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Toward a neuroscience of parenting : adult attachment and oxytocin affect neural and behavioral responses to infant attachment signals

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Does intranasal oxytocin promote prosocial behavior to an excluded fellow player? A randomized-controlled trial with Cyberball

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ABSTRACT

The neuropeptide oxytocin has been shown to stimulate prosocial behavior. However, recent studies indicate that adverse early caregiving experiences may moderate the positive effects of oxytocin. In this double blind randomized-controlled trial we investigated the effects of oxytocin on prosocial behavior during a virtual ball-tossing game called Cyberball. We examined the influence of oxytocin on prosocial helping behavior toward a socially excluded person who was known to the participant, taking into account early caregiving experiences and the emotional facial expression of the excluded person as potential moderators. Participants were 54 women who received a nasal spray containing either 16 IU of oxytocin or a placebo and had reported how often their mother used love withdrawal as a disciplinary strategy involving withholding love and affection after a failure or misbehavior. We found that participants compensated for other players' ostracism by throwing the ball more often toward the excluded player. Oxytocin administration further increased the number of ball throws toward the excluded person, but only in individuals who experienced low levels of maternal love withdrawal. The facial expression of the excluded person did not affect prosocial helping behavior and did not moderate the effects of oxytocin. Our findings indicate that the positive effects of oxytocin on prosocial behavior toward a victim of social exclusion are limited to individuals with supportive family backgrounds.

INTRODUCTION

Ostracism, the exclusion of an individual by other group members, induces strong negative emotions. Several studies have examined the effects of being ostracized with a virtual ball-tossing game called Cyberball (Williams & Jarvis, 2006). Being excluded during Cyberball results in lower levels of feelings of belonging, control, and meaningful existence (Eisenberger & Lieberman, 2004; Eisenberger, Lieberman, & Williams, 2003; Gonsalkorale & Williams, 2007; Zadro, Williams, & Richardson, 2004), and emotional responses such as aggression (Chen, DeWall, Poon, & Chen., 2012), anger (Chow, Tiedens, & Govan, 2008), and jealousy (Harmon-Jones, Peterson, & Harris, 2009). In addition, exclusion during Cyberball has been associated with activation of a neural pain network consisting of brain regions involved in bodily injury as well as social pain (Eisenberger, Jarcho, Lieberman, & Naliboff, 2006).

Although many studies used Cyberball to study the effects of being excluded, few studies investigated the way individuals respond when they observe someone else being excluded. Observing someone being ostracized during Cyberball confronts the participant with a dilemma: he or she can help the excluded person by throwing the ball more often to the victim, or he or she can go along with the crowd and also exclude the victim (Williams & Jarvis, 2006). The latter might be the safest option, because helping an excluded person participants is facing the risk of being excluded yourself. Beoney, Franklin, Levy, and Adams (2011) found that the neural pain network involved in social pain is similarly activated when participants see someone else suffering social rejection during Cyberball or when they suffer exclusion themselves, especially when they know the ostracized person. Observing someone else being ostracized however also activates brain regions involved in empathy (Masten, Eisenberger, Pfeifer, & Dapretto, 2010). Masten, Morelli and Eisenberger (2011) showed that activation in empathy-related brain regions was associated with later prosocial behavior toward the victim, indicating that individuals who feel more empathy for a person in distress will make greater efforts to help the victim. However, their study focused on subsequent prosocial behavior, operationalized as sending prosocial emails to the victim, and it is not yet known whether individuals show prosocial helping behavior toward the victim *during* social exclusion.

A number of studies have shown that prosocial behavior is enhanced by the neuropeptide oxytocin (Insel, 2010; Van IJzendoorn & Bakermans-Kranenburg, 2012). Oxytocin is involved in mother-infant bonding, sensitive parenting, and the perception of infant signals (Feldman, Gordon, Schneiderman, Weisman, & Zagoory-Sharon, 2010; Riem et al., 2011; Riem, Pieper, Out, Bakermans-Kranenburg, & Van IJzendoorn, 2011). Studies have shown that intranasal administration of oxytocin promotes a range of social behaviors, including trust (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005), in-group altruism (De Dreu et al., 2010), empathy (Bartz, Zaki, Bolger, et al., 2010) and sensitivity to infant signals (Naber, Van IJzendoorn, Deschamps, Van Engeland, & Bakermans-Kranenburg, 2010; Riem et al., 2012). In addition, it has been shown that intranasal oxytocin influences social behavior during the Cyberball game in individuals

with autism (Andari et al., 2010). Participants played the ball-tossing game with three fictitious players with different cooperative profiles (good, bad, neutral). After oxytocin administration, participants with autism responded more strongly to the most socially cooperative partner, indicating that oxytocin enhanced their ability to process socially relevant cues.

