by their subtraction, whereas the constants in the formula preserve the theoretical range 0—96 points, (secure-preoccupied)/2 + 48.

The value of this integrated scale increased from the mean 46.2 ($s = 11.4$) under the placebo to 48.4 (10.1) under the oxytocin condition. A significant majority of subjects changed to a higher security score (see Fig. 2): 20 (77%) out of 26 participants increased on that scale ($p = .005$).

For the sake of statistical discussion of these results, we have addressed two questions. The first is the influence of time (1st vs. 2nd session within the AB-BA design); the second is the influence of mood, wakefulness and arousal. The comparison of the first and the second session scores for each of the four attachment scales, which were randomly assigned with regard to placebo or oxytocin administration, demonstrated that the effect was not a simple practice effect. The comparison was not significant according to the two-tailed exact sign test for the "secure scale" ($p = 1.000$), "dismissing scale" ($p = 1.000$), "preoccupied scale" ($p = .690$), and "unresolved trauma scale" ($p = .307$). There were no significant differences between the oxytocin versus the placebo condition in terms of mood, wakefulness, and arousal throughout the experiment. Dividing the sample into two sub-groups of subjects, no differences between the groups receiving oxytocin or placebo first were observed. For instance, remember that the effect of oxytocin leads by 18 subjects to the increase on the scale "secure" and by 8 to the decrease on this scale. In both subgroups (oxytocin or placebo first), this ratio was exactly the same, 9:4. The variance analysis (two repeated measures in AB-BA design) also did not show carry-over effects of oxytocin between the first and second session.

4. Discussion

To our knowledge this is the first study that shows that a single dose of intranasally administered oxytocin is sufficient to enhance the experience of attachment security. Oxytocin seems to induce a *momentary* state of mind change in which subjects classified as insecure shift to higher rankings of attachment security. Attachment security is characterized as the individuals' confidence to rely on attachment figures to achieve care, safety, and protection and, when alone, to have access to internalized attachment relationships. Thus, under the oxytocin condition, these insecure individuals demonstrated an increased propensity to select phrases as more appropriate associated with attachment related to comfort, secure base and feelings of safety.

Focusing sharply on the first ranked statements only, the number of the preferred "secure" statements on this most privileged position increased in 16 cases and decreased in 8 cases under the oxytocin condition ($p = .076$). This additional examination focusing on shifts to the first positions would need a larger sample to increase the test power. However, only subjects with insecure attachment status were selected in the baseline assessment. Under these preconditions we consider that the shift of the secure statement for instance from the last (fourth) position to the second one also represents a notable improvement.

We observed furthermore a significant decrease in the number of subjects ranking the pictures with "preoccupied" phrases from the placebo to the oxytocin condition, whereas no differences were noted in the "dismissing" or "unresolved" scales. A recent fMRI study found that oxytocin dampens the amygdala response to social stimuli (angry faces) (Vrtička et al., 2008) only in insecure subjects with preoccupied attachment status.

Moreover our results concur with recent findings from neuroimaging studies in healthy humans, demonstrating that looking at pictures of significant others showed marked overlap with regions that show high densities of oxytocin receptors (e.g. striatum) (Bartel and Zeki, 2004). Intranasal oxytocin has recently been shown to attenuate amygdala responses to emotional faces (Domes et al., 2007b) and during trusting behavior (Baumgartner et al., 2008), suggest-

ing a key role of oxytocin in reducing the uncertainty about the predictive value of social stimuli. Oxytocin is suggested to be released during key pair-bonding events like sexual climax or childbirth. Indeed, oxytocin levels at early pregnancy and the postpartum period are related to a clearly defined set of maternal bonding behaviors (Feldman et al., 2007). In addition, oxytocin levels were also associated with bonding to one's own parents in young adults (Gordon et al., 2008).

By investigating a momentary shift of attachment experience towards security, we do not conclude that oxytocin has changed the subjects' mental attachment representation in general. The observed differences were significant, although relatively small between the two conditions; specifically we have observed a *small* change by the *majority* of subjects. It should be kept in mind that these systematic differences were caused by a minimal intervention and they were independent of mood, wakefulness and arousal.

We administered the Multidimensional Mood Questionnaire (MMQ; Steyer et al., 1994) three times. There were no direct effects of oxytocin on the three measured mood dimensions, a finding that is in line with previous findings using the same dose of intranasal oxytocin (e.g. Kosfeld et al., 2005; Baumgartner et al., 2008; Rimmele et al., 2009). In the most recent oxytocin study on memory for faces (Rimmele et al., 2009) neither negative affects (e.g. anxious, frightened, and worried), measured with the Positive and Negative Affect Scale (PANAS, Watson et al., 1988), nor the three mood dimensions measured by the MMQ differed between oxytocin and placebo groups.

In our study, we analyzed the potential influence of these MMQ-items using Spearman correlation coefficients between 9 potential covariates (3 mood dimensions at 3 points of measurement) and 4 attachment scales of the used measure on the sample of 26 subjects in the two experimental conditions. None of the 36 Spearman rank correlation coefficients was significant.

Research findings suggest that oxytocin has anxiolytic properties (e.g. Heinrichs and Domes, 2008). In this study we measured mood as mentioned above, but not specifically state anxiety as a possible covariate; hence we cannot rule out that oxytocin was exerting its effects on attachment via anxiety reduction, especially on the scale "preoccupied." Integration of other important variables such as state anxiety, prosocial behavior, and more detailed measures of mood (including physiological measures) and the investigation of the possible long-term effects of oxytocin administration on attachment are a challenge for future research.

We note too that the attachment task used in this study was not established so far in that kind of experimental design. Further validation of the modified AAP task is a goal of an on-going study.

What are possible clinical implications of these results? Psychotherapy researchers emphasize that therapists should take into account that psychotherapy activates attachment (Fonagy and Bateman, 2006). Insecure attachment patterns are predominant in clinical populations (Westen et al., 2006). The shift from insecure to secure attachment during psychotherapy usually requires a year or more in order to work through maladaptive attachment patterns (Fonagy and Bateman, 2006). The present study implies that oxytocin might have the potential to change the *momentary* state of mind when the attachment system is activated. In psychotherapy,

an enhanced readiness for experiencing attachment security is considered to be helpful in perceiving an emotional corrective experience. Hence, future clinical studies might consider whether oxytocin is helpful to be integrated as an add-on treatment in the course of the psychotherapeutic process (Heinrichs and Domes, 2008).

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Conflict of interest

None declared.

Acknowledgments

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.psyneuen.2009.04.002.

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