

Dissecting the Role of Oxytocin in the Formation and Loss of Social Relationships

Supplemental Information

Table S1. Theoretical models of social oxytocin effects in humans

Model	Main Mechanism	Reference
Anxiety and reward sensitivity	OXT reduces anxiety and stress for social interaction and increases social reward sensitivity and thereby influences the attribution of social salience.	(1)
Balance of OXT and vasopressin (AVP)	The balanced activities of the brain OXT and AVP systems impact upon individual variations in anxiety and stress-coping style.	(2)
Bio-behavioral synchrony	OXT orients the organism to the social world by enhancing the temporal concordance of biological and social processes.	(3)
General approach-avoidance	OXT effects are not limited to social behaviors but rather extend to the broad range of adaptive and maladaptive behaviors mediated by approach and avoidance motivational processes.	(4)
Interactionist component process	Contextual factors and interindividual variables (e.g., psychiatric illnesses) constrain or amplify the social effects of intranasal OXT.	(5)
Non-specific reduction in anxiety	Several higher-level social-cognitive effects of OXT can emerge via OXT's broad influence on lower-level general states such as anxiety.	(6)
Tend and befriend	Gaps in positive social relationships elicit elevations in OXT plasma and prompt affiliative efforts aimed at restoring positive social contacts.	(7)
Two-level approach	OXT ^{IN} delivered to the amygdala, prefrontal cortex, and brainstem modulates executive functioning related to social cognition, whereas OXT ^{IN} delivered to the brainstem and systemic circulation modulates general approach-related behaviors and reduces anxiety.	(8)
Social approach / withdrawal	OXT facilitates approach-related behaviors (i.e., emotional engagement) and reduces withdrawal-related behaviors (i.e., anxiety and fear).	(9)
Social salience	OXT increases the salience of social agents and therefore promotes a wide range of social behaviors.	(10)

AVP, vasopressin; IN, intranasal; OXT, oxytocin.

Supplemental References

1. Bethlehem RA, Baron-Cohen S, van Honk J, Auyeung B, Bos PA (2014): The oxytocin paradox. *Front Behav Neurosci* 8:48.
2. Neumann ID, Landgraf R (2012): Balance of brain oxytocin and vasopressin: implications for anxiety, depression, and social behaviors. *Trends Neurosci* 35:649-659.
3. Feldman R (2012): Oxytocin and social affiliation in humans. *Horm Behav* 61:380-391.
4. Harari-Dahan O, Bernstein A (2014): A general approach-avoidance hypothesis of oxytocin: accounting for social and non-social effects of oxytocin. *Neurosci Biobehav Rev* 47:506-519.
5. Olf M, Frijling JL, Kubzansky LD, Bradley B, Ellenbogen MA, Cardoso C, *et al.* (2013): The role of oxytocin in social bonding, stress regulation and mental health: An update on the moderating effects of context and interindividual differences. *Psychoneuroendocrinology* 38:1883-1894.
6. Churchland PS, Winkielman P (2012): Modulating social behavior with oxytocin: how does it work? What does it mean? *Horm Behav* 61:392-399.
7. Taylor SE (2006): Tend and befriend: Biobehavioral bases of affiliation under stress. *Curr Dir Psychol Sci* 15:273-277.
8. Quintana DS, Alvares GA, Hickie IB, Guastella AJ (2015): Do delivery routes of intranasally administered oxytocin account for observed effects on social cognition and behavior? A two-level model. *Neurosci Biobehav Rev* 49C:182-192.
9. Kemp AH, Guastella AJ (2011): The role of oxytocin in human affect: A novel hypothesis. *Curr Dir Psychol Sci* 20:222-231.
10. Shamay-Tsoory SG, Fischer M, Dvash J, Harari H, Perach-Bloom N, Levkovitz Y (2009): Intranasal administration of oxytocin increases envy and schadenfreude (gloating). *Biol Psychiatry* 66:864-870.