The Neurobiology of Trust

PAUL J. ZAK,[a,b,c] ROBERT KURZBAN,[d] AND WILLIAM T. MATZNER[a]

[a]*Center for Neuroeconomics Studies, Claremont Graduate University, Claremont, California 91711-6167, USA*

[b]*Department of Neurology, Loma Linda University, Loma Linda, California, USA*

[c]*Gruter Institute for Law and Behavioral Research, Portola Valley, California, USA*
[d]*Department of Psychology, University of Pennsylvania, Philadelphia, Pennsylvania, USA*

ABSTRACT: This is the first report that endogenous oxytocin in humans is related to social behaviors, which is consistent with a large animal literature. Subjects are put into a social dilemma in which absent communication, cooperative behavior can benefit both parties randomly assigned to a dyad. The dilemma arises because one participant must make a monetary sacrifice to signal the degree of trust in the other before the other's behavioral response is known. We show that receipt of a signal of trust is associated with a higher level of peripheral oxytocin than that in subjects receiving a random monetary transfer of the same average amount. Oxytocin levels were also related to trustworthy behavior (sharing a greater proportion of the monetary gains). We conclude that oxytocin may be part of the human physiology that motivates cooperation.

KEYWORDS: trust; neurobiology; oxytocin

INTRODUCTION

Social ties are known to reduce morbidity and mortality,[1,2] and those who engage in more social interactions are less stressed physiologically.[3] Animal models identify a prominent role for the neuroactive hormone oxytocin (OT) in facilitating various social behaviors, including social recognition,[4,5] maternal attachment,[6–8] and, in some species, pair bonding.[9,10] Recent work has demonstrated that oxytocin infusion and social support during public speaking reduces stress responses.[11]

Our work has examined the role of OT in facilitating interpersonal trust.[12] Humans trust unrelated others repeatedly during daily activities, and trust is an essential element in building social relations. We hypothesized that OT would rise in response to a social signal of trust and that an increase in OT would be associated with trustworthy behavior (the reciprocation of trust).

Address for correspondence: Center for Neuroeconomics Studies, Claremont Graduate University, Claremont, CA 91711-6165. Voice: 909-621-8788; fax: 909-621-8460.
paul.zak@cgu.edu

Ann. N.Y. Acad. Sci. 1032: 224–227 (2004).
doi: 10.1196/annals.1314.025

MATERIAL AND METHODS

Trust and trustworthiness are operationalized using a paradigm from experimental economics using monetary transfers.[13] Subjects are recruited and earn $10 for showing up for the experiment and then are randomly assigned to the role of decision-maker 1 (DM1) or decision-maker 2 (DM2) in DM1-DM2 dyads. Subjects are informed that their own decisions and those of the other DM in their dyad will determine how much money they leave with; however, they cannot communicate directly with, and are unacquainted with, the other DM. All interactions are made through a computer interface in a large lab. There is no deception of any kind. Important to the experimental paradigm is that DM1s incurred a direct cost to send a signal of trust, whereas DM2s incurred a direct cost of being trustworthy.

DM1s are queried by software to send an integer amount of their $10 show-up payment, including zero, to the DM2 in their dyad. Both DMs are advised that whatever DM1 sends to DM2 will be tripled in DM2's account. DM2s are informed of how much the DM1 in their dyad sent them and the total in their accounts, and are prompted to send some integer amount, including zero, to the DM1 in their dyad. The degree of trust is measured by the amount that DM1 sends to DM2. Similarly, the amount DM2 transfers to DM1 is an index of trustworthiness.[13] Participants made a single decision serially, and immediately after each decision 28 mL of blood was drawn from an antecubital vein. After all decisions, subjects were privately paid their earnings.

We conducted two experimental conditions. In the Intention condition, the trust game just described was implemented; in the Random Draw condition, DM1 publicly pulled a numbered ball from an urn. The urn contained 11 balls numbered 0, 1, … 10, corresponding to the set of choices DM1s could make in the Intention condition. The Random Draw condition held constant the receipt of money by DM2 from DM1,

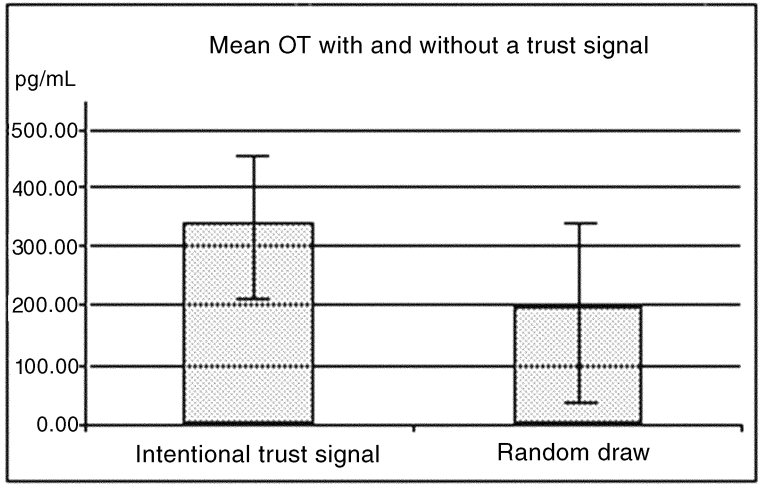

FIGURE 1. Oxytocin (OT) levels and standard errors for DM2s with and without receipt of an intention of trust.

but removed the intentional signaling element from DM1's decision, allowing us to extract the behavioral and endocrine effects of the trust signal.

DM2s who received an intentional trust signal have nearly twice the OT levels as DM2s in the Random Draw condition (F-test, one-tailed, $n = 38$, $P < .004$, FIG. 1) even though the average monetary transfers received by DM2s in both conditions are identical (F-test, two-tailed, $n = 82$, $P > .87$). The two conditions also result in different behaviors. DM2s who receive an intentional trust signal return on average 53% of the amount they received to the DM1 in their dyad, whereas in the Random Draw condition the mean amount DM2 returns to DM1 is 18%, which is not statistically different from zero (t-test, two-tailed, $P > .45$). Trustworthy behavior (DM2's transfer to DM1) is statistically different between conditions (F-test, two-tailed, $P < 8.4E\text{-}5$). Moreover, OT is associated with the behavior of DM2s in the Intention condition. Estimating a multiple regression model of the percent DM2s return to DM1s (relative trustworthiness), on OT, OT^2, including age, gender, and a progesterone-based indicator of ovulation as covariates, we find that both OT and OT^2 were significantly related to DM2 trustworthiness (OT [+][OT^2 [−], one-tailed t-test, $P > 0.035$). Ovulating women are also statistically less trustworthy (one-tailed t-test, $P > .036$), presumably because of the inhibition of OT binding to its receptor by progesterone.[14] None of eight other hormones assayed are related to DM2 behaviors, nor are the age and gender covariates, indicating that OT is having a direct effect.

DISCUSSION

To summarize our findings, peripheral OT responds to the receipt of a social signal of trust and is statistically related to trustworthy behavior. When the social signal of trust is removed, so are the OT response and the high degree of trustworthiness.

REFERENCES

1. BERKMAN, L.F. & T. GLASS. 2000. Social integration, social networks, social support, and health. *In* Social Epidemiology. L.F. Berkman & I. Kawachi, Eds. :137–173. Oxford University Press. Oxford.
2. WELIN, L., G. TIBBLIN, K. SVARDSUDD, *et al.* 1985. Prospective study of social influences on mortality: the study of men born in 1913 and 1923. Lancet **1:** 915–918.
3. CACIOPPO, J.T., J.M. ERNST, M.H. BURLESON, *et al.* 2000. Lonely traits and concomitant physiological processes: the MacArthur social neuroscience studies. Int. J. Psychophysiol. **35:** 143–154.
4. CHOLERIS, E., J.A. GUSTAFSSON, K.S. KORACH, *et al*. 2003. An estrogen-dependent four-gene micronet regulating social recognition: a study with oxytocin and estrogen receptor-alpha and -beta knockout mice. Proc. Natl. Acad. Sci. USA **100:** 6192–6197.
5. WINSLOW, J.T. & T.R. INSEL. 2002. The social deficits of the oxytocin knockout mouse. Neuropeptides **36:** 221–229.
6. CARTER, C.S. & E.B. KEVERNE. 2002. The neurobiology of social affiliation and pair bonding. *In* Hormones, Brain, and Behavior. D. Pfaff, A. Arnold, A. Etgen, S. Fahrbach & R. Rubin, Eds. :299-337. Academic Press. San Diego.
7. INSEL, T.R. & L.J. YOUNG. 2001. The neurobiology of attachment. Nat. Rev. Neurosci. **2:** 129–135.
8. PEDERSEN, C.A. & A.J. PRANGE, Jr. 1979. Induction of maternal behavior in virgin rats after intracerebroventricular administration of oxytocin. Proc. Natl. Acad. Sci. USA **76:** 6661–6665.

9. DLUZEN, D.E. & C.S. CARTER. 1979. Ovarian hormones regulating sexual and social behaviors in female prairie voles, *Microtus ochrogaster*. Physiol. Behav. **23:** 597–600.
10. INSEL, T.R. & L.E. SHAPIRO. 1992. Oxytocin receptor distribution reflects social organization in monogamous and polygamous voles. Proc. Natl. Acad. Sci. USA **89:** 5981–5985.
11. HEINRICHS, M., T. BAUMGARTNER, C. KIRSCHBAUM, *et al.* 2003. Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. Biol. Psychiatry **54:** 1389–1398.
12. ZAK, P.J., R. KURZBAN & W. MATZNER. 2003. Oxytocin is associated with interpersonal trust in humans. Submitted.
13. BERG, J., J. DICKHAUT & K. MCCABE. 1995. Trust, reciprocity, and social history. Games Econ. Behav. **10:** 12–42.
14. GRAZZINI, E., G. GUILLON, B. MOUILLAC, *et al.* 1998. Inhibition of oxytocin receptor function by direct binding of progesterone. Nature **392:** 509–512.