However, oxytocin might not enhance social behavior similarly for all people. Contextual and individual differences seem to moderate oxytocin effects on social behavior and cognition (Bartz, Zaki, Bolger, & Ochsner, 2011; Van IJzendoorn, Huffmeijer, Alink, Bakermans-Kranenburg, & Tops, 2011; Bakermans-Kranenburg, Van IJzendoorn, Riem, Tops, & Alink, 2012). Bartz, Zaki, Ochsner, et al. (2010) found that effects of oxytocin administration on childhood memories were moderated by participants' attachment representations. Less anxious individuals remembered their mother as more caring and close after oxytocin (vs. placebo) administration, whereas more anxiously attached individuals remembered their relationship with their mother in a more negative light in the oxytocin (vs. placebo) condition. Furthermore, De Dreu et al. (2010) found that intranasal oxytocin enhanced in-group altruism, but at the same time increased defensive reactions toward out-group members. Thus, oxytocin may drive a 'tend and defend' response.

Others studies found that the beneficial effects of oxytocin on prosocial behavior are moderated by harsh caregiving experiences. Intranasal oxytocin decreased the use of excessive handgrip force in response to infant crying, but only in individuals with supportive family backgrounds (Bakermans-Kranenburg et al., 2012). Similarly, Van IJzendoorn et al. (2011) found that oxytocin administration increased participants' willingness to donate money to a charity, but only in participants who experienced low levels of parental love withdrawal, a parental disciplinary strategy that involves withholding love and affection when a child misbehaves or fails at a task. Moreover, effects of oxytocin on complex brain networks involved in self-referential processing and affectionate touch were moderated by experiences of maternal love withdrawal, indicating that unsupportive caregiving experiences also suppress the effects of oxytocin at the neural level (Riem et al., in press). Love withdrawal is considered psychological maltreatment when used excessively (Euser, Van IJzendoorn, Prinzie, & Bakermans-Kranenburg, 2010) and has been related to high concern over mistakes, low emotional well-being and feelings of rejection and resentment toward the parents (Elliot & Thrash, 2004; Goldstein & Heaven, 2000; Renk, McKinney, Klein, & Oliveros, 2006). These negative emotions may hinder empathic responses and prosocial helping behaviors toward victims of social exclusion.

To our knowledge, this is the first randomized-controlled trial investigating the effects of oxytocin administration on prosocial behavior during Cyberball. Whereas previous studies used Cyberball to study the effects of being socially excluded, we are the first to examine individuals' responses when they see someone else being excluded. We examined the influence of oxytocin on prosocial helping behavior toward an excluded person who was known to the participant, namely the experimenter. In addition, we examined whether the effects of oxytocin were

dependent on maternal use of love withdrawal and on the facial expression of the excluded experimenter. We expected that oxytocin administration would increase the number of ball throws to the excluded experimenter, but only in individuals who experienced low levels of maternal love withdrawal. Furthermore, as sad facial expressions might elicit more empathic feelings compared with neutral facial expressions, we expected larger increases in the number of ball throws to the excluded experimenter when she showed a sad facial expression compared to the excluded experimenter with a neutral facial expression.

