Supplementary Information

Opposing oxytocin effects on inter-group cooperative behavior in intuitive and reflective minds

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Supplementary Information: 8 supplementary sections, including 5 figures and 13 tables

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1. Group manipulation check.

After participants had completed all the tasks, we assessed participants' first impression and likeness toward in-group and out-group members, respectively. The significant main effect of Group (in-group vs. out-group) suggested that participants had a better first impression ($F(1, 146)=159.992$, $p<0.001$, see statistic details in Table S1) and liked their in-group members more than out-group members ($F(1, 146)=241.447$, $p<0.001$). This provides evidence for success of our minimal group manipulation. However, such in-group favoritism in first impression and likeness rating did not differ significantly across conditions (neither the main effect of Priming/Treatment nor their interaction reached significance, $ps>0.1$). Thus, the effects of treatment and/or priming on the in-group favoritism during cooperative behaviors can not be simply explained by distinct first impression or likeness between in-group and out-group members. To control for any potential influence, the in-group favoritism in first impression and likeness rating was also included in the models that analyzed contribution during PGG.

2. Intuitive vs. reflective cognitive style induction

2.1 The procedure of cognitive style induction.

A cognitive process induction procedure was employed to induce mindsets favoring intuition or reflection during decision-making. The priming procedure employed in the current study was similar to that used in the previous studies[6], which has been demonstrated to promote intuition or reflective thinking in cooperative behaviors[6]. Before the economic game, participants were asked to write down a paragraph recalling an episode from their daily life that was consistent with the suggestion of intuition or reflection. We employed a between-subjects design in which participants were randomly assigned to adopt a more intuitive or reflective cognitive style. The instructions for the intuitive and reflective conditions are listed below:

Intuition-promotion: A recent study has shown evidence that people who make decisions based on their intuition/first instinct in their daily life would result in a more successful life in that they have a more desirable relationship with people around, higher salary and higher social status. We find this result very interesting and want to conduct related research. Please write a paragraph (8-10 sentences) describing a time your intuition/first instinct led you in the right direction and resulted in a good outcome.

Reflection-promotion: A recent study has shown evidence that people who makes decisions based on their reflection/careful reasoning in their daily life would result in a more successful life in that they have a more desirable relationship with people around, higher salary and higher social status. We find this result very interesting and want to conduct related research. Please write a paragraph (8-10 sentences) describing a time carefully reasoning through a situation led you in the right direction and resulted in a good outcome.

2.2 Cognitive style induction coding and manipulation check.

Two experimenters independently read participants' episodes to assess: 1) whether the participant in the situation made his decision based on his intuition/first instinct or careful reasoning/calculation and 2) whether such a decision led the participant in the right or wrong direction or resulted in a good or a bad outcome. All episodes were consistent with the assigned experimental condition except that one participant wrote an essay about his intuitive decision while he was assigned to the reflection induction. This participant was excluded from further analysis.

At the end of the experiment, participants were asked to report: 1) "How much do you agree with the scientific finding introduced at the beginning of the experiment?" and 2) "How much do you think knowing this scientific finding influences your decisions during the experiment?" on a 10-point Likert scale with 1=strongly disagree/no influence at all, 10=strongly agree/extremely influential). Participants assigned to the Intuition and Reflection priming conditions recognized the "scientific finding" at a similar level ($F(1, 148)= 2.268$, $p=0.134$; Intuition group: 6.1 vs. Reflection group: 6.6). However, participants were not explicitly aware of that this "scientific finding" introduction would influence their decisions in the experiment, as they reported about 3.5 out of 10 regarding the influence on their decisions and this did not differ between participants assigned to Intuition and Reflection induction ($F(1, 148)= 1.905$, $p=0.170$; Intuition group: 3.8 vs. Reflection group: 3.3). Moreover, oxytocin administration did not affect participants' trust on the priming materials ($F(1, 146)= 0.519$, $p=0.472$).

One of the psychological features used to distinguish intuition from reflection is processing speed: intuitive responses are relatively fast, whereas reflective responses require additional time for deliberation. To further validate that our cognitive style priming was successful through the whole experiment, we examine the priming effect on response speeds during the risk game (Exp. 2, see Section 7 for details). The response speed in the risk game was chosen as the checking index of priming based on two reasons: 1) the risk game did not involve group relationship and it was between the participants and the computer. This removed any potential influence of group relationships; 2) the risk game was the last economic game. If the priming effect were significant at the end of the experiment, then it would be also effective for both shots of PGG. A significant main effect of Priming was found ($F(1, 146)=5.607$, $p=0.019$), suggesting that participants in the Intuition priming condition responded faster than those in the Reflection priming condition, further validated our priming procedure.

3. Questionnaire measurement.

On arrival at the testing room, participants were first asked to complete the questionnaires before oxytocin or placebo treatments to measure their current mood, trait optimism, interpersonal trust, and importance of intuition/reflection in daily-life decision making. These questionnaires were included to test 1) whether Treatment/Priming effects on contributions during PGGs can be attributed to differences in mood and psychological traits; 2) whether Treatment/Priming effects on contribution during PGG continue significant even after controlling for individual differences in these variables.

3.1 Mood measurement.

Mood was assessed using the Positive and Negative Affect Scale (PANAS[7]). PANAS was completed twice, one before oxytocin/placebo administration and one after the experiment to examine participants' mood change (see Table S3 for statistic details of each mood measurement). Mood changes from baseline (pre-experiment) to post-experiment were subjected to 2 (Treatment: oxytocin vs. placebo) × 2 (Priming: intuition vs. reflection) ANOVAs. First, we showed there is no significant mood change (post- vs. pre-experiment mood) in any of the 4 groups in positive mood (Intuition-Oxytocin group: $F(1, 37) = 0.190$, $p=0.666$; Intuition-Placebo group: $F(1, 37) = 0$, $p=1$; reflective-oxytocin group: $F(1, 36) = 0.339$, $p=0.564$; reflective-placebo group: $F(1, 36) = 2.748$, $p=0.106$) or in negative mood (Intuition-Oxytocin group: $F(1, 37) = 0.260$, $p=0.141$; Intuition-Placebo group: $F(1, 37) = 1.008$, $p=0.322$; reflective-oxytocin group: $F(1, 36) = 2.162$, $p=0.150$; reflective-placebo group: $F(1, 36) = 0.108$, $p=0.744$). Moreover, there was no significant effect of Treatment, Priming or Treatment × Priming interaction on changes on positive mood (Treatment: $F(1, 146) = 0.880$, $p=0.350$; Priming: $F(1, 146) = 0.076$, $p=0.783$; Treatment × Priming: $F(1, 146) = 1.871$, $p=0.173$; see Table S3 for the detailed means and standard errors of the mood rating scores) or negative mood (Treatment: $F(1, 146) = 1.850$, $p=0.176$; Priming: $F(1, 146) = 0.268$, $p=0.606$; Treatment × Priming: $F(1, 146) = 0.416$, $p=0.520$).

