

# Interactive Effects Between Extraversion and Oxytocin Administration: Implications for Positive Social Processes

Social Psychological and  
Personality Science  
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sagepub.com/journalsPermissions.nav  
DOI: 10.1177/1948550616644964  
spps.sagepub.com



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## Abstract

Intranasal administration of the neuropeptide oxytocin (OT) appears to have positive social consequences, but these effects are often highly context- and person-specific. The present research examined whether the core personality trait of extraversion may be one important person-specific factor that plays a role in these associations. Across two double-blind randomized placebo-controlled studies (total *ns*: Study 1 = 121; Study 2 = 112), we observed significant interactions between OT administration and extraversion predicting prosocial outcomes. For individuals low in extraversion, OT administration relative to placebo led to greater perceived social connection and prosocial tendencies (Study 1) and more positive behavioral responses to help and greater trust of an interaction partner (Study 2). In contrast, OT administration was not beneficial for individuals high in extraversion. Overall, these findings contribute to growing evidence that OT administration has complex, person-specific effects on social behavior, indicating that extraversion plays an important role in these associations.

## Keywords

oxytocin administration, extraversion, social outcomes, prosocial behavior

The hypothalamic neuropeptide oxytocin (OT) is argued to play an important role in social bonding and affiliation (Bartz & Hollander, 2006; Taylor et al., 2000), in turn facilitating positive social behavior. For example, OT administration has been linked to greater trust (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005; Mikolajczak, Gross, et al., 2010; Mikolajczak, Pinon, Lane, de Timary, & Luminet, 2010), generosity (Riem, Bakermans-Kranenburg, Huffmeijer, & van Ijzendoorn, 2013; van Ijzendoorn, Huffmeijer, Alink, & Bakermans-Kranenburg, 2011; Zak, Stanton, & Ahmadi, 2007), and positive social perceptions (Cardoso, Orlando, Brown, & Ellenbogen, 2014; Di Simplicio, Massey-Chase, Cowen, & Harmer, 2009; Marsh, Yu, Pine, & Blair, 2010; Unkelbach, Guastella, & Forgas, 2008). Yet, the relationship between OT and social behavior is rarely straightforward, with OT administration sometimes demonstrating no effect on prosocial behavior (e.g., Baumgartner, Heinrichs, Vonlanthen, Fischbacher, & Fehr, 2008; Conlisk, 2011; Klackl, Pfundmair, Agroskin, & Jonas, 2013; see Nave, Camerer, & McCullough, 2015, for critical review) or even having negative effects (e.g., Bartz, Simeon, et al., 2011; De Dreu et al., 2010; Shamay-Tsoory et al., 2009). This may be due in part to the highly context-specific and person-specific effects of OT administration (Bakermans-Kranenburg & van Ijzendoorn, 2013; Bartz, Zaki, Bolger, & Ochsner, 2011; Guastella & MacLeod, 2012; van Ijzendoorn & Bakermans-Kranenburg, 2012).

One factor that may help to explain the apparently inconsistent effects of OT administration is affiliative motivation, a tendency to desire, approach, and foster social bonds and attachments. Specifically, OT administration may be selectively beneficial for those who are lower in social engagement or affiliative tendencies (see Bartz & Hollander, 2006; Bartz, Zaki, et al., 2011, for reviews). For example, OT administration has social benefits for those higher in avoidant attachment (Bartz et al., 2015; De Dreu, 2012) and on the autism spectrum (Bartz et al., 2010; Domes, Heinrichs, Michel, Berger, & Herpertz, 2007; Guastella et al., 2010). Thus, underlying levels of affiliative motivations may play a key role in determining whether OT administration is beneficial for social processes. One central trait that is linked to affiliative motivations and that has not yet been explored in the context of OT administration is the personality trait extraversion.

Extraversion involves greater sociability, dominance, excitement seeking, and positive affect. Underlying these

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somewhat distinct features of extraversion appears to be a heightened reward sensitivity and motivation toward pleasant stimuli (Lucas, Diener, Grob, Suh, & Shao, 2000), which may engender greater social engagement and affiliative motivations (Costa & MacCrae, 1992; Depue & Collins, 1999; Watson & Clark, 1997). In turn, extraversion relates to positive social behavior and outcomes (see Ozer & Benet-Martinez, 2006, for review). For example, high levels of extraversion predict greater prosocial behavior, such as helpfulness (Penner, 2002) and volunteerism (Carlo, Okun, Knight, & de Guzman, 2005), and positive social outcomes, such as social support (Berkman, Glass, Brissette, & Seeman, 2000), acceptance (Anderson, John, Keltner, & Kring, 2001), and relationship satisfaction (Watson, Hubbard, & Wiese, 2000).

