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18

Oxytocin instantiates empathy and produces prosocial behaviors

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18.1 Introduction

In January of 2007, Wesley Autrey was waiting for the New York City subway with his two young daughters when a young man nearby starting seizing and fell onto the tracks. With a train coming, Mr. Autrey leapt toward the tracks and moved the man, Cameron Hollopeter, between two tracks as the subway raced towards them. Autrey lay on top of Hollopeter to hold him down as the subway passed over them. Both lived.

Autrey's actions are an extreme form of altruistic behavior; that is, a behavior that is individually costly but benefits another (West, Griffin, and Gardner, 2006). This chapter focuses on prosocial behaviors, by which we mean intentional altruistic behaviors. Indeed, prosocial behaviors are so quotidian that we often fail to notice the countless ways people assist others, often with no ability or expectation of reciprocation. Did human evolution really select for survival of the nicest? (Bowles, 2009) If so, there must be one or more neural substrates promoting prosociality.

The neuropeptide oxytocin (OT) has been implicated in a number of prosocial behaviors (Zak, 2011; also see Campbell, 2010; Meyer-Lindenberg, 2008; Tost et al., 2010). We divide the research on prosocial behaviors into four domains: reciprocity, trust, generosity, and altruistic helping. Although each behavior is likely to have its own distinct neural processes that produce it, we have found that they all depend on OT. Our lab has taken a comprehensive approach to the study of prosocial behaviors and OT, developing both correlational and causal evidence. Our approach first designs tasks that induce OT release. Much of the early OT research relied on basal OT levels that are both low and highly variable and are unpredictive of most prosocial behaviors in humans. It is the release of OT, not its basal level, that motivates social engagement. Once we have confirmed that a prosocial behavior induces OT release, we then establish the causal relationship by infusing OT, showing that we can directly manipulate the behavior being studied.

This chapter reviews and puts into context recent findings on the role OT in producing prosocial behaviors in humans. We also connect this physiologic mechanism to psychological states that produce these behaviors, particularly empathy. Empathy causes one to attend to another's plight, and can be a motivation to invest resources to assist someone in distress. An OT-empathy relationship has been suggested based on similar behavior effects, but several lines of emerging research appear to show that OT does instantiate the experience of empathy.

18.2 Prosocial behavior

Prosocial behavior can be a single event (e.g., donating money to a beggar) or can extend over a long

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period of time (e.g., joining a volunteer organization). For this review, we focus on prosocial behaviors that can be studied in the lab. These include reciprocity, trust, generosity, and altruistic helping. Reciprocity and generosity, as operationalized in the proceeding studies, can be classified as sharing tasks in which benefits for another reduce one's own resources. Trust can be classified as potentially cooperative, where people can obtain a mutually beneficial outcome. Finally, we discuss our recent research done on a distinct form of prosociality, altruistic helping, in which assistance occurs at a distance and many external incentives to benefit another are absent.

Prior to reviewing the literature, we note that there are a number of benefits to using economic games to study human prosociality. The first is that the measure of prosociality – money transferred to another person – is active, objective, and scales to measure degrees of prosociality. This means that there is meaning behind an incremental change, unlike differences across Likert-type 7-point scales. Secondly, behavior is not gratuitous; one cannot simply claim to be trusting or generous, a tangible action must take place in order to classify it as such. For instance, to gauge trust, money must be sent to another person without a guarantee of return. Finally, measuring prosociality using money motivates participants in experiments to attend to the task by adding value to the decision.

18.2.1 Reciprocity

A key ingredient to cooperation is reciprocity. Reciprocity is an important aspect in many evolutionarily based explanations for the existence of prosocial behaviors (e.g., Gintis, 2000; Nowak and Sigmund, 2006; Trivers, 1971). Reciprocation can be either positive or negative, that is, responding in-kind to how one is treated. This reflects a tit-for-tat strategy that is among the best strategies in prisoner's dilemma tournaments (Axelrod, 1984) and is part of the evolutionary model of strong reciprocity (Gintis, 2000).

Positive reciprocity. Reciprocity that comes at an individual cost may make sense when extended cooperation is possible. However, humans appear to return favors even knowing that the initial giver will not know that the favor was reciprocated (Burger, Sanchez, Imberi, and Grande, 2009). A turning point in the study of reciprocity was the discovery of the role of OT (Zak et al., 2004; 2005; Zak, 2007; Zak, 2008). The impact of OT on reciprocity (and trust, discussed below) has been largely studied using a sequential cooperative dilemma known as the trust game (Berg, Dickhaut, and McCabe, 1995).

In the trust game (TG), participants are placed into dyads and randomly assigned to the roles of decision-maker 1 (DM1) and decision-maker 2 (DM2). Both DMs are allocated a fixed dollar amount, often $10, as an endowment from the experimenters. After instruction, DM1 can choose to send any integer amount (including zero) of his or her $10 to the DM2 in his or her dyad. Participants know that whatever is sent comes out of DM1's account and is tripled in DM2's account. DM2 is then prompted to send some integer amount back to DM1 (including zero). Transfers from DM2 to DM1 are not multiplied and constitute a dollar-for-dollar allocation out of DM2's account and into DM1's account. The typical version of the trust game used in OT studies has participants making a single decision as either DM1 or DM2 so that the effects of reputation are minimized. Moreover, decisions are made via computer so that matched participants are not identifiable to each other or to the experimenters. This minimizes extraneous factors that might influence the decision (e.g. partner demographics).

The consensus view in experimental economics is that the amount that DM1 sends to DM2 is a measure of *trust* (Smith, 1998). The more money DM1 sends to DM2, the greater degree of trust since more money is at risk if DM2 defects. Similarly, the money sent by DM2 to DM1 is an index of the former's *reciprocity* or *trustworthiness*, i.e. the amount DM2 reciprocates given a signal of trust from DM1. In the TG, 98% of DM2s who are sent money return at least some (Smith, 1998; Zak, 2008). Remember

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that participants typically play a single round of the TG, so there is no chance of future cooperation as a rationale for reciprocity. There are therefore strong incentives for DM2s to defect. Moreover, the interaction is computer mediated and anonymous, so defectors can escape identification. If there are no tangible incentives to reciprocate, then what motivates or signals reciprocity?

Using the TG, we found that peripheral OT for DM2s who received an intentional signal of trust was an average of 41% higher compared to DM2 controls receiving the same average amount of money determined by a random draw and therefore not denoting trust ($N = 67$, $p = 0.05$; Zak et al., 2004; 2005). We have also found that the within-subjects change in OT is proportional to the money received (Morhenn et al., 2008). The TG was the first non-reproductive stimulus shown in humans to our knowledge that stimulated OT release. Among nine other hormones assayed, including arginine vasopressin, testosterone, dihydrotestosterone, adrenocorticotropic hormone (ACTH), cortisol, prolactin, estradiol, and progesterone; none had direct or indirect effects on OT or reciprocity.

In a related study, we sought to test if raising OT would subsequently increase reciprocity. Based on the animal literature showing that belly stroking sometimes raises OT, we used licensed massage therapists to give participants 15-min moderate pressure back massages prior to making decisions in the TG (Morhenn et al., 2008). A control group rested quietly for 15 min on different days and was therefore unaware that others received massages. Blood draws preceded the massages and followed the TG decision. We found that massage alone did not raise OT ($N = 24$, $p = 0.62$). However, in DM2s massage appeared to prime OT release when combined with the receipt of a monetary transfer denoting trust. The change in OT for DM2s who were massaged and trusted was 16% higher than DM2 controls who [illegible] received the same average monetary transfer denoting trust ($N = 32$, $p = 0.006$). The most intriguing finding was that reciprocation was 243% higher for DM2s in the massage-primed group relative to DM2 controls. The increase in OT for this group predicted the amount of money reciprocated by DM2s ($r = 0.43$, $p = 0.03$). As in our previous studies, no direct or indirect effects of hormones that interact with OT were found.

Even though the majority of participants in these studies tend to follow the reciprocity norm, about five percent of DM2s in the TG are unconditional non-reciprocators. These participants return zero or near zero, no matter how much money they receive from DM1s. OT levels for non-reciprocating participants were more than one standard deviation above the average DM2 OT level (>470 pg/ml), indicating a possible OT dysregulation. Nonreciprocators also have psychological traits similar to psychopaths (Zak, et al., 2005. A study of those with social anxiety disorder ($N = 24$) found a similar OT dysregulation relative to controls ($N = 20$) in which greater symptom severity was associated with higher basal OT ($p = 0.04$; Hoge et al., 2008).

Negative reciprocity. Negative reciprocity, also termed altruistic punishment or moralistic punishment, is an intentional action in which one punishes someone who has harmed oneself or another individual (e.g., Ostrom, Gardner, and Walker, 1994). Many experiments show that people are willing to incur a cost in order to "punish" others who violate reciprocity norms (e.g., Kurzban et al., 2007; Camerer, 2003). The use of resources to punish a non-reciprocator in a one-shot setting is prosocial because it provides a disincentive for defection that can motivate the defector to cooperate with others in future interactions.

One way to measure negative reciprocity in the lab is to have participants make decisions in the ultimatum game (UG; Güth, Schmittberger, and Schwarze, 1982). In the UG, participants are randomly assigned the roles of DM1 and DM2 and placed into dyads and decisions are made in sequence and anonymously. After instruction, DM1 offers a split of an endowment (e.g., $10) s/he received from the experimenters to DM2 who has no endowment. DM2 then decides whether to accept or reject the offer from DM1. If DM2 rejects, both DMs receive nothing. If DM2 accepts, the funds are distributed according to the offer made by DM1. A

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rejection by DM2 is costly punishment since DM2 is incurring a cost (ending up with zero) to punish DM1 for acting in a selfish manner. Note that the UG is a zero-sum game producing winners and losers; in contrast, the TG is a positive-sum game and allows for win-win outcomes.

OT infusion does not affect the punishment threshold (the minimum amount of money DM2 is willing to accept from DM1; Zak, Stanton, and Ahmadi, 2007); and plasma OT is uncorrelated with DM2 rejections (Barraza and Zak, 2009). Yet, testosterone (T), which inhibits OT binding (Insel, Young, Witt, and Crews, 1993; Arsenijevic and Tribollet, 1998), appears to promote punishment. Men with high endogenous T are more likely to reject low offers in the UG as DM2s (Burnham, 2007). Moreover, Zak, Borja, et al., (2005) find that the biologically active metabolite of T, dihydrotestosterone (DHT), increases for DM2 men in the TG who receive low trust signals (i.e. small transfers from DM1) and predicts nonreciprocity. This effect was not found for women.

Stronger evidence comes from a study that administered 10 g of transdermal T to men using a double-blind within-subjects design with before and after blood draws to measure the change in T levels (Zak et al., 2009). Men with artificially elevated T, which was roughly doubled over baseline (average increases: total T 60%; free T 97%, DHT 128%, all $p < 0.05$), did not set an overall higher punishment threshold as DM2s in the UG. However, the punishment threshold increased linearly for all three measures of T ($N = 200$, r range 0.15 to 0.23, p range = 0.001 to 0.03). In other words, these artificial "alpha males" set the bar higher for what they deemed as a fair distribution and were willing to punish others for violating this sharing norm at a cost to themselves.

Although negative reciprocity can produce a prosocial outcome, it is unlikely that punishment of non-cooperators is motivated by prosocial considerations. Several studies have shown that punishing those who show low levels of reciprocity is rewarding, particularly for men (e.g., Singer et al., 2006; De Quervain, 2004). In the UG, DM2s report rejecting offers because they feel anger toward DM1s (Pillutla and Murnighan, 1996). DM2s who receive stingy offers also have greater activity in the anterior insula, a brain region associated with visceral disgust (Sanfey et al., 2003). Moreover, punishment may serve reputational advantages (Gintis, Smith and Bowles, 2001), as it is enhanced by the presence of others (Kurzban et al., 2007).

18.2.2 Trust

Trust is an essential component of cooperation and other forms of collective action (Zak and Barraza, in review). Trust occurs when the other party is deemed to be trustworthy. The subgame perfect Nash equilibrium prediction of a one-shot trust game is for DM1 to send zero and for DM2 to return zero, since there is no requirement for DM2 to reciprocate and thus no reason for DM1 to trust. However, less than 10% of DM1s chose this strategy (Smith, 1998; Zak, 2008). So why would anyone trust a stranger when there are no repercussions if the stranger keeps the money? Moreover, what helps people determine when and whom to trust?

We have used the TG to examine if OT administration would impact the decision to trust a stranger. After a one-hour loading period, a 24IU dose of OT given intranasally more than doubled the number of DM1s who sent all their money to the DM2s in their dyads (45% vs. 22% for those on placebo; Kosfeld et al., 2005). In this study, OT had no effect on an objective risk-taking task where participants made choices with a computer rather than a human. Participants in the OT condition did not have cognition or mood changes mediating these effects. There was no effect on DM2s in this experiment, mostly likely due to the high degree of trust and the subsequent action of endogenous OT release. Others have found that OT infusion increases evaluations of trustworthiness of strangers in healthy adults using the TG (Theodoriou, Rowe, Penton-Voak, and Rogers, 2009) and for people with Asperger's syndrome using a cooperative task similar to the trust game (Andari et al., 2010).

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Brain-imaging experiments have discovered that OT facilitates trust primarily by reducing amygdala activation, as well as in the anterior cingulate, dorsal striatum and midbrain regions (Baumgartner, et al., 2008; Zak et al., 2006). Baumgartner and colleagues (2008) had participants play multiple rounds of the TG as DM1, with feedback that their trust had been "betrayed" (non-reciprocal DM2s). OT participants were more likely to continue to trust after betrayal relative to placebo participants.

These findings open the issue of whether OT leads to indiscriminant trust. A recent study finds that additional information on TG partners may inhibit OT's effect on trust. In order to manipulate the trustworthiness of a person (i.e. DM2), Mikolajczak and colleagues (2010a), provided participants playing the TG as DM1s with information on their DM2 dyadic partner. DM2s were either presented as reliable or unreliable based on information on the academic field (e.g. philosophy vs. marketing) and leisure activities (practicing first aid vs. playing violent games). DM1s in the OT condition (32IU) were more likely to trust dyadic partners who were presented as reliable compared DM1s receiving a placebo. An OT-induced increase in trust by DM1s was not found when dyadic partners were presented as untrustworthy. A within-subjects study using participants with Asperger's syndrome also finds a contingent OT-trust effect (Andari et al., 2010). Participants played [illegible] tossing game with three fictitious players that, unbeknownst to the participants, reciprocated a ball toss at varying rates. An allocation of money was made each time the ball was "tossed" to a person, so there was incentive to throw to those likely to reciprocate. Participants on 24IU OT were more likely to toss the ball to the player that exhibited a greater probability of reciprocation, as compared to themselves on placebo. Moreover, participants were also more likely to express feelings of trust toward the cooperative player when on OT than on placebo. In other words, OT participants showed a stronger preference to trust those who were worthy of trust.

There are now examples of other forms of trust being enhanced by OT in addition to the TG. Mikolajczak and colleagues (2010b) demonstrated that participants receiving 32IU OT trusted strangers more with personal information. In their study, participants were asked to complete a questionnaire where they reported intimate sexual practices (e.g. use of toys, sado-masochism practices). After a 45-min drug load period, participants were then instructed to place the questionnaire in an envelope that they were able to seal and tape before handing to the experimenter, if d[illegible]. Participants in the OT condition showed [illegible] more "trust" in handing the experimenter an unsealed envelope (60% vs. 3.3% for those on placebo). This indicates that the OT-trust relationship appears to extend beyond behaviors where there is possible self-gain.

18.2.3 Generosity

We have used the UG to investigate generosity. Generosity is defined as giving more than is needed in order to satisfy expectations in an exchange (Zak et al., 2007). By giving DM2s the option to reject an offer, the UG requires that DM1s consider how the DM2 in the dyad would react to an offer. That is, an effective choice in the UG requires that DM1 take the perspective of DM2. A purely resource-driven model of human behavior predicts that DM2 should accept any positive offer from DM1 (Zak, 2011). However, experimental studies find that most offers smaller than 30% are nearly always rejected by DM2s in Western countries (Camerer, 2003).

Plasma OT release has been found to correlate indirectly with DM1 transfers in the UG (Barraza and Zak, 2009). Participants in this study viewed an emotionally charged video prior to playing the UG. Although the change in OT did not predict generosity, OT did predict the experience of empathy in response to the video. Those who were more empathically engaged made more generous offers in the UG ($N = 56$, $r = 0.24$, $p = 0.05$).

OT infusion has been used in the UG to establish a causal relationship with generosity (Zak et al., 2007). In this experiment, each participant made decisions as both DM1 and DM2 with actual

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assignment of roles determined by random draw after choices were made. Generosity was operationalized as the amount DM1 offers exceeding one's minimal acceptable offer as DM2. Infusing 40IU of OT increased generosity by 80% relative to those who received a placebo ($N = 34$, $p = 0.005$).

We have also found that testosterone administration reduces generosity (Zak et al., 2009). Men whose testosterone was artificially raised, compared to themselves on placebo, were 27% less generous in the UG ($N = 200$, $p = 0.04$). The reduction in generosity declined linearly as levels of total-, free-, and dihydrotestosterone rose (r range: –0.19 to –0.31, $p = 0.01$). For example, generosity by participants in the lowest decile of DHT averaged 85% higher ($3.65 out of $10) compared to generosity by those in the highest decile of DHT ($0.55 out of $10).

18.2.4 Altruistic helping

Behavior in the TG and UG can be[illegible]fied jointly cooperative, i.e. the individual may benefit tangibly and directly by acting prosocially. Altruistic helping, such as anonymous unilateral transfers, lacks this self-benefiting motive. In laboratory studies, we remove external incentives that may drive altruistic helping, for instance, increasing one's social status or building a positive reputation. In experimental economics the dictator game (DG) has been used to measure altruism, removing the extrinsic and self-serving benefits that are typically involved in such acts (e.g., Camerer, 2003). The DG is similar to the UG in that DM1 begins with an allocated sum (e.g., $10) and DM2 has nothing. DM1 is asked to choose some amount to send to DM2 (including zero), but unlike the UG, DM2 has no choice but to accept the offer. As a result, DM1 has no incentive to consider DM2's perspective and likely response to a transfer. Indeed, without any need to consider DM2's response, offers tend to be much lower in the DG than in the UG (e.g., Zak et al., 2007).

An intranasal infusion of 40IU of OT did not affect DM1 transfers in the DG ($3.77 vs. $3.58 placebo, $p = 0.51$; Zak et al., 2007). The reason for this appears to be that, unlike the UG, emotional engagement (via perspective taking) is absent in the DG. This is consistent with the lack of an effect from 10g of transdermal T administration on choices in the DG. Men on T, compared to themselves, did not offer less in the DG ($N = 200$; T: $3.34, placebo: $3.56, $p = 0.86$).

Genetic research indicates that OT and related peptides may be involved in altruistic helpin[illegible] DG. Variations in both the arginine vasopressin 1a (AVPR1a) RS3 promoter [illegible]n repeat region (Knafo et al., 2008) and single nucleotide polymorphisms (SNPs) in the oxytocin receptor gene (OXTR rs1042778; Israel et al., 2009) show significant associations with DM1 transfers in the DG. Yet, a subsequent study by another research team was unable to replicate the association between 9 SNPs of OXTR (including rs1042778) and DG allocations (Apicella et al., 2010).