3.2 Psychological traits measurement.

Interpersonal trust was measured using the Interpersonal Trust Scale[8], which consists of 25 items on a 5-point Likert scale. Participants were also asked to complete the Life Orientation Test Revised scale (LOT-R[9]), which measured participants' trait optimism on a scale from 0 (pessimistic) to 30 (optimistic).

We examined whether individuals assigned to different condition groups were different in age, trait optimism, and interpersonal trust by performing 2 (Treatment: placebo vs. oxytocin) × 2 (Priming: intuition vs. reflection) ANOVAs of these variables. Neither the Treatment/Priming main effect nor their interaction was significant ($ps>0.2$, Table S4). We then examined whether individual differences in these trait measurements

could predict contributions during PGGs across all participants. However, none of these measurements was significantly correlated with contribution amount during PGG (Table S5).

3.3 Post-experimental self-report.

After completing all the tasks, participants were given a post-game survey, in which participants' mood was measured once again. Participants were also asked about:

1) Their experience with similar experiments: "To what extent have you participated in studies like this one before? (i.e., where you choose how much to keep for yourself versus contributing to benefit others)", with options of "never", "participated in similar experiment", "participated in exact the same experiment". Participants who chose the response "Never" were classified as naïve. Participants who chose the response "participated in exact the same experiment" were excluded from further analysis.

When reporting on prior experience with similar experiments, 111 participants (74%) chose the response "Never", 39 participants (26%) chose the response "participated in similar experiment" and no participant chose the response "participated in exact the same experiment". The frequencies of experienced or naïve participants were similar among different condition groups: 26 naïve participants (68.4%) and 12 experienced participants (31.6%) in the Intuition-Placebo group; 29 naïve participants (76.3%) and 9 experienced participants (23.7%) in the Intuition-Oxytocin group; 27 naïve participants (73%) and 10 experienced participants (27%) in the Reflection-Placebo group; 29 naïve participants (78.4%) and 8 experienced participants (21.6%) in the Reflection-Oxytocin group. Chi-square test further confirmed that the frequencies of experienced or naïve participants did not differ among the 4 condition groups (chi-square value=1.110, p=0.775).

2) Their first impression, and likeness about the in-group and out-group members, respectively, on a 10-point Likert scale (1=very terrible impression/not like them at all; 10=extremely good impression/extremely like them). Results were reported in Section 1.

3) "How much do you believe that your payment will be totally determined by your own decisions during the experiment", on a 10-point Likert scale (1= did not believe at all; 10= extremely believed).

Participants in different conditions similarly believed that their payment would be totally determined by their own decisions made during the experiment (Mean=7.3; Treatment main effect: $F(1, 146)=0.011$, $p=0.918$; Priming main effect: $F(1, 146)=0.305$, $p=0.582$; Treatment × Priming interaction: $F(1, 146)=1.262$, $p=0.263$).

4. Mediation analysis

Mediation analyses were performed to examine whether the Priming x Treatment interaction on the in-group favoritism occurs through contribution amount to in-group members (rather than that to out-group members). Similar to our previous studies[10], a classic approach[11,12] was used to establish mediation. Three different regression models were constructed, as shown below:

$$Y = \beta_{11}x + \beta_{10} \quad (1)$$
$$\text{Mediator} = \beta_{21}x + \beta_{20} \quad (2)$$
$$Y = \beta_{31}x + \beta_{32}\text{Mediator} + \beta_{30} \quad (3)$$

Four conditions for establishing mediation are: (a) in Equation 1, the independent variable ("Treatment × Priming interaction") must predict the dependent variable (in-group favoritism in contribution amount during PGG), β_{11} is significant; (b) in Equation 2, the independent variable must predict the mediator (contribution to in-group member), β_{21} is significant; (c) in Equation 3, when regressing the dependent variable onto the mediator and the independent variable, the mediator must predict the dependent variable, β_{32} is significant; and (d) in Equation 3, the effects of the independent variable on the dependent variable must be reduced or even eliminated, $\beta_{31}<\beta_{11}$ (in absolute value, partial mediation) or β_{31} is insignificant (full mediation). The "Treatment × Priming interaction" was calculated by multiplying the normalized variables together[13]. The in-group favoritism in contribution amount during PGG was calculated as "contribution in the in-group game" minus "contribution in the out-group game". The Sobel test[14] was conducted to further confirm the significance of the mediator.

Moreover, a resampling method known as bootstrapping was also used. Bootstrapping is a nonparametric approach to effect-size estimation and hypothesis testing that is increasingly recommended for many types of analyses, including mediation[15,16]. Rather than impose questionable distributional assumptions, bootstrapping generates an empirical approximation of the sampling distribution of a statistic by repeated random resampling from the available data, and uses this distribution to calculate p-values and construct confidence intervals (5,000 resamples were taken for these analyses). Moreover, this procedure supplies superior confidence intervals (CIs) that are bias-corrected and accelerated (see Ref. 17 for details). To maintain congruence with results of more familiar analyses, our description of findings below include data showing that all models conform with Baron and Kenny's criteria, and also include results based on Sobel's test.

5. ***Decision time transformation.***

Decision times were further analyzed for cognitive style priming manipulation check. The average decision time across in-group and out-group games during PGG was used to index the decision speed. Since the distribution of decision times is heavily right skewed, linear regression is not appropriate. Similar to previous study[6], we first log 10-transform decision times in all the analyses that involved decision times.

