

# Opposing Oxytocin Effects on Intergroup Cooperative Behavior in Intuitive and Reflective Minds

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*Oxytocin administration.*

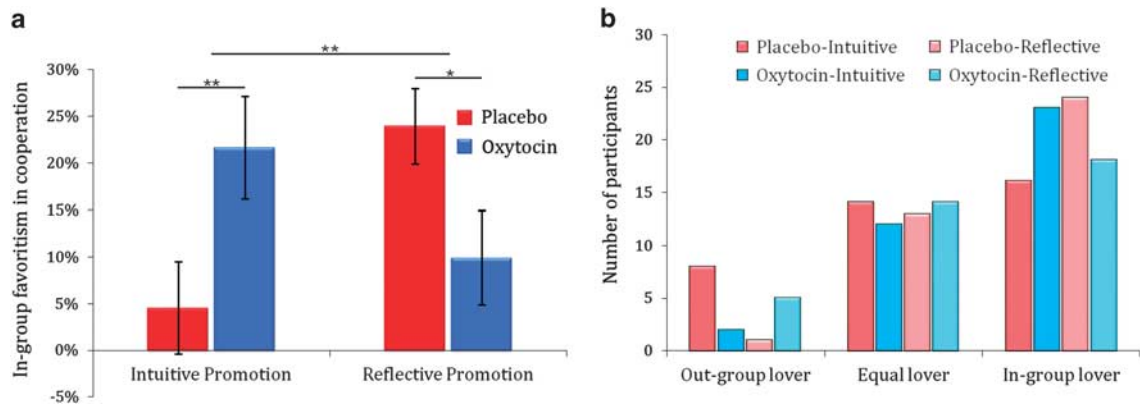
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*Minimal group paradigm.*

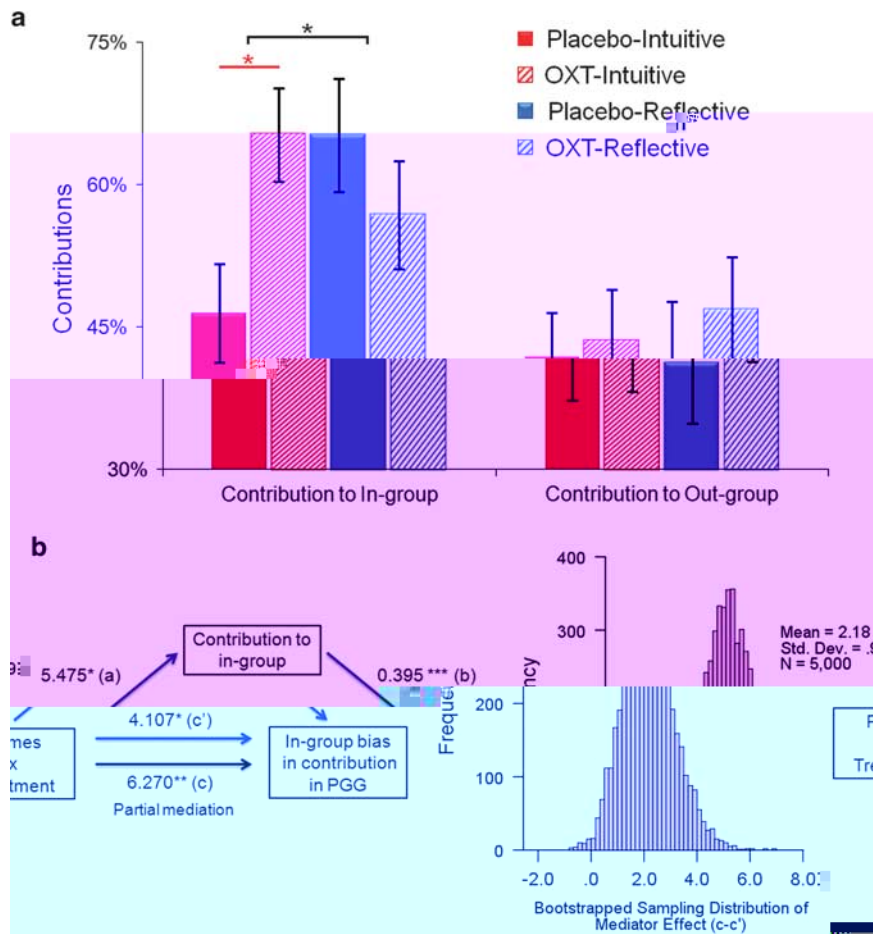
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*Cognitive-style manipulation.*