METHOD

Participants

A total of 343 female undergraduate students from the departments of education and child studies, and psychology at Leiden University participated in the first phase of the study. In this phase, the participants completed online questionnaires on their perception of parenting by their mothers, and some demographic details. One participant was excluded due to random responses. Five females with children of their own were also excluded. One hundred eighty six students participated in the second phase of the study, which was designed to examine behavioral and physiological responding to infant crying. Fifty participants with scores ranging from low to high on a questionnaire on parenting were selected to participate in the third phase of the study, consisting of an fMRI study and the Cyberball task. Participants were randomly assigned to the oxytocin or the placebo condition. Four additional participants were selected because of problems with fMRI data acquisition, resulting in a total sample size of 54 participants for the current study (28 participants in the oxytocin condition and 26 participants in the placebo condition). Participants were screened for MRI contraindications, psychiatric or neurological disorders, hearing problems, pregnancy, and alcohol and drug abuse. The mean age of the participants was 19.63 years ($SD = 1.43$, range 18-27). The majority (72.2 %) used oral contraceptives. Permission for this study was obtained from the Ethics Committees of the Institute of Education and Child Studies of Leiden University and of the Leiden University Medical Center. The results of the fMRI study will be reported elsewhere.

Procedure

Participants were invited for Cyberball preferably in the luteal phase of their menstrual cycle in order to control for influences of menstrual cycle. During the luteal phase, plasma oxytocin levels are lower (Salonia et al, 2005) and more responsive to stimulation such as by nipple stimulation (Leake et al, 1984). Therefore, effects of oxytocin nasal administration might be more pronounced during the luteal phase. Approximately 90 min before the start of the Cyberball task participants took 6 puffs of nasal spray containing of oxytocin (16 IU total) or 6 puffs of a placebo-spray under supervision of the experimenter. Salivary oxytocin levels have been shown to remain strongly elevated in a stable way up to at least 2¼ after administration of nasal spray containing 16 IU of oxytocin (Huffmeijer et al., 2012) and effects of 16 IU of oxytocin on social behavior and

neural activity have been reported in previous studies (Bakermans-Kranenburg et al., 2012; Riem et al., 2011; Riem et al., 2012). Drug administration was double-blind. Participants were led to believe that they were playing an online ball-toss game called Cyberball (Williams & Jarvis, 2006) with the experimenter who gave instructions during the first part of the lab session (the fMRI study) and two other unknown female individuals. After fMRI data acquisition participants were told by the experimenter that they were going to play a game over the internet and they were introduced to a second experimenter who set up the Cyberball task. The participants were told that the experimenter and the two other players were playing the game in other rooms.

The Cyberball task

The Cyberball game was an adapted version of the task that was used in the study by Crowley, Wu Molfese, and Mayes (2010). The participants' glove was at the bottom of the screen. The gloves, pictures, and names of the unknown players were to the left and right of the screen center, and the glove, name, and picture of the experimenter with a neutral or sad expression were at the upper part of the screen, see Figure 1. The experimenter was a 27-year-old female, similar to the average participant and the two other players and the same person for all participants. The experimenter was selected as the known person in order to control for differences in familiarity of the known person among participants. Participants were instructed to throw the ball to the other players using the keyboard. The game consisted of three blocks of 48 trials each. The first block was a fair situation in which all players received one fourth of the throws. In the second and third block, the experimenter was excluded from the game and did not receive any throws from the two unknown players. In the third block, the facial expression of the excluded experimenter changed from neutral to sad in the sad condition, but it did not change in the neutral condition. The sad facial expression did not change when the participant threw the ball to the ostracized experimenter. Participants played the entire game (fair play block, unfair play block 1, unfair play block 2) twice: once with the experimenter with a neutral expression and once with the experimenter with a sad expression. There was a short break between the sad and the neutral condition and the order of neutral and sad conditions was counterbalanced across participants. There were small differences in the total number of total throws of the participants. Therefore, we calculated the ratio of throws of the participant to the experimenter by dividing the number of throws of the participant to the experimenter by the total number of throws by the participant to any of the players. A ratio larger than .33 in the unfair play block indicates that participants compensate for the other players' ostracism by throwing the ball more often to the excluded experimenter. Ratios were calculated for each play block. We calculated ratios for the sad and neutral condition separately as well as the ratio of ball throws to the known player in the sad and neutral condition together, independent of emotion. One of our questions was whether the effect of oxytocin on prosocial behavior depended on facial expression of the excluded player, which did not change before the third block. Therefore, unfair play block 1 was excluded from the analysis on the

