The Effects of Opponents' Facial Expressions on Cooperative Behavior in Prisoner' s Dilemma Games and Their Mechanisms*

Authors:

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Abstract

三个实验逐步深入地考察了囚徒困境博弈中，对手的高兴、中性和愤怒面部表情对个体合作行为的影响及相关变量的中介和调节作用。实验 1 的结果表明，对手的高兴表情比愤怒表情诱发了更高的合作水平，且高兴和中性表情均比愤怒表情产生了更高的合作预期，合作预期中介了面部表情与合作行为的关系；实验 2 引入指导语操纵被试的直觉或理性决策模式，发现实验 1 的结果仅出现在直觉条件下，却未出现在理性条件下，且整体而言直觉决策模式下比理性决策模式下更合作；实验 3 采用更加严格的时间压力范式操纵被试的直觉或理性决策模式，发现除了高兴表情比中性表情也诱发了更多的合作行为外，其他几乎复制了实验 2 的结果。基于这些结果，建立了有调节的中介模型，以期揭示他人面部表情、合作预期、合作行为及个体决策模式之间的复杂关系。

Full Text

The Effects of Opponents' Facial Expressions on Cooperative Behavior in Prisoner' s Dilemma Games and Their Mechanisms*

Chengqing Xiong1,2 Jiaying Xu1 Danyang Ma1 Yongfang Liu1

(1 School of Psychology and Cognitive Science, East China Normal University; Shanghai Key Laboratory of Mental Health and Psychological Crisis Intervention, Shanghai 200062)

(2 School of Educational Science, Xinyang Normal University, Xinyang 464000)

Abstract Three experiments progressively examined, in the prisoner's dilemma game, the effects of an opponent' s happy, neutral, and angry facial expressions on individuals' cooperative behavior, as well as the mediating and moderating roles of related variables. The results of Experiment 1 showed that an opponent'

s happy expression elicited a higher level of cooperation than an angry expression, and both happy and neutral expressions generated higher expectations of cooperation than angry expressions; expectations of cooperation mediated the relationship between facial expression and cooperative behavior. Experiment 2 introduced instructions to manipulate participants' intuitive or rational decision-making mode, and found that the results of Experiment 1 appeared only under the intuitive condition, not under the rational condition; overall, participants were more cooperative in the intuitive decision-making mode than in the rational decision-making mode. Experiment 3 used a more rigorous time-pressure paradigm to manipulate participants' intuitive or rational decision-making mode, and found that, apart from happy expressions also eliciting more cooperative behavior than neutral expressions, the other results almost replicated those of Experiment 2. Based on these findings, a moderated mediation model was established to reveal the complex relationships among others' facial expressions, expectations of cooperation, cooperative behavior, and individuals' decision-making modes.

Keywords facial expressions; expectations of cooperation; cooperative behavior; decision-making mode; social functions of emotions

Classification No. B842:C91

1. Statement of the Problem

A large body of previous research has shown that, in social interaction, the other party' s facial expression affects an individual' s cooperative behavior. In the ultimatum game, compared with offers made by proposers with neutral expressions, offers made by proposers with smiling expressions are more likely to be accepted, whereas offers made by proposers with angry expressions have the lowest acceptance rate (Mussel et al., 2013). In the dictator game, compared with happy or disappointed recipients, participants allocate a smaller share to angry recipients (Lelieved et al., 2013). In the prisoner' s dilemma game, people are more willing to cooperate with opponents who display smiling expressions (Mieth et al., 2016; Raoul et al., 2017), whereas when they are betrayed, they spend more

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Corresponding author: Yongfang Liu, E-mail: yfliu@psy.ecnu.edu.cn

money to punish smiling opponents (Mieth et al., 2016); participants can decide whether to cooperate with virtual agents solely on the basis of different facial expressions (de Melo et al., 2011; de Melo et al., 2014). Compared with virtual agents who display happy expressions after being exploited, people

are more willing to cooperate with virtual agents who display happy expressions after mutual cooperation, and this effect is more pronounced for human-controlled virtual agents than for computer-controlled virtual agents (de Melo et al., 2015). In trust games, smiling expressions promote cooperation between strangers (Scharlemann et al., 2001), whereas angry expressions weaken cooperation between strangers (Campellone & Kring, 2013); happy expressions accelerate participants' cooperative decisions, whereas angry expressions accelerate participants' noncooperative decisions (Alguacil et al., 2015). All these studies indicate that others' positive, happy facial expressions positively influence people's cooperative behavior, whereas negative, angry facial expressions negatively influence people' s cooperative behavior.

