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OT promotes closer interpersonal distance among highly empathic individuals

Anat Perry,[1] **David Mankuta,**[2] **and Simone G. Shamay-Tsoory**[1]
[1]Psychology Department, University of Haifa, Mount Carmel, Haifa, 3498838, Israel and [2]Obstetrics and Gynecology Department, Hadassah Hebrew University Hospital, Jerusalem, 91120, Israel

The space between people, or 'interpersonal distance', creates and defines the dynamics of social interactions and is a salient cue signaling responsiveness and feeling comfortable. This distance is implicit yet clearly felt, especially if someone stands closer or farther away than expected. Increasing evidence suggests that Oxytocin (OT) serves as a social hormone in humans, and that one of its roles may be to alter the perceptual salience of social cues. Considering that empathic ability may shape the way individuals process social stimuli, we predicted that OT will differentially affect preferred interpersonal distance depending on individual differences in empathy. Participants took part in two interpersonal distance experiments: In the first, they had to stop a (computer visualized) protagonist when feeling most comfortable; in the second, they were asked to choose the room in which they would later discuss intimate topics with another. Both experiments revealed an interaction between the effect of OT and empathy level. Among highly empathic individuals, OT promoted the choice of closer interpersonal distances. Yet, OT had an opposite effect on individuals with low empathic traits. We conclude that the enhancement of social cues following OT administration may have opposite effects on individuals with different empathic abilities.

Keywords: oxytocin; interpersonal distance; social distance; empathy

INTRODUCTION

The space between people, known as 'interpersonal distance', creates and defines the dynamics of social interactions and is a salient cue signaling responsiveness and feeling comfortable (Meisels and Guardo, 1969; Birtchnell, 1996; Roberts, 1997; Feeney, 1999; Lloyd, 2009). Although interpersonal distance differs from one culture to another, within each culture this distance is implicit but clearly felt, especially if someone stands closer or farther away than expected. Once an individual's interpersonal space has been encroached, the person may feel threatened, emphasizing the important influence of emotional and motivational factors on the use of space between people (Horowitz *et al.*, 1964; Lloyd, 2009). The use of social space by both animals and humans is an inherent feature of social interactions and can be empirically mapped using measures of proximity and observation. Hall (1966) introduced four zones of spatial distance that coincide with other forms of interpersonal behavior: intimate distance, used between lovers or close family members, where all senses are involved but vision is limited; personal distance, used in everyday social interactions with (familiar or unfamiliar) others, where the individual can see, touch and hear but usually cannot smell the other person; social distance, used in more formal interactions with others (eye gaze, loud voice and body movements are often present); and finally, public distance, which is the distance kept from public figures (e.g. a lecturer), where a loud voice and body movements are often present.

In specific cultural and social situations, however, personality traits and interpersonal differences may also affect the distance a given individual prefers to maintain between himself and others. Recent research has shown that levels of social anxiety are correlated with preferred interpersonal distance, such that individuals with greater social anxiety traits prefer to stay further away from others (Scheele *et al.*, 2012; Perry *et al.*, 2013). This phenomenon has implications for daily social interactions, as two people standing far away from one another are unlikely to disclose personal information (because it could be heard by others) or to gaze steadily into each other's eyes (due to the large visual angle). At the other extreme, soft whispers and subtle emotional cues are possible only when people are physically close to one another (Hall, 1963; Hall, 1966; Kaitz *et al.*, 2004). Not surprisingly, levels of friendship and attraction have been found to correlate with interpersonal distance (Sundstrom and Altman, 1976).

Interestingly, the amygdala has been suggested as playing an important role in interpersonal distance regulation. Research has shown that lesions to the amygdala dramatically reduce the need for interpersonal distance, and that amygdala activity in healthy individuals is correlated with feeling uncomfortable at a close interpersonal distance (Kennedy *et al.*, 2009). Importantly, the activity of amygdala sub-regions has been shown to be modulated by the neuropeptide oxytocin (OT; Gamer *et al.*, 2010; Hurlemann *et al.*, 2010), indicating that OT is a candidate hormone for modulating interpersonal distance.