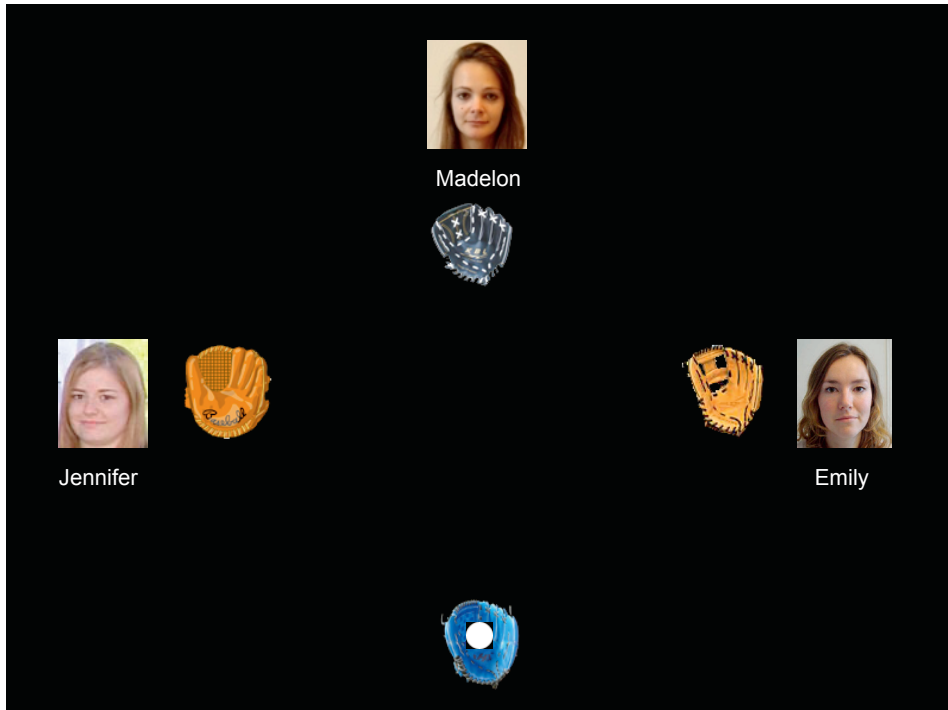


Figure 1. Set-up Cyberball task in the neutral condition. The participants' glove was at the bottom of the screen. The gloves, pictures and names of the unknown players were to the left and right of the screen center. The glove, name and picture of the experimenter with a neutral or sad expression were at the upper part of the screen.

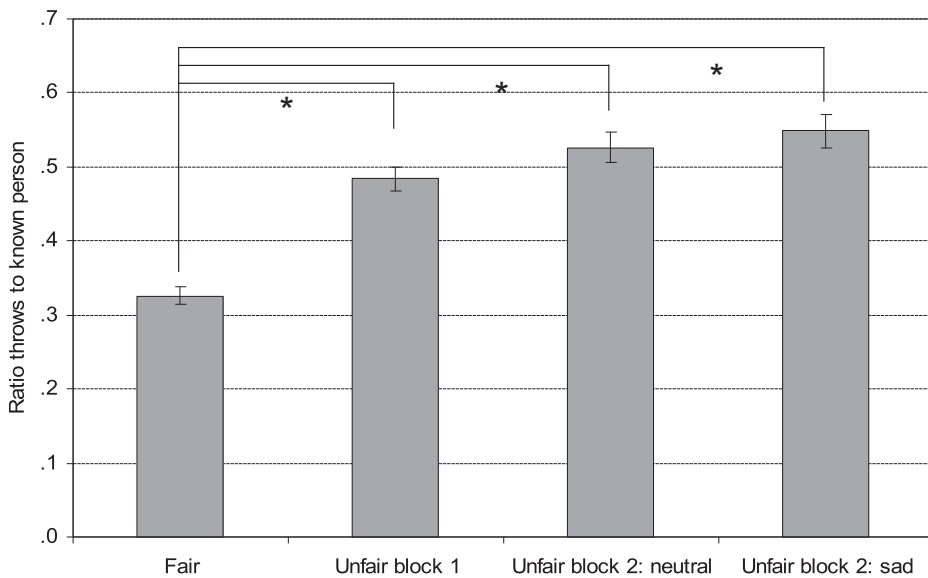


Figure 2. Ratio of throws (*M*, *SE*) to the known player in the fair play block, unfair play block 1, and unfair play block 2 with the neutral and the sad experimenter. * $p < .001$

effects of oxytocin on prosocial responding to the excluded experimenter with a sad or neutral expression.