Although the studies reviewed above have described relatively well what effects others' facial expressions have on cooperative behavior, they have not deeply revealed the internal psychological mechanisms underlying these effects. According to goal-expectation theory (Pruitt & Kimmel, 1977), cooperation requires two conditions: payoff maximization and the expectation that the other party will cooperate. In social dilemmas, mutual cooperation can maximize overall payoffs, and both parties hope to increase their own payoffs through cooperation; however, neither can be certain whether the other party will cooperate with them. Therefore, making accurate expectations about the other party' s behavior becomes an important prerequisite for cooperative decision-making: if one expects the other party to cooperate, one chooses cooperation in pursuit of maximizing both parties' interests; if one expects the other party not to cooperate, one chooses noncooperation in order to avoid being exploited and thereby having one' s own interests minimized. In classical game-theoretic models and related laboratory studies, because explicit information about whether the other party will cooperate is sometimes difficult to obtain and is sometimes deliberately concealed or disguised, nonverbal information such as facial expressions—which is relatively difficult to deliberately fake—becomes a useful, or even the only, basis for forming expectations.

According to the social functional theory of emotion, others' facial expressions contain information about their personality traits and social attitudes, thereby influencing the individual's expectations about their subsequent behavior. First, others'facial expressions influence the individual's perception of their personality traits. For example, people who display happy expressions are more likable (Clark & Taraban, 1991; Wang et al., 2018) and more trustworthy (Krumhuber et al., 2007; Todorov et al., 2008; Wang et al., 2018), whereas angry people are less trustworthy (Kausel & Connolly, 2014; Todorov et al., 2008), and trust evaluations based on facial expressions elicit amygdala activation (Todorov et al., 2008). Second, others' facial expressions influence the individual' s perception of their social attitudes. Happiness conveys more positive and active social attitudes than anger (Stouten & Cremer, 2009), and happiness and sadness convey affiliativeness and an intention to establish close relationships (Hess et al., 2000; Sutherland et al., 2017); in trust games, happy expressions release signals of reciprocal intent (Eckel & Wilson, 2003). Third, when people capture

information from others' facial expressions and thereby form impressions or inferences about their personality traits and social attitudes, they naturally generate expectations about their subsequent behavior, and these expectations influence people' s decisions about whether to cooperate with them (Ng & Au, 2016; Pletzer et al., 2018; Ruz et al., 2011). For example, even children aged 2–5 can distinguish genuine from fake smiles and expect people with genuine smiles to be more prosocial (Song et al., 2016). In short, humans have evolved the ability to use emotions to transmit social information, and have also evolved the ability to capture others' emotions

information and to interpret others' intentions, thereby providing a basis and assurance for anticipating others' cooperative behavior. Integrating the above literature from different sources, we propose Hypothesis 1 of the present study:

Hypothesis 1: Others' happy facial expressions elicit the highest expectations of cooperation, followed by neutral expressions, with angry expressions eliciting the lowest expectations; these expectations mediate the relationship between others' facial expressions and individuals' cooperative behavior.

However, is this "facial expression → cooperation expectation → cooperative behavior" mechanism strengthened or weakened under certain conditions? To date, the answer to this question remains unclear (Mussel et al., 2013). According to dual-process theories (Evans & Stanovich, 2013; Kahneman, 2011), people have two relatively independent decision-making systems, "hot" and "cold." The former adopts a relatively intuitive, emotional, rapid, and effortless mode of information processing, whereas the latter adopts a relatively deliberative, rationalized, slow, and effortful mode of information processing (Rand, 2016). A large body of research has manipulated decision-making modes using paradigms such as instructions, time pressure, or cognitive load, and has found that these manipulations can effectively activate participants' "hot" or "cold" systems to varying degrees, thereby changing the mode of information processing during decision making. Generally speaking, instructions explicitly guide participants to consciously and actively switch decision-making modes (Levine et al., 2018; Liu & Hao, 2011), whereas time pressure and cognitive load, respectively, by reducing the motivation to process information systematically (De Dreu, 2003; Van Kleef et al., 2004) and by reducing working-memory capacity (Engle, 2002), force participants to change the strategy or depth of cognitive control and information processing (De Dreu & Carnevale, 2003; Jaeger et al., 2019; Lavie et al., 2004; Van Kleef, 2016; Van Kleef et al., 2004; Van Kleef et al., 2015). In social interactive decision-making, nonverbal distal implicit information such as facial expressions is mainly related to the functions and processing modes of the "hot" system, whereas proximal explicit information such as language and economic payoffs is mainly related to the functions and processing modes of the "cold" system (Evans & Stanovich, 2013; Kahneman, 2011). A recent study found that, in a trust game, under an intuitive (vs. analytic) decision-making mode, people reduced their reliance on economic-payoff cues but did not reduce their reliance on facial-expression cues (Jaeger et al., 2019). Based on these

