Acute Intranasal Oxytocin Improves Positive Self-Perceptions of Personality

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ABSTRACT

Acute Intranasal Oxytocin Improves Positive Self-Perceptions of Personality

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Research suggests the experimental manipulation of oxytocin facilitates positive interactions, cooperation and trust. The mechanism by which oxytocin influences social behavior is not well understood. We explored the hypothesis that oxytocin alters how people perceive themselves, which could be one mechanism by which oxytocin promotes prosocial behavior. In a between-subject, randomized, and double-blind experiment, 100 university students received a 24 I.U. dose of intranasal oxytocin or placebo, and then completed the Revised NEO Personality Inventory (NEO-PI-R) and other self-report measures 90 minutes later. Intranasal oxytocin increased ratings of NEO-PI-R extraversion and openness to experiences ($F(1,98) = 4.910$, $p = .025$, partial $\eta^2 = .05$; $F(1,98) = 6.021$, $p = .016$, partial $\eta^2 = .06$), particularly for the following facets: positive emotions ($d = 0.48$, $p < .05$), warmth ($d = 0.47$, $p < .05$), openness to values ($d = 0.45$, $p < .05$) and ideas ($d = 0.40$, $p < .05$), trust ($d = 0.44$, $p < .05$) and altruism ($d = 0.40$, $p < .05$). Oxytocin had no influence on ratings of negative emotionality, conscientiousness, rejection sensitivity, depression, worry, self-esteem, and perceived social support. The administration of oxytocin improved participants' self-perceptions of their personality, at least for certain traits important for social affiliation. Increased positive self-referential processing may be one mechanism by which oxytocin promotes positive social behaviors.

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Acute intranasal oxytocin improves positive self-perceptions of personality

Introduction

The nonapeptide oxytocin is known for its role in reproduction and maternal behavior (Gimpl & Farenholz, 2001). In the last two decades, oxytocin has gained recognition for its effects on social behavior in animals (Carter, 1998; Insel, 2010). Since it was reported that the intranasal administration of neuropeptides increases their levels in cerebrospinal fluid (Born et al., 2002), there has been an upsurge of interest in experimental manipulations of central oxytocin in human populations (Bartz & Hollander, 2006; Campbell 2010; Heinrichs, von Dawans, & Domes, 2009). This body of research shows that oxytocin facilitates positive interactions (Ditzen et al., 2009; Naber, van Ijzendoorn, Deschamps, van Engeland, & Bakermans-Kranenburg, 2010), and improves cooperation, altruism, and trust in a variety of experimental contexts (Barraza, McCullough, Ahmadi, & Zak, 2011; Baumgartner, Heinrichs, Vonlanthen, Fischbacher, & Fehr, 2008; Declerck, Boone, & Kiyonari, 2010; Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005; Mikolajczak et al., 2010a; Mikolajczak, Pinon, Lane, de Timary, & Luminet, 2010b).

While the mechanism by which oxytocin facilitates prosocial behavior is unknown, a common view is that oxytocin alters how social signals in the external environment are processed, encoded, and/or interpreted (Bartz et al., 2010a; Ellenbogen, Linnen, Grumet, Cardoso, & Joober, 2012; Guastella, Mitchell, & Dadds, 2008; Marsh, Yu, Pine, & Blair, 2010; Theodoridou, Rowe, Penton-Voak, & Rogers, 2009). More recently, a hypothesis has been put forward that oxytocin alters cognition by increasing the salience of social cues in the environment (Bartz, Zaki, Bolger, & Ochsner, 2011).

One advantage of this proposal is that it can explain why there are putative negative behavioral effects of oxytocin (Bartz et al., 2011b; De Dreu et al., 2010; De Dreu, Greer, Van Kleef, Shalvi, & Handgraaf, 2011; Shamay-Tsoory et al., 2009). The view that oxytocin increases attention to social cues is consistent with recent evidence showing that oxytocin influences the allocation of attentional resources to biological motion (Perry et al., 2010) and strengthens the orienting response to the eye region of the face—an effect that is associated with increased functional coupling of the basal amygdaloid nucleus and the superior colliculi (Gamer, Zurowski, & Büchel, 2010).

