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Antisocial oxytocin: complex effects on social behavior

Annaliese K Beery

Research on the role of oxytocin and other neuropeptides in vertebrate social behavior provides a quintessential example of integrative biology — spanning species, scientific disciplines, and levels of analysis to address mechanisms of behavior. Oxytocin is involved in a wide variety of processes related to social behavior, including social recognition, affiliation, and maternal behavior. While there is a great deal of well-placed emphasis on the prosocial effects of oxytocin, antisocial effects related to decreased or deterred social interaction have also been documented. Studies from the human literature reveal increased outgroup discrimination and reduced affiliative behavior in certain individuals following oxytocin administration. Animal studies shed further light on the role of oxytocin in fear conditioning, stranger avoidance, and aggression. In some cases, prosocial behavior toward one individual or group may come at the expense of prosociality toward another. From this growing literature we learn that the antisocial effects of oxytocin are an integral aspect of its effects on social behavior.

Address
Department of Psychology, Department of Biology, and Neuroscience Program, Smith College, Northampton, MA, USA

Corresponding author: Beery, Annaliese K (abeery@smith.edu)

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Introduction

The role of oxytocin (OT) in social processes ranging from maternal behavior to mate affiliation is well established, leading to its popular designation as the 'love' or 'cuddle' hormone. There is growing appreciation, however, that OT also plays a role in a different side of social behavior [1–8]: in animals, OT has been associated with aggression, social selectivity, and fear. In humans, OT has been linked to dishonesty, ethnocentrism, social stress, envy, and reduced cooperation, among other outcomes (Table 1). These antisocial behaviors and emotions — characterized by avoidance, aggression, or reduced prosocial behavior — are nonetheless important features of the behavioral repertoires of social individuals.

Oxytocin is a 9-amino-acid peptide hormone that acts in the brain and in the periphery. In mammals, these peripheral functions include muscle contractions related to reproduction, such as orgasm, milk ejection for lactation, and uterine contractions leading to birth [9]. Astonishingly, oxytocin and related nonapeptides play a role in reproductive functions across the animal kingdom [10,11], for example: modulating ejaculation and egg deposition in snails, movements characteristic of mating in leeches, and sex-specific mating behaviors in the roundworm *Caenorhabditis elegans* [12–14]. These reproduction-related functions of oxytocin and related peptides evolutionarily preceded their roles in the central regulation of complex behaviors [15], many of which also relate to reproduction, including maternal behavior and formation of mating partnerships. Despite the remarkable consistency with which oxytocin-like peptides play important roles in reproductive and social functions across the animal kingdom, it is important to note that oxytocin has a host of additional effects, including regulation of heart rate and blood pressure, motor activity, water balance, pain sensitivity, and opiate tolerance. Behaviorally, OT also contributes to stress and anxiety-related behaviors, feeding, grooming, and learning and memory [9]. Thus oxytocin cannot be defined by any one of its functions [16].

With this diversity of roles in mind, we should adopt a multidimensional view of oxytocin [2,5], including behaviors traditionally considered to be within the antisocial realm of social behavior. Here I present the body of research findings on antisocial effects of oxytocin to date. These antisocial effects of oxytocin are often complementary to prosocial effects, occurring in the same individuals, and triggered by the same events.

The human literature on antisocial effects of oxytocin has been reviewed elsewhere [2–4,7], and is synthesized in Table 1. Many of these studies indicate that prosocial and antisocial effects of oxytocin vary with individual and social context. This review surveys the complexity of studying oxytocin and social behavior in humans and other animals, with an emphasis on the roles of oxytocin in decreased social contact, aggression, and fear in nonhuman mammals.

Complexity of studying social behavior

Scientists often refer to the neurobiology of social behavior as if it were a single process, but social behaviors are

Table 1

Overview of human studies illustrating the role of oxytocin in negatively valenced social behaviors and emotions, often in a person-specific or context-specific manner.

	Study summary	Subjects	Reference
Envy andgroup identity	OT increased envy or gloating following relative financial loss or gain.	M + F	Shamay-Tsoory *et al.* [82]
	OT increased racial in-group bias in neural responses, correlated with positive implicit attitudes toward racial in-group.	M	Sheng *et al.* [83]
	OT increased in-group favoritism and sometimes out-group derogation.	M	De Dreu *et al.* [84]
	OT was associated with group-benefitting (but not self-benefitting) lies when gains were at stake.	M	Shalvi and De Dreu [44•]
	OT promoted in-group trust and cooperation, and defensive but not offensive out-group aggression.	M	De Dreu *et al.* [85]
Stress	Increased perceived social stress after OT.	M	Eckstein *et al.* [86]
	Increased defensive response to unpredictable (but not predictable) shocks following OT.		Grillon *et al.* [87]
	OT potentiated startle response to negative stimuli, and negatively biased subsequent memory.	M	Striepens *et al.* [88]
	High plasma OT was associated with gaps in social relationships, less positive relationships, and cort levels.	F	Taylor *et al.* [89]
Context	OT enhanced cooperation when social information was present, but decreased cooperation when it was absent.	M + F	Declerck *et al.* [90]
	OT enhanced cooperation after prior contact with game partner; increased self-interested behavior in anonymous conditions (in participants lacking prosocial value orientations).	M + F	Declerck *et al.* [91]
Individual differences	OT increased interpersonal violence inclinations only in those prone to physical aggression.	M + F	DeWall *et al.* [92]
	Males in relationships but not single males maintained more space between themselves and attractive females following OT exposure.	M	Scheele *et al.* [93]
	Anxiously and securely attached individuals remembered mothers as less or more caring (respectively) following OT.	M	Bartz *et al.* [94]
	Only anxiously attached individuals demonstrated selective decreases in agency following OT.	M	Bartz *et al.* [95]
Sex differences	Increased anger and math performance in women following OT and social stress; less negative affect and greater vagal rebound in men.	M + F	Kubzansky *et al.* [96]
	Amygdalar activity decreased in males, but increased in females in response to faces following OT.	M + F	Domes *et al.* [97,98]
	OT promoted altered neural responses, and self interest in males, but altruism in females.	M + F	Scheele *et al.* [99]
	Plasma OT was elevated with relationship distress in women but not men.	M + F	Taylor *et al.* [25]
	Less evidence of trust repair in females than men following OT, particularly in high trait forgiveness females.	M + F	Yao *et al.* [100]
Mental illness	Decreased trust and cooperation in anxiously attached, rejection sensitive borderline personality disorder participants.	M + F	Bartz *et al.* [101]
	Patients with psychopathic characteristics had high urinary OT.	M	Mitchell *et al.* [102]
	Traits associated with a socially deviant lifestyle were correlated with OT.		
	Serum OT was positively associated with positive symptom severity in schizophrenia.	M + F	Rubin *et al.* [103]
	Higher plasma OT was related to increased schizotypal traits.	F	Tseng *et al.* [104]

Note: this is not an exhaustive list, and not all replication studies find these effects — see [111•].

diverse, and similar behaviors in different species may be mediated in different ways, necessitating caution in generalization. Neurobiological investigations of social behavior typically focus on specific measures such as social preference, motivation, and recognition. These behaviors are important aspects of the lives of social species, but are part of larger, species-specific social repertoires. For example, affiliation toward other individuals is common to social species, but may vary in intensity and social targets across different social systems. The study of oxytocin and social behavior has benefitted greatly from studies of prairie voles (*Microtus ochrogaster*), in which closely