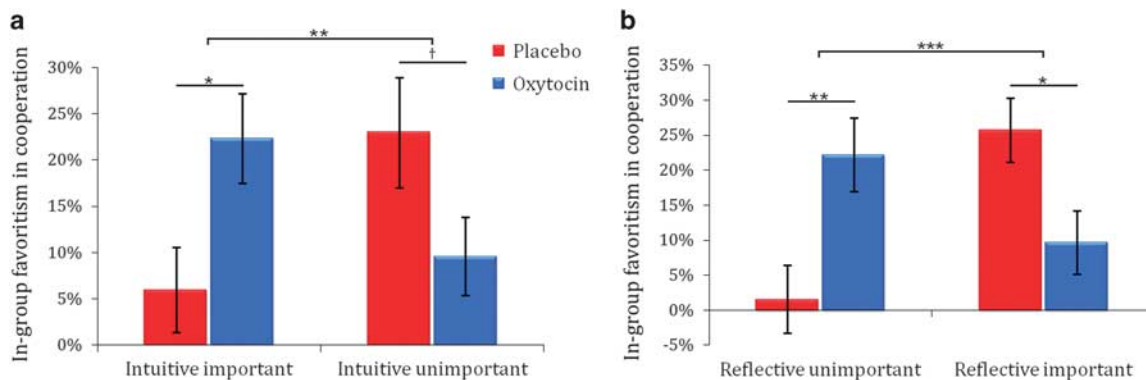
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**Figure 1** Distinct oxytocin effects on ingroup favoritism when intuition or reflection was promoted. (a) Oxytocin administration significantly enhanced ingroup favoritism when intuition was encouraged, whereas oxytocin significantly decreased ingroup favoritism when reflection was favored. (b) Distribution of outgroup-favored, equal, and ingroup-favored players. The distribution of ‘ingroup-favored players’ and ‘outgroup-favored players’ differed significantly across the four conditions. Oxytocin increased the number of ingroup-favored players among the individuals who were primed with intuition, whereas oxytocin decreased the number of ingroup-favored players among those who were primed with reflection.



**Figure 2** Effects on ingroup facilitation and outgroup deterioration. (a) Oxytocin increased contribution to ingroup members when intuition was encouraged, but decreased ingroup cooperation when reflection was favored. However, there was no significant Treatment × Priming interaction when playing with outgroup members. (b) The Treatment × Priming interaction on ingroup favoritism was mediated by its effect on contribution amount to ingroup members. The bootstrapped sampling distribution of mediator effect was provided on the right panel.



**Figure 3** Influence of intuition vs reflection importance in daily life on ingroup favoritism during PGGs. Oxytocin administration increased ingroup favoritism on the contribution during PGG in individuals who thought intuition-important (a) or reflection-unimportant (b) in daily-life decision-making. However, oxytocin administration reduced ingroup favoritism during PGG in those who thought intuition-unimportant (a) or valued reflection-important (b) in daily-life decision-making. <sup>†</sup> $P < 0.07$ ; \*  $< 0.05$ ; \*\*  $< 0.01$ ; \*\*\*  $< 0.001$ .

16 (n = 97),  $p = 0.023$ ).  $\chi^2 = 9.543$ ,  $C = 0.26$ ,  $V = 0.314$  (n = 97),  $p = 0.023$ ).  $\chi^2 = 9.543$ ,  $C = 0.26$ ,  $V = 0.314$ .  
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**Intuitive vs Reflective Cognitive Styles in Daily Life**

ANOVA:  $F(1,146) = 8.863, p = 0.003, \eta^2 = 0.057$  ( $F(1,146) = 14.198, p < 0.001, \eta^2 = 0.089$ ).  
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**Treatment x Priming Interaction on Contributions to Ingroup vs Outgroup Members**

$F(1,146) = 6.614, p = 0.011, \eta^2 = 0.043$ ;  $F(1,146) = 0.127, p = 0.722, \eta^2 = 0.001$ .  
 $Z = -2.28, p = 0.023$ ;  $F(1,146) = 6.614, p = 0.011, \eta^2 = 0.043$ .  
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**Prosociality vs Expectations**

$F(1,146) = 8.863, p = 0.003, \eta^2 = 0.057$  ( $F(1,146) = 14.198, p < 0.001, \eta^2 = 0.089$ ).