Maternal love withdrawal

The questionnaire on maternal use of love withdrawal contained 8 items of the Withdrawal of Relations subscale of the Children's Report of Parental Behavior Inventory (CRPBI; Beyers and Goossens, 2003; Schludermann and Schludermann, 1983). Because it is in particular the use of *maternal* love withdrawal that has been related to low emotional well-being in adolescence and adulthood (Elliot & Thrash, 2004; Renk, McKinney, Klein, & Oliveros, 2006), we focused on maternal caregiving only. The questionnaire was completed online during the first phase of the study. Participants rated how well each of the 8 statements described their mother (e.g., "My mother is a person who, when I disappoint her, tells me how sad I make her") on a 5-point scale ranging from 1 (not at all) to 5 (very well). The average item score on the love withdrawal questionnaire was 1.68 ($SD = 0.77$). The scores did not differ for participants in the oxytocin or placebo condition, $t(52) = -0.36, p = 0.72$. Love withdrawal was dichotomized into low versus high love withdrawal using a median split (median = 1.40). In the placebo group, 12 participants reported low levels of love withdrawal and 14 participants reported high levels of love withdrawal. In the oxytocin group, 15 participants reported low levels of love withdrawal and 13 participants reported high levels of love withdrawal.

RESULTS

To examine whether participants compensated for the other players' ostracism by throwing the ball more often to the excluded player, a repeated measures analysis was performed with the ratio of ball throws to the known player as dependent variable and play block (fair play blocks, unfair play block 1, unfair play block 2 with neutral experimenter, unfair play block 2 with sad experimenter) as within-subject variable. There was a significant effect of play block on throws to the experimenter ($F(2.54, 134.60) = 50.70, p < .001$). Contrasts indicated that participants threw the ball more often to the excluded experimenter in unfair play block 1 ($F(1, 53) = 89.54, p < .001$) compared with the fair play block. In addition, participants threw the ball significantly more often to both the neutral and sad experimenter in the unfair play block 2 compared with the fair play block (neutral: $F(1, 53) = 98.33, p < .001$; sad: $F(1, 53) = 97.80, p < .001$) (see Figure 2). There was no significant difference between the neutral and sad condition in the unfair play block 2 ($F(1, 53) = 0.86, p = .36$).

In order to examine the effects of love withdrawal on prosocial helping behavior under natural circumstances, a repeated-measures analysis was conducted with ratio of ball throws to the known player as dependent variable, emotion (excluded experimenter with neutral *versus* sad facial expression) as within-subject variable and love withdrawal (low *versus* high) as between-subject factor for participants in the placebo group. Participants with high levels of love withdrawal tended to be more prosocial than participants with low levels of

love withdrawal, but the difference was not significant ($F(1,24) = 3.53, p = .07$). Furthermore, there was no significant difference between ratio throws to the excluded experimenter with a neutral and sad facial expression ($F(1,24) = 0.79, p = .38$) and no significant interaction between love withdrawal and facial expression ($F(1,24) = 0.11, p = .75$).