Figure 1. Hypothesized model in which the opponent' s incidental emotional facial expression influences an individual' s cooperative behavior. The diagram includes: the individual' s decision-making mode, the opponent' s facial expression, expected cooperation by the opponent, and the individual' s cooperative behavior.

Figure 1: Figure 1. Hypothesized model in which the opponent' s incidental emotional facial expression influences an individual' s cooperative behavior. The diagram includes: the individual' s decision-making mode, the opponent' s facial expression, expected cooperation by the opponent, and the individual' s cooperative behavior.

findings, together with the aforementioned literature on the influence of facial expressions on cooperative behavior, we propose the following hypothesis:

Hypothesis 2: Under an intuitive decision-making mode, others' happy facial expressions elicit the highest expectations of cooperation, followed by neutral expressions, with angry expressions eliciting the lowest expectations; these expectations mediate the relationship between others' facial expressions and individuals' cooperative behavior. Under a rational decision-making mode, however, this effect disappears or is at least weakened.

Based on the above analysis, we constructed the moderated mediation model shown in Figure 1. The present study will use a prisoner' s dilemma task and, through three experiments, progressively and in depth test the two hypotheses above and examine the hypothesized model on the basis of the data obtained. Experiment 1 examined whether others' facial expressions affect cooperative behavior and cooperation expectations, and whether cooperation expectations have a mediating role, thereby providing an initial test of Hypothesis 1. On this basis, Experiment 2 introduced instructions to manipulate decision-making mode, exploring whether it moderates the effects of facial expressions on cooperative behavior and cooperation expectations, again testing Hypothesis 1, with an emphasis on testing Hypothesis 2. Experiment 3 used a more stringent time-pressure paradigm to manipulate decision-making mode, further testing Hypothesis 1 and again testing Hypothesis 2.

Figure 1 Hypothesized model in which the opponent' s incidental emotional facial expression influences an individual' s cooperative behavior

G*Power 3.1 (Faul et al., 2007) was used in advance to determine the sample size. For Experiment 1, assuming an effect size of $f = 0.25$ and a significance level of $\alpha = 0.05$, 159 participants were required to achieve statistical power of 80% $(1 - \beta)$. For Experiments 2 and 3, assuming an interaction effect size of $f = 0.25$ and a significance level of $\alpha = 0.05$, 158 participants were required to achieve statistical power of 80% $(1 - \beta)$.

2 Experiment 1

2.1 Method

2.1.1 Participants A total of 180 adult participants were recruited (109 women), with a mean age of 22.36 years ($SD = 4.10$). All were physically and mentally healthy and had normal or corrected-to-normal vision. There were 50 participants in the happy-expression group, 71 in the neutral-expression group, and 59 in the angry-expression group. After the experiment, participants received a cash payment of 10 yuan.

2.1.2 Experimental design A single-factor, three-level, fully between-subjects design was adopted. The independent variable was the opponent' s facial expression (happy, neutral, and angry). The dependent variables were the individual' s level of cooperation (the total number of times the participant chose to transfer in the five rounds of the game task) and the expected level of the opponent' s cooperation (the total number of times the participant expected the partner to choose to transfer in the five rounds of the game task).

2.1.3 Experimental materials

(1) Facial-expression images. Three pairs of frontal grayscale emotional-face images of Chinese individuals were selected from the standardized Chinese Affective Picture System (CAPS; Bai Lu et al., 2005), with three male and three female images depicting happy, neutral, and angry expressions, respectively. The images were 260 × 300 pixels in size and were used as the materials for manipulating facial expression (see Appendix 1).