To examine whether the Treatment × Priming interaction on in-group favoritism on contribution simply by changing the decision speed, we conducted a 2 (Treatment: placebo vs. oxytocin) × 2 (Priming: intuitive vs. reflective) × 2 (Group: in-group vs. out-group) ANOVA on log-transformed decision times during PGG. Oxytocin did not affect in-group favoritism simply by changing decision speed as oxytocin (vs. placebo) administration did not affect participants' decision times ($F(1, 146)= 1.316$, $p=0.253$). Moreover, there was no Treatment × Priming × Group interaction on decision speed ($F(1, 146)= 0.590$, $p=0.444$).

6. Experiment 2: The risk game.

We conducted the risk game (RG[18]) to explore whether the Treatment × Priming interaction on in-group favoritism during PGG was driven by its effect on participants' risk attitude or risk-taking behavior. Each participant was given 80 units and was asked to put any amount between 0 and 80 units into an "investment", which yielded triple the amount invested with 50% probability and 0 with 50% probability. The amount of the investment was used to index participants' risk-taking preference. More risk-averse participants would invest less whereas more risk-taking participants would invest more.

It is reasonable to expect that intuition priming would result in more risk taking behaviors. Indeed, participants tended to invest more money in RG when intuition was primed, though this effect did not reach significance ($F(1, 146)=2.35$, $p=0.127$, Figure S4). The Treatment × Priming interaction was not significant ($F(1, 146)=0.14$, $p=0.709$).

7. Experiment 3: The calculation task.

To further explore whether the observed cognitive style and/or treatment effects on participants' behaviors during PGGs are driven by the effects of cognitive style induction and treatment on their calculation ability, we asked participants to perform 64 self-paced calculations while response speed and accuracy were emphasized. To incentivize this calculation task, we offered an extra monetary reward of 20 units to participants depending on the accuracy and speed of calculations.

The calculation performance is indexed by dividing total calculation time by number of correct calculations. On average participants took 6.3 seconds to correctly solve one

calculation. Neither the main effect of Treatment/Priming nor their interaction was significant on participants' calculation performances (ps>0.3, Figure S5).

8. In-group favoritism in intuitive vs. reflective minds under placebo

8.1 Effects of intuition vs. reflection induction under placebo

We analyzed contributions during PGG from participants who received placebo treatment to examine, which, intuition or reflective thinking, led to in-group favoritism. Participants primed with intuition contributed comparable amounts of money when playing with in-group and out-group members (Mean±SE=46.48%±5.19% vs. 41.91%±4.64%, F (1, 37)=0.86, p=0.36). However, participants primed with reflection showed a robust in-group favoritism, i.e., they contributed significantly more money when playing with in-group compared to out-group members (65.24%±5.96% vs. 41.28%±6.40%; F (1, 36)=19.10, p<0.001). The difference in in-group favoritism between the two participant groups was confirmed by a significant Priming (intuition vs. reflection) × Group (in-group vs. out-group) interaction on contributions during PGGs (F (1, 73)=6.928, p=0.010). This result suggests that intuition motivates people to cooperate equally with in-group and out-group members, whereas reflection causes parochial cooperation that favors in-group members.

8.2 Effects of intuition vs. reflection in daily-life

We also showed greater in-group favoritism in the intuition-unimportant vs. intuition-important groups during PGGs (F (1, 73)=5.225, p=0.025). A similar analysis of the rating scores of reflection importance revealed that the "reflection-important" group showed greater in-group favoritism than the "reflection-unimportant" group during PGGs (F (1, 73)=11.361, p<0.001). Across all participants receiving placebo treatment we found that self-reported importance of intuition in daily life was negatively correlated with in-group favoritism (r=-0.273, p=0.018), whereas self-reported importance of reflection was positively correlated with in-group favoritism during PGG (r=0.413, p<0.001). Together, these results are consistent with the effects of intuition/reflection priming and suggest that promoting reflection in laboratory and daily favor of reflection similarly enhanced in-group favoritism during cooperation.

8.3 Discussion

Our findings uncover distinct roles of intuition and reflective thinking in in-group favoritism during economic decisions. Both temporarily promoted intuition and preference of intuition in daily-life lead to equal cooperation with in-group and out-group members. In contrast, individuals promoted with reflection or with preference of reflective thinking in daily life exhibited in-group favoritism during PGG. While in-group favoritism is well documented in the literature[19-26], our findings reveal that the

emergence of in-group favoritism strongly depends on the reflective, deliberate processing system employed during economic decisions.

We urge caution in the implications of these results. First, our findings were based on group situations where the group identity was built on trivial features and no explicit intergroup conflict was introduced. It is important to further examine whether the effects observed here can be generalized to diverse group types (such as racial/ethnic groups or political parties) and situations (such as when facing intergroup competition/conflict or out-group threat is detected). Second, people exhibited in-group favoritism in many dimensions. They favor in-group over out-group members in face perception, evaluation, allocation of resources and other ways[26]. We show that reflective/deliberate processing promotes in-group favoritism in cooperative behaviors (i.e., monetary allocation). However, we speculate that the effects of intuition and reflection on in-group favoritism may vary across different task dimensions. For example, in-group favoritism may occur automatically in face perception and attitude evaluation[27-29]. Alternatively, there is no interactive influence of intuition and reflection on in-group favoritism in attitude evaluation, such that we did not found significant priming effect on in-group favoritism in first impression and likeness rating in the current study (Table S1).

In conclusion, while recent research has shown inconsistent results regarding whether people are intuitively cooperative[6,30], our results reveal complicated social (group relationship) and biological (neuropeptide oxytocin) modulators of human cooperative behaviors. Intuition and reflection processes play distinct roles in group-situated cooperation with intuition supporting indiscriminative cooperation with in-group and out-group members and reflection inducing in-group favoritism during economic decision.

Author Contributions

Y. Ma conceived the research, designed the experiment and analyzed data; Y. Ma, and Y. Liu performed research; Y. Ma, D. G. Rand, T. F. Heatherton and S. Han wrote the paper. All authors approved the final version of the manuscript for submission.

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The authors declare no conflict of interest.

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Supplemental Figures

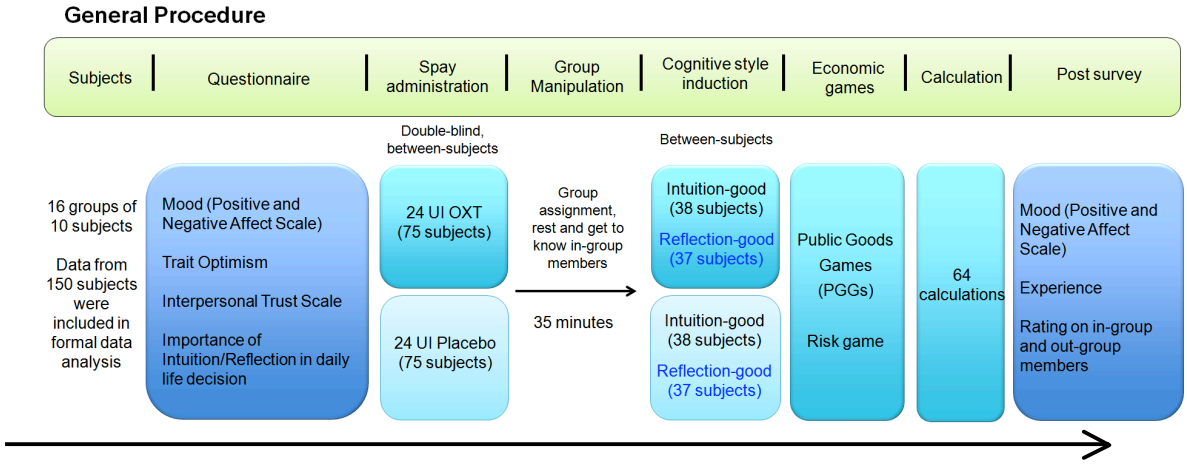

Figure S1. Illustration of the general experimental procedure.

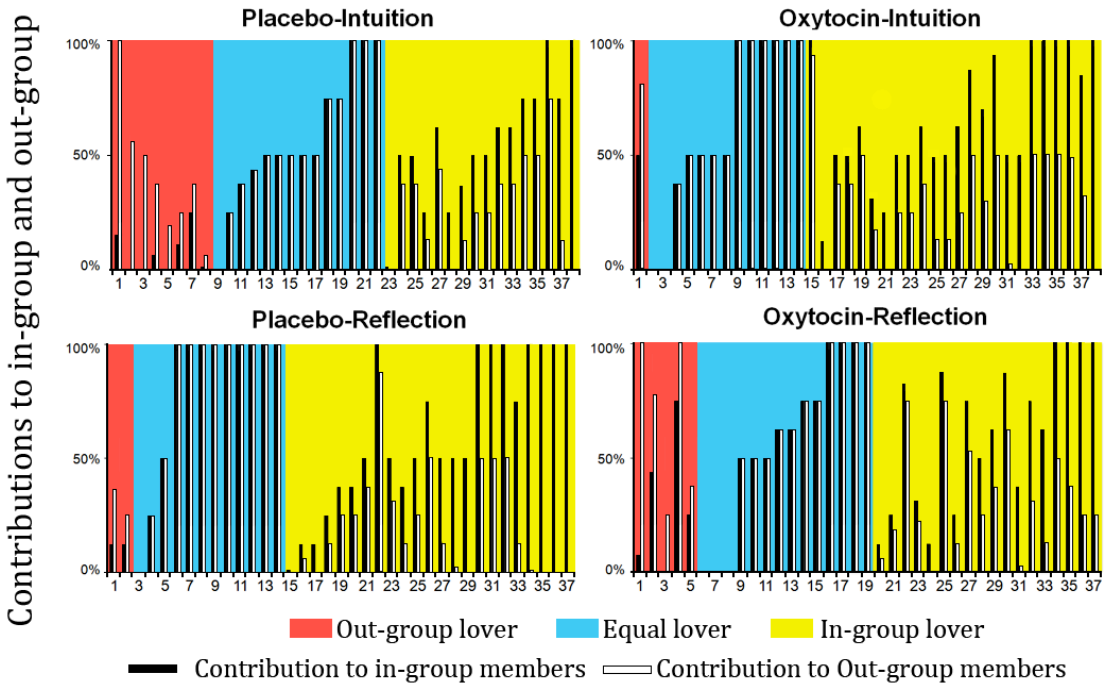

Figure S2. Each participant's contribution during PGGs. The contribution amount to a common project when playing with in-group or out-group members is shown for each participant under different conditions. According to the differential contribution to in-group and out-group members, we classified participants as out-group lovers (who contributed more to out-group than to in-group members, in red shadow), equal lovers (who contribute equal amount of money to in-group and out-group members, in blue shadow) and in-group lovers (who contributed more to in-group than to out-group members, in yellow shadow).

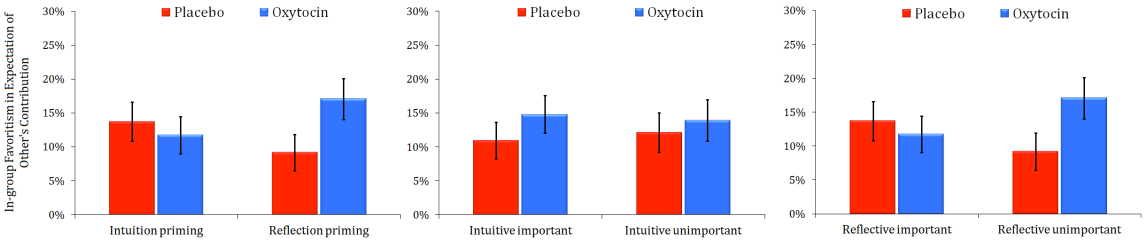

Figure S3. In-group favoritism in expectation of others' contributions. Participants expected that the in-group players would contribute more than that of out-group players ($F(1, 144)= 81.867$, $p<0.001$; in-group favoritism in expectation of other's contribution). However, neither the Treatment/Cognitive style (either temporarily promoted or adapted in daily-life decision making) main effect nor their interaction was significant on such in-group favoritism in expectation of others' contributions.