In order to examine oxytocin effects during the Cyberball task on prosocial behavior depending on emotional expression and love withdrawal we conducted a repeated-measures analysis with the ratio of ball throws to the known player in the unfair condition as dependent variable, emotion (neutral, sad) as within-subject factor and nasal spray group (oxytocin, placebo) and love withdrawal group (low versus high love withdrawal) as between-subject factors. There were no significant main effects of emotion ($F(1,50) = 0.81, p = .37$), nasal spray group ($F(1,50) = 0.56, p = .46$) and love withdrawal group ($F(1,50) = 0.00, p = .97$). Neither were there significant interactions between emotion and nasal spray group ($F(1,50) = 0.05, p = .83$) or between emotion and love withdrawal group ($F(1,50) = 0.10, p = .76$). However, there was a significant interaction between nasal spray and love withdrawal ($F(1,50) = 6.78, p = .01$, partial $\eta^2 = .12$). The interaction between nasal spray and love withdrawal was also significant when the fair condition was included in the repeated measures analysis as the first measurement of the within subject factor play block (fair play blocks, unfair play block with neutral experimenter, unfair play block with sad experimenter) ($F(1,50) = 4.52, p = .04$, partial $\eta^2 = .08$). Including order of emotion condition (neutral experimenter in first round or sad experimenter in first round) as covariate did not change the significance of the interaction between love withdrawal and nasal spray group ($F(1,49) = 6.59, p = .01$, partial $\eta^2 = .12$) and there was no main effect of order ($F(1,49) = 0.47, p = .50$). In addition, a hierarchical regression analysis was conducted with ratio of throws as outcome measure, nasal spray group and continuous scores on love withdrawal (centered) in the first step and the interaction between nasal spray and love withdrawal in the second step. The model was not significant ($F(3,50) = 2.00, p = 0.13$) and there were no significant effects of nasal spray group ($\beta = -0.10, p = 0.46$) and love withdrawal ($\beta = -0.00, p = 0.99$). However, the effects of oxytocin were significantly moderated by love withdrawal ($\beta = 0.31, p = 0.03$); and this was also the case when love withdrawal was dichotomized into a low love withdrawal group consisting of the 60% lowest scores versus a high love withdrawal group consisting of the 40% highest scores ($F(1,50) = 5.27, p = .026$, partial $\eta^2 = .10$), showing the robustness of the interaction effect. Participants threw the ball more often to the excluded player when they were administered oxytocin, but only when they had experienced low levels of love withdrawal. To examine the group differences in mean ratio of ball throws to the excluded player (sad and neutral together) we created four groups: participants reporting high versus low love withdrawal in the oxytocin group and participants reporting high versus low love withdrawal in the placebo group. A one-way ANOVA with planned contrasts showed that oxytocin significantly increased the number of ball throws in participants with low love withdrawal scores, $t(50) = 2.36, p = .02$, but oxytocin did not have a significant effect for participants reporting high love withdrawal, $t(50) = -1.32, p = .19$ (see Figure 3).

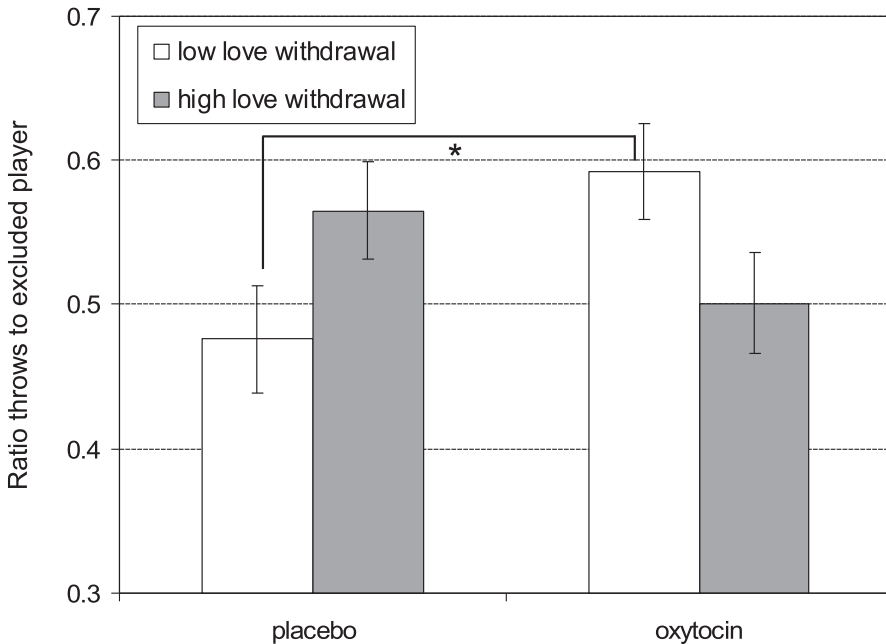


Figure 3. Ratio of throws (M , SE) to the excluded player for participants reporting low and high love withdrawal in the placebo and oxytocin group. * $p < .05$