(2) Prisoner' s dilemma task. Following the method of Levine et al. (2018), a payoff matrix for the prisoner' s dilemma game was set up (see Table 1). Across five rounds of the game, players chose between transferring (cooperation) and keeping (defection), and the payoff in each round depended on the choices made by both players. For example, each person had an initial endowment of 5 tokens and could choose either to transfer the 5 tokens to the other person or to keep them. Tokens that were transferred were doubled by the experimenter and became part of the other person' s payoff. Specifically, if both parties chose to transfer, each person would receive 10 tokens; if both parties chose to keep, each person would retain the initial 5 tokens; if one party transferred

whereas if the other party keeps, the party who keeps will receive 15 tokens, and the party who transfers will receive 0 tokens. Therefore, for an individual, the expected payoff from choosing to keep is higher than the expected payoff from choosing to transfer; however, for both parties, choosing to transfer results in a greater total payoff for the two players than choosing to keep.

Table 1. Payoff matrix for the two-person prisoner' s dilemma game task

Round 1

Round 2

Round 3

Round 4

Round 5

Player 2

Transfer

Keep

Transfer

Keep

Transfer

Keep

Transfer

Keep

Transfer

Keep

Player 1

Transfer

10/10

0/15

12/12

0/18

14/14

0/21

16/16

0/24

18/18

0/27

Keep

15/0

5/5

18/0

6/6

21/0

7/7

24/0

8/8

27/0

9/9

Note: The number to the left of "/" is Player 1' s payoff, and the number to the right is Player 2' s payoff.

2.1.4 Experimental Procedure

After participants agreed to take part in the experiment, the experimenter welcomed and thanked them, and then explained the contents of the participant information sheet and the informed-consent form. The specific experimental procedure was as follows:

(1) Understanding the game task. The task was described as follows: "This game is a two-person game. In the game, each person initially has 30 tokens and may choose whether to transfer the 30 tokens to the other party. The transferred tokens will be doubled by the experimenter and become part of the other party's payoff. Specifically, if both parties choose to transfer, each person will receive 60 tokens; if neither party transfers, each person will still keep 30 tokens; if one person transfers while the other does not, the non-transferring party will receive 90 tokens, and the transferring party will receive 0 tokens." After reading this, participants answered three questions to ensure that they understood the rules of the game: When you choose to transfer and the other party also chooses to transfer, how many tokens will you ultimately have? When you choose to keep and the other party also chooses to keep, how many tokens will the other party ultimately have? When you choose to transfer and the other party chooses to keep, how many tokens will you ultimately have? If participants answered incorrectly, they were instructed to understand the task again and answer the questions until all answers were completely correct.

(2) Formal game task. Emotional images were embedded in the program and presented randomly to participants. The experimenter told participants: "In a previous experiment, we collected a set of data recording participants' facial expressions and their choices at the time. We have randomly matched you with a same-sex participant who previously completed the same experiment. You will see his/her photograph; apart from this, you will not know any other information about him/her. You will then need

to decide whether to transfer. I will match the choice you make with the choice made at that time by your same-sex counterpart, in order to determine your participation payment." In actual operation, each participant saw another same-sex player with one type of facial expression on the decision-making interface and played five rounds of the game with that player. In each round, participants had to decide whether to transfer tokens and predict whether the other party would transfer tokens. No outcome feedback was provided in any round of the game.

(3) Facial-expression manipulation check. After completing the five rounds of the game, participants rated on a 5-point scale (1 = strongly disagree, 5 =

···on a scale from "strongly disagree"to "strongly agree,"they evaluated the player' s expression in the program (Hillebrandt & Barclay, 2017). This evaluation consisted of three parts: (1) the degree of happiness was assessed with three items: "the other person looks very happy,""the other person looks very satisfied," and "the other person looks very pleased" ; (2) neutrality was assessed with one item: "the other person does not seem to have any particular emotion" ; and (3) the degree of anger was assessed with three items: "the other person looks very angry," "the other person looks very annoyed," and "the other person looks very irritated." Finally, participants completed demographic information such as gender and age; the purpose of the experiment was explained to them, and they were thanked.