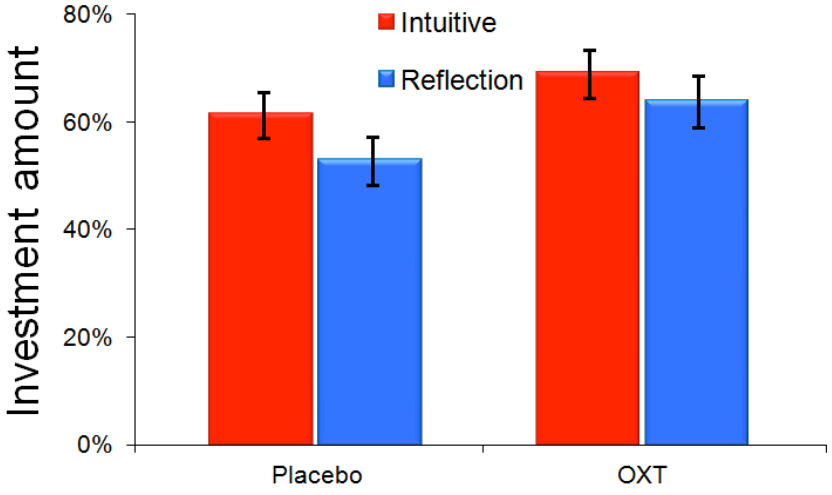

Figure S4. The results of investment during the risk game.

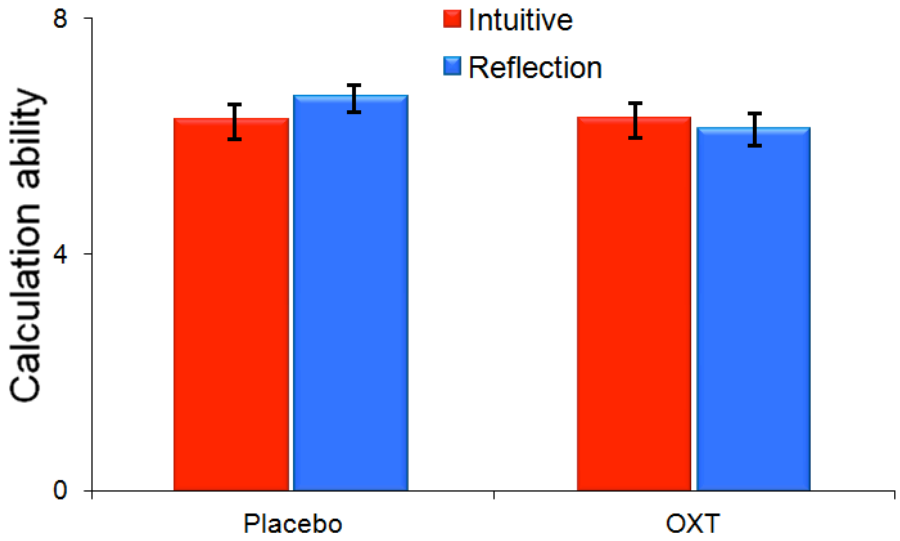

Figure S5. The results of the calculation task.

Supplemental tables

Table S1. Results of minimal group manipulation check.

	Int-Pl	Int-oxytocin	Ref-Pl	Ref-oxytocin
Num. of subjects	38	38	37	37
		First Impression		
In-group	8.08 (1.6)	8.21 (1.8)	8.00 (1.6)	7.59 (1.8)
Out-group	5.82 (1.7)	6.24 (2.3)	5.34 (2.0)	5.49 (1.2)
In- vs. out-group (F)	53.198***	25.717***	56.858***	32.966***
		Likeness		
In-group	7.87 (1.3)	7.95 (1.7)	8.08 (1.4)	7.76 (1.5)
Out-group	5.53 (1.7)	5.29 (2.0)	5.28 (1.9)	5.62 (1.2)
In- vs. out-group (F)	59.076***	51.584***	65.252***	79.599***

*** $p<0.001$

Int-Pl=Intuition priming under placebo; Int-oxytocin=Intuition priming under oxytocin; Ref-Pl=Reflection priming under placebo; Ref-oxytocin= Reflection priming under oxytocin

Table S2. Regression analysis on Treatment x Priming effect on in-group favoritism in cooperation during PGG.

	Regression 1		Regression 2		Regression 3	
	Beta	t	Beta	t	Beta	t
Priming	0.02	0.29	0.02	0.26	-0.03	-0.36
Treatment	0.06	0.72	0.06	0.75	0.07	0.94
Treatment × Priming	-0.26***	-3.28	-0.22*	-2.58	-0.17*	-2.27
Age			-0.05	-0.34	0.05	0.35
Education			0.16	1.07	0.05	0.40
Failed Comprehension			0.12	1.41	0.04	0.53
Trait optimistic			0.15	1.65	0.16*	2.07
Interpersonal Trust			0.04	0.42	0.10	1.30
Experiment trust rating			0.11	1.26	0.15*	2.02
Previous Experience			-0.03	-0.31	-0.08	-1.03
Total contribution			-0.01	-0.13	-0.03	-0.47
In-group favoritism in:						
First impression					-0.18	-1.60
Likeness					0.14	1.27
Expectation from others					0.52***	6.99

* p<0.05; *** p<0.001.

Regression 1 examined the effects of Cognitive style priming, Treatment and Treatment × Priming interaction on in-group favoritism during PGG. This revealed a significant interaction between Priming and Treatment participants' in-group favoritism during PGG. Regression 2 showed that the Treatment × Priming interaction continued reliable after controlling for age, education, failing to correctly answering the comprehension questions, trait optimism, interpersonal trust scores, previous experience with similar experiment, trust rating of the experiment, total contribution to the common project in the in-group and out-group games. Moreover, we examined whether the Treatment × Priming interaction on in-group favoritism during PGG would stay significant after controlling for potential influences from the in-group favoritism in other aspects. Regression 3 confirmed that the Treatment × Priming interaction on in-group favoritism during PGG stayed significant even after controlling for in-group favoritism in first impression, likeness and differential expectations from in-group vs. out-group members.

Table S3. Mood changes from pre-experiment to post-experiment.