Given links with affiliative motivations and positive social outcomes, extraversion is therefore a key person-specific characteristic that may influence the associations between OT administration and social processes. In particular, if lower extraversion is related to lower affiliative motivations, then OT administration is likely to be more beneficial for individuals low in extraversion. Indeed, OT administration can enhance self-perceptions of extraversion and affiliation-relevant traits, such as warmth, trust, altruism (Cardoso, Ellenbogen, & Linnen, 2012), and communion (Bartz et al., 2015). Increases in affiliative motivations are in turn likely to carry positive social consequences for those lower in extraversion—even though individuals lower in extraversion tend to experience fewer social interactions, they benefit from them to a similar extent as those high in extraversion (Lucas, Le, & Dyrenforth, 2008). In contrast, if individuals high in extraversion already experience high affiliative motivations, then OT administration is less likely to be socially beneficial.

To test these possibilities, we examined data from two randomized, double-blind, placebo-controlled studies where participants reported their levels of extraversion and received a single dose of intranasal OT (40 IU) or a placebo, prior to the assessment of several positive social outcomes. In Study 1, positive social outcomes included perceived social connection to others in general and prosocial tendencies toward several charitable organizations. Study 2 examined actual social behavior toward an interaction partner, including positive behavior in response to receiving help and interpersonal trust. We predicted that while OT administration may promote positive social consequences for those lower in extraversion, it would be less socially beneficial for those higher in extraversion.

## Method

### Participants and Design

The data for the current studies come from two larger studies that involved additional manipulations and measures; details and additional analyses are provided in the Supplemental Online Materials (SOM) and other manuscripts (Human, Thorson, Woolley, & Mendes, 2015; Human, Woolley, & Mendes, 2015). Both studies share a similar general paradigm, and

therefore, the methods and results are presented together. In both studies, participants between the ages of 18 and 35 who spoke English as their first language were recruited from the San Francisco/Bay Area community. Prior to scheduling a lab appointment, participants were prescreened and excluded if they were pregnant, lactating, or self-reported poor mental or physical health. Once scheduled, participants were sent a personality questionnaire to complete online prior to their lab visit. Sample size was determined a priori based on published between-subjects studies examining interactive effects of OT and individual differences, which typically report between 60–80 participants (e.g., De Dreu, 2012). Because there is reason to believe that past studies were underpowered (Cohen, 1962; Vankov, Bowers, & Munafo, 2014), we aimed to collect larger samples of roughly 120 participants per study, in an effort to balance power and cost/feasibility concerns (studies were run sequentially over 2 years each). For Study 1, a total of 121 participants completed the online questionnaire as well as the lab visit (64 female, 57 male;  $M_{age} = 25.01$ ,  $SD_{age} = 4.01$ ); for Study 2, a total of 112 participants completed the online questionnaire as well as the lab visit (67 female, 45 male;  $M_{age} = 24.27$ ,  $SD_{age} = 3.62$ ). No cases with full data were excluded, but there were additional missing data on the individual social outcome measures; sample sizes for each analysis are reported below.

### Procedure

**Personality assessment.** Prior to arrival at the lab, participants rated their personality traits in an online survey. Extraversion was assessed on the extraversion subscale of the Big Five Mini Markers (Saucier, 1994), which includes the following items: bashful (reversed), bold, energetic, extraverted, quiet (reversed), shy (reversed), talkative, and withdrawn (reversed; Study 1:  $M = 5.67$ ,  $SD = 1.35$ ,  $\alpha = .83$ ; Study 2:  $M = 5.82$ ,  $SD = 1.46$ ,  $\alpha = .89$ ). Each item was rated on a 1 (*extremely inaccurate*)–9 (*extremely accurate*) scale.<sup>1</sup>

**Arrival and nasal spray administration.** Upon arrival at the lab, participants were given a brief overview of the procedure, and a trained experimenter obtained informed consent. The experimenter then confirmed a negative test for pregnancy for all female participants via a urine sample. Participants were randomly assigned to the placebo versus OT administration condition and were instructed how to administer the nasal spray. The spray bottles were indistinguishable other than a colored dot on the bottom of the bottle; no one who interacted with the participants knew which color indicated OT/placebo. The spray contained either 40 IU of OT (Syntocinon spray, Novartis, Switzerland) or a placebo (same compounds as Syntocinon minus OT). In line with recommendations by Guastella et al. (2013), participants utilized a metered multidose pump spray bottle, with each spray containing no more than 100  $\mu\text{L}$  and alternated nostrils until the bottle was empty (approximately 3 puffs per nostril). Participants self-administered the spray in the presence of an MD-trained research assistant.