( $F(1,144) = 81.867, p < 0.001, \eta^2 = 0.362$ ). H  $\times$  C ( $p > 0.05$ ;  $F(1,144) = 0.003$ ). C  $\times$  I ( $p > 0.05$ ;  $F(1,144) = 0.003$ ). C  $\times$  O ( $p > 0.05$ ;  $F(1,144) = 0.003$ ). C  $\times$  I  $\times$  O ( $p > 0.05$ ;  $F(1,144) = 0.003$ ).

### DISCUSSION

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2012). O (vs ) decreased decreased . O vs A ( et al, 2011), (D D et al, 2010) ( et al, 2009). O (D D et al, 2010). B ( et al, 2012), i GG ( ) . F , ( vs :  $46.48 \pm 5.19\%$  vs  $41.91 \pm 4.64\%$ ,  $F(1,37) = 0.86, p = 0.36$ ). A I , F ( / ) / ( / ). O I , 8 ( ).

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## REFERENCES

- A JM, O KK, NA, H A (2005).  
I : E .  
*Trends Cogn Sci* **9**: 367–373.
- A 87 H (2007). E9 .  
*Science* **318**:  
581–582.
- B -K MJ, 9 IJ MH (2013).  
: 9 87 - .  
*Transl Psychiatry* **3**: 258.
- B JA, H E (2006). :  
87 - .  
*Horm Behav* **50**: 518–528.
- B , H M, A, F , F E  
(2008). O .  
*Neuron* **22**: 639–650.
- B JA, J, B E, L 87 NN, K 9 A, O KN  
(2010). O 9 9 .  
*Psychol Sci* **21**: 1426–1428.
- B JA, J, B N, O KN (2011) .  
: .  
*Trends Cogn Sci*  
**15**: 301–309.
- B JA, D, H H, K , C , B A,  
, H E (2011) . O .  
*Soc Cogn Affect Neurosci* **6**: 556–563.
- B C, M A, , O A, N 9 , E E et al  
(2014). N 87 9 :  
87 9 .  
*Eur Psychiatry*  
**30**: 160–165.
- C G, A (2011). G  
87 .  
*Games Econ Behav* **72**: 77–85.
- C , B J, K (1998). 87 : 9  
9 9 .  
*J Pers Soc Psychol* **75**: 1490–1502.
- D (2004). .  
*Nat Rev* **5**: 582–589.
- D D CKO (2012). O 87 : 9 9 87  
87 .  
*Horm Behav* **61**: 419–428.
- D D CKO, G LL, 9 K GA, 9 , H MJ  
(2011). O .  
*Proc Natl Acad Sci USA* **108**: 1262–1266.
- D D CKO, H , 9 O FA, K  
(2015). O 87 : 9  
( :10.1093/ / 109).  
*Soc Cogn Affect Neurosci*  
**6**: 194.
- D D CKO, G LL, H MJ, 9 , 9 K GA,  
B M et al (2010). .  
*Science*  
**328**: 1408–1411.
- D M B, H NA, K , B G, D J (2008).  
E .  
*J Neurosci* **28**: 10746–10750.
- D CH, B C, K (2010). O : 9  
: .  
*Horm Behav* **57**: 368–374.
- D G, H M, G J, B C, B DF,  
H C (2007). O 9 .  
*Biol Psychiatry* **62**: 1187–1190.
- D , LJ (2008). O 9  
: .  
*Science* **322**: 900–903.
- E N (2012). .  
*Science* **336**: 848–852.
- E9 J (2008). D - .  
*Annu Rev Psychol* **59**: 255–278.
- F - M, L 9 9 , - G (2013). O -  
87 .  
*Soc Cogn Affect Neurosci* **8**: 313–317.
- G M, G, L , L J, L , B C et al (2012).  
: .  
*Philos Trans R Soc Ser B* **367**:  
692–703.
- G I, 9 O 87 BC, B H, C C, L M ,  
E JA et al (2013). O  
87 .  
*Proc Natl Acad Sci USA* **110**: 20953–20958.
- G E, G A, L, H A, O L,  
G G et al (2013). O  
9 .  
*Biol Psychiatry* **74**: 172–179.
- H M, 9 D 87 B, D G (2009). O  
9 .  
*Front Neuroendocrinol*  
**30**: 548–557.
- I (2010). :  
9 87 9 9 .  
*Neuron*  
**65**: 768–779.
- J 87 D , M , H L, H 87 L (1999). M B  
I i -  
87 .  
*Bipolar Disord* **1**: 98–108.
- K D (2011). *Thinking Fast and Slow*. G .  
K B, H G (2008). - 9 -  
9 .  
*Depress Anxiety* **25**: 535–541.
- K M, H M, i J, F , F E (2005).  
O .  
*Nature* **435**: 673–676.
- L CO, 9 M, , ML, i F,  
D B et al (2008). G - 9 -  
9 : ( )  
9 .  
*J Pers Soc Psychol* **95**: 144–165.
- L MD (2007). 9 : 9 87  
9 .  
*Annu Rev Psychol* **58**: 259–289.
- L 87 M , F, D DL, F 9 F (1979). i  
87 9 .  
*Acta Psychiatr Scand* **60**: 214–224.
- L 87 M, L G (2006). D -  
9 .  
*Nat Rev Neurosci* **7**: 126–136.
- M , L B, O , H (2015). A 9  
5-H Li 87 .  
*Br J Psychiatry*; - 5 M 2015.  
( :10.1192/ .114.150128).  
M (2015). N : -  
: .  
*Mol Psychiatry* **20**:  
311–319.
- M K (2012). : 9 87  
9 .  
*Front Neurosci* **6**: 194.
- M -L A, D G, K i, H M (2011).  
O 9 : -  
: .  
*Nat Rev Neurosci* **12**: 524–538.
- M EK, C JD (2001). A 9  
: .  
*Annu Rev Neurosci* **24**: 167–202.
- N 87 MA, K (2005). E9 .  
*Nature* **437**: 1291–1298.
- i 9 i, K , D J (2008). O -  
9 9 .  
9 .  
*J Neurosci* **28**: 6607–6615.
- i M, A N, F D, E G (2014).  
9  
9 .  
*J Exp Soc Psychol* **55**: 246–251.