DISCUSSION

In the current study, we examined the influence of intranasal oxytocin administration on prosocial helping behaviors during social exclusion of a player in Cyberball. This study is the first to demonstrate that participants compensate for other players' ostracism by passing the ball more often toward an excluded player who is known to the participant, indicating that individuals show prosocial helping behavior toward a victim of the social exclusion. In addition, we found that oxytocin further increased the number of ball throws toward the excluded person, but only in individuals who experienced a supportive rearing environment. Our findings indicate that the positive effects of oxytocin on prosocial helping behavior are moderated by adverse caregiving experiences. This is in line with previous studies showing that oxytocin does not enhance prosocial behavior in all people under all circumstances (Bakermans-Kranenburg et al., 2012; Bartz et al., 2011; Van IJzendoorn et al., 2011).

What processes might underlie the positive effects of oxytocin on prosocial helping behaviors toward a socially excluded person? As oxytocin has been shown to enhance empathy (Bartz, Zaki, Bolger, et al., 2010) and mentalizing (Domes, Heinrichs, Michel, Berger, & Herpertz, 2007), one way in which it may enhance prosocial helping behavior in individuals with supportive family background is by increasing empathic feelings and the understanding of the emotions felt by the excluded victim. This is consistent with previous research showing that

oxytocin enhances the ability to process socially relevant cues during Cyberball in participants with autism (Andari et al., 2010). Oxytocin may promote the efficient processing of information in empathy-related and social pain-related brain networks involved in seeing someone else being ostracized (Beeney et al., 2011; Masten, Morelli, & Eisenberger, 2011), resulting in more efforts to help the victim.

However, according to Carter (1998), oxytocin promotes social affiliation not only by enhancing social approach-related behavior but also by reducing feelings of anxiety and fear of novelty, which is supported by studies showing that oxytocin has anxiolytic properties (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003). These anxiolytic effects may be mediated by the inhibitory influence of oxytocin on the amygdala (Gamer, Zurowski, & Buchel, 2010; Kirsch et al., 2005; Riem et al., 2011), a brain region involved in fear processing (MacLean, 1990). Helping a victim of social exclusion can be risky and may elicit anxious feelings since individuals who help an ostracized person face the risk of being excluded themselves (Kanetsuna & Smith, 2002; Latane & Nida, 1981). Therefore, another process explaining our findings may be that oxytocin decreases anxious feelings and thus increases participants' willingness to accept social risks, which is in line with studies showing that oxytocin increases trust among humans (Kosfeld et al., 2005), even when trust has been breached (Baumgartner, Heinrichs, Vonlanthen, Fischbacher, & Fehr, 2008).

In our study, the effects of oxytocin were hindered but not altered in individuals who experienced high levels of maternal love withdrawal, as opposed to studies showing negative effects of oxytocin in some conditions (Bartz, Zaki, Ochsner, et al., 2010; De Dreu et al., 2010). Our findings are in line with previous research showing that in individuals with harsh caregiving experiences the beneficiary oxytocin effects are absent at the behavioral (Bakermans-Kranenburg et al., 2012) as well as at the neural level (Riem et al., in press). Fries, Ziegler, Kurian, Jacoris, and Pollak (2005) showed that children who experienced early adversity did not show a change in oxytocin levels after physical contact with their mother, whereas oxytocin levels were increased in children who were reared in a supportive family. Another study showed that subjects who experienced early parental separation exhibited attenuated cortisol decreases after intranasal oxytocin administration (versus placebo) compared with control subjects without early separation experiences (Meinlschmidt & Heim, 2007). Furthermore, Heim et al. (2009) found that women who were exposed to child abuse or neglect showed lower oxytocin concentrations in cerebrospinal fluid. Early adversity may lead to a dysregulation of the oxytocinergic system, possibly by influencing the level of methylation in genetic areas regulating the oxytocinergic system (McGowan et al., 2009; Van IJzendoorn, Caspers, Bakermans-Kranenburg, Beach, & Philibert, 2010), which might lead to lower oxytocin levels and a decreased sensitivity to intranasal oxytocin.