Intranasal administration has been shown to lead to significant increases in cerebrospinal fluid OT levels in humans as measured by lumbar puncture (Striepens et al., 2013), although it was only detectable 75 min after administration, and there is controversy surrounding the nature and the mechanisms of the effects of OT administration on the brain (Leng & Ludwig, 2016). Other experimental work with intranasal OT in humans has consistently utilized an absorption period ranging between 40 and 50 min (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003; Kosfeld et al., 2005; Shamay-Tsoory et al., 2009); we therefore assessed social outcomes at least 40 min postadministration. During the waiting period, participants watched a neutral video about hiking the Appalachian Trail.

### Social Outcomes: Study 1

**Social connection.** A total of 117 participants (placebo = 57; OT = 60) completed a measure assessing how close participants felt to others with the Inclusion of Other in Self scale (Aron, Aron, & Smollan, 1992). In this version, participants selected a single picture that best described the closeness of two groups, “me” and “other people,” on a 1 (*complete separation*)–7 (*almost complete overlap*) scale ( $M = 4.12$ ;  $SD = 1.45$ ).

**Prosocial tendencies.** A total of 114 participants (placebo = 56; OT = 58) completed a measure assessing prosocial tendencies with a questionnaire we developed and pilot tested prior to the study, which assessed participants’ support for a variety of organizations seeking help. Participants were told:

As part of the UC system, many research labs at UCSF partner with local charities. Every week, UCSF receives information about charities interested in finding volunteers. On the computer screen, you’ll be able to learn about organizations currently seeking help, and then UCSF would like you to indicate your interest in helping them by clicking your answer choice.

Participants were told their contact information would not be shared with the organizations but that their responses would be useful to nonprofit groups as they try to gauge the public’s interest in their missions.

Participants then viewed one of two sets of three organizations (versions were equated in pilot testing). In each set, one organization was depicted as helping the environment (e.g., help in picking up trash or coordinating recycling drives), one as helping animals (e.g., assistance for care with abandoned animals or ending animal testing), and, the key category of interest, one as helping people (e.g., seeking tutors or mentors for young children). Each description was paired with a relevant image (see Supplemental Appendix online). All effects held controlling for version.

For each organization, participants responded to the following questions on a 1 (*not at all*)–9 (*very*) scale: “How interested are you in helping this organization,” “How important is it to you that this organization is funded by state and federal taxes,” and “How important is this organization to you?” Responses

were combined together to assess overall support for each organization (environment:  $M = 6.49$ ,  $SD = 1.85$ ,  $\alpha = .86$ ; animals:  $M = 6.18$ ,  $SD = 2.20$ ,  $\alpha = .89$ ; children:  $M = 7.02$ ,  $SD = 1.78$ ,  $\alpha = .87$ ). Given that OT administration and extraversion are arguably most relevant to prosociality, our primary outcome was support for the organization involving children, which was most directly social in nature, while support for animals and the environment was examined to determine the specificity of effects.

Support for each organization type was highly correlated ( $r_s = .54$ – $.60$ , all  $p_s < .001$ ). Perceived social connection was not significantly correlated with prosocial tendencies toward children ( $r = .11$ ,  $p = .23$ ) or animals ( $r = .10$ ,  $p = .30$ ) but was with support for environmental causes ( $r = .20$ ,  $p = .04$ ).

### Social Outcomes: Study 2

**Positive behavior.** Study 2 extended Study 1 by examining actual social behaviors with another person. Specifically, participants were exposed to a help manipulation, derived from DeSteno and colleagues (Bartlett & DeSteno, 2006; DeSteno, Bartlett, Baumann, Williams, & Dickens, 2010). In our version of this paradigm, participants engaged in three trials of a tedious computer task. Right at the end of the third trial, the computer ostensibly crashed. Participants were led to believe that they would therefore have to redo the task from the start. However, the computer was then “fixed” (in one condition by a technician who gives instructions to the experimenter and in another by a confederate—a research assistant that the participant believed was another participant, who was of the same gender and roughly the same age and ethnicity), providing the opportunity to assess participant social behavior in response to receiving help from another person. The provider of help (technician/experimenter vs. confederate) did not impact the results presented here (see SOM for additional information on this manipulation and other aspects of this study); as such, we examined social behavior in response to help on average across help provider conditions.