OT has been suggested as playing an essential role in the regulation of social behavior and social cognition in animals and in humans (see Meyer-Lindenberg *et al.*, 2011; Van IJzendoorn and Bakermans-Kranenburg, 2012 for reviews), often facilitating pro-social and approach behaviors (Kemp and Guastella, 2011; Striepens *et al.*, 2011). Yet OT does not always promote approach behaviors, and has been shown to be dependent both on context and on individual differences. For example, in some contexts OT has been shown to promote risk aversion (Declerck *et al.*, 2010), envy (Shamay-Tsoory *et al.*, 2009) and lack of cooperation with perceived out-group members (De Dreu *et al.*, 2010). In a recent study, Scheele *et al.* (2012) reported that administration of OT increased the preferred interpersonal distance between the self and an attractive woman, but only among men in a monogamous relationship and in the physical presence of female but not male experimenters. OT had no effect on single men participants and no effect in promoting 'closer' interpersonal distance. The social salience hypothesis, a recent leading hypotheses about the mechanism underlying the social effects of OT, has attempted to explain these conflicting reports by suggesting that OT alters the perceptual salience and/or the

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Correspondence should be addressed to Anat Perry, Psychology Department, University of Haifa, Mount Carmel, Haifa, 3498838, Israel. Currently at UC Berkeley. E-mail: anat.perry@berkeley.edu

processing of social cues (Shamay-Tsoory *et al.*, 2009; Bartz *et al.*, 2011). Support for this hypothesis also comes from neuroimaging studies. Some of these studies reveal differential activation in amygdala regions following OT administration while participating in social compared with non-social tasks (Kirsch *et al.*, 2005; Domes *et al.*, 2007), and others reveal enhanced Electroencephalography mu/alpha and beta suppression in response to biological *vs* non-biological motion following OT administration (Perry *et al.*, 2010).

Thus, according to the social salience hypothesis, if OT increases attention to social cues, it should have widely varying effects on downstream cognition and behavior, depending on the interpersonal context (such as in the presence of an attractive women for men in a relationship), as well as on how an individual perceives social situations and tends to react in different interpersonal settings. For example, one person may find a social setting comforting and enjoyable, whereas another may find it intimidating or threatening. Social saliency may therefore have opposite consequences for different individuals.

One of the most prominent features affecting our social behavior is the feeling of empathy (Davis *et al.*, 1999; Kaukiainen *et al.*, 1999; Findlay *et al.*, 2006). Empathy is broadly defined as the way in which one individual reacts to the observed experiences of another (Davis, 1983). Davis defined empathy as a complex measure of interpersonal reactivity consisting of four different measures: perspective taking, empathic concern, personal distress and fantasy abilities. Although these four dimensions are very different in content, each fits the general definition of empathy as a reaction to the observed experiences of others, whether by adopting the perspective of others, feeling concern or distress for them or imagining what it feels like to be in their shoes. Remarkably, individual differences in empathy have been shown to affect the way people recognize facial expressions (Besel and Yuille, 2010) and react emotionally to social cues (Eisenberg and Miller, 1987), suggesting that empathic abilities may shape the way we process social cues.

With the social salience hypothesis in mind, we predicted that controlling for empathic traits, or reactivity to others, would reveal the effect of OT on interpersonal distance. We predicted that highly empathic individuals would prefer closer distances following OT administration, whereas less empathic individuals would show an opposite effect and prefer to maintain greater distances.

In the following two experiments, we examined whether OT has a differential effect on preferred interpersonal distance depending on the individual's initial empathy traits. We used two different interpersonal paradigms. The first measured interpersonal distance preferences in an approach–avoidance context. In this paradigm, known as the comfortable interpersonal distance paradigm (CID; Duke and Nowicki, 1972), a protagonist approaches the participant who is standing in a computer visualized room, and the participant is asked to indicate where he would like the protagonist to stop. This is a widely used validated paradigm (Little, 1965; Duke and Kiebach, 1974), which has been previously tested on different sex and age groups (e.g. Duke *et al.*, 1974; Tennis and Dabbs, 1975), and modulated using different protagonists (Nechamkin *et al.*, 2003). The second experiment measures interpersonal distance preferences in the context of intimacy. In this experiment, participants are asked to choose which of several computer visualized rooms they would later prefer to sit in to discuss intimate topics with another participant. This is an original paradigm, previously tested in our lab (in preparation) and shown to significantly predict CID scores (see Results). We hypothesized that the enhancement of social cues following OT administration would promote closeness among participants who are highly empathic, but might have an opposite effect on those with low empathic traits.

MATERIALS AND METHODS

Participants

Fifty-four male participants took part in the study. All were undergraduate students at the University of Haifa, ranging in age from 19 to 32 (mean age 25.29, s.d. = 2.74). They participated in the experiment in exchange for course credit or payment. Five of the participants were left-handed. All participants reported normal or corrected-to-normal visual acuity and had no history of psychiatric or neurological disorders (confirmed by a screening interview). Because of our a priori predictions regarding differential effects for individuals with high and low empathy, the participants were divided into those with high and low Interpersonal Reactivity Index (IRI) scores, as determined by half a standard deviation from the mean IRI (36.25, s.d. = 7.7). This created two groups: High Interpersonal Reactivity (high empathy, IRI $\geq$ 40, n = 20; mean age = 23.9, s.d. = 2.5) and Low Interpersonal Reactivity (low empathy, IRI $\leq$ 33, n = 20; mean age = 25.9, s.d. = 3.0). Written consent was obtained, and ethical approval was provided by The Hadassah Medical Center's Ethics Committee, as well as the Ethics Committee of the University of Haifa.

Stimuli task and design

OT administration

Participants were invited to come twice, 1 week apart, on the same day and time. Each participant signed an informed consent form. During each appointment, each participant was randomly administered either a solution of 24 international units in 250 ml of intranasal (IN) OT (Sigma) or a sterile saline solution for the placebo treatment (the same salt solution in which the hormone was dissolved but without the hormone itself). Both solutions were self-administered in the presence of the experimenter by means of IN drops applied with a medicine dropper, three drops to each nostril. Neither the experimenter nor the participant knew whether the participant had received the OT or the placebo. No significant physical, local or systemic side effects were observed in either the OT or the placebo group.

Assessment of empathy

After the solution was administered during their first appointment, participants were asked to complete an online questionnaire: the IRI (Davis, 1983), a 28-item self-report measure consisting of four 7-item subscales, each tapping a different aspect of the global concept of empathy, broadly defined as a measure of reactivity to others.

After completing the questionnaire, each participant was asked to wait until 45 min had elapsed since the time of administration to ensure that the OT levels in the central nervous system had reached a plateau (Illum, 2000). During this waiting period, participants sat in a comfortable quiet room and were given three issues of a popular Israeli nature magazine in order to keep any social interaction to a minimum. After the 45 min had elapsed, participants began the experiments. The order of the experiments was counterbalanced among the participants.

Experiment 1: CID

The stimuli used were a modified version of a paper-and-pencil validated measure of CID (Duke and Nowicki, 1972; Duke and Kiebach, 1974). In the original version, a circle was presented and participants were instructed to imagine themselves in the center of the room and to respond to an imaginary protagonist approaching them along a particular radius by making a mark on the radius indicating where they would want the person to stop. Preferred interpersonal distance as measured by this projective technique was found to be highly correlated with physical distance in actual real-life interactions (Duke and Kiebach, 1974; as well as current validation in our lab, unpublished).

In this study, we transformed the test into a computerized animated version, and extended the options for the protagonists entering the room to include a close friend, a stranger, an authority figure (boss or teacher) and a rolling ball (see also Perry *et al.*, 2013 for a similar design). Each participant was shown the name of the approaching figure (stranger, friend, authority, or ball) for 1 s, followed by a fixation point for 0.5 s. After that the participant was shown a still picture of a circular room with a figure at the center and an approaching figure at one of the eight entrances (1 s), followed by a 3 s animation showing this figure approaching the center of the circle. Participants were instructed to imagine themselves at the center of the room and to respond to the figure approaching them along a particular radius by pressing the spacebar indicating when they would like the person to stop. The animation stopped after 3 s when the two figures collided, or before that at the point the participant pressed the spacebar (Figure 1). Each of the four figures appeared three times from each of the eight radii, resulting in 24 trials for each figure and 96 trials in total. Responses were computed as the percentage of the remaining distance from the total distance, where 0 represented the approaching figure reaching the inner figure and 100 represented the approaching figure being stopped immediately.

In accordance with the social salience hypothesis, we predicted that OT would promote the choice of closer distances among highly empathic individuals and the choice of farther distances for less empathic individuals. In addition, we predicted that OT would have a differential effect depending upon the protagonist. That is, it might promote closeness only with known figures (friend and authority) but not with ball or stranger, or it might promote closeness only with human figures, but not with a ball.

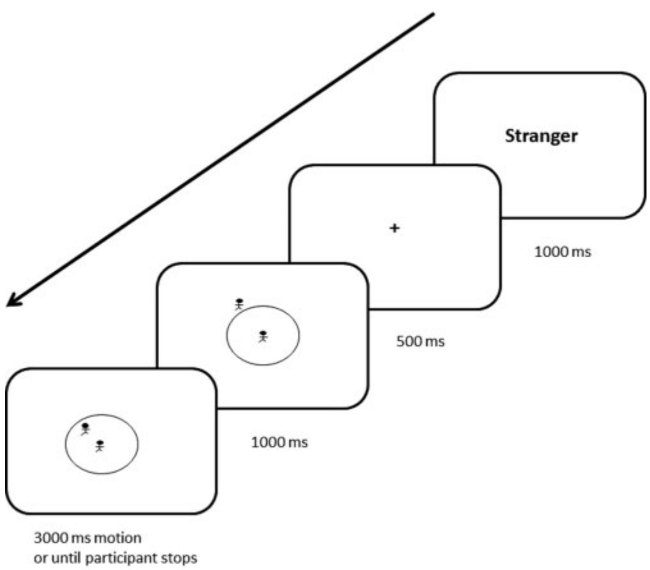

Fig. 1 The CID experimental design: The name of the approaching figure appeared for 1 s (stranger, friend, authority, or ball), followed by a fixation point for 0.5 s, a still picture (1 s) of the circular room with a figure at the center and the approaching figure at one of the eight entrances, followed by a 3 s animation in which this figure approaches the center of the circle. Participants were instructed to imagine themselves at the center of the room and to respond to the figure approaching along a particular radius by pressing the spacebar to indicate where they would like the figure to stop.

Experiment 2: choosing rooms

In Experiment 2, participants were told that after participating in two runs of the experiment (OT and placebo), they would be asked to sit in a room with another participant and discuss personal topics, to be given to them at the time of interaction. During the experiment, they would be shown pairs of very similar rooms and for each trial would have to choose which room they preferred. They were further told that at the end of the 2 weeks of experiments, the computer would calculate an average room based on their preferences and that the personal conversation would be held in a room designed according to these preferences. In reality, no such stage of discussing personal topics took place. At the end of the 2 weeks, the participants were informed of the purpose of the study.

The stimuli used were colored pictures depicting rooms very similar to each other. Each had two identical chairs in the middle, a table on one side, a plant on the other, a closet, a lamp and a clock. The rooms were created using Google Sketchup tools (http://sketchup.google.com/) that make it possible to model a room using real distances. In each trial, the participant was shown two rooms simultaneously. The two rooms differed on one of the following parameters: the distance between the chairs (distances varied from 20 to 140 cm, in intervals of 20 cm), the distance between the table and the plant (distances varied from 200 to 320 cm, in intervals of 20 cm), the angles of the chairs' positions [0° (both facing forward), 45° each, 90° (facing each other)], or the angle of the positions of the table and the plant [0° (both facing forward), 45° each, 90° (facing each other)]. Each distance was compared with every other distance, while the other three variables were chosen randomly but were always the same in both pictures (Figure 2). For example, one participant might be shown a distance between chairs of 20 cm in one of the paired pictures compared with a 40 cm distance in the other picture. In both pictures, the distance between table and plant was 200 cm, the chair angle was 45° and the angle of the positions of the table and the plant was 90°. Another participant might be shown the same distance between chairs of 20 cm in one of the pictures and a 40 cm distance in the other picture, but with a different combination of the other three variables. The experiment included 21 different pairs of chair distances, 21 different pairs of table–plant distances, and three options for each pair of angles, which were repeated seven times to yield 21 pairs of comparative angles as well. Altogether, each participant was shown a total of 84 pairs. Each pair was repeated twice, yielding a total of 168 pairs.

In each trial, after a 0.5 s fixation point the participant was shown a pair of two rooms simultaneously. As described earlier, these rooms differed from each other on one of the following parameters: the distance between the chairs, the distance between the table and plant, the angle between the chairs or the angle between the table and plant. This two-picture set was shown for 2 s, followed by a screen asking the participant to choose the preferred room (left/right). The pictures were displayed on a computer screen 60 cm from the participant's eyes, with the two pictures subtending a visual angle of $8^\circ \times 20^\circ$. E-Prime (Psychological Software Tools) was used for stimulus presentation. For each participant, an average preferred distance between chairs was computed, along with an average preferred table–plant distance and the preferred angles for each of these furniture pairs. The distance and angle between the chairs represent a potential distance from another individual in an intimate situation of discussing personal topics. Hence, we predicted that these measures would be affected by OT in interaction with empathy measures. The table–plant distance and angle were used as a control of non-interpersonal distance that should not be affected by OT or by empathy measures.

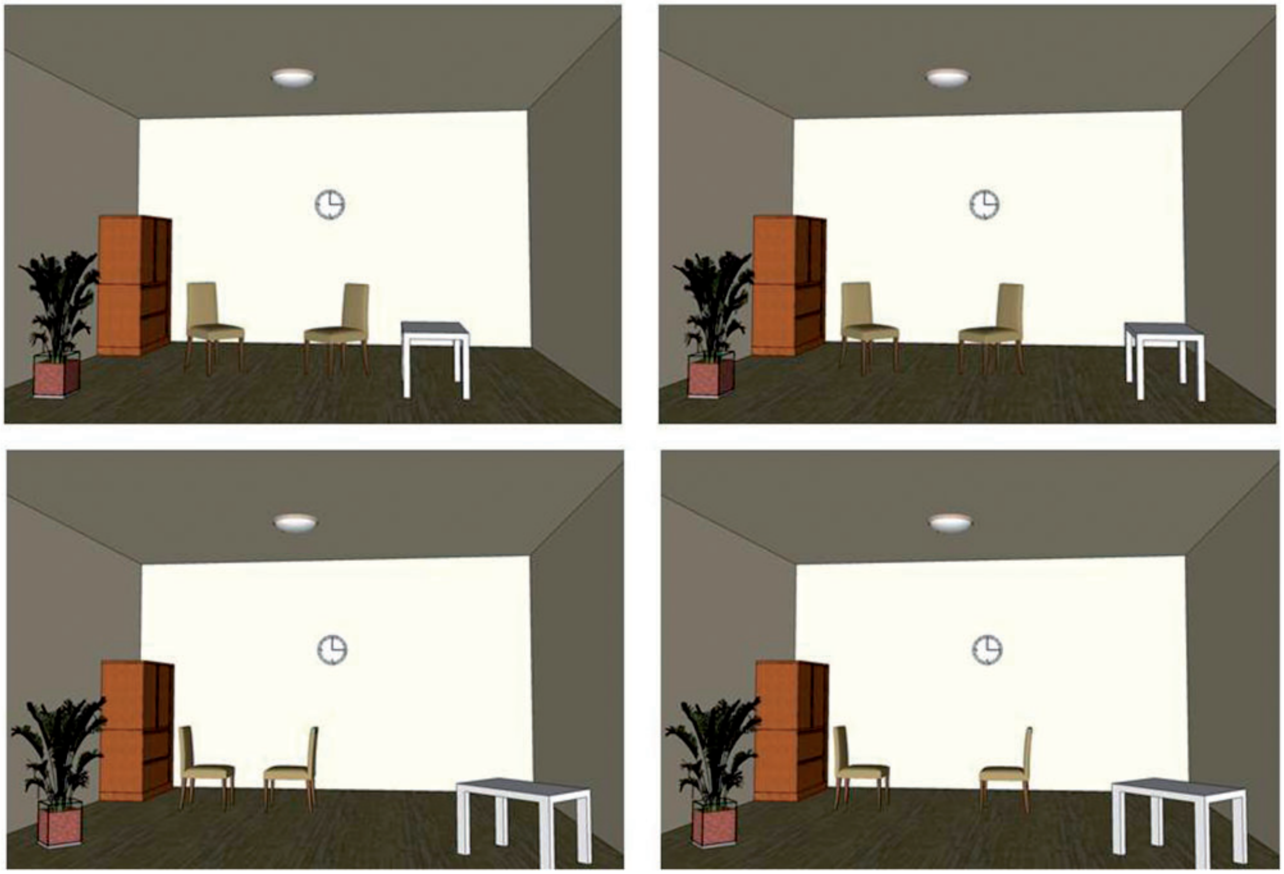

Fig. 2 Examples of the stimuli used in the choosing rooms experiment. The top two pictures depict rooms that differ only in the distance between the table and the plant, whereas the bottom two pictures depict rooms that differ only in the distance between the chairs. Simulated distances in top pictures: chairs at 60 cm distance at 45° each; table and plant at 260 cm distance (left) and 320 cm distance (right), at 90° each. Bottom pictures: chairs at 40 cm distance (left) and 100 cm distance (right), at 90° each; table and plant at 320 cm distance and an angle of 45° each.

RESULTS

Experiment 1: CID

The data were analyzed using a mixed-model analysis of variance (ANOVA), with empathy (high, low) as a between-subject factor, and treatment (OT, placebo) and condition (stranger, authority, friend, ball) as within-subject factors. The degrees of freedom were corrected using the Greenhouse–Geisser epsilon values when needed.

A main effect was found for condition [mean % distance from stranger = 39.82, from authority = 34.12, from friend = 12.46 and from ball = 20.20; $F(3,114) = 35.53$, $P < 0.001$]. Bonferroni-corrected pairwise comparisons revealed that all comparisons were highly significant ($P \leq 0.001$), with the exception of authority *vs* stranger ($P < 0.05$), and friend *vs* ball, which only reached significance ($P = 0.07$). No significant effects were found for treatment or empathy (both Fs < 1); however, the interaction between treatment and empathy approached significance [$F(1,38) = 2.95$, $P = 0.09$]. This interaction indicated that although OT decreased the mean distance from self to other in the high empathy group (with placebo (PL) = 26.11, with OT = 23.29), it had an opposite effect in the low empathy group, increasing the preferred distance between self and other (with PL = 26.98, with OT = 30.20; Figure 3). The main effect of treatment was not significant within each group ($P > 0.1$). Finally, the three-way interaction between treatment × condition × empathy was significant [$F(3,114) = 4.87$, $P = 0.01$]. Separate ANOVAs for the high and low empathy groups revealed that the treatment × condition interaction was significant for the high empathy group [$F(3,57) = 4.92$, $P = 0.005$], but not for the low empathy group ($P = 0.18$). *Post hoc* pairwise comparisons (Bonferroni corrected) in the high empathy group revealed that with PL, there were significant differences between the preferred distances from friend and authority (11.02 and 33.92, respectively, $P < 0.001$) and friend and stranger (38.55, $P < 0.001$), with no significant difference between stranger and authority, or between ball (20.96) and all other conditions. With OT, the same differences appeared (friend = 8.49, authority = 30.55, stranger = 39.73; $P < 0.001$ for both pairs), along with significant differences between ball (14.42) and stranger ($P = 0.005$) and ball and authority ($P < 0.05$, Table 1).

Experiment 2: choosing rooms

An analysis was conducted using a mixed-model ANOVA, with empathy (high, low) as a between-subject factor, and treatment (OT, placebo) and condition [preferred distance between chairs (chairs) and preferred distance between table and plant (tables)] as within-subject factors. One participant did not complete this task due to technical problems, so the analysis was conducted with 19 participants in the high empathy group.

A significant effect was found for condition [mean distance chairs = 79.28, mean distance tables = 261.46; $F(1,37) = 31,287$, $P < 0.001$]; however, this effect was expected and not of interest, because the tables and chairs had been placed at different distances in the first place (with the chairs at the center of the room and the table and plant at the sides; Figure 2). There was no main effect for treatment and no significant second-order interactions [all Fs < 1]. However, there was a significant third-order interaction between

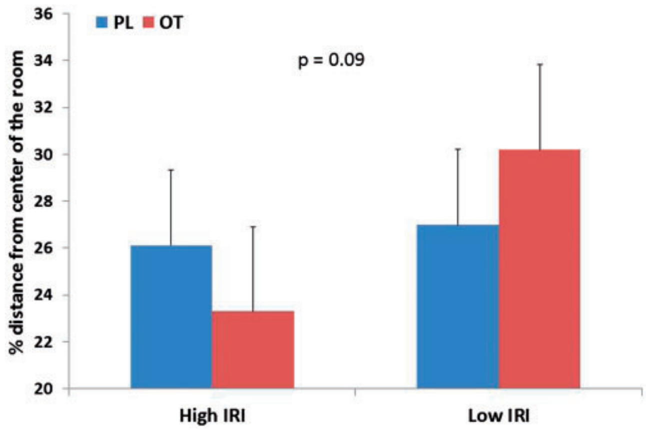

Fig. 3 Results of the CID experiment: The interaction between high and low IRI groups and treatment is close to significant. Although OT decreased the mean distance from self to other in the high empathy group, it had an opposite effect in the low empathy group, increasing the preferred distance between self and other. Error bars denote standard error of the mean.

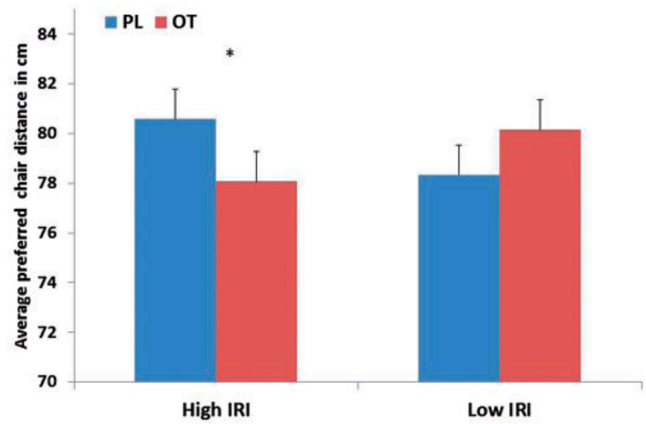

Fig. 4 Results of the choosing rooms experiment: a significant interaction was found between the high and low empathy groups and treatment. Although OT decreased the mean distance between chairs in the high empathy group, it had no significant effect in the low empathy group. Error bars denote standard error of the mean.

Table 1 The mean, s.d. and standard error (s.e) of each condition, in each treatment run, for each empathy group: (a) high empathy group ($N = 20$), (b) low empathy group ($N = 20$)

Treatment	Condition	Mean	s.d.	s.e.
(a)				
PL	Friend	11.028	12.616	2.821
	Ball	20.956	24.293	5.432
	Authority	33.920	21.299	4.762
	Stranger	38.552	25.372	5.673
OT	Friend	8.486	7.431	1.661
	Ball	14.418	17.431	3.897
	Authority	30.554	19.213	4.296
	Stranger	39.734	25.896	5.790
(b)				
PL	Friend	14.000	8.730	1.952
	Ball	18.630	15.952	3.567
	Authority	35.178	18.110	4.049
	Stranger	40.136	20.164	4.508
OT	Friend	16.318	15.793	3.531
	Ball	26.806	26.221	5.863
	Authority	36.826	20.373	4.555
	Stranger	40.836	22.031	4.926

condition × treatment × empathy [$F(1,37) = 4.91$, $P < 0.05$]. Because the differences in the distances between conditions were built into the design and were not of interest in this experiment, we ran separate ANOVAs for the chairs and tables conditions, revealing that the treatment × empathy interaction was significant only for the chairs condition [$F(1,37) = 4.06$, $P = 0.05$], and not for the tables ($P > 0.4$). As in Experiment 1, this interaction revealed that although those in the high empathy group chose closer chair distances following OT administration (with PL = 80.58, with OT = 78.07), the opposite was true for those in the low empathy group (with PL = 78.33, with OT = 80.14). Separate t-tests for each empathy group revealed that this difference approached significance ($P = 0.079$) only in the high empathy group, but not in the low empathy group ($P = 0.28$; Figure 4).

A similar analysis was conducted for the averaged preferred angles, with empathy (high, low) as a between-subject factor, and treatment (OT, placebo) and condition [preferred angle between chairs (chairs) and preferred angle between table and plant (tables)] as within-subject factors. There were no significant effects or interactions [all Fs < 1, except for the third-order interaction, condition × treatment × empathy, in which $F(1,37) = 2.13$, $P = 1.5$].

Finally, to confirm that the two experiments are indeed related, we examined the correlation between the average distance chosen in the CID task under PL and the average chair distance chosen under PL in the choosing rooms task. We found a significant although moderate correlation between them ($r = 0.278$, $P < 0.05$).

DISCUSSION

In two different experiments, we showed that administering OT had an impact on interpersonal distance preferences, depending on trait empathy levels of the participants. Participants with high empathy traits preferred closer interpersonal distances following OT administration, whereas an opposite trend was revealed among participants with low empathy traits.

Apart from the empathy × treatment interaction, in the CID experiment across-group differences were found in how participants approached the four protagonists—stranger, authority figure, ball and friend—with preferred distance in this order. Perceived threat from others is considered to be one of the most salient factors in mediating the equilibrium between interpersonal distance and social interaction (Lloyd, 2009). Hence, it may be that the distance preferences in this paradigm are determined by the degree of perceived threat from each protagonist. A ball may be considered more threatening than a friend, but less threatening than an authority figure or a stranger. As this hypothesis was not explicitly measured, it requires future investigation.[1] A third-order interaction revealed that in the high empathy group, in addition to significant differences between friend on the one hand and the stranger and authority figures on the other, OT further differentiated between the approaching ball and these two figures. It is not clear why the OT effect was most pronounced with the ball protagonist, that is, why OT differentiated preferred distance from the ball from preferred distance from the stranger and the authority figures. One possible interpretation is that balls are generally associated with pleasant social interactions, so that a rolling ball may be perceived as an invitation to social interaction. It also may be that OT enhances closeness in highly empathic individuals only for the less threatening

[1] Another interpretation, which we did investigate, is that a ball entering a room may actually be considered more social or more interpersonal than a stranger or an authority figure. However, a validation study conducted in our lab ($n = 30$ men) did not confirm this interpretation, and indeed showed that the ball was considered the least social or interpersonal protagonist, followed by the authority figure, the stranger and the friend.

interactions, i.e. not for the stranger, slightly so for the authority figure (although not significant on its own), more so for the ball and again slightly for the friend, may be as the friend figure had already reached a floor effect, being stopped closest to the center (Table 1). Future research is needed to decipher the rolling ball's role in social interactions, especially as it is widely used as a baseline or control for social stimuli.

In the choosing rooms experiment, as predicted, a third-order interaction revealed that the interaction of treatment × empathy was relevant only in an interpersonal context in which participants had to choose between distances between the chairs, with no effect on choices of distances of the plant and table. In other words, OT did not affect one's general distance preferences, but only those with social implications. As mentioned in the Introduction and validated in the Results section, these two tasks are correlated but seem to measure slightly different constructs. Although the CID task involves a dynamic figure approaching and may be related to approach–avoidance mechanisms and threat perception, the choosing rooms task enables the participant to choose his preferred room in advance, thus perhaps eliciting less threat. Yet, this task also involves a future intimate conversation with another. Despite the differing demands, the common denominator between these tasks is interpersonal distance, and indeed the findings of the effect of OT on interpersonal distance preferences in the two tasks were strikingly similar.

As noted in the Introduction, the four IRI subscales are fundamentally different from one another. Yet we chose to analyze them as a whole, because these different aspects of interpersonal reactivity add up to a general measure relevant to empathy traits, whether from a cognitive or an emotional perspective. For example, an individual may have moderate fantasy skills, but together with some perspective-taking skills and empathic concern may also have overall high empathic abilities. Therefore, the total IRI score was relevant for our purposes. Note that in an exploratory investigation, all four subscales were highly positively correlated in our group, and the above effects do not seem to be specifically driven by one of the factors.

As opposed to the previously simplistic hypothesis regarding OT's role in social behavior, i.e. that it may have a general positive social bonding effect, the current findings substantially support the social salience hypothesis, highlighting the notion that individual difference moderators play a crucial role in determining what type of effect OT will have on social cognition and behavior. Bartz *et al.* (2011) gave the example of trust and showed that, contrary to the former notion that OT promotes trust-related behavior and cooperation, this effect can be diminished or even reversed depending on context and personality traits. Although Scheele *et al.* (2012) showed that relationship status modulates OT's effect on preferred interpersonal distance, this study shows that, at least in males, an individual's initial empathy trait level interacts with the effect of OT on preferred interpersonal distance. OT may, for example, generate more openness and interest in others among those who are highly reactive to interpersonal situations, but may signal stress or a need for privacy or withdrawal among those initially less reactive to interpersonal situations.

A few limitations of this study should be acknowledged. First, although the second-order interaction of treatment × empathy was significant in the choosing rooms experiment, it was only marginally significant in the CID experiment ($P = 0.09$). Significant results emerged again only in third-order interactions, i.e. in the high empathy group in interaction with the different conditions, making the results harder to interpret, especially when considering the complexity of the design and the number of participants in the study. Nevertheless, as the same results were replicated in two different interpersonal distance experiments, we believe that they reveal a true effect. A second limitation is the use of male participants only, due to local IRB restrictions regarding the use of IN OT in female participants. OT is best known for its peripheral role in lactation and parturition in females. Moreover, previous studies have shown differential effects of OT on male and female participants (e.g. Domes *et al.*, 2010; Feldman *et al.*, 2010). Therefore, we cannot conclude from this study how OT would affect interpersonal distance preferences in females, and we hope that future research can answer this question. Unpublished results from our lab, using the same paradigms without OT, show similar behavioral results in female participants. Finally, the use of computerized experiments rather than a real life setting has its advantages and disadvantages. While ensuring all participants see the exact same stimuli and perform the same procedures again a week later, we lose ecological validity. However, behavioral experiments in our lab, as well as others, show strong correlations between participants' preferences in these experiments and preferences in a more realistic behavioral measure of interpersonal distance in which participants choose their preferred distance from a stranger in a live interaction in the laboratory (i.e. the stop-distance paradigm, Hayduk, 1983; Perry Anat, Levy-Gigi Einat, Richter-Levin Gal, Shamay-Tsoory Simone S., submitted for publication).

Finally, these results have important clinical implications. Previous research has shown modest effects of OT on people suffering from social deficits, such as autism spectrum disorders (Hollander *et al.*, 2007), schizophrenia (Pedersen *et al.*, 2011) or social anxiety disorder (Guastella *et al.*, 2009). This study and others contribute to lowering expectations that OT will have profound generalized positive effects on individuals with social disorders. Researchers looking into such effects should carry out their research with extra caution, as our results suggest that at least in some cases OT does not have a general effect on improving social behavior, but may actually strengthen patients' initial social biases.

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