2.2 Results

2.2.1 Manipulation Check for Facial Expressions

For the three items assessing happy expressions, Cronbach' s $\alpha = 0.95$; for the three items assessing angry expressions, Cronbach' s $\alpha = 0.98$. The mean scores of the three happy-expression items and the three angry-expression items were taken separately as participants' evaluations of the opponent' s facial expression. A one-way analysis of variance was conducted on participants' evaluation scores for the opponent' s facial expression, with facial expression as the independent variable. The results showed that the main effect of group on ratings of happy expressions was significant, $F(2, 177) = 48.71$, $p < 0.001$, $\eta_p^2 = 0.36$. Post hoc multiple comparisons indicated that participants in the happy-expression group rated the opponent' s happy expression ($M = 3.50$, $SD = 0.93$) significantly higher than did those in the angry-expression group ($M = 1.93$, $SD = 0.94$) and the neutral-expression group ($M = 2.71$, $SD = 0.81$). The main effect of group on ratings of angry expressions was significant, $F(2, 177) = 51.62$, $p < 0.001$, $\eta_p^2 = 0.37$. Post hoc multiple comparisons indicated that participants in the angry-expression group rated the opponent' s angry expression ($M = 3.75$, $SD = 1.01$) significantly higher than did those in the happy-expression group ($M = 2.13$, $SD = 1.04$) and the neutral-expression group ($M = 2.30$, $SD = 0.92$). The main effect of group on ratings of neutral expres-

sions was significant, $F(2, 177) = 43.40$, $p < 0.001$, $\eta_p^2 = 0.33$. Post hoc multiple comparisons indicated that participants in the neutral-expression group rated the opponent' s neutral expression ($M = 3.58$, $SD = 1.16$) significantly higher than did those in the angry-expression group ($M = 1.83$, $SD = 0.93$) and the happy-expression group ($M = 2.64$, $SD = 1.00$), indicating that the manipulation of facial expressions was effective.

2.2.2 The Effect of Facial Expressions on Cooperative Behavior

A one-way analysis of variance was conducted on participants' level of cooperation. The results showed that the main effect of facial expression was significant, $F(2, 177) = 4.01$, $p = 0.020$, $\eta_p^2 = 0.043$. Post hoc multiple comparisons indicated that there was no significant difference between the cooperation level of participants in the happy-expression group ($M = 2.80$, $SD = 2.01$) and that of participants in the neutral-expression group ($M = 2.22$, $SD = 1.54$), $p = 0.108$; the cooperation level of participants in the happy-expression group was significantly higher than that of participants in the angry-expression group ($M = 1.87$, $SD = 1.93$), $p = 0.005$; and there was no significant difference between the cooperation level of participants in the neutral-expression group and that of participants in the angry-expression group, $p = 0.313$.

2.2.3 The Effect of Facial Expressions on Expected Cooperation from the Opponent

A one-way analysis of variance was conducted on participants' expected level of cooperation from the opponent. The results showed that the main effect of facial expression was significant, $F(2, 177) = 3.09$, $p = 0.048$, $\eta_p^2 = 0.034$. Post hoc multiple comparisons indicated that participants' expected cooperation level for a happy-expression opponent ($M = 2.90$, $SD = 1.97$) did not differ significantly from their expected cooperation level for a neutral-expression opponent ($M = 2.86$, $SD = 1.55$), $p = 0.914$; the expected cooperation level for a happy-expression opponent was significantly higher than that for an angry-expression opponent ($M = 2.18$, $SD = 1.92$), $p = 0.029$; the expected cooperation level for a neutral-expression opponent was significantly higher than that for an angry-expression opponent, $p =$

0.048.

2.2.4 Mediation Effect Analysis

To test whether the expected cooperation level of the opponent mediated the effect of the opponent' s facial expression on the individual' s level of cooperation, Model 4 in the PROCESS 3.3 macro was used to conduct a mediation analysis of the above variables (Hayes, 2018). The percentile bootstrap method was used to compute the 95% confidence interval (CI) for the indirect effect based on 10,000 bootstrapped samples. The opponent' s facial expression was dummy-coded, with the neutral-expression group as the reference group, and