Specifically, the computer crash and subsequent fix were video-recorded, and three observers (trained research assistants), unaware of OT condition and not involved in data collection, coded participants’ social behaviors in response to help. Video-recording of this interaction was included partway through data collection ( $n = 69$ ), and two of these participants did not complete the extraversion measure, resulting in 67 videos available for analyses (placebo = 37; OT = 30). Observers rated participant affective and social behavior on a 1 (*not at all*)–5 (*a great deal*) scale on the following items: grateful ( $M = 2.22$ ;  $SD = 1.27$ ), happy ( $M = 2.51$ ;  $SD = 1.32$ ), amused ( $M = 1.29$ ;  $SD = .62$ ), and friendly ( $M = 3.20$ ;  $SD = 1.05$ ). Roughly 20% of the video clips were double-coded ( $n = 20$ ) and intraclass correlation coefficients were acceptable ( $M = .76$ ). These ratings were combined together to form an overall composite indicator of positive behavioral responses to help ( $M = 2.30$ ;  $SD = .86$ ;  $\alpha = .79$ ).

**Trust task.** Participants then engaged in two cooperative tasks with the confederate (see SOM for details). These tasks involved the ability to earn money for correct responses. At the end of the tasks, the participant and the confederate were brought into different rooms, and participants were informed that they and the confederate each earned USD\$11 for their performance. Participants were then presented with a “common goods” task designed to assess interpersonal trust. Specifically, participants were told that both they and the confederate would separately decide how much of the USD\$11 they would like to put in a common pot (they were not able to communicate with one another about this task). They were told that the total amount placed in the pot by the participant and partner would be multiplied by 1.5 and the total pot would be divided equally between the participant and the confederate. Participants were provided with a list of all possible payouts that could occur based on the participant’s and confederate’s contributions in order to ensure understanding of possible task outcomes. Variations in this task are used extensively to measure trust because the more a participant puts in the pot, the more they can earn, but only if their partner also puts a large amount in the common pot; if not, they stand to earn less than the original amount. Thus, sharing a large amount of money requires trust that one’s partner will do the same.

A total of 110 participants (placebo = 58; OT = 52) provided both extraversion and trust task data. On average, participants tended to place the majority of the money in the shared pot ( $M = 9.34$ ;  $SD = 2.78$ ); indeed, 77 (68%) participants shared the full amount, making this variable negatively skewed ( $skew = -1.44$ ). We therefore log-transformed the reflected variable and then returned it to its original direction of scoring so that higher values represent placing more money in the common pot. Positive behavior in response to help and interpersonal trust were not significantly correlated ( $r = .10$ ,  $p = .43$ ).

## Results

The effects of extraversion and OT administration were examined with a series of regressions with OT administration (0 = placebo; 1 = OT administration), extraversion (centered), and their interaction as predictors of each social outcome (see Table 1). There were no main effects of OT administration on the social outcomes examined here (all  $ps > .17$ ), but there were main effects of extraversion on social connection and trust (all  $ps < .05$ ). However, these main effects were qualified by significant interactions with OT administration, described below.

### Study 1

#### Social Connection

We observed a significant interaction between OT administration and extraversion predicting ratings of social connection,  $b = -.41$ ,  $t(113) = -2.19$ ,  $p = .03$ . Specifically, within the placebo condition, extraversion was associated with significantly greater social connection to other people in general,  $b = .57$ ,  $\beta = .52$ , 95% CI [.28, .77],  $t(113) = 4.21$ ,  $p < .001$ . However,

extraversion and social connection were not significantly related among participants who received OT administration,  $b = .15$ ,  $\beta = .14$ , 95% CI [-.10, .39],  $t(113) = 1.18$ ,  $p = .24$  (see Figure 1).

To further understand the nature of this interaction, we examined the effect of OT administration for those who reported low (1 SD below the mean) and high (1 SD above the mean) levels of extraversion. For individuals low in extraversion, receiving OT administration was associated with marginally greater levels of perceived social connection relative to those who received placebo,  $b = .60$ ,  $d = .41$ , 95% CI [.04, .77],  $t(113) = 1.65$ ,  $p = .10$ . In contrast, for those high in extraversion, receiving OT administration was not significantly associated with social connection relative to those who received placebo,  $b = -.51$ ,  $d = -.35$ , 95% CI [-.71, .02],  $t(113) = -1.46$ ,  $p = .15$ .

#### Prosocial Tendencies

We next examined interactive effects on support for charitable organizations, examining each type of organization separately to examine the specificity of the effects.<sup>2</sup> Looking first at organizations supporting children, we again observed a significant interaction between OT/placebo and extraversion predicting charitable support,  $b = -.76$ ,  $t(110) = -2.96$ ,  $p = .004$ . Similar to the pattern with social connection, in the placebo condition, greater extraversion was associated with greater support for children organizations,  $b = .44$ ,  $\beta = .34$ , 95% CI [.07, .61],  $t(110) = 2.46$ ,  $p = .02$ . However, in the OT administration condition, greater extraversion was associated with marginally lower support for children organizations,  $b = -.32$ ,  $\beta = -.25$ , 95% CI [-.52, .03],  $t(110) = -1.74$ ,  $p = .09$  (see Figure 2).

