Psychiatry Research 219 (2014) 198–203

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Gender differences in oxytocin-associated disruption of decision bias during emotion perception

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ARTICLE INFO

Article history:
Received 12 March 2013
Received in revised form
8 April 2014
Accepted 17 April 2014
Available online 26 April 2014

Keywords:
Signal detection theory
Face perception
Risk sensitivity
Behavioral economics

ABSTRACT

Oxytocin is associated with differences in the perception of and response to socially mediated information, such as facial expressions. Across studies, however, oxytocin's effect on emotion perception has been inconsistent. Outside the laboratory, emotion perception involves interpretation of perceptual uncertainty and assessment of behavioral risk. An account of these factors is largely missing from studies of oxytocin's effect on emotion perception and might explain inconsistent results across studies. Of relevance, studies of oxytocin's effect on learning and decision-making indicate that oxytocin attenuates risk aversion. We used the probability of encountering angry faces and the cost of misidentifying them as not angry to create a risky environment wherein bias to categorize faces as angry would maximize point earnings. Consistent with an underestimation of the factors creating risk (i.e., encounter rate and cost), men given oxytocin exhibited a worse (i.e., less liberal) response bias than men given placebo. Oxytocin did not influence women's performance. These results suggest that oxytocin may impair men's ability to adapt to changes in risk and uncertainty when introduced to novel or changing social environments. Because oxytocin also influences behavior in non-social realms, oxytocin pharmacotherapy could have unintended consequences (i.e., risk-prone decision-making) while nonetheless normalizing pathological social interaction.

1. Introduction

Accumulating studies document changes in the perception of and response to socially mediated information, including emotion perceived from faces, associated with intranasal administration of oxytocin in humans (see meta-analyses by Van IJzendoorn and Bakermans-Kranenburg, 2012; Shahrestani et al., 2013). For example, Domes et al. (2007b) found that oxytocin increased men's accuracy for difficult mental state attributions on the Reading the Mind in the Eyes task. Bartz et al. (2010) found that oxytocin rescued "empathic accuracy" of men who scored toward the high end of the normal range on the Autism Spectrum Quotient self-report questionnaire.

Although studies report oxytocin-associated increases in accuracy of facial emotion perception, there appears to be variation in the effect of oxytocin across different facial expressions. Guastella et al. (2008) found that oxytocin increased accuracy of men's recall of previously seen faces depicting happiness but not angry or neutral faces. Marsh et al. (2010) found that oxytocin increased accuracy of men's and women's categorization of faces depicting happiness, but not anger, disgust, fear, sadness, or surprise. In contrast, however, Di Simplicio et al. (2009) reported that oxytocin increased accuracy of men's categorization of neutral faces and depictions of surprise, but not of happiness. Similarly, Fischer-Shofty et al. (2010) found that oxytocin increased accuracy of men's categorization of depictions of fear, but not of happiness. Lischke et al. (2012) found that oxytocin reduced the intensity of expression at which men identified depictions of angry and fearful faces but did not significantly affect accuracy of labeling faces as happy, angry, sad, or fearful. Thus, across studies the effects of oxytocin on emotion perception have been inconsistent (reviewed by Bartz et al., 2011; Graustella and MacLeod, 2012).

Generalizing across social cognition studies, oxytocin may improve the "salience" of social stimuli, and a variety of possible mechanisms have been identified including effects on initial stimulus appraisal, attention, behavioral motivation, and memory (see, e.g., Bartz et al., 2011; Kemp and Guastella, 2011; Churchland and Winkielman, 2012; Graustella and MacLeod, 2012). Individual differences, internal to the perceiver, and situational differences,

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http://dx.doi.org/10.1016/j.psychres.2014.04.031
0165-1781/

such as aspects of study design, may account for some of the variation across emotion perception studies (Bartz et al., 2011; Graustella and MacLeod, 2012; Lischke et al., 2012).

Nonetheless, one consideration missing from studies of the effects of oxytocin on emotion perception is a characterization of emotion perception as a decision. Outside the laboratory, affective judgments about another person (e.g., Is that person angry at me? Do I trust that person?) involve interpretation of perceptual uncertainty (e.g., scowls do not always indicate anger) and assessment of behavioral risk (e.g., there are different costs to inferring an instance of anger when it does not exist, a "false alarm," vs. missing an instance of anger when it does exist, a "missed detection"). Differences in the decision-like characteristics implemented by different study designs and analytic approaches could contribute to the apparent inconsistency of oxytocin's effects. Although the results of emotion perception studies are often characterized as "improved" perception, generalization across studies or to perception outside the laboratory remains challenging. This difficulty arises, in part, because many studies have not sufficiently distinguished among various measures of performance, which include accuracy (proportion of trials answered correctly), conformation to a consensus norm, response bias, perceptual sensitivity, and decision optimality. For example, accuracy on the Reading the Minds in the Eyes task is a measure of congruence with a sample norm rather than a measure of performance over items that have objectively correct or incorrect answers (Baron-Cohen et al., 2001). Additionally, accuracy, even when it does reflect objective performance, is a function of sensitivity (ability to discriminate perceptual differences) and response bias (propensity to judge percepts as one alternative vs. another); high sensitivity and neutral bias both contribute to high accuracy (Macmillan and Creelman, 1991). Further, "accurate" perception (maximizing proportion correct) does not necessarily imply "optimal" perception (maximizing net benefit earned); it is the value earned from correct decisions, not the number of correct decisions, that is ultimately important. In environments where the costs of false alarm and missed detection differ, perceivers maximize net benefit by matching their behavior to the biased cost structure (Lynn et al., 2012), even though such bias can reduce accuracy.