- DG, G JD, N & MA (2012). *Nature* **489**: 427–430.
- D, N & GE, O OM (2015). *J Behav Dec Making* **28**: 159–166.
- DG, N & MA (2013). H. *Trends Cogn Sci* **17**: 413–425.
- JK, D AC, H i D, C , G i, et al (2014). *Psychoneuroendocrinology* **39**: 237–248.
- D, K KM, K C, K E, E, -O B et al (2014). A. *Neuropsychopharmacology* **39**: 2078–2085.
- & , K AH, G AJ (2013). *Neuropsychopharmacology* **38**: 1929–1936.
- & , D D CKO (2014). O. *Proc Natl Acad Sci USA* **111**: 5503–5507.
- G, F M, D & J, H H, i -B N, L & & (2009). I. *Biol Psychiatry* **66**: 864–870.
- F, L , B, O, H (2013). O. *Biol Psychol* **92**: 380–386.
- & KK, C & LJ (2013). & &: *J Child Psychol Psychiatry* **54**: 603–618.
- N, K KM, M O, H (2011). i. *Front Neuroendocrinol* **32**: 426–450.
- H, B MG, B i, F C (1971). - & IJ MH, B -K MJ (2012). A - *Eur J Soc Psychol* **1**: 149–178.
- & . *Psychoneuroendocrinology* **37**: 438–443.
- & M, C D, J Di (2007). G. *Psychol Sci* **18**: 19–23.
- J, M Ji (2013). I & . *Curr Dir Psychol Sci* **22**: 466–470.
- & ( ://&&&. . / )