Examining the effects at high versus low levels of extraversion revealed that, for those low in extraversion, OT administration was associated with significantly greater support for these organizations, relative to those who received placebo,  $b = 1.53$ ,  $d = .87$ , 95% CI [.48, 1.25],  $t(110) = 3.12$ ,  $p = .002$ . In contrast, for those high in extraversion, OT administration was not significantly associated with support for these organizations relative to placebo,  $b = -.52$ ,  $d = -.30$ , 95% CI [-.66, .07],  $t(110) = -1.14$ ,  $p = .26$ .

Of note, although there was a significant main effect of extraversion predicting greater support for animal organizations,  $b = .51$ ,  $\beta = .69$ , 95% CI [.09, 1.29],  $t(110) = 2.28$ ,  $p = .02$ , we did not observe significant interactions between extraversion and OT administration predicting support for animal organizations,  $b = -.43$ ,  $t(110) = -1.33$ ,  $p = .19$ , or environmental organizations,  $b = -.02$ ,  $t(110) = -.09$ ,  $p = .93$ .

### Study 2

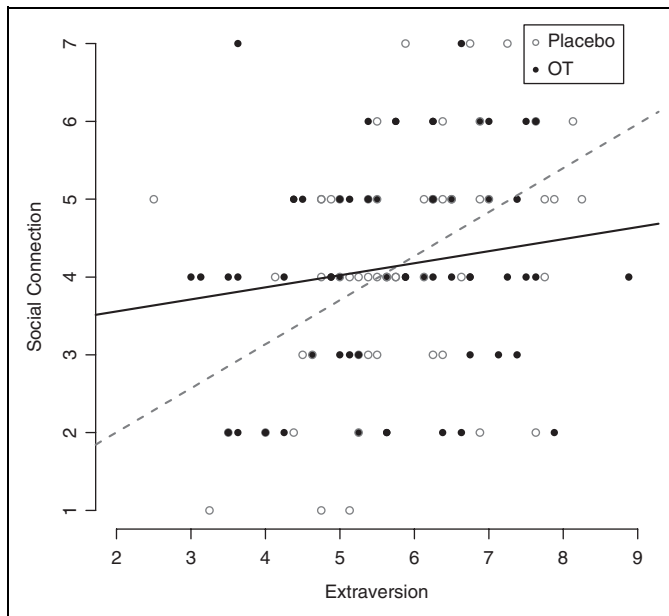
#### Positive Responses to Help

We next examined effects on positive social behavior in response to receiving help. As above, we observed a significant interaction between extraversion and OT administration,

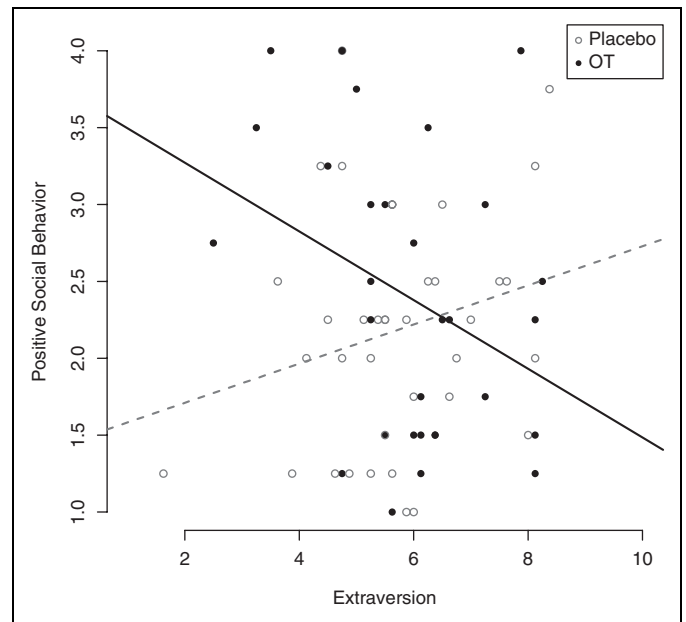
**Table 1.** Full Regression Models With Extraversion, Oxytocin Condition, and Their Interaction Predicting Each Social Outcome.

Predictor	Extraversion				OT condition				Interaction			
	b (SE)	$\beta$	95% CI [Upper, Lower]	t	b (SE)	$\beta$	95% CI [Upper, Lower]	t	b (SE)	$\beta$	95% CI [Upper, Lower]	t
<b>Study 1</b>												
Social Connection	.57 (.13)	.52***	[.28, .77]	4.21	.04 (.25)	.03	[-.31, .37]	.17	-.41 (.19)	-.38*	[-.73, -.04]	-2.19
Volunteer												
Children	.44 (.18)	.34*	[.07, .61]	2.46	.50 (.32)	.29	[-.07, .65]	1.56	-.76 (.26)	-.59**	[-.97, -.19]	-2.96
Animals	.51 (.23)	.31*	[.04, .59]	2.28	.35 (.41)	.16	[-.21, .53]	1.47	-.43 (.32)	-.26	[-.65, .13]	-1.33
Environment	.20 (.19)	.14	[-.13, .42]	1.03	.51 (.35)	.28	[-.09, .65]	1.48	-.02 (.27)	-.02	[-.41, .38]	-.09
<b>Study 2</b>												
Response to help	.13 (.10)	.21	[-.11, .54]	1.31	.21 (.20)	.27	[-.20, .28]	1.06	-.35 (.14)	-.59*	[-1.06, -.11]	-2.45
Trust	.02 (.07)	.03	[-.21, .26]	.23	.15 (.16)	.19	[-.18, .55]	.98	-.30 (.11)	-.51**	[-.88, .14]	-2.75

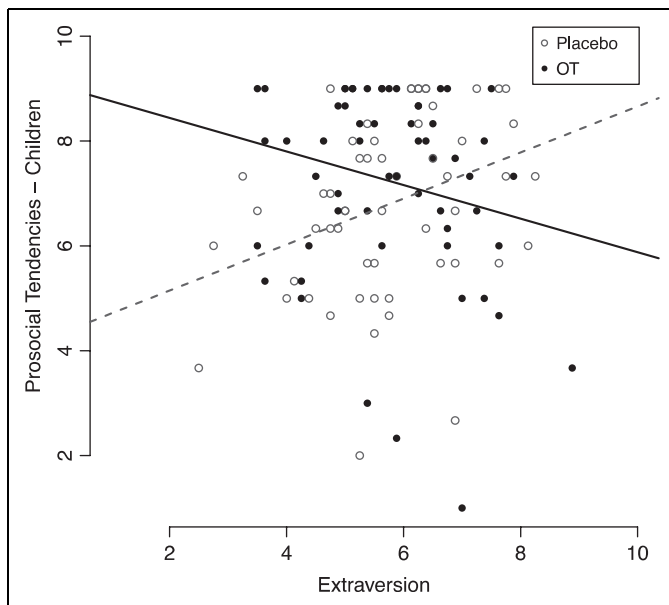
Note. OT condition scored such that 0 = placebo and 1 = oxytocin. OT = oxytocin.  
 \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .



**Figure 1.** Relationship between trait levels of extraversion and social connection (inclusion of others in self) as a function of oxytocin versus placebo administration.



**Figure 3.** Relationship between trait levels of extraversion and positive social behavior as a function of oxytocin versus placebo administration.



**Figure 2.** Relationship between trait levels of extraversion and support for organizations involving children as a function of oxytocin versus placebo administration.

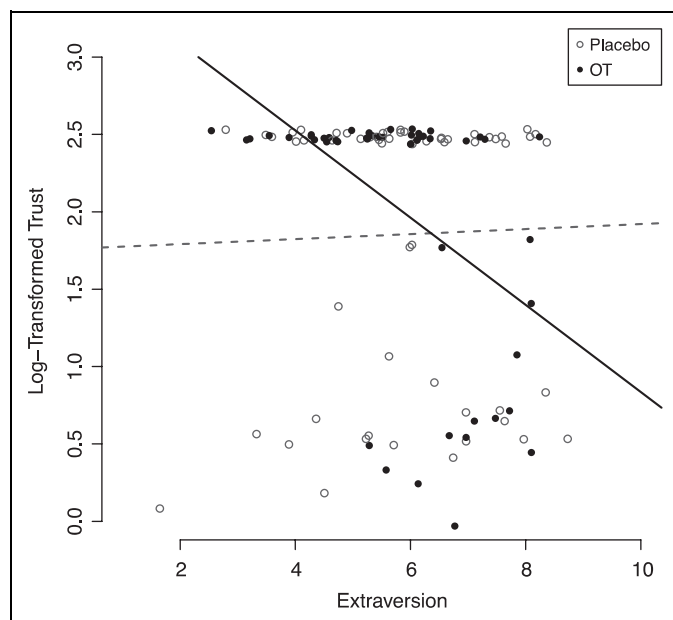
$b = -.35$ ,  $t(63) = -2.45$ ,  $p = .02$ . In the placebo condition, extraversion was not significantly associated with more positive behavioral responses to help,  $b = .13$ ,  $\beta = .21$ , 95% CI  $[-.11, .54]$ ,  $t(63) = 1.31$ ,  $p = .19$ . However, in the OT administration condition, extraversion was significantly *negatively* associated with positive responses to help,  $b = -.22$ ,  $\beta = -.37$ , 95% CI  $[-.72, -.02]$ ,  $t(63) = -2.12$ ,  $p = .04$  (see Figure 3).

Examining the effect for individuals low and high in extraversion demonstrated that OT administration was associated with significantly more positive social behavior in response to receiving help for those low in extraversion,  $b = .72$ ,  $d = .83$ , 95% CI  $[.32, 1.33]$ ,  $t(63) = 2.50$ ,  $p = .02$ , but not for those high in extraversion,  $b = -.30$ ,  $d = -.34$ , 95% CI  $[-.82, .15]$ ,  $t(63) = -1.01$ ,  $p = .31$ .

### Trust

Finally, we examined the interactive effects on trust toward a social interaction partner (the confederate), indexed by the amount of money put in the common pot, log-transformed. Once again, we observed a significant interaction,  $b = -.30$ ,  $t(106) = -2.75$ ,  $p = .007$ . In the placebo condition, extraversion was not significantly associated with greater trust,  $b = .02$ ,  $\beta = .03$ , 95% CI  $[-.21, .26]$ ,  $t(106) = .23$ ,  $p = .82$ . However, in the OT administration condition, greater extraversion was associated with significantly lower trust,  $b = -.28$ ,  $\beta = -.48$ , 95% CI  $[-.77, -.20]$ ,  $t(106) = -3.38$ ,  $p = .001$  (see Figure 4).

Examining this effect as a function of low versus high extraversion revealed that receiving OT administration versus placebo was associated with exhibiting significantly greater trust for those low in extraversion,  $b = .59$ ,  $d = .69$ , 95% CI  $[.31, 1.08]$ ,  $z = 2.66$ ,  $p = .009$ . In contrast, for those high in extraversion, OT administration versus placebo was not significantly associated with trust,  $b = -.28$ ,  $d = -.33$ , 95% CI  $[-.71, .05]$ ,  $z = -1.25$ ,  $p = .21$ . Thus, for individuals low in extraversion, receiving OT administration enhanced the likelihood of putting more money in the common pot, indicating greater trust that their partner would do the same.



**Figure 4.** Relationship between trait levels of extraversion and trust as a function of oxytocin versus placebo administration. Data are slightly jittered (randomly perturbed) to minimize overplotting.

## General Discussion

Although OT is argued to have the potential to benefit social behavior, its effects tend to be highly context-specific and person-specific (Bakermans-Kranenburg & van Ijzendoorn, 2013; Bartz, Zaki, et al., 2011; Guastella & MacLeod, 2012; van Ijzendoorn & Bakermans-Kranenburg, 2012). The current studies contribute to this literature by demonstrating that a core personality trait, extraversion, plays a role in these associations. Specifically, across two studies with a total of 233 participants, OT administration relative to placebo had selectively beneficial effects for individuals lower in extraversion. These effects were found across four conceptually related yet distinct social outcomes, including greater social connection, prosocial tendencies, positive behavioral responses to help, and interpersonal trust. In contrast, OT administration had less social benefit for individuals high in extraversion.

The finding that OT administration was related to greater positive social experiences is consistent with a large body of prior work demonstrating social benefits of OT administration for processes such as trust (Kosfield et al., 2005; Mikolajczak, Gross, et al., 2010; Mikolajczak, Pinon, et al., 2010), generosity (Riem et al., 2013; van Ijzendoorn et al., 2011; Zak et al., 2007), and positive social perceptions (Cardoso, Orlando, et al., 2014; Di Simplicio et al., 2009; Marsh et al., 2010; Unkelbach et al., 2008). Yet these findings also contribute to the growing recognition that the effects of OT administration are nuanced and often selectively beneficial, in this case for those lower levels in extraversion. Indeed, we did not observe any significant main effects of OT on social outcomes. Given the benefits of prosocial behavior and positive social experiences for well-being and health (e.g., Deci, La Guardia, Moller,

Scheiner, & Ryan, 2006; Hawley & Cacioppo, 2010; Thomas, 2010), acute increases in OT may therefore be beneficial for individuals who are less extraverted.

One reason that OT administration may selectively benefit social outcomes for those lower in extraversion may be via enhanced affiliative motivations (Bartz & Hollander, 2006; Bartz, Zaki, et al., 2011). That is, OT administration may have boosted affiliative motivations for those lower in extraversion, making them more likely to view the world and behave in ways that would foster social bonds—to generalized others in Study 1 and specific interaction partners in Study 2. This is consistent with findings that those higher in avoidant attachment (Bartz et al., 2015; De Dreu, 2012) or on the autism spectrum (Bartz et al., 2010) demonstrate greater social benefit from OT administration than those lower on these dimensions—effects that also may be driven, at least partly, by affiliative motivations. Although affiliative motivations and attachment style were not directly assessed in the current studies, taken together, these findings lend support to affiliation as a key mechanistic process that underlies a range of person-specific effects of OT administration. Indeed, extraversion and avoidant attachment style are inversely related (Carver, 1997), making it possible these effects are driven by the same underlying mechanism. Additional research directly examining how these broader person-specific characteristics relate to one another and to the proposed mechanistic process of affiliation, ideally within the same studies and with large samples, is needed.