	Int-Pl		Int-oxytocin		Ref-Pl		Ref-oxytocin		Interaction
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F (p)
Interested	0.08	1.02	0.26	0.98	-0.05	0.91	0.78	3.42	1.11 (0.29)
Distressed	-0.34	1.07	-0.29	1.01	-0.08	1.46	-0.46	1.04	1.30 (0.26)
Excited	0.42	1.13	0.29	0.93	-0.05	1.33	0.46	1.07	3.09 (0.08)
Upset	-0.08	0.97	-0.13	0.99	-0.03	1.19	-0.24	1.23	0.21 (0.65)
Strong	-0.29	0.77	-0.21	1.12	-0.41	0.90	-0.05	1.00	0.76 (0.38)
Guilty	0.05	0.90	-0.32	1.36	0.08	0.80	-0.24	1.01	0.02 (0.90)
Scared	-0.08	0.59	-0.18	1.29	0.14	0.75	-0.16	0.87	0.41 (0.52)
Hostile	0.16	0.95	0.05	0.87	0.22	1.03	-0.14	0.86	0.66 (0.42)
Enthusiastic	-0.18	1.06	-0.24	1.10	-0.51	1.04	-0.24	1.23	0.79 (0.38)
Proud	-0.05	0.87	-0.13	1.04	-0.19	1.22	-0.03	1.07	0.49 (0.49)
Irritable	-0.08	0.97	-0.08	0.88	-0.05	1.00	0.08	1.34	0.15 (0.70)
Alert	0.29	0.84	0.08	1.08	-0.08	1.19	0.00	0.94	0.77 (0.38)
Ashamed	-0.11	0.80	-0.24	1.17	0.03	1.04	-0.22	0.92	0.12 (0.73)
Inspired	-0.26	1.06	-0.32	1.28	0.00	1.49	-0.22	1.08	0.16 (0.69)
Nervous	-0.08	0.82	-0.11	1.09	0.00	1.11	0.05	1.00	0.06 (0.81)
Determined	0.16	1.03	-0.29	1.16	-0.30	1.05	0.00	0.94	4.73 (0.03*)
Attentive	-0.13	0.91	-0.11	1.16	-0.30	1.05	-0.03	1.01	0.52 (0.47)
Jittery	-0.18	0.69	-0.03	0.88	0.05	0.74	-0.08	0.76	1.35 (0.25)
Active	-0.03	1.05	0.18	1.01	0.08	1.01	0.05	1.05	0.50 (0.48)
Afraid	-0.11	0.73	-0.21	0.99	-0.08	0.98	-0.24	0.76	0.04 (0.84)
Positive	0.00	5.93	-0.47	6.71	-1.81	6.65	0.73	7.62	1.87 (0.17)
Negative	-0.84	5.17	-1.53	6.26	0.27	5.00	-1.65	6.82	0.42 (0.52)

Int-Pl=Intuition priming under placebo; Int-oxytocin=Intuition priming under oxytocin;
Ref-Pl=Reflection priming under placebo; Ref-oxytocin= Reflection priming under oxytocin

Table S4. Questionnaire measurement

	Int-Pl	Int-oxytocin	Ref-Pl	Ref-oxytocin	Interaction
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	F (p)
Num.	38	38	37	37	-
Age	22.34 (2.6)	22.63 (2.9)	23.00 (3.0)	22.51 (4.1)	0.56 (0.46)
Trust	80.50 (10.3)	79.13 (9.6)	78.49 (9.8)	77.76 (9.7)	0.04 (0.84)
Optimism	21.95 (2.6)	22.24(3.5)	22.51 (3.4)	22.22 (2.8)	0.34 (0.56)

Int-Pl=Intuition priming under placebo; Int-oxytocin=Intuition priming under oxytocin;
Ref-Pl=Reflection priming under placebo; Ref-oxytocin= Reflection priming under oxytocin

Table S5. Coefficient of the correlation between psychological traits/measurement and contribution amount during PGGs.

Contributions	In-group	Out-group	In- vs. Out-group
Age	0.060	-0.005	0.072
Trust	-0.090	-0.048	-0.047
Optimistism	0.077	-0.058	0.147
Impression (In-group)	-0.013	-	-
Impression (Out-group)	-	0.187*	
Impression (In- vs. Out-group)	-	-	0.064
Likeness (In-group)	0.087	-	-
Likeness (Out-group)	-	0.197*	-
Likeness (In- vs. Out)	-	-	0.143

* $p<0.05$

Table S6. Regression analysis on contribution amount to in-group members during PGG.

	Regression 1		Regression 2		Regression 3	
	Beta	t	Beta	t	Beta	t
Priming	0.07	0.93	0.07	0.91	0.08	1.72
Treatment	0.07	0.89	0.07	0.88	0.00	-0.03
Treatment × Priming	-0.21**	-2.57	-0.16†	-1.90	-0.10†	-1.87
Age			-0.03	-0.22	0.13	1.45
Education			0.06	0.39	-0.09	-0.94
Failed Comprehension			-0.09	-1.11	-0.05	-1.06
Trait optimistic			0.04	0.46	0.02	0.39
Interpersonal Trust			0.02	0.23	0.11*	2.03
Experiment trust rating			0.19*	2.24	0.24***	4.63
Previous Experience			-0.17*	-2.03	-0.07	-1.44
First impression (in-group)					-0.21**	-2.89
Likeness (in-group)					0.09	1.24
Expectation from in-group					0.78***	15.45

† p<0.07; * p<0.01; ** p<0.005; *** p<0.001.

Regression 1 examined the effects of Cognitive style Priming, Treatment, and Treatment × Priming interaction on the contribution amount when playing PGG with in-group members. This revealed that Treatment × Priming interaction was a good predictor of participants' contribution to in-group member during PGG. Regression 2 showed that this continued reliable when controlling for age, failing to correctly answering the comprehension questions, trait optimism, interpersonal trust scores, previous experience with similar experiment, and trust rating of the experiment. Moreover, we examined whether the Treatment × Priming interaction on cooperative decisions would stay significant after controlling for rating or behaviors towards in-group member in other aspects. Regression 3 confirmed that the Treatment × Priming interaction on cooperative behavior towards in-group members stayed reliable even after controlling for first impression/likeness of in-group member and expectation of contributions from in-group members.

Table S7. Regression analysis on contribution amount to out-group members during PGG.