entered as the independent variable; the participant' s expected cooperation by the opponent was entered as the mediator; and the individual' s cooperation was entered as the dependent variable in the regression analysis. The results showed that the three predictors explained 55.85% of the variance in individuals' cooperative behavior, $F(3, 176) = 74.23$, $p < 0.001$. The relative direct effect of the opponent' s happy expression (vs. neutral expression) on individuals' cooperative behavior was significant, $\beta = 0.55$, 95% CI [0.0685, 1.0281], whereas the relative indirect effect was not significant (the confidence interval included 0), $a_1 * b = 0.03$, 95% CI [-0.4534, 0.5265]. The relative direct effect of the opponent' s angry expression (vs. neutral expression) on individuals' cooperative behavior was not significant, $\beta = 0.15$, 95% CI [-0.3118, 0.6200], whereas the relative indirect effect was significant (the confidence interval did not include 0), $a_2 * b = -0.50$, 95% CI [-0.9588, -0.0248]. This indicates that, compared with neutral expressions, participants expected partners with angry expressions to be less cooperative, and consequently they themselves were less cooperative in the prisoner' s dilemma.

Table 2
Test of the mediation-effect model of the influence of facial expression on individuals' cooperative behavior

	Equation 1Dependent variable: participant' s cooperation (Y)				Equation 2Dependent variable: expected opponent cooperation (M)				Equation 3Dependent variable: participant' s cooperation (Y)			
Variable		β	SE	t		β	SE	t		β	SE	t
Opponent' s facial expression (D_1)	c_1	0.58	0.36	1.62	a_1	0.04	0.35	0.11	c_1'	0.55*	0.24	2.26

Variable	Equation 1Dependent variable: participant's cooperation (M)				Equation 2Dependent variable: expected opponent cooperation (M)				Equation 3Dependent variable: participant's cooperation (Y)			
		β	SE	t		β	SE	t		β	SE	t
Opponent's facial expression (D_2)	c_2	-0.35	0.34	-1.01	a_2	-0.68*	0.34	-1.99	c'_2	0.15	0.23	0.65
Expected opponent cooperation (M)									b	0.74***	0.05	14.33
Constant	i_y	2.22***	0.26	8.46	i_m	2.86***	0.26	10.98	i_y	0.10	0.23	0.45
		$R^2 = 0.043$ $F(2,177) = 4.01$, $p = 0.020$				$R^2 = 0.034$ $F(2,177) = 3.09$, $p = 0.048$				$R^2 = 0.559$ $F(3,176) = 74.23$, $p < 0.001$		

Note: D_1: neutral = 0, happy = 1, angry = 0; D_2: neutral = 0, happy = 0, angry = 1; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

3 Experiment 2

3.1 Method

3.1.1 Participants A total of 185 adult participants were recruited (130 women), with a mean age of 21.48 years ($SD = 2.71$). All were physically and mentally healthy and had normal or corrected-to-normal vision. There were 34 participants in the happy-expression–rational group, 30 in the happy-expression–intuitive group, and 32 in the neutral-expression–rational group.

participants, 30 in the neutral-expression–intuition group, 29 in the angry-expression–rational group, and 30 in the angry-expression–intuition group. After the experiment, participants received a cash reward of 10 yuan.

3.1.2 Experimental Design A 3 (opponent' s facial expression: happy/neutral/angry) × 2 (decision mode: intuitive/rational) completely between-subjects design was adopted. The independent variables were the opponent' s facial expression and the individual' s decision mode; the dependent variable was the same as in Experiment 1.

3.1.3 Experimental Materials

(1) Facial-expression images. Same as in Experiment 1.

(2) Prisoner' s dilemma task. Same as in Experiment 1.

3.1.4 Experimental Procedure After participants agreed to take part in the experiment, the experimenter welcomed and thanked them, and then explained the content of the participant information sheet and informed-consent form. The specific experimental procedure was as follows:

(1) Understanding the game task. Same as in Experiment 1.

(2) Manipulation of decision mode. Following the method of Levine et al. (2018), participants were guided by instructions to rely on intuition or rationality when making decisions. Participants in the intuition group were told: "Sometimes people make decisions by using their feelings and relying on intuition; sometimes people make decisions by using logic and relying on rationality. Many people believe that intuition leads to good decisions. When we use intuition rather than logic, we make emotional and satisfying decisions. Please rely on intuition rather than rationality when making your transfer decision." Participants in the rational group were told: "Sometimes people make decisions by using logic and relying on rationality; sometimes people make decisions by using feelings and relying on intuition. Many people believe that rationality leads to good decisions. When we use logic rather than intuition, we make rational and satisfying decisions. Please rely on rationality rather than intuition when making your transfer decision."