It is also plausible that OT administration enhanced positive social perceptions and behavior for those low in extraversion because of the more general anxiety-reducing effects of OT administration (Churchland & Winkielman, 2012; Neumann, 2008; Uvnäs-Moberg, 1998), which may have dampened anxieties about one's existing relationships or possible future behaviors in Study 1 and the immediate social interactions in Study 2. However, our finding that OT administration enhanced prosocial tendencies for explicitly social causes, rather than those supporting animals and the environment, suggests a social specificity more consistent with an affiliation explanation. Understanding the mechanisms underlying these effects is critical, as this will shed light both on the complex role of OT administration in social processes and on the psychological and neurobiological underpinnings of extraversion.

In contrast to the positive effects of OT administration for those low in extraversion, OT administration had less benefit for individuals high in extraversion. It is possible, however, that OT administration is socially beneficial for those higher in extraversion but that there were ceiling effects making it difficult to detect increases. However, if any effect of OT administration was detected for those higher in extraversion, it actually appeared to be negative: For three of the four outcomes, the association between extraversion and positive social processes was marginally or significantly negative in the OT administration condition. That is, while in the placebo condition extraversion was either positively or not significantly related to positive social processes, within the OT administration condition, higher extraversion was actually associated with

less positive social processes than lower extraversion. These findings are in line with other evidence that OT administration can have negative consequences for individuals who may be higher in affiliative motivations or social engagement. For example, there are indications that OT administration can decrease perceived cooperation and trust for those low in avoidant attachment (De Dreu, 2012). Further, OT administration has been shown to hinder social perception accuracy for normative individuals, arguably by pushing such individuals past beneficial levels of social sensitivity to a more detrimental point (Cardoso, Ellenbogen, & Linnen, 2014). Similarly, then, perhaps OT administration may push individuals who are already high in affiliative tendencies, such as extraverts, past beneficial levels of affiliation, resulting in less positive social responses. Such an argument is in line with other indications that it may be possible for levels of social engagement or affiliation to increase beyond an optimal level, resulting in negative outcomes for relationships and well-being (e.g., Clark & Lemay, 2010; Kogan, Gruber, Shallcross, Ford, & Mauss, 2013; Kogan et al., 2014). It will be important for future research to continue to examine the potential downsides of OT administration for individuals high in affiliation and/or social engagement.

## Conclusion

Collectively, these findings contribute to the growing recognition that effects of OT administration on social behavior are highly person-specific, highlighting the importance of a core personality trait: extraversion. Specifically, a single dose of OT helped to increase positive social outcomes for those low in extraversion, whereas there were indications that OT administration may have negative social consequences for those higher in extraversion. This is consistent with emerging evidence that OT administration may be selectively beneficial for those lower in affiliation, indicating that affiliative motivations may be a key mechanism linking the apparently inconsistent effects of OT administration on social outcomes. Additional research is needed to replicate these effects, ideally with larger samples and at different dosages of OT (Cardoso, Ellenbogen, Orlando, Bacon, & Joober, 2013; Cardoso, Orlando et al., 2014) and to directly examine the potential underlying mechanisms. In sum, these findings suggest that OT administration may selectively benefit those lower in extraversion, facilitating more positive social experiences and behaviors.

## Acknowledgments

We are grateful to our dedicated research assistants at the University of California, San Francisco (UCSF) for their assistance in collecting these data and to Jennifer Bartz for helpful feedback on an earlier version of this manuscript.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The research was supported in part by Lauren J. Human's Social Sciences and Humanities Research Council Postdoctoral Fellowship and a Greater Good Science Center grant to Wendy Berry Mendes.

## Notes

1. Participants also rated themselves on the other Big 5 personality traits, but these traits were generally not associated with the social outcomes examined here, nor did they interact with OT administration (see Supplemental Online Materials).
2. Note that the three-way interaction between extraversion, OT administration, and type of organization predicting support was significant,  $b = .37$ ,  $t(111) = 2.65$ ,  $p = .009$ , indicating that the interactive effects between OT administration and extraversion did differ across organization types.

## Supplemental Material

The online supplements are available at <http://spp.sagepub.com/supplemental>

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