In light of the inconsistencies in how emotion perception is conceptualized and measured, the results of oxytocin studies that utilize economic decision-making games may be relevant to understanding oxytocin's effect on emotion perception. In the social economic "trust" game, "investors" decide how much money to transfer to a partner, the "trustee." Trustees have the option to return the investment, with interest, or keep some or all of the investment and interest for themselves. Studies using the trust game indicate that oxytocin attenuates aversion to the risk of economic loss. Kosfeld et al. (2005) found that oxytocin increased the magnitude of men's investments. Investors given oxytocin appeared less averse to the risk that their partner in the game might respond to the investment selfishly. Behavior between oxytocin and placebo groups did not differ in a non-social version of the game. Kosfeld et al. did not provide feedback to investors about whether or not trustees responded to the investment fairly or selfishly, indicating that the difference in "trust" was not based on learning from trial to trial.

Mikolajczak et al. (2010) directly manipulated men's perception of risk in the trust game. While they found that oxytocin attenuated aversion to the risk of monetary loss, they also established a lower bound to the effect. Among men provided with vignettes (prior to the game) describing trustees as trustworthy, men given oxytocin made larger investments than those given placebo (replicating Kosfeld et al., 2005). However, men provided with vignettes describing trustees as untrustworthy invested little money, regardless of oxytocin treatment. This finding indicates that if risk is great enough, oxytocin does not noticeably alter risk perception.

Contrary to (Kosfeld et al., 2005; see also Baumgartner et al., 2008), in a non-social version of the game, Mikolajczak et al. (2010) found that men who received oxytocin invested more than men who received placebo. Mikolajczak et al. (2010) showed that this "non-social" difference between studies lay in the different investment risk that participants inferred from the task instructions for the non-social game. Perception of economic risk may therefore be a salient domain of oxytocin's activity, regardless of whether the risk has a social component.

Optimizing decisions (i.e., maximizing net benefit accrued over a series of decisions) involves learning from the outcomes of one's past decisions. Baumgartner et al. (2008) found that oxytocin caused the magnitude of men's investments in the trust game to remain unchanged following feedback that trustees had behaved selfishly. Men receiving placebo reduced their investment magnitude under the same conditions. Therefore, while the reduced risk aversion caused by oxytocin does not require feedback about the outcomes of one's decisions in order to become established (Kosfeld et al., 2005), the reduction also appears immune to the consequences of poor decisions.

Although the results of studies utilizing this economic game are framed in the social terms of "trust" and risk of "betrayal", more generally the economic loss resulting from poor decisions (e.g., the feedback provided by Baumgartner et al., 2008) may also be viewed as aversive feedback (i.e., punishment, as opposed to reward). Further evidence for a link between oxytocin and the perception of aversive feedback comes from a study utilizing aversive conditioning. Petrovic et al. (2008) initially elicited low ratings of how sympathetic individual faces appeared by pairing the faces with electric shock. Men who then received oxytocin (subsequent to the aversive conditioning) re-rated the faces as more sympathetic than did men who received placebo. Oxytocin, then, appears to reduce negatively valenced affective value associated with a stimulus, providing an explanation for why the effects of aversive feedback about one's decisions are attenuated by oxytocin (i.e., Baumgartner et al., 2008).

Risk can be quantified with two parameters: estimated payoff value (e.g., magnitude of aversive feedback), and the estimated likelihood of accruing the payoff. Oxytocin may be decreasing either or both to bring about attenuated risk aversion. Although the two studies that involved aversive conditioning (Baumgartner et al., 2008; Petrovic et al., 2008) did not investigate oxytocin's effects in these terms, a study of pain perception (Singer et al., 2008) may be relevant to understanding oxytocin's effect on risk sensitivity. Singer et al. (2008) found that oxytocin reduced amygdala activation elicited by painful electric shock in men, which suggests that oxytocin may attenuate risk aversion by reducing the influence of negatively valent stimulation (e.g., the perceived relevance of aversive feedback), rather than the estimated likelihood of accruing the aversive feedback.

1.1. The current study

In sum, emotion perception may be viewed as a decision made under conditions of uncertainty and risk. Nonetheless, prior studies of emotion perception have not modeled this uncertainty and risk. Prior studies involving risk indicate that oxytocin attenuates risk aversion, but have not investigated emotion perception. Prior studies utilizing aversive stimulation and conditioning indicate that oxytocin's influence on risk aversion could result from reducing the influence of aversive feedback on subsequent behavior. To bring together these elements and characterize oxytocin's effects on emotion perception from a