In contrast to our expectations, the emotional expression of the excluded person did not have a significant effect on prosocial helping behavior. Thus, additional information about the feelings of a socially excluded person does not lead to enhanced helping behavior, possibly because observers already feel the pain of

the victim even if the victim shows a neutral facial expression. Neither were the effects of oxytocin on prosocial behavior moderated by the facial expression of the victim. This latter finding is consistent with previous studies showing that the effects of oxytocin on perception of facial expressions are independent of valence. For example, Domes, Heinrichs, Glascher, et al. (2007) found that oxytocin reduces amygdala activation during exposure to happy, fearful and angry facial expressions, with no significant effect of valence (but see Domes et al., 2010). The authors reasoned that decreased amygdala activation during exposure to both positive and negative stimuli might reflect reduced arousal and ambiguity about the predictive value of social stimuli in general (Hsu, Bhatt, Adolphs, Tranel, & Camerer, 2005). This might motivate the individual to initiate approach behavior in order to encounter the social stimulus. In addition, Hurlemann et al. (2010) found that oxytocin increased emotional empathy in response to both positive and negative social stimuli. Thus, our finding that the effects of oxytocin on prosocial helping behaviors were not moderated by the facial expression of the excluded person seems to converge with previous work demonstrating that valence does not strongly affect oxytocin induced changes in empathic feelings and negative emotional arousal.

Some limitations should be noted. First, the use of a between-subject design implies the risk of pre-existing differences between the placebo and oxytocin group. Randomization and double-blind application have decreased this risk substantially. The use of self-reported maternal love withdrawal is another limitation of our study, and interview assessments or observations of experiences with the parents might yield more valid data. In addition, effects of oxytocin administration on prosocial helping behavior might be different in males and women with children. The results of the current study can only be generalized to women without children. Furthermore, further research is needed to specify the effects of oxytocin on prosocial helping behaviors. Neuro-imaging studies may shed more light on the mechanism underlying oxytocin effects, and may clarify whether oxytocin enhances prosocial behaviors such as social helping by increasing empathy and emotion understanding, by decreasing anxious feelings, or by both processes. Lastly, we found that individuals reporting higher levels of love withdrawal tended to be more prosocial in the placebo condition compared with individuals with low levels of love withdrawal. This trend is in contrast with our expectation that love withdrawal would hinder empathic concerns for others. Alternatively, participants with high levels of love withdrawal experienced negative consequences after misbehaving or failing at a task during childhood. Therefore, they might have thrown the ball more often to the experimenter in order to avoid disapproval by the experimenter. It should be noted, however, that this association was not significant and thus should not be taken for granted before being replicated.

The current study is the first to show that oxytocin increases prosocial helping behavior toward an ostracized individual who is known to the participant. Previous studies focused on prosocial behavior toward strangers (e.g. Van IJzendoorn et al., 2011, Kosfeld et al., 2005). Familiarity might facilitate understanding of the mental state of a person and influence the way the brain responds when

observing that person being socially excluded (Beeney et al., 2011). Moreover, a known person might be considered to be an in-group member, whereas an unknown person might be perceived as an out-group member. The effects of oxytocin tend to be dependent on this in-group *versus* out-group distinction (De Dreu et al, 2010; but see Van IJzendoorn and Bakermans-Kranenburg, 2012). It has been suggested that oxytocin up-regulates behavioral expressions of concern for others more strongly if the other belongs to the in-group (De Dreu, 2012). Thus, it still is unclear whether oxytocin also increases prosocial helping behavior toward an excluded unknown person.

In sum, this study is the first randomized-controlled trial investigating the effects of oxytocin on prosocial helping behavior toward an excluded person during Cyberball. Whereas previous studies used Cyberball to study the effects of being ostracized, our study is the first to examine how individuals respond when they see someone else being ostracized. We found that oxytocin increased prosocial helping behavior toward the excluded person, possibly because of enhanced empathic feelings and understanding of the emotions of the victim and an increased willingness to take social risks. However, the oxytocin induced increases in prosocial helping behavior were only brought about in individuals with supportive family backgrounds. Our findings indicate that the positive effects of oxytocin on social behavior are moderated by early caregiving experiences and provide support for the suggestion that early social adversity can lead to decreased sensitivity to intranasal oxytocin, possibly through methylation of genetic areas regulating the oxytocinergic system.