	Regression 1		Regression 2		Regression 3	
	Beta	t	Beta	t	Beta	t
Priming	0.05	0.66	0.06	0.67	0.10	1.76
Treatment	0.02	0.24	0.02	0.20	-0.03	-0.43
Treatment × Priming	0.03	0.36	0.04	0.43	0.07	1.10
Age			0.01	0.09	0.07	0.63
Education			-0.09	-0.57	-0.15	-1.35
Failed Comprehension			-0.21*	-2.40	-0.10	-1.57
Trait optimistic			-0.09	-1.04	-0.13*	-2.01
Interpersonal Trust Scale			-0.01	-0.15	0.03	0.43
Experiment trust rating			0.09	1.08	0.11	1.81
Previous Experience			-0.15	-1.75	0.00	0.00
First impression (out-group)					-0.02	-0.18
Likeness (out-group)					0.02	0.24
Expectation from out-group					0.73***	11.99

* p<0.01; ** p<0.005; *** p<0.001.

Regression 1 showed that neither the Priming /Treatment main effect nor the Treatment × Priming interaction was associated with the contribution amount when playing PGG with out-group members. Regression 2 and 3 further showed that this continued insignificant when controlling for age, failing to correctly answering the comprehension questions, trait optimism, interpersonal trust scores, previous experience with similar experiment, trust rating of the experiment, and rating or behaviors towards out-group member in other aspects (i.e., first impression/likeness of out-group members and expectation of contributions from out-group members).

Table S8. Results of mediation analysis to test in-group contribution as a mediator of in-group favoritism during PGG

Variable	Coeff	SE	t	p
Regression Model 1 (Total effect of Treatment × Priming on in-group favoritism)				
Treatment × Priming	-6.27	1.96	-3.19	0.002
Dependent: In-group favoritism				
Regression Model 2 (Treatment × Priming to in-group contribution)				
Independent: Treatment × Priming	-5.48	2.19	-.2.50	0.014
Mediator: Contribution to in-group member				
Direct effects of mediator on in-group favoritism				
Independent: Treatment × Priming	0.395	0.066	.95	).000
Remaining direct effect of Treatment × Priming on in-group favoritism				
Independent: Treatment × Priming	-4.11	1.81	-2.27	0.024
	Coeff	**SE**	**LLCI95**	**ULCI95**
Indirect effect of Treatment × Priming on in-group favoritism via contribution to in-group (Sobel test result)				
Contribution to in-group member	-2.16*	0.95	-4.02	-0.30
Indirect effect of Treatment × Priming on in-group favoritism via contribution to in-group (bootstrap results)				
Contribution to in-group member	-2.16*	0.96	-4.39	-0.59

*p<0.05, **p<0.01, ***p<0.001

Notes. Confidence intervals for indirect effect are bias-corrected and accelerated; bootstrap resamples=5000; N=150 for all tests.

Table S9. Results of mediation analysis to test out-group contribution as a mediator of in-group favoritism in PGG.

Variable	Coeff	SE	t	p
Regression Model 1 (Total effect of Treatment × Priming on in-group bias)				
Treatment × Priming	-6.27	1.96	-3.19	0.002
Dependent: In-group favoritism				
Regression Model 2 (Treatment × Priming to out-group contribution)				
Treatment × Priming	0.79	2.21	0.36	0.720
Mediator: Contribution to out-group member				
Direct effects of mediator on out-group favoritism				
Treatment × Priming	-0.40	0.066	6.15	0.000
Remaining direct effect of Treatment × Priming on in-group favoritism				
Treatment × Priming	-5.95	1.76	-3.38	0.001

	Coeff	SE	LLCI95	ULCI95
Indirect effect of Treatment × Priming on in-group favoritism via contribution to in-group (Sobel test result)				
Contribution to out-group member	-0.32	0.90	-2.09	1.45
Indirect effect of Treatment × Priming on in-group favoritism via contribution to in-group (bootstrap results)				
Contribution to out-group member	-0.32	0.89	-2.19	1.40

*p<0.05, **p<0.01, ***p<0.001

Notes. Confidence intervals for indirect effect are bias corrected and accelerated; bootstrap resamples=5000; N=150 for all tests.

Table S10. Cognitive style (Based on daily intuition importance rating) × Treatment interaction on in-group favoritism during PGG.

	Regression 1		Regression 2		Regression 3	
	Beta	t	Beta	t	Beta	t
Cognitive style	-0.04	-0.51	0.01	0.18	-0.03	-0.40
Treatment	0.02	0.28	-0.05	-0.55	-0.03	-0.38
Cognitive style × Treatment	-0.24**	2.98	0.25**	2.98	0.22**	3.02
Age			-0.05	-0.35	0.07	0.52
Education			0.21	1.39	0.07	0.54
Failed Comprehension			0.14	1.61	0.06	0.76
Optimistism			0.19*	2.10	0.20*	2.56
Interpersonal Trust			0.02	0.22	0.07	0.88
Experiment trust rating			0.07	0.80	0.06	0.84
Previous Experience			-0.01	-0.17	-0.05	-0.67
contribution			0.06	0.66	0.03	0.47
In-group favoritism in: First impression					-0.13	-1.14
Likeness					0.11	1.02
Expectation from other					0.51***	6.79

* p<0.05; ** p<0.01; *** p<0.001.

Regression 1 examined Cognitive style (Based on daily intuition importance rating, intuition important and intuition unimportant groups), Treatment, Cognitive style × Treatment interaction effect on in-group favoritism during PGG. This analysis revealed that Cognitive style × Treatment interaction was a good predictor of participants' in-group favoritism in cooperation during PGG. Regression 2 showed that this continued reliable after controlling for age, failing to correctly answering the comprehension questions, trait optimism, interpersonal trust scores, previous experience with similar experiment, trust rating of the experiment, total contribution to the common project in the in-group and out-group shots. Moreover, we examined whether the Treatment × Cognitive style interaction on in-group favoritism during PGG would stay significant after controlling potential influences from the in-group favoritism in other aspects. Regression 3 uncovered that the Treatment × Cognitive style interaction on cooperative behavior stayed significant after controlling for potential influences from the in-group favoritism in other aspects, i.e., in-group favoritism in first impression, likeness and differential expectations from in-group vs. out-group members.