(3) Formal game task. Same as in Experiment 1.

(4) Decision-mode manipulation check. After completing the decision task, participants answered three manipulation-check questions to examine the extent to which they relied on intuition and rationality in making decisions (Levine et al., 2018): "How did you make your decision?" (1 = used only rationality, 7 = used only intuition), "When making the decision, to what extent did you rely on your feelings?" (1 = not at all, 7 = completely), and "When making the decision, to what extent did you rely on your rationality?" (1 = not at all, 7 = completely; reverse-scored).

(5) Facial-expression manipulation check. Same as in Experiment 1.

3.2 Results

3.2.1 Experimental Manipulation Check Decision-mode manipulation check. The Cronbach' s α for the three decision-mode items was 0.91. The mean of the three items was taken

as the participants' decision-mode score. With decision-mode group as the independent variable and participants'decision-mode score as the dependent variable, an independent-samples (t) test was conducted. The results showed that the difference in decision-mode scores between the different decision-mode groups was significant, (t(183)=15.74), (p<0.001), Cohen' s (d=2.33). Participants in the intuitive group ((M=3.98, SD=0.73)) reported using intuition to make decisions more often than did participants in the rational group ((M=2.22, SD=0.78)), indicating that the decision-mode manipulation was effective.

For the manipulation check of facial expressions, the Cronbach' s ( ) for the three happy-expression items was 0.95, and the Cronbach' s ( ) for the three angry-expression items was 0.98. The mean scores of the three happy items and the three angry items were taken respectively as participants' evaluations of the opponent' s facial expression. With facial expression as the independent variable, one-way analyses of variance were conducted on the evaluation scores of the opponent' s facial expression. The results showed that the between-group main effect on happy-expression ratings was significant, (F(2,182)=152.55), (p<0.001), (_p^2=0.63). Post hoc multiple comparisons indicated that participants in the happy-expression group rated the opponent' s happy expression ((M=4.09, SD=0.93)) significantly higher than did those in the angry-expression group ((M=1.34, SD=0.68)) and the neutral-expression group ((M=2.83, SD=0.97)). The between-group main effect on angry-expression ratings was significant, (F(2,182)=185.67), (p<0.001), (_p^2=0.67). Post hoc multiple comparisons indicated that participants in the angry-expression group rated the opponent' s angry expression ((M=4.35, SD=0.93)) significantly higher than did those in the happy-expression group ((M=1.39, SD=0.88)) and the neutral-expression group ((M=1.92, SD=0.90)). The between-group main effect on neutral-expression ratings was significant, (F(2,182)=78.38), (p<0.001), (_p^2=0.46). Post hoc multiple comparisons

Figure 3. Cooperation of participants facing opponents with different facial expressions under different decision modes. Y-axis: participants' cooperation; X-axis: opponent' s facial expression. Categories: happy, neutral, angry. Legend: intuitive, rational.

Figure 2: Figure 3. Cooperation of participants facing opponents with different facial expressions under different decision modes. Y-axis: participants' cooperation; X-axis: opponent' s facial expression. Categories: happy, neutral, angry. Legend: intuitive, rational.

indicated that participants in the neutral-expression group rated the opponent' s neutral expression ((M=3.19, SD=1.24)) significantly higher than did those in the angry-expression group ((M=1.27, SD=0.55)) and the happy-expression group ((M=1.56, SD=0.81)). These results indicated that the facial-expression manipulation was effective.

3.2.2 Effects of Facial Expression and Decision Mode on Cooperative Behavior

With facial expression and decision mode as the independent variables, an analysis of variance was conducted on participants' level of cooperation. The results showed that the main effect of facial expression was significant, (F(2,179)=14.49), (p<0.001), (_p^2=0.14). The level of cooperation among participants in the happy-expression group ((M=2.83, SD=1.76)) and the neutral-expression group ((M=2.55, SD=1.79)) was significantly higher than that among participants in the angry-expression group ((M=1.41, SD=1.38)), (ps<0.001); the level of cooperation in the happy-expression group did not differ significantly from that in the neutral-expression group, (p=0.292). The main effect of decision mode was significant, (F(1,179)=11.62), (p=0.001), (_p^2=0.061); the level of cooperation among participants in the intuitive group ((M=2.68, SