Empathy toward Strangers Triggers Oxytocin Release and Subsequent Generosity

Jorge A. Barraza[a] **and Paul J. Zak**[b]

[a] *School of Organizational and Behavioral Studies and Center for Neuroeconomics Studies, Claremont Graduate University, Claremont, California 91711, USA*

[b] *Department of Economics and Center for Neuroeconomics Studies, Claremont Graduate University, Claremont, California 91711, USA*

Empathy is related to a variety of prosocial behaviors, but the brain mechanisms producing the experience of empathy have not been fully characterized. This study investigated whether the experience of empathy raises oxytocin levels and affects subsequent generosity toward strangers. Short video clips of an emotional scene and an unemotional scene were used as stimuli. Participants rated the emotions they experienced and then played a $40 ultimatum game to gauge their generosity. We found that empathy was associated with a 47% increase in oxytocin from baseline. We also found the empathy–oxytocin response was stronger in women than in men. Higher levels of empathy were also associated with more generous monetary offers toward strangers in the ultimatum game. Our findings provide the first evidence that oxytocin is a physiologic signature for empathy and that empathy mediates generosity.

Key words: **oxytocin; empathy; distress; gender; hormones; emotion induction**

Introduction

Humans are often aroused by the distress of others. Empathy allows us to perceive another's affective state and motivates action if the other is perceived to be in an aversive state.[1–3] The enduring interest in empathy across disciplines (as illustrated by this issue) is caused, in part, by its relationship to moral behaviors, as argued by Aristotle in *The Nicomachean Ethics*[4] and Adam Smith in *The Theory of Moral Sentiments*[5] as well as other scholars. Altruism can be considered morally virtuous and has been associated with empathy.[2,6] The experience of empathy has been shown to motivate prosocial behaviors, such as volunteering and donations to charities.[7,8]

Although much is known about the behavioral outcomes when people are empathic, the physiologic mechanisms of empathy are not well understood.[7,9] Specifically, little is known about how observing the aversive states of others translates into the subjective experience of empathy. In addition, the physiologic substrates causing individuals to experience different empathic states, such as empathic concern or personal distress when observing aversive states in others, is unknown. We propose that the neurohormone oxytocin (OT) may be part of the brain architecture that produces experienced empathy. OT is associated with attachment behaviors in mammals, and we identified OT as a likely mechanism that causes human beings to respond to the affective states of others. OT is a neuroactive hormone that is directly synthesized in the hypothalamus and projects to brain areas that are associated with emotions and social behaviors (e.g., amygdala and cingulate cortex).[10] In socially monogamous mammals, OT mediates prosocial behaviors, such as partner preference, social recognition, parental care, and social approach.[11–14]

Address for correspondence: Paul J. Zak, Department of Economics and Center for Neuroeconomics Studies, Claremont Graduate University, 160 East 10th Street, Claremont, CA 91711-6165. paul.zak@cgu.edu

Values, Empathy, and Fairness across Social Barriers: Ann. N.Y. Acad. Sci. 1167: 182–189 (2009).
doi: 10.1111/j.1749-6632.2009.04504.x

Recent studies in humans have revealed that OT promotes prosocial behaviors, including trust, reciprocity, and generosity measured using monetary transfers to strangers.[15–19] Specifically, OT levels measured in plasma were 41% higher in subjects after a monetary transfer denoting trust was received compared to those who received a randomly chosen transfer of the same average amount. In these studies, OT levels were positively associated with increased monetary reciprocity toward the person who initiated trust.[17,18] We discovered recently that endogenous OT release and self-sacrificial reciprocity can be magnified by exposing participants to touch prior to making decisions. Fifteen minutes of moderate pressure massage increased the change in OT after being trusted by 16% and increased reciprocity by 243% compared to controls who rested for 15 min.[20]

Exogenous OT infusion studies in humans have demonstrated its causal effect on prosocial behaviors. Intranasal infusion of 24 IU of OT increased monetary transfers to a stranger (denoting trust) by 17%.[15] Further, in a monetary transfer task that involves making an offer to share a fixed sum of money, known as the ultimatum game (UG), 40 IU of intranasal OT increased the generosity of offers by 80% over placebo.[19] These studies show that OT is associated with prosocial behaviors but leave open the question of whether OT is associated with empathy.

The Current Study

Herein we report a direct test of whether OT is a proximate mechanism modulating the subjective experience of empathy. We hypothesized that OT would spike after exposure to an emotional stimulus and would be associated with the experience of two empathic states: personal distress and empathic concern. We also tested if elevated OT would elicit a prosocial behavior—generosity toward a stranger. Two behavioral tasks were used to test the empathy–prosociality association: offers in the UG and monetary donations to charity. We used the UG, as reported in Zak and colleagues,[19] as it requires perspective taking by participants—a cognitive exercise that has been shown to provoke empathy.[6,21]

Materials and Methods

Participants and Procedure

One hundred and forty-five college students (52% female students, mean age 20.8 years, SD = 3.3) from the University of California, Los Angeles (UCLA) participated in this study. Participants were randomly assigned to one of three groups: emotional video and UG (EU, $n = 61$), control video and UG (CU, $n = 56$), or emotional video only (E, $n = 24$). Three participants (one from each condition) were excluded from analyses because of OT levels outside of the acceptable assay range (>2500 pg/mL) at baseline, which is 5 SD above the mean.

Participants were recruited by email and earned $10 for agreeing to be part of the experiment. Total earnings were based on the decision task as discussed below. After consent, participants were led to a private room for their first blood draw by a licensed phlebotomist. Participants were then seated at partitioned computer stations and asked to fill out a survey. Once finished, participants viewed one of two brief videos and were asked to rate the degree to which particular emotions were felt. Participants then played a single round of the UG sequentially for money (except for the E group). Survey, video, and UG instructions and decisions were made via computer. No interpersonal communication was permitted. Immediately after the decision in the UG, a second blood draw was performed for those in the EU and CU groups. The E group had their second blood draw after viewing the video. After the second blood draw, participants were privately informed of their study earnings and presented with the option to donate to a charity. When all tasks were completed, participants were privately paid by a lab administrator who was not associated with the study. The protocol was approved by the Institutional Review Boards of UCLA and Claremont Graduate University. The study was double blind and no deception of any kind was used.

Ultimatum Game

Participants played a single round of the UG to assess generosity toward a stranger.[19,22] In the UG, participants were randomly put into dyads and in each dyad were randomly assigned to the role of decision maker 1 (DM1) or decision maker 2 (DM2). Both DMs received extensive and identical instructions for the UG, including examples. In our version of the UG, DM1s were endowed with $40 and were asked to choose an offer of a split of this money to the DM2 in his or her dyad. DM2s had no endowment. If DM2 accepted the offer from DM1, both DMs were subsequently paid the money according to the accepted division. However, both DMs earned nothing if DM2 rejected the offer from DM1. The UG task is designed to have participants consider how the DM2 in the dyad would react to an offer (perspective taking) because DM2s can reject offers. A rejection of the offer from DM1 in the UG allows DM2 to punish DM1 for stinginess but at a cost of the loss of the money offered. Although most UG experiments are played with $10,[23] a $40 endowment was used in this experiment in order to compensate participants for two blood draws as well as to explore whether a parametric relationship existed between DM2 offers and the change in OT, as has been found for DM2s in a related monetary decision task called the trust game.[18,20]

Blood Draw

After consent, all participants had 20 mL of blood drawn by a licensed phlebotomist from an antecubital vein. Two, 8-mL, EDTA, whole-blood tubes and one serum-separator tube were drawn while maintaining a sterile field and using a Vacutainer© (BD, Franklin Lakes, NJ, USA). Those in the EU and CU groups had a 20-mL second blood draw immediately following their decision in the UG. Participants were prompted to make their decisions serially so that the decision and blood draw were temporally close, typically occurring within 2 min after the decision, as in Zak and colleagues.[18] Participants in the E group received a second 20-mL blood draw following viewing and rating of the emotional video. Blood tubes were immediately placed on ice after being drawn. The tubes were then placed in a refrigerated centrifuge and spun at 1500 rpm for 12 min at 4°C. Plasma and serum were removed from the tubes and placed into 2-mL microtubes with screw caps. These tubes were immediately placed on dry ice and then transferred to a −70°C freezer until analysis.

Assays

Five hormones were assayed using either radioimmunoassay (RIA) or enzyme-linked immunosorbent assays (ELISA). Andrenocorticotropin hormone (ACTH) (plasma-RIA) samples were assayed using a kit produced by DiaSorin, Inc. (Stillwater, MN, USA), cortisol (serum-RIA) samples were assayed using a Diagnostic Systems Laboratories (Webster, TX, USA) kit, and progesterone (serum-RIA) and estradiol (serum-RIA) were assayed with kits from Siemens Healthcare Diagnostics Inc. (Los Angeles, CA, USA). OT was assayed using a competitive ELISA assay from Assay Designs, Inc. (Ann Arbor, MI, USA). The inter- and intra-assay coefficients of variations for OT were 7.8% at 484.68 pg/mL and 10.2% at 494.63 pg/mL (10 replicates), respectively. All tests were performed by the Endocrine Core Laboratory of the Yerkes National Primate Research Center at Emory University, Atlanta, GA.

Surveys

Participants filled out several survey instruments to examine the effects of personality factors on OT release and behavior. Instruments included the Interpersonal Reactivity Index,[24] the Affect Intensity Measure,[25] the Big Five Inventory,[26] Cognitive Hardiness,[27] along with basic demographic questions taken from Zak and colleagues.[18]

Video

All participants, using headphones, privately viewed a 2-min long video in their partitioned computer stations. Participants in the EU and E conditions watched a video in which a father explains his current experiences with his 2-year-old son who has terminal brain cancer. The video includes scenes of the child in the hospital and with his father who narrates the video clip. Participants in the CU condition watched a clip similar in length with images of the father and child. However, the narration was of the father describing a day at the zoo and has no mention of the child's illness or any expression of concern for the child.

Video Ratings

At the end of the video, participants were asked to rate the degree to which they experienced particular emotions while viewing the video. This list included 12 adjectives previously used to assess empathy toward others[5] (e.g., *sympathetic*, *compassion*, *moved, tender, warm, soft-hearted*) and personal distress (e.g., *anxious*, *distressed*, *sad, annoyed, frightened, disturbed*). Participants rated these adjectives from 1 (*did not feel this way at all*) to 5 (*felt this way very much*). Composite measures were created for both empathy ($\alpha = 0.75$) and distress ($\alpha = 0.60$).

Donation Task

After the UG and second blood draw, participants were informed of their study earnings in private and presented with the opportunity to donate any amount of their study earnings to one of two well-known charities (St. Jude Children's Hospital, or the American Red Cross). The experimenters informed participants that there was no obligation to donate and that their decision to donate was anonymous.

Results

Response to Video

There was no change in OT in those who viewed the emotional video (EU + E: baseline OT = 474.87 pg/mL, SD = 306.75, post-video OT = 448.91 pg/mL, SD = 288.72; one-tailed paired t test, $P = 0.21$, $n = 80$). There was a significant decrease in OT in those who viewed the control video (CU: baseline OT = 464.96 pg/mL, SD = 341.90, post-video OT = 377.64 pg/mL, SD = 250.95; two-tailed paired t test, $P = 0.03$). However, separating emotional video conditions we found different results. OT significantly increased among participants in the E condition who viewed the emotional video but did not play the UG (baseline OT = 401.83 pg/mL, SD = 230.06, post-video OT = 592.19 pg/mL, SD = 225.34; two-tailed paired t test, $P = 0.004$). Alternatively, there was a significant decrease in OT for those who viewed the emotional video and played the UG (EU: baseline OT = 502.57 pg/mL, SD = 328.75, post-video OT = 394.56 pg/mL, SD = 293.08; two-tailed paired t test, $P < 0.001$). As Figure 1 shows, the emotional video increased OT but not when the second blood draw followed the UG.

Emotional Ratings

Participants in the E and EU conditions rated the emotional video as eliciting greater empathy than those in the CU condition (CU $M = 2.88$, E $M = 3.46$, $P < 0.001$; EU $M = 3.53$, $P < 0.001$, both one-tailed t tests)

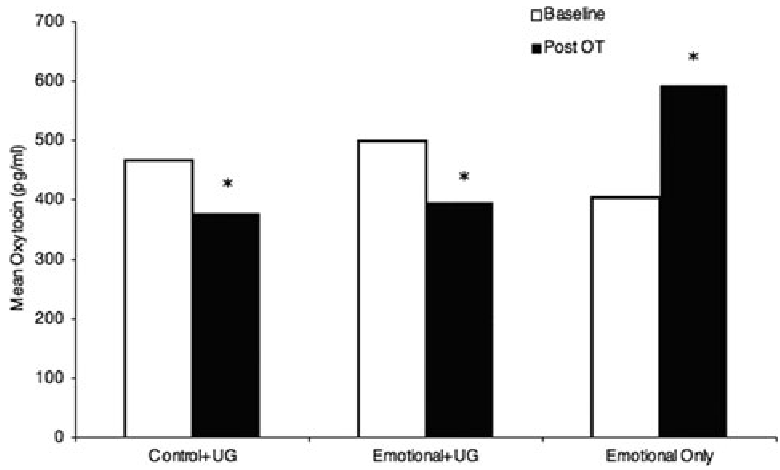

Figure 1. Change in oxytocin (OT) from baseline to post video across all conditions; UG, ultimatum game. *denotes a significant difference at p < .05.

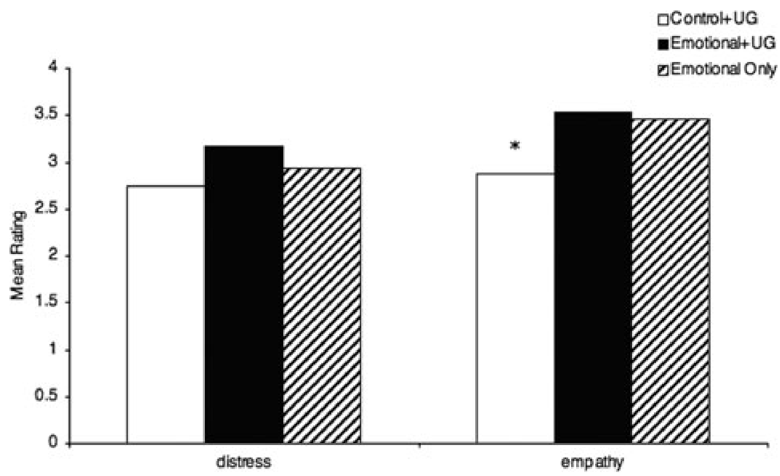

Figure 2. Participant video ratings of empathy and distress across all conditions.*denotes a significant difference at p < .05.

and distress (CU $M = 2.74$, E $M = 2.93$, $P = 0.08$; EU $M = 3.17$, $P < 0.001$, both one-tailed t tests). Participants in the E and EU condition reported statistically equal experiences of empathy ($P = 0.63$) and distress ($P = 0.12$). See Figure 2.

Using simple correlations across all conditions, there was no relationship between a change in OT and subjective empathy ($r = 0.053$, $P = 0.28$) or distress ($r = -0.074$, $P = 0.21$). We discovered, however, a high correlation between self-reported empathy and distress ($r = 0.81$, $P < 0.001$). As a result, partial correlations were examined between OT and each emotion, controlling for the other one. Controlling for these cross-effects, a spike in OT was significantly associated with increased feelings of empathy ($r = 0.197$, $P = 0.01$) as well as decreased feelings of distress ($r = -0.188$, $P = 0.02$). A hierarchical regression analysis was conducted to test if empathy and distress predicted a change in OT when controlling for changes in other hormones (ACTH, cortisol). Changes in hormones related to OT and gender were entered in the first step, followed by empathy and distress video ratings in the second step of the equation. This analysis revealed a significant overall regression equation:

$F(5, 118) = 3.09$, $P < 0.01$. Both empathy ($\beta = 0.294$, $P < 0.05$) and distress ($\beta = -0.301$, $P < 0.05$) were significant predictors of the change in OT in different directions. This result was maintained in separate analyses controlling for basal levels of progesterone or estradiol in women.

Emotional Ratings and Other Hormones

Across all conditions, emotional ratings were not significantly correlated with any of the hormones (ACTH, cortisol, estradiol, progesterone) at baseline or post video. However, when controlling for one another, empathy and distress were significantly correlated with the change in cortisol (empathy $r = 0.134$, $P = 0.07$; distress $r = -0.203$, $P = 0.01$). Empathy and distress ratings were marginally correlated with post-video OT (empathy $r = 0.121$, $P = 0.09$; distress $r = -0.118$, $P = 0.09$) and post-video cortisol (empathy $r = 0.162$, $P = 0.04$; distress $r = -0.171$, $P = 0.03$).

Generosity in UG

Of the participants playing as DM1 ($n = 56$), 35 (62.5%) offered an equal split, 20 (26%) made unequal offers of \$10–\$19, and two made supra-equal offers of \$21 and \$30. There were 49 participants who participated as DM2s. Of those, only one person in the EU and one in the CU groups rejected DM1 offers of \$10; all other offers were accepted. DM2s whose offers were rejected were removed from subsequent analyses. There were no differences in the mean DM1 offers between the EU (M = \$18.18, SD = \$3.19) and CU (M = \$17.62, SD = \$4.54; one-tailed t test, $P = 0.29$) conditions.

Consistent with our hypothesis, DM1 proposals in the UG were positively correlated with reported empathy after the video ($r = 0.239$, $P = 0.05$). There was a weak relationship between DM1 offers and distress levels ($r = 0.171$, $P = 0.11$). Similar to studies of OT in the trust game,[18] DM1 behavior was uncorrelated with the change in OT ($r = -0.150$, $P = 0.14$). The amount offered to DM2s was marginally negatively correlated to the change in DM2 cortisol ($r = -0.202$, $P = 0.07$) but not to change in OT ($r = -0.120$, $P = 0.20$). Controlling for gender and changes in ACTH and cortisol, the money offered to DM2s did not predict change in OT ($\beta = -0.08$, $P = 0.54$).

Charitable Donations

Forty-four participants (32%) made monetary donations (M = \$6.09, SD = 6.31). Donations were significantly correlated with the amount sent by DM1s ($r = 0.356$, $P = 0.004$). Among all participants, donations were positively related to the change in cortisol ($r = 0.146$, $P = 0.05$) but were unrelated to the change in OT ($r = -0.010$, $P = 0.45$) or to the change in ACTH ($r = -0.084$, $P = 0.18$). Donations were not associated with emotional video ratings (empathy $r = -0.088$, $P = 0.16$; distress $r = -0.080$, $P = 0.19$).

Gender and Personality

Pooling all conditions, we found that emotional ratings (controlling for one another) were more strongly associated with changes in OT for women (empathy $r = 0.245$, $P = 0.03$; distress $r = -0.258$, $P = 0.02$) than for men (empathy $r = 0.158$, $P = 0.11$; distress $r = -0.134$, $P = 0.15$). Behaviorally, more women made charitable donations than men (23% of men versus 41% of women, $\chi^2 = 4.78$, $P = 0.03$) and gave more in donations than men (M = \$2.89 versus M = \$1.08; two-tailed t test, $P = 0.02$). The average amount sent by DM1s was also greater for women than men (women \$18.85, men \$17.10; one-tailed t test, $P = 0.05$). The change in OT was associated with increased dispositional empathy ($r = .187$, $p = .02$) as measured in the IRI. No other personality variables were associated with basal OT or the change in OT.

Discussion

There were three main findings from this study. First, viewing an emotional video raised OT by an average of 47% over baseline compared to those who watched an emotionally neutral video. Second, there was a positive relationship between the degree of empathy experienced and the change in OT. Third, an increase in experienced empathy was associated with greater generosity in the UG.

Past research has purported that emotional videos may induce OT release.[28] We provide the first direct evidence for this claim, and we have demonstrated both a statistically and quantitatively significant increase in OT after an emotional stimulus. Even more compelling, we discovered a positive parametric relationship between the experience of empathy and the change in OT. The relationship between empathy and the change in OT was especially strong for women. Moreover, we found that the empathic concern subscale of the IRI, a measure of dispositional empathy (e.g., sympathy, compassion), to be the only personality variable to predict a spike in OT. The lack of a relationship between the change in OT when the emotional video was followed by the UG is likely a result of the time lag between the video and the second blood draw, which was required for instructions and UG decisions. The half-life of OT is very short, with estimates of between 1–2 min.[29]

We also reported that the experience of empathy positively influenced prosociality. Participants who were empathically engaged by the video they viewed made more generous offers in the UG. Those who made more generous offers also donated more money to charity, with this effect associated with physiologic distress (a positive change in cortisol). Donations were highest among women in the sample. At the same time, the change in OT was strongest among women. Post-hoc analyses found that these gender differences were not driven by the upregulation of OT by estrogen.[30]

We also found an interesting counteracting effect of distress on OT release. Empathy and distress were highly related in our sample and they appear to work against each other at a physiologic level. Psychologists have also distinguished between empathy and distress as motivators to help others.[6,21] Batson's empathy–altruism hypothesis[6,31] posits that these affective states lead to divergent motivations to help others. Those who experience distress are motivated to reduce their own aversive state, while those who experience empathy are focused on relieving the aversive state of another.[32] Our physiologic data support the separation of these two effects in relation to OT. Interestingly, empathy and distress levels were also associated with changes in cortisol. In animal studies, cortisol suppresses OT release.[33] In human studies the findings are less clear; OT administration suppresses cortisol induced by social stress,[34,35] but cortisol administration increases plasma OT levels.[36,37] Our study showed that cortisol was elevated in people who reported experiencing empathy while it declined in those reporting distress.

This study indicates that OT is a physiologic signature for empathy and modulates two types of prosocial behaviors: generosity in the UG and charitable donations. These findings identify a proximate mechanism that explains why humans help each other—even at a cost to themselves.

Conflicts of Interest

The authors declare no conflicts of interest.

References

1. Dovidio, J.F. *et al*. 1991. The arousal: Cost-reward model and the process of intervention. In *Review of Personality and Social Psychology: Prosocial Behavior*, Vol. 2. M.S. Clark, Ed.: 86–118. Sage. Newbury Park, CA.
2. de Waal, F.B.M. 2008. Putting the altruism back into altruism: The evolution of empathy. *Annu. Rev. Psychol.* **59:** 279–300.

3. Preston, S.D. & F.B.M. de Waal. 2002. Empathy: Its ultimate and proximate bases. *Behav. Brain Sci.* **25:** 1–72.
4. Aristotle. 2000. *The Nicomachean Ethics*. Cambridge University Press. Cambridge, UK.
5. Smith, A. 2006 [1759]. *A Theory of Moral Sentiments*. Dover Publications. Mineola, NY.
6. Batson, C.D. 1991. *The Altruism Question: Toward a Social-Psychological Answer*. Lawrence Erlbaum. Hillsdale, NY.
7. Dovidio, J.F. *et al*. 2006. *The Social Psychology of Prosocial Behavior*. Lawrence Erlbaum. Hillsdale, NY.
8. Brooks, A.C. 2006. *Who Really Cares*. Basic Books. New York, NY.
9. Eisenberg, N. & P.A. Miller. 1987. The relation of empathy to prosocial and related behaviors. *Psychol. Bull.* **101:** 91–119.
10. Sofroniew, M.V. 1983. Vasopressin and oxytocin in the mammalian brain and spinal cord. *Trends. Neurosci.* **6:** 467–472.
11. Insel, T.R. 1997. A neurobiological basis of social attachment. *Am. J. Psychiatry* **154:** 726–735.
12. Insel, T.R. & L.J. Young. 2001. The neurobiology of attachment. *Nat. Rev. Neurosci.* **2:** 129–136.
13. Carter, C. 2003. Developmental consequences of oxytocin. *Physiol. Behav.* **79:** 383–397.
14. Keverne, E.B. & Curley, J.P. 2004. Vasopressin, oxytocin and social behaviour. *Curr. Opin. Neurobiol.* **14:** 777–783.
15. Kosfeld, M. *et al*. 2005. Oxytocin increases trust in humans. *Nature* **435:** 673–676.
16. Zak, P.J. 2005. Trust: A temporary human attachment facilitated by oxytocin. *Behav. Brain Sci.* **28:** 368–369.
17. Zak, P.J., R. Kurzban & W.T. Matzner. 2004. The neurobiology of trust. *Ann. N. Y. Acad. Sci.* **1032:** 224–227.
18. Zak, P.J., R. Kurzban & W.T. Matzner. 2005. Oxytocin is associated with human trustworthiness. *Horm. Behav.* **48:** 522–527.
19. Zak, P.J., A. Stanton & S. Ahmadi. 2007. Oxytocin increases generosity in humans. *PLoS ONE* **2:** e1128.
20. Morhenn, V.B. *et al*. 2008. Monetary sacrifice among strangers is mediated by endogenous oxytocin release after physical contact. *Evol. Hum. Behav.* **29:** 375–383.
21. Davis, M.H. 1996. *Empathy: A Social Psychological Approach*. Westview Press. Boulder, CO.
22. Güth, W., R. Schmittberger & B. Schwarze. 1982. An experimental analysis of ultimatum bargaining. *J. Econ. Behav. Organ.* **3:** 367–388.
23. Camerer, C. 2003. *Behavioral Game Theory: Experiments in Strategic Interaction*. Princeton University Press. Princeton, NJ.
24. Davis, M.H. 1983. Measuring individual differences in empathy: Evidence for a multidimensional approach. *J. Pers. Soc. Psychol.* **44:** 113–126.
25. Larsen R.J. & E. Diener. 1987. Affect intensity as an individual difference characteristic: A review. *J. Res. Pers.* **21:** 1–39.
26. John, O.P., E.M. Donahue & R.L. Kentle. 1991. *The Big Five Inventory- Versions 4a and 54*. University of California, Berkeley, Institute of Personality and Social Research. Berkeley, CA.
27. Nowack, K.M. 1990. Initial development of an inventory to assess stress and health risk. *Am. J. Health Promot.* **4:** 173–180.
28. Silvers, J.A. & J. Haidt. 2008. Moral elevation can induce nursing. *Emotion* **8:** 291–295.
29. Meyer, C. *et al*. 1987. Relationship between oxytocin release and amplitude of oxytocin cell neurosecretory bursts during suckling in the rat. *J. Endocrinol.* **114:** 263–270.
30. McCarthy, M.M. 1995. Estrogen modulation of oxytocin and its relation to behavior. In *Oxytocin: Cellular and Molecular Approaches in Medicine and Research*: 235–245.
31. Batson, C.D. & K.C. Oleson. 1991. Current status of the empathy-altruism hypothesis. In *Review of Personality and Social Psychology: Prosocial Behavior*, Vol. 2. M.S. Clark, Ed.: 62–85. Sage. Newbury Park, CA.
32. Batson, C.D. 1987. Prosocial motivation: Is it ever truly altruistic? In *Advances in Experimental Social Psychology*, Vol. 20. L. Berkowitz, Ed.: 65–122.
33. Carter, C.S. 1998. Neuroendocrine perspectives on social attachment and love. *Psychoneuroendocrin* **23:** 779–818.
34. Ditzen, B. *et al*. 2008. Intranasal oxytocin increases positive communication and reduces cortisol levels during couple conflict. *Biol. Psychiatry*. in press.
35. Heinrichs, M. *et al*. 2003. Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. *Biol. Psychiatry* **54:** 1389–1398.
36. Tops, M., J.M. van Peer & J. Korf. 2007. Individual differences in emotional expressivity predict oxytocin responses to cortisol administration: Relevance to breast cancer? *Biol. Psychol.* **75:** 119–123.
37. Tops, M. *et al*. 2007. Anxiety, cortisol, and attachment predict plasma oxytocin. *Psychophysiology* **44:** 444–449.