Table S11. Cognitive style (Based on daily reflection importance rating) × Treatment interaction on in-group favoritism in PGG.

	Regression 1		Regression 2		Regression 3	
	Beta	t	Beta	t	Beta	t
Cognitive style	0.10	1.29	0.12	1.44	-0.02	-0.28
Treatment	0.03	0.31	0.03	0.34	0.12	1.77
Cognitive style × Treatment	-0.30***	-3.77	-0.29***	-3.61	-0.22**	-3.08
Age			-0.07	-0.47	0.04	0.33
Education			0.22	1.51	0.09	0.70
Failed Comprehension			0.12	1.35	0.03	0.42
Optimistic			0.18*	2.04	0.19*	2.51
Interpersonal Trust			0.07	0.74	0.11	1.39
Experiment trust rating			0.06	0.77	0.06	0.77
Previous Experience			-0.04	-0.48	-0.07	-0.93
Total contribution			0.00	0.01	-0.01	-0.18
In-group favoritism in: First impression					-0.17	-1.51
Likeness					0.14	1.29
Expectation from other					0.49***	6.56

* p<0.05; ** p<0.01; *** p<0.001.

Regression 1 examined Cognitive style (Based on daily reflection importance rating, reflection important and reflection unimportant groups), Treatment, Cognitive style × Treatment interaction effect on in-group favoritism during PGG. This analysis revealed that Cognitive style × Treatment interaction was a good predictor of participants' in-group favoritism in cooperation during PGG. Regression 2 showed that this continues to be reliable after controlling for age, failing to correctly answering the comprehension questions, trait optimism, interpersonal trust scores, previous experience with similar experiment, trust rating of the experiment, total contribution to the public pool in the in-group and out-group shots. Moreover, we examined whether the Treatment × Cognitive style interaction on in-group favoritism during PGG would stay significant after controlling for potential influences from the in-group favoritism in other aspects. Regression 3 uncovered that the Treatment × Cognitive style interaction on cooperative behavior stayed significant after controlling potential influences from the in-group favoritism in other aspects, i.e., in-group favoritism in first impression, likeness and differential expectations from in-group vs. out-group members.

Table S12. Intuition importance × Treatment interaction on in-group favoritism in PGG.

	Regression 1		Regression 2		Regression 3	
	Beta	t	Beta	t	Beta	t
Intuition importance	0.02	0.29	0.02	0.29	-0.03	-0.38
Treatment	-0.07	-0.82	-0.06	-0.73	-0.05	-0.69
Intuition importance × Treatment	0.16*	2.01	0.15†	1.77	0.20**	2.85
Age			-0.09	-0.60	0.05	0.42
Education			0.23	1.54	0.07	0.57
Failed Comprehension			0.12	1.37	0.04	0.55
Optimistic			0.16	1.76	0.17*	2.22
Interpersonal Trust			0.04	0.39	0.11	1.36
Experiment trust rating			0.11	1.30	0.15*	2.05
Previous Experience			-0.02	-0.28	-0.08	-1.01
Total contribution			0.02	0.26	0.00	-0.03
In-group favoritism in: First impression					-0.15	-1.37
Likeness					0.12	1.08
Expectation from other					0.55***	7.49

† p<0.07; * p<0.05; ** p<0.01; *** p<0.001.

Regression 1 examined the effects of Intuition importance rating, Treatment, Intuition importance × Treatment interaction on in-group favoritism during PGGs. This revealed that Intuition importance × Treatment interaction was a good predictor of participants' in-group favoritism during PGGs. Regression 2 showed that this continued reliable after controlling for age, failing to correctly answering the comprehension questions, trait optimism, interpersonal trust scores, previous experience with similar experiment, trust rating of the experiment, total contribution to the public pool in the in-group and out-group shots. Moreover, we examined whether the Treatment × Intuition importance interaction on in-group favoritism during PGG would stay significant after controlling for potential influences from the in-group favoritism in other aspects. Regression 3 uncovered that the Treatment × Intuition importance interaction on cooperative behavior stayed significant after controlling potential influences from the in-group favoritism in other aspects, i.e., in-group favoritism in first impression, likeness and differential expectations from in-group vs. out-group members.

Table S13. Reflection importance × Treatment interaction on in-group favoritism in PGG.

	Regression 1		Regression 2		Regression 3	
	Beta	t	Beta	t	Beta	t
Reflection importance	0.03	0.39	0.03	0.44	-0.02	-0.25
Treatment	0.20	2.49	0.21*	2.61	0.15*	2.22
Reflection importance × Treatment	-0.29***	-3.60	-0.25**	-3.14	-0.23***	-3.38
Age			-0.11	-0.78	0.01	0.11
Education			0.26	1.80	0.12	0.94
Failed Comprehension			0.13	1.50	0.05	0.66
Optimistic			0.13	1.46	0.14†	1.84
Interpersonal Trust			0.05	0.56	0.11	1.40
Experiment trust rating			0.12	1.42	0.16*	2.13
Previous Experience			-0.03	-0.41	-0.08	-1.10
Total contribution			0.00	-0.01	-0.03	-0.39
In-group favoritism in: First impression					-0.18	-1.62
Likeness					0.14	1.29
Expectation from other					0.51***	7.13

† p<0.07; * p<0.05; ** p<0.01; *** p<0.001.

Regression 1 examined the effects of Reflection importance rating, Treatment, Reflection importance × Treatment interaction on in-group favoritism during PGGs, and revealed that Reflection importance × Treatment interaction was a good predictor of participants' in-group favoritism during PGG. Regression 2 showed that this continued reliable after controlling for age, failing to correctly answering the comprehension questions, trait optimism, interpersonal trust scores, previous experience with similar experiment, trust rating of the experiment, total contribution to the public pool in the in-group and out-group shots. Moreover, we examined whether the Treatment × Reflection importance interaction on in-group favoritism during PGG would stay significant after controlling for potential influences from the in-group favoritism in other aspects. Regression 3 uncovered that the Treatment × Reflection importance interaction on cooperative behavior stayed significant after controlling potential influences from the in-group favoritism in other aspects, i.e., in-group favoritism in first impression, likeness and differential expectations from in-group vs. out-group members.

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