Charitable giving. Our lab has recently examined whether OT affects another form of altruistic helping, charitable giving. Charitable giving is an indirect form of altruistic helping done through institutions. Charitiable donations are typically made without any direct exposure to the beneficiary or direct knowledge of how the money will be used. Like the DG, charitable giving is a unilateral transfer of money to strangers. However, charitable giving provides a motive to transfer money because of the perceived need of eventual recipients; perceived need tends to increase the expression of empathy (Batson, 1991; Davis, 1996; de Waal, 2008).

In a study investigating emotionally induced OT release (Barraza and Zak, 2009), we found no correlation between basal or emotionally reactive OT and charitable donations ($p = 0.45$). However, we found a positive correlation between the amount donated to charity and DM1 transfers in the UG ($r = 0.36$, $p = 0.004$). Since OT has a direct effect on DM1 transfers in the UG, it is possible that OT infusion could affect charitable donations.

Barraza and colleagues (2011) examined whether 40IU of OT would increase the likelihood and size of donations. Participants were first allowed to earn varying amounts of money by making monetary

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decisions in the lab since out-of-the-lab donations are made from earned income, not windfalls. Next, participants were presented with an option to donate to one of two charities, the American Red Cross or the Palestinian Red Crescent Society. OT did not significantly affect the decision to make a donation to charity (40% vs. 32% placebo, $N = 132$, $p = 0.15$), but for people who decided to donate, those on oxytocin gave 48% more money than those on placebo (OT: \$4.76; placebo: \$3.22, $p = 0.03$). This difference was largely driven by donations to the American Red Cross (OT: \$5.12, placebo: \$3.09, $p = 0.04$); OT infusion had no significant effect on donations to the Red Crescent Society relative to placebo ($p = 0.35$). This result is consistent with the in-group prosocial preference of OT infusion found by other researchers (e.g., de Dreu et al., 2010).

A related study had participants view public service announcements (PSA; Lin, Sparks, Morin, and Zak, 2011). After receiving 40IU of OT ($N = 40$; OT = 20), participants watched 16 PSAs that involved social and health related issues. To make donations salient, participants earned \$5 for correctly answering one question regarding content following each PSA. Next, they were given an opportunity to donate some of the money they earned to the charitable causes in the ads. Those who received OT donated to 33% of the causes compared to participants receiving the placebo who donated to 21% ($N = 538$; $p = 0.001$). OT also increased the average donation by 56% compared to controls (OT = \$0.84; placebo= \$0.54, $p < 0.001$).

18.3 Relating physiological and psychological mechanisms

The review above has shown that OT promotes a variety of prosocial behaviors in human beings. People in these experiments have difficulty during debriefing explaining why they willingly shared resources in one-shot anonymous settings (Zak, 2011). This is consistent with the highest densities of OT receptors being found mostly in subcortical brains regions (Barberis and Tribollet, 1996). Although multiple motives may drive prosocial behavior, empathy is a likely proximal mechanism for other-regarding behavior. The role of empathy in motivating prosocial behaviors has been proposed by philosophers like Adam Smith (1759) and in evolutionary models of reciprocal altruism (e.g., Trivers, 1971). Since 2007, a handful of studies have been published examining the relationship between empathy and OT directly.

18.3.1 Empathy

Here, we discuss three distinct forms of empathy found in the literature and their relation to OT; two forms of emotional empathy – empathic distress and empathic concern (compassion), and a cognitive form of empathy, perspective taking (the process of inferring the mental state of others). The former two are more associated with affective states while the latter is believed to be a primarily cognitive process.

Empathic distress. Empathy conceptualized as empathic distress, or personal distress, is an aversive state brought on by witnessing physical or emotion pain in another (Batson, 1991; Davis, 1983; 1996). Empathic distress is characterized by reactive and aversive feelings (e.g., worry, anxiety, discomfort) that are focused on the self (e.g., Batson, 1991; Davis, 1996). Brain-imaging studies have examined empathic distress by having participants view another person receiving a painful stimulus, or view the facial expression of someone in pain (i.e. an empathy-for-pain paradigm, see Singer and Lamm, 2009). These studies find shared activation for pain in self and pain in others in the anterior insula, a brain region associated with the affective experience of pain. Singer and colleagues (2008) tested the effects of OT on the experience of empathy using the empathy-for-pain paradigm and subsequent behavior in the trust game. Participants received either 24IU of OT or a placebo intranasally prior to the pain procedure and trust game. The authors found that OT did not affect brain activation in regions previously found to be associated with empathy (e.g. anterior insula) for self-experienced

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pain or for other-witnessed pain. In addition, OT did not impact decisions in the trust game. The authors concluded that OT does not promote empathy; however, this result only applies to a particular kind of empathy, empathic distress.

While empathic distress can bring awareness to the suffering of another, it appears to do so via sympathetic arousal rather than through a desire to engage with another. The lack of an effect of OT on empathic distress is not surprising since OT functions as an anxiolytic for moderate stress (Bartz and Hollander, 2006; Heinrichs, Baumgartner, Kirschbaum, and Ehlert, 2003). By reducing the degree of vicarious arousal, OT may reduce distress but also allow for other-focused empathic states to occur.

Empathic concern. A second form of empathy is described as an other-focused emotion that is ultimately felt *for* another person (Batson, 2009; Batson et al., 2009). Deriving from the "parental instinct," empathic concern generates an impulse to protect others and is perhaps the "root of all altruism" (McDougall, 1926). Many refer to this affective state as compassion (also "pity," "sympathy," and "empathy," see Batson, 2009), which is classified as one of the human virtues (Peterson and Seligman, 2004) and resides in the family of moral emotions (Haidt, 2003). In a series of studies, Decety and colleagues (see Decety and Lamm, 2009) have shown that empathic distress and empathic concern are separable phenomena in terms of brain function. Moreover, those who become physiologically overaroused (elevated heart rate and skin conductance) experience distress, and become motivated to address egoistic concerns (Eisenberg and Fabes, 1990; Eisenberg et al., 2004; Hoffman, 1981). Alternatively, those who are aware of distress in others and are able to regulate the arousal that arises from it are more likely to experience empathic concern (i.e. sympathy; Eisenberg and Fabes, 1990).

We find that empathic concern, and not empathic distress, is associated with endogenous OT release (Barraza and Zak, 2009). Using a 100-s video of a two-year-old boy who has terminal brain cancer narrated by his father, we asked viewers to rate a series of adjectives relating to their affective states after viewing the video. We found a 47% increase in OT immediately after viewing this video relative to baseline ($N = 23$, $p = 0.004$). This increase in OT was positively correlated with self-reported empathic concern ($r = 0.20$, $p = 0.01$) after controlling for self-reported empathic distress. We also found a positive correlation between self-reported concern and DM1 generosity in the UG ($r = 0.24$, $p = 0.05$). The analyses for self-reported empathic distress yielded negative or null correlations. These null findings for empathic distress parallel those from Singer and colleagues (2008) investigating the effects of OT infusion on empathy using the empathy-for-pain paradigm.

We also tested whether trait empathy was correlated with emotionally reactive OT. Participants were measured on dispositional empathic distress, concern, and perspective taking using the Interpersonal Reactivity Index (Davis, 1983). The increase in OT after viewing the emotional video was significantly and positively correlated with scores on dispositional empathic concern, but not with empathic distress or perspective-taking trait measures. This study was the first to provide direct evidence that OT is associated with empathy. It is the other-focused nature of empathic concern that appears to induce OT release and to promote prosocial behaviors.

Perspective taking. Empathy has been viewed as a cognitive function where one is able to imagine the feeling state of another without sharing the particular state themselves or feeling for the person's plight (e.g., Batson, 2009; Davis, 2005). Perspective taking has been found to increase empathic concern for people belonging to different stigmatized social groups like the homeless, persons with AIDS, and drug users (e.g., Batson, Early, and Salvarani, 1997; Davis, 2005; Davis et al., 2004; Lamm, Batson, and Decety, 2007). Moreover, perspective-taking instructions decrease brain activity in pain regions when witnessing pain in others (Lamm, Batson, and Decety, 2007), possibly enhancing the likelihood of experiencing empathic concern.

Research in humans has found that OT modulates the ability to infer the emotions of others. Domes and colleagues (2007) tested if OT affected

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performance on the "Reading the Mind in the Eyes" (RMET), a task that measures the ability to read emotional states in others. When given 24IU OT intranasally, participants were able to accurately identify more emotional faces in the RMET than those given placebo (72% vs 69% placebo, $p = 0.02$). OT also increased the ability to correctly assess emotions that were difficult to identify by those on placebo ($p < 0.006$). A separate study finds that an OXTR polymorphism (rs53576) is also related to performance in RMET, with homozygous GG allele performing better than AA/AG participants (Rodrigues et al., 2009). These researchers also found that the same allelic variations related to self-reported trait empathy scores (as measured by composite of the empathic concern, perspective taking, and fantasy subscales of the Interpersonal Reactivity Index; Davis, 1983), with GG reporting higher trait empathy than AA/AG participants.

This research suggests that OT allows humans to infer the emotional states of others. However, the evidence appears to be stronger for a link between OT and emotional rather than cognitive forms of empathy. For instance, a recent study by Hurlemann et al., (2010) found that while OT infusion enhanced "emotional empathy" (how much they *feel* for a target in an image), there was no difference for "cognitive empathy" (ability to accurately infer the emotional state of a target in an image) relative to placebo. Although presented separately, it is likely that these different empathic states co-occur or initiate the experience of one another. Perspective taking may make someone aware of the plight of others, thereby facilitating the experience of empathic concern. In turn, feeling empathy for another may motivate greater interest in the emotional and psychological state of another. Through the release of OT, these empathic states can lead to prosocial behavior.

18.4 Conclusion

Human beings feel empathy for individuals with whom they are unacquainted, as evidenced by prosocial assistance in and outside the lab. The review of findings herein has shown that OT release in the brain is one physiologic factor that changes the self–other relationship by causing human beings to experience empathy, and empathic concern in particular. The OT infusion studies from our lab and others establish the causal relationship between prosocial behaviors and OT. Taken together, this research shows that OT is part of the neurophysiology of human prosociality, even producing prosocial behaviors where these is little incentive to help others. Future research is likely to find many other examples of prosocial behaviors associated with OT. For instance, unpublished data from our lab suggests that in both a college-aged and general adult sample, those who regularly volunteer have higher basal OT and a larger change in OT after a stimulus than non-volunteers. Engagement in habitual prosocial behaviors, like volunteering, may result in a positive feedback loop tuning the oxytocineric system to be more responsive to social stimuli.

We have also found that women who release more OT after a trust stimulus, compared to those who release less report greater happiness with their lives ($r = 0.31$, $p = 0.05$; Grosberg, Merlin and Zak, 2012). These "super-releasers" had fewer depressive symptoms ($r = -0.35$, $p = 0.05$), and had more sex ($r = 0.29$, $p = 0.05$) with fewer partners ($r = -0.33$, $p = 0.022$). High OT releasers appear to be happier because of the rich social milieu that they inhabit, with higher quality romantic relationships ($r = .42$, $p = 0.01$) and more friends ($r = 0.27$, $p = 0.06$). As gregariously social creatures, most human beings crave social connections. Indeed, those with larger social networks report better health (e.g., Myers, 2001). Social relationships are sustained by prosocial behaviors, and OT appears to be a critical component of human prosociality.

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