Past research on intranasal oxytocin has focused primarily on how information in the external world is processed or interpreted (i.e. emotional faces, laboratory games, etc.). As an alternate or complimentary mechanism explaining the effect of oxytocin on social behavior, oxytocin may alter self-perceptions. That is, oxytocin may elicit changes in a person's self-perceived altruistic, accepting, and socially-oriented traits, which in turn could promote affiliative behavior. There is some, albeit sparse, evidence consistent with this proposal. For example, acute intranasal oxytocin improves self-perceived coping style in humans (Cardoso, Linnen, Joober, & Ellenbogen, 2011) and attachment security in adult males (Buchheim et al., 2009). To further explore this hypothesis, we examined whether intranasal oxytocin influenced self-reported personality on the Revised NEO Personality Inventory (NEO-PI-R)— an instrument with excellent psychometric properties (Costa & McCrae, 1992) and temporal stability across 6 to 9 years (Costa, Herbst, McCrae, & Siegler, 2000). Considering that personality traits are deemed to be stable and enduring (Caspi, Roberts, & Shiner, 2005), this study represents an opportunity to determine whether oxytocin alters core perceptions of the self. In the

context of personality, the tendency to experience frequent positive emotions, and to evoke and enjoy social interactions characterizes extraversion, while agreeableness is characterized by prosocial tendencies like being empathetic, considerate, and helpful. Extraverted and agreeable children are more socially competent in their youth and later in adulthood, and these personality traits are associated with more positive responses from social partners (Asendorpf & van Aken, 2003; Caspi et al., 2005; Shiner, 2000). Thus, consistent with the prosocial literature on oxytocin, oxytocin-induced changes in self-perception would likely target extraversion and agreeableness, rather than the other core personality factors such as neuroticism.

We predicted that, relative to placebo, oxytocin would elicit higher self-report ratings of extraversion and agreeableness because these traits are deemed to promote social affiliation. Because there are no studies in this area, we included all five factors of the NEO-PI-R in the data analyses. We also conducted exploratory analyses on the NEO-PI-R facets (sub-scales) to follow up significant findings and to examine apriori predictions based on the literature (i.e. oxytocin influences trust). To determine whether oxytocin alters core perceptions of the "social" self, via the assessment of personality traits, or whether it alters self-perceptions in general, we examined the influence of oxytocin and placebo on participants' self-report of current depressive symptoms, trait worry, perceived social support, rejection sensitivity, goal adjustment style, and global self-esteem.

Method

Participants

One hundred healthy university students (50 women) between the age of 18 and 35 were recruited to participate in this study. Exclusion criteria included current medication use, presence of a medical illness or of a current or past mental disorder, lifetime recreational drug use (with the exception of cannabis, which required one-year abstinence and no history of use more than once every 6 months), smoking, pregnancy, and poor English language fluency. Exclusion criteria were assessed using an in-house structured interview protocol prior to participation. Participants were queried about current or past substance use, mental disorders, use of anti-depressants, anxiolytics, or any psychotropic medications and psychological treatments. For female participants, information regarding the menstrual cycle (date of last menses, average length of cycle) was collected.

Forty-eight (24 women) and 52 (26 women) participants were randomized to an intranasal oxytocin and placebo condition, respectively. Participants randomized to the oxytocin and placebo condition were (mean ± SD) 22.4 ± 3.47 and 21.7 ± 3.35 years old, respectively. Four of 13 women in the follicular phase and 5 of 13 women in the luteal phase of their menstrual cycle were taking oral contraceptives in the placebo condition. Five of 13 women in the follicular phase and 2 of 11 women in the luteal phase of their menstrual cycle were taking oral contraceptives in the oxytocin condition. Statistical tests revealed that the following variables were balanced across drug condition: sex ($t(98) = 0$, $p > .05$), age ($t(98) = -0.924$, $p > .05$), menstrual phase ($t(48) = 0.289$, $p > .05$), and oral contraceptive use ($t(48) = 1.230$, $p > .05$). The project was approved by the Human

Research Ethics Committee at Concordia University (Montréal, Canada), and informed written consent was obtained from all participants.

Measures

The Revised NEO Personality Inventory (NEO-PI-R; Costa and McCrae 1992) consists of 240 items that define five factors of personality. High internal consistency has been reported for the NEO-PI-R, with coefficients ranging from .89 to .95 (Costa & McCrae, 1992), and temporal stability over six years (Costa et al. 2000; Herbst, McCrae, Costa, Feaganes, & Siegler). In the current sample, internal consistencies for the Neuroticism ($\alpha = .93$), Extraversion ($\alpha = .90$), Openness to experiences ($\alpha = .89$), Agreeableness ($\alpha = .90$), and Conscientiousness ($\alpha = .91$) scales of the NEO-PI-R ranged from good to excellent.

The Interpersonal Support Evaluation List – College Version (ISEL; Cohen & Hoberman, 1983) is a 48-item inventory used to evaluate an individual's perceived social support. The appraisal scale measures how comfortable an individual feels discussing their problems with people they know. The belonging scale measures an individual's access to partners for social activities (e.g., people to go to the movies with). The self-esteem scale measures how positively an individual compares themselves to people they know. The tangible scale measures an individual's access to material resources (e.g., people who can loan them money). Scores range from 0 to 12 on each scale, with higher scores reflecting stronger endorsement of each category. The internal consistency for the ISEL ($\alpha = .84$) in the current sample was good.

The Rejection Sensitivity Questionnaire (RSQ; Downey & Feldman, 1996) is an 18 item inventory that measures an individual's sensitivity to rejection during social

exchanges. Scores on this inventory range from 0 to 36, with higher scores reflecting greater sensitivity to social rejection. The internal consistency for the RSQ (α = .86) in the current sample was good.

The Beck Depression Inventory-II (BDI; Beck, Steer, & Brown, 1996) is a 21-item inventory that measures depressive symptoms. Scores on this inventory range from 0 to 63, with higher scores reflecting more depressive symptoms. The internal consistency for the BDI (α = .89) in the current sample was good.

The Rosenberg Self-Esteem Scale (RSE; Rosenberg, 1965) is a 10-item inventory that measures global self-esteem. Scores on this inventory range from 10 to 40, with greater scores reflecting higher global self-esteem. The internal consistency for the RSE (α = .90) in the current sample was excellent.

The Penn-State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990) is a 16-item inventory that measures trait worry. Scores on this inventory range from 16 to 80, with greater scores reflecting higher trait worry. The internal consistency for the PSWQ (α = .94) in the current sample was excellent.

The Goal Adjustment Questionnaire (GAQ; Wrosch, Scheier, Miller, Schulz, & Carver, 2003) is a 10-item inventory that measures ability to disengage and reengage goals. Scores on goal disengagement range from 4 to 20, with higher scores reflecting a greater ability to disengage from goal attainment. Scores on the goal reengagement scale range from 6 to 30, with higher scores reflecting a greater ability to reengage goals. Internal consistencies for the goal disengagement (α = .86) and goal reengagement scales (α = .84) were good in the current sample.

Procedure

Participants self-administered a 24 I.U. dose of intranasal oxytocin (Syntocinon, *Novartis*, Basel, Switzerland) or a placebo (saline) 50 minutes prior to participating in the Yale Interpersonal Stressor, a standardized social rejection paradigm (Stroud, Tanofsky-Kraff, Wilfley, & Salovey, 2000; Stroud, Salovey, & Epel, 2002). The stressor consisted of two staged conversations among three students (two of them being confederates), where the participant was increasingly excluded over time from the conversation. Findings associated with the stress manipulation are reported elsewhere (Cardoso et al., 2011; Linnen, Ellenbogen, Cardoso, & Joober, 2012). Both the participant and experimenter were blind to the content of the nasal spray. Participants' mood was measured using the Profile of Mood States (McNair, Lorr, & Droppleman, 1988) 10 minutes before drug administration, 50 minutes after drug administration, 65 minutes after drug administration (after the first staged conversation) and 80 minutes after drug administration (after the second staged conversation). Mood ratings did not differ between the oxytocin and placebo conditions at any time point, and at 80 minutes post-drug administration, mood ratings (higher scores = more positive mood) were 136 ± 36 and 139 ± 34 in the oxytocin and placebo groups, respectively (Linnen et al., 2012). At 90 minutes post-administration, participants completed a battery of questionnaires. Participants were then debriefed and asked to rate (1) how bad they felt in response to the social rejection paradigm and (2) how stressful they perceived the interaction to be, which were rated on a 5 point likert scale ranging from 1 (not at all) to 5 (extremely). Participants were then remunerated $50 for their participation.

Statistical Analyses

Separate drug X sex multivariate analyses of variance (MANOVAs) were conducted on the five factors of personality on the NEO-PI-R, the 4 scales of the ISEL, and the 2 scales of the GAQ. Individual scales and relevant facets were subsequently probed with univariate tests to disambiguate statistically significant multivariate effects, or statistical trends. Separate drug X sex analyses of variance (ANOVAs) were conducted on the ISEL, RSQ, BDI-II, RSE, and PSWQ, all of which had single measures. Planned comparisons on facets of the agreeableness factor of the NEO-PI-R were conducted based on apriori predictions supported by the literature (e.g., oxytocin influences trust.)

All statistically significant multivariate effects were explored for interactions with oral contraceptive use and menstrual cycle phase in females using multivariate analysis of covariance (MANCOVAs) to determine if additional univariate tests should be conducted to probe these interactions. Finally, we examined whether exposure to the interpersonal stressor prior to completing the battery of tests influenced the relation between oxytocin and the aforementioned outcome variables. To do this, we conducted t-tests to determine if changes in personality paralleled changes in participant ratings of their subjective stress and negative affect following social rejection. We also conducted mediation analysis using Sobel's test (Sobel, 1982) to determine if the effects of oxytocin on the outcome variables were mediated by the ratings of subjective stress and negative affect.

Results

The effect of drug administration on personality

We detected a statistical trend for the association between drug condition and scores on the NEO-PI-R, a statistically significant effect of sex, and no interaction

between drug and sex following a Drug (placebo, oxytocin) X Sex MANOVA of the NEO-PI-R five factors (drug: Wilks' λ=.896, $F(5, 92) = 2.146$, $p = .067$; sex: Wilks' λ=.845, $F(5, 92) = 3.383$, $p = .008$; drugXsex: Wilks' λ=.986, $F(5, 92) = 0.270$, $p = .928$). Women (116.70 ± 17.56) scored higher than men (106.64 ± 20.39) on the agreeableness factor of the NEO-PI-R ($F(1, 98) = 7.032$, $p = .009$, partial $\eta^2 = .07$). No significant sex differences were found on the remaining scales of the NEO-PI-R (data not shown).

Participants reported higher extraversion and openness to experiences following oxytocin administration (See Figure 1), but we did not detect a statistical association between drug condition and neuroticism, agreeableness, or conscientiousness (extraversion: $F(1, 98) = 4.910$, $p = .025$, partial $\eta^2 = .05$; openness to experiences: $F(1, 98) = 6.021$, $p = .016$, partial $\eta^2 = .06$; neuroticism $F(1, 98) = 0.381$, $p = .539$; agreeableness: $F(1, 98) = 0.397$, $p = .530$; conscientiousness: $F(1, 98) = 0.001$, $p = .981$).

Oxytocin administration was associated with higher ratings of *positive emotions* ($d = 0.48$, $p < .05$) and *warmth* ($d = 0.47$, $p < .05$) on the extraversion scale, and *openness to values* ($d = 0.45$, $p < .05$) and *ideas* ($d = 0.40$, $p < .05$) on the openness to experience scale following planned comparisons on facets of the NEO-PI-R. Since the literature indicates that oxytocin augments prosocial behavior, we conducted additional analyses on facets of the agreeableness factor. Ratings of *trust* ($d = 0.44$, $p < .05$) and *altruism* ($d = 0.40$, $p < .05$) were higher following oxytocin administration. Statistics describing the facets of the extraversion, openness to experiences, and agreeableness factors can be found in Table 1.

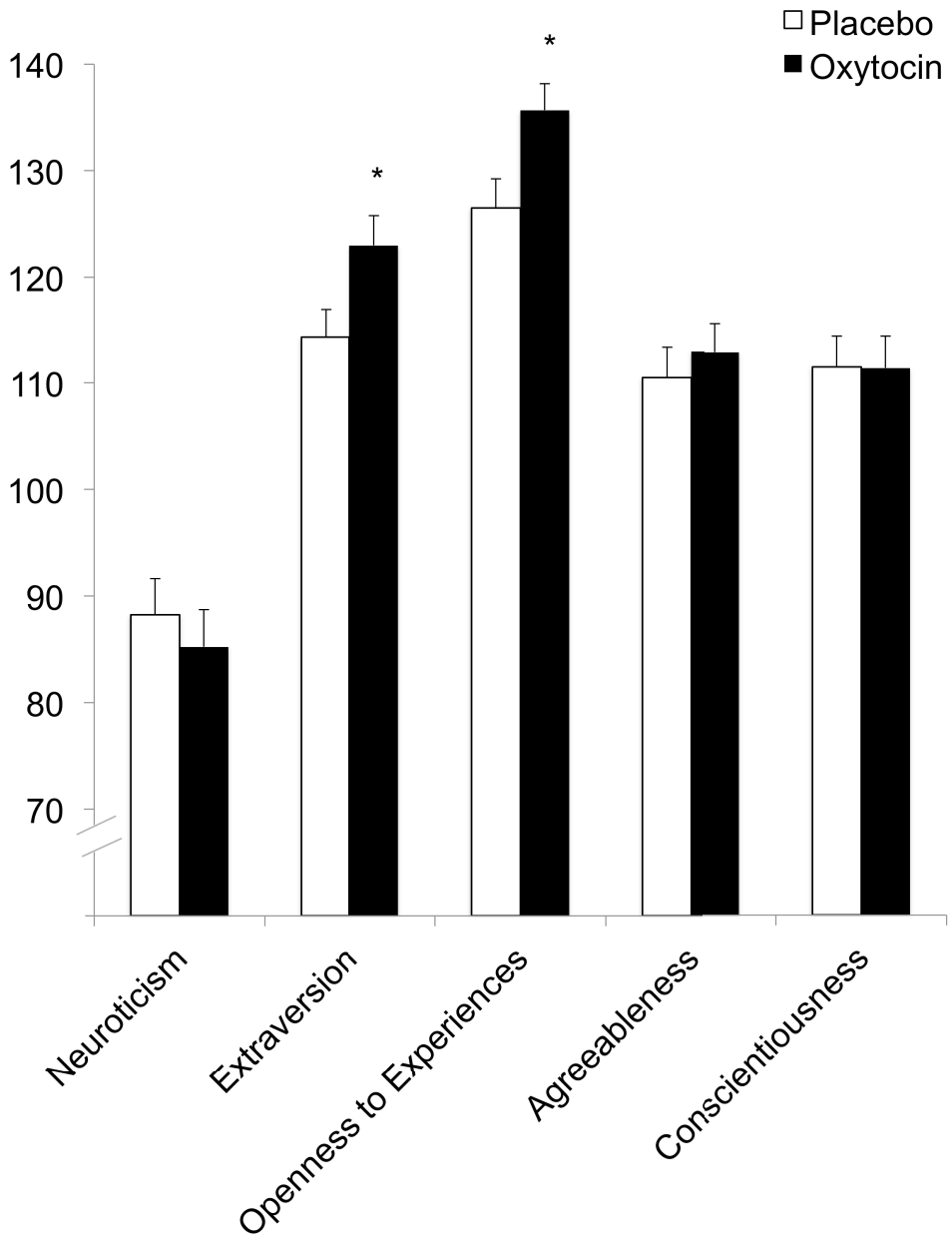

Figure 1. Total scores on the five personality scales of the Revised NEO Personality Inventory in participants who self-administered intranasal oxytocin (n=48) or a placebo (n=52). Error bars represent 1 standard error. * $p < .05$

Table 1. Descriptive statistics for subscales of the NEO-PI by drug condition.

Variable	Oxytocin[a]		Placebo[b]		95% CI		Cohen *d*
	M	SD	M	SD	*LL*	*UL*	
Warmth (E1)*	23.15	4.17	21.06	4.45	0.37	3.80	0.47
Gregariousness (E2)	18.83	4.57	18.23	5.06	-1.32	2.52	0.13
Assertiveness (E3)	17.58	5.31	15.81	5.30	-0.33	3.88	0.33
Activity (E4)	18.33	3.80	18.06	3.08	-1.09	1.66	0.08
Excitement-Seeking (E5)	21.75	4.81	20.38	4.84	-0.55	3.28	0.28
Positive Emotions (E6)*	23.33	4.54	20.77	5.84	0.49	4.64	0.48
Openness to Fantasy (O1)	22.29	4.59	20.61	4.79	-0.19	3.54	0.35
Openness to Aesthetics (O2)	21.54	5.95	20.14	5.34	-0.83	3.65	0.25
Openness to Feelings (O3)	23.15	4.82	22.04	3.71	-0.59	2.81	0.26
Openness to Actions (O4)	19.60	4.03	18.81	3.88	-0.77	2.37	0.21
Openness to Ideas (O5)*	24.42	4.92	22.04	6.56	0.06	4.69	0.40
Openness to Values (O6)*	20.15	4.87	17.04	5.11	0.25	3.32	0.45
Trust (A1)*	20.15	4.87	17.89	5.11	0.28	4.25	0.44
Straightforwardness (A2)	17.04	5.55	17.13	5.13	-2.21	2.03	-0.02
Altruism (A3)*	23.56	3.63	21.94	4.30	0.03	3.21	0.40
Compliance (A4)	15.88	4.37	16.42	4.84	-2.38	1.29	-0.12
Modesty (A5)	15.90	5.28	16.90	5.49	-3.15	1.13	-0.19
Tender-Mindedness (A6)	20.44	3.91	20.19	4.33	-1.40	1.89	0.06

Note: $N = 48^{a}$, $N = 52^{b}$, * $p < .05$

Examining potential confounds: Oral contraceptives, menstrual phase, and the impact of the interpersonal stressor

We investigated a possible confounding relation between oxytocin, personality, oral contraceptive use, and menstrual phase. We did not detect a statistical interaction between oral contraceptive use and drug condition, or between menstrual phase and drug condition on scores on the NEO-PI-R following a drug X oral contraceptive use (no, yes) MANCOVA, controlling for menstrual phase (follicular, luteal), and a drug X menstrual phase MANCOVA, controlling for oral contraceptive use (drugXcontraceptive use: Wilks' λ=.960, $F(5, 41) = 0.342$, p = .884; drugXmenstrual phase: Wilks' λ=.865, $F(5, 41) = 1.280$, p = .291). For this reason, we did not conduct further univariate tests to probe these interactions.

We investigated a possible confounding relation between oxytocin, personality, and social rejection (which preceded completion of the questionnaire battery). If such a relation existed, we anticipated that ratings of stress and negative affect would parallel changes in personality across drug condition, or mediate the relation between oxytocin and personality. Ratings of stress did not differ between those administered oxytocin (1.93 ± 0.98) and those administered placebo [2.14 ± 0.91; $F(1, 96) = 1.135$, p = .289]. Ratings of negative affect (i.e. how bad did you feel?) did not differ between participants administered oxytocin (2.02 ± .96) and those administered placebo [2.19 ± 1.05; $F(1,96) = 0.719$, p = .399]. Further, the effect of oxytocin on personality was not mediated by stress or negative affect, respectively, using Sobel's test of mediation (1982) [extraversion (z = -1.041, p = .297; z = -0.574, p = .566); openness to experiences (z = 1.203, p = .229; z = 0.759, p = .448); warmth (z = -0.171, p = .864; z = 0.305, p = .760);

positive emotions (z = 0.771, p = .440; z = -0.397, p = .691); openness to ideas (z = 0.182, p = .855; z = -0.573, p = .567); openness to values (z = 0.022, p = .983; z = 0.141 , p = .888); trust (z = -0.249, p = .803; z = -1.306, p = .191); altruism (z = 0.267, p = .790; z = 0.576, p = .565)]. In summary, we found no evidence that oral contraceptive use, phase of menstrual cycle, or stressor-related effects influenced the relation between oxytocin and personality.

The effect of drug administration on clinical symptoms, social support, and other questionnaires

Descriptive statistics for the measures to follow are presented in Table 2. We detected no statistical relation between drug condition and the four subscales of the ISEL (social support), a statistical trend for the effect of sex, and no interaction between drug condition and sex following a drug X sex MANOVA (drug: Wilks' λ=.984, $F(4, 93) = 0.373$, p = .827; sex: Wilks' λ=.920, $F(4, 93) = 2.018$, p = .098; drugXsex Wilks' λ=.986, $F(4, 93) = 0.270$, p = .928).

We detected no statistical relation between drug condition and the two subscales of the GAQ (goal engagement), no effect of sex, and no interaction between drug condition and sex following a drug X sex MANOVA (drug: Wilks' λ=.988, $F(2, 95) = 0.575$, p = .565; sex: Wilks' λ=.999, $F(2, 95) = 0.062$, p = .940; drugXsex: Wilks' λ=.999, $F(4, 93) = 0.040$, p = .961). Women (46.02 ± 13.51) scored higher on the PSWQ (trait worry) than men [40.48 ± 12.91; $F(1,96) = 4.240$, $p = .042$, partial η2 = .04], and our analyses revealed an interaction between sex and drug condition on scores on the BDI (depressive symptoms), as well as a statistical trend for the interaction between sex and drug condition on scores

Table 2. Descriptive statistics for perceived social support, global self-esteem, depressive symptoms, trait worry, rejection sensitivity, and goal adjustment style.

	Oxytocin[a]		Placebo[b]	
Variable	M	SD	M	SD
Interpersonal Support Evaluation List (ISEL)				
Appraisal	10.71	1.99	10.40	2.47
Belonging	8.21	2.39	8.19	2.72
Self-Esteem	8.79	1.98	8.48	2.26
Tangible	10.40	1.78	10.10	1.72
Rejection Sensitivity (RSQ)	8.18	3.20	7.83	3.56
Rosenberg's Self-Esteem (RSE)	21.85	4.93	21.54	5.39
Beck Depression Inventory (BDI)	6.83	5.78	6.44	6.75
Penn-State Worry (PSWQ)	42.54	13.12	43.90	13.82
Goal Adjustment Questionnaire (GAQ)				
Goal Disengagement	11.69	1.53	11.37	1.41
Goal Reengagement	22.40	4.32	22.18	4.21

Note: $N = 48^{a}$, $N = 52^{b}$

on the RSE (global self-esteem) (BDI: drugXsex: $F(1,96) = 4.581$, $p = .035$; RSE: drugXsex: $F(1,96) = 3.072$, $p = .083$). Follow-up analyses revealed no statistically significant effect of drug on the RSE or BDI in men or women [RSE men:($t(48) = 1.05$, p = .299; women: $t(48) = -1.420$, p = .242)], [BDI men: $t(48) = -1.924$, p = .063; women: $t(48) = 1.185$, p = .242).We did not detect a statistical relation between drug, sex, and the interaction between drug and sex with any other variable [RSQ (rejection sensitivity) drug: $F(1,96) = 0.265$, $p = .608$; sex: $F(1,96) = 0.016$, $p = .898$; drugXsex: $F(1,96) = 0.237$, $p = .627$)], [BDI drug: $F(1,96) = 0.098$, $p = .754$; sex: $F(1,96) = 0.018$, $p = .894$), [RSE drug: $F(1,96) = 0.094$, $p = .760$; sex: $F(1,96) = 0.173$, $p = .678$], [PSWQ drug: $F(1,96) = 0.261$, $p = .610$; drugXsex: $F(1,96) = 0.246$, $p = .621$].

Discussion

The results of the present experiment indicate that intranasal oxytocin changes how participants perceive and report self-referential information deemed to be enduring and stable. Participants who self-administered intranasal oxytocin reported higher ratings of extraversion and openness to experiences than participants administered a placebo. Specifically, personality traits characterized by positive emotions, warmth, trust, altruism, and openness to values and ideas were most sensitive to oxytocin administration.

The pattern of results was strikingly consistent with the experimental literature (Ditzen et al., 2009; Kosfeld et al., 2005; Marsh et al., 2010)— only scales related to social behavior were altered by the administration of intranasal oxytocin relative to a placebo, with the exception of openness to experiences. The effects of oxytocin on self-perceptions showed remarkable specificity. Oxytocin had no effect on how participants

perceived their trait negative emotionality, conscientiousness, rejection sensitivity, worry, self-esteem, symptoms of depression, or ability to disengage from thwarted goals. Moreover, oxytocin had no impact on participants' perceptions of their *external* social environment, in that it had no measurable impact on any of the perceived social support sub-scales assessed. Importantly, these findings cannot be attributed to mood change or changes in the perceived stressfulness of the social rejection paradigm, which all study participants experienced prior to completing questionnaires. Neither the mood (Linnen et al., 2012) nor subjective stress ratings were influenced by intranasal oxytocin. This is consistent with other research that suggests oxytocin does not have an appreciable effect on self-reported emotional states (Alvares, Hickie, & Guastella, 2010; Kirsch et al. 2005; Kosfeld et al. 2005). These data suggest that oxytocin modulated self-perceived personality (i.e. core traits) without modulating how participants responded to social rejection (i.e. current emotional state).

These present results warrant consideration in the broader context of the experimental work on oxytocin. Recent evidence suggests intranasal oxytocin has differential effects on social behavior depending on contextual factors (Bartz et al., 2011). For example, intranasal oxytocin has been shown to improve altruism only for people perceived to be part of an individual's group, and not for people perceived to be part of an out-group (De Dreu et al., 2010; De Dreu et al., 2011). Further, oxytocin did not improve social cooperation when social partners were perceived to be untrustworthy (Mikolajczak et al., 2010a), uncooperative (Declerck et al., 2010), or antagonistic (Shamay-Tsoory et al. 2009; but see Baumgartner et al. 2008 for an exception). Other research suggests that the effect of oxytocin on cooperative behavior depends on

characteristics of the individual (Andari et al. 2010; Bartz et al. 2010a; Bartz et al. 2011). Taken together, there is a need to better understand the context- and person-dependent effects of oxytocin on social behavior, which now include changes in self-perception.

The findings have important implications regarding the influence of oxytocin on human social behavior. We contend that increased self-perception of positive trait characteristics in response to oxytocin is consistent with a frame of mind that is tailored to the acquisition of new social relationships. This may occur, in part, via three distinct changes in information processing: increased salience of social stimuli (Bartz et al., 2011; Gamer et al., 2010; Perry et al., 2010), facilitated processing of positive interpersonal stimuli in the environment (Marsh et al., 2010; Unkelbach et al., 2008) and increased positive self-referential processing. Changes in the processing of external positive social stimuli may enable approach behavior (i.e. identifying cues that signal potential social interactions), while changes in positive self-referential processing may facilitate and reinforce actual social interactions (i.e. promoting reciprocal and affiliative social behavior). In support of the latter contention, oxytocin improves self-perceived attachment security (Bucheim et al., 2009) and coping style (Cardoso et al., 2011).

In contrast to the findings for extraversion, the effect of oxytocin on openness to experiences was unexpected. The factor is defined as the active seeking and appreciation of experiences for their own sake (Costa et al., 2005; Costa & McCrae, 1992), and could theoretically facilitate the development of new relationships. Alternatively, the effect of oxytocin on increasing openness to experiences may be associated with a recent finding that oxytocin, relative to placebo, increases suggestibility during hypnosis (referred to as "hypnotizeability"; Bryant, Hung, Guastella, & Mitchell, 2012). Openness to experiences

and hypnotizeability are known to correlate (Glisky, Tataryn, Tobias, Kihlstrom, & McConkey, 1991). Thus, it is possible that oxytocin-induced changes in self-perceived openness to experiences parallel behavioral changes in suggestibility. Clearly, the relation between openness to experiences, oxytocin, and suggestibility warrants further investigation.

A number of study limitations warrant consideration. In the current study, the battery of questionnaires was administered to participants after a social rejection paradigm. It is possible that the reported findings are the result of a combined effect of social rejection and the drug manipulation. For example, it could be argued that oxytocin "prevented" a stress-induced decline in extraversion and openness to experiences, as opposed to increasing self-report ratings of these personality factors. While we cannot definitively rule out this possibility, it is unlikely for at least two reasons. If oxytocin prevented a stress-induced decline in personality ratings, one would expect to see similar changes in ratings of mood and subjective stress, which are more sensitive to interpersonal stress than trait measures of personality. Participants' ratings of negative mood (Linnen et al., 2012) and subjective stress did not differ between the oxytocin and placebo conditions. Mediation analyses further supported our contention: ratings of subjective stress failed to mediate the relation between drug administration and personality. In addition, participants' scores on the NEO-PI-R were within the normal range, and were comparable to an age-matched sample that did not undergo an interpersonal stress challenge or drug administration. For example, 102 participants from a previous study (Ellenbogen et al. 2012) who did not experience a social rejection

stressor scored 114.03 on extraversion, whereas participants in the present sample during the placebo condition scored 114.31.

History of mental illness was assessed using self-report, and it is possible that some participants had undiagnosed mental disorders that could have been screened using a structured diagnostic interview. The placebo nasal spray contained saline solution but none of the pharmacologically inactive compounds found in the oxytocin spray. Thus, it is possible that the findings observed in the present study could be due to the effects of a non-active compound administered with oxytocin. The present findings should be interpreted in light of a number of methodological issues in the study of intranasal oxytocin in humans, including the absence of data on dose-response individual differences (i.e. absorption rates). Timing issues also warrant some consideration. While most studies examine the effects of oxytocin 45 minutes after administration (Ditzen et al., 2009; Kosfeld et al., 2005), there was a 90 minute delay between testing and drug administration in the present study. It is unlikely that the delay had any impact on the results, as previous research has shown that peptide concentrations in the cerebrospinal fluid remain relatively stable even 80 minutes after administration (Born et al., 2002). Further, we have reported effects of oxytocin on cognition that can still be detected at 85-115 minutes post-administration (Ellenbogen et al., 2012). Finally, it should be noted that while we did not find an effect of menstrual cycle or contraceptive use in the current study, self-report methods are not entirely reliable, and more subtle hormonal interactions may only become evident with use of better measures (e.g., hormone assays).

An important implication of this research is that hormones, which fluctuate abreast changing life events (i.e. getting involved in intimate relationships, which putatively

increases endogenous oxytocin (Diamond, 2004), can influence the self-reporting of purportedly stable and enduring traits. Further, these data provide one explanation of how contextual effects (DeLongis & Holzman, 2005) influence the reporting of traits. In summary, the present study builds on previous experimental work to show that intranasal oxytocin influences how people perceive themselves, which is pertinent to our understanding of the role of oxytocin in affiliative behavior.

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Addendum

In conducting our analyses, we detected a statistically significant interaction between sex and drug condition on scores on the BDI (depressive symptoms) [$F(1,96) = 4.581$, $p = .035$]. Follow-up analyses with simple comparisons revealed that there was no statistically significant effect of drug condition on female BDI scores [$t(48) = 1.185$, $p = .242$]. However, men in the placebo condition reported lower BDI scores (5.32 ± 5.10) relative to participants who administered intranasal oxytocin (7.69 ± 8.02), but this effect fell short of conventional statistical significance [$t(48) = -1.924$, $p = .063$].

Interpretation of this effect requires caution, since it did not meet criteria for conventional statistical significance. One possible hypothesis for this effect is that men, who typically underreport depressive symptoms (Addis, 2008), were more likely to report depressive symptoms they experienced over the last 2 weeks more accurately because they felt more trusting towards this experimenter, which is consistent with our own results and that of other research (Mikolajczak, 2010). In addition to improved trust in the experimenter, this effect could have been partly driven by improved recall of autobiographical memories for the last 2 weeks, which is consistent with experimental findings in our own laboratory (Cardoso et al., 2012). In short, participants may have been able to better remember episodes in the last 2 weeks where they experienced depressive symptoms, and also felt more inclined to disclose this information as a result of improved trust in the experimenter. Further research is needed to explore the possibility that oxytocin changes how men report depressive symptoms, and possibly other clinically relevant information, which could have implications in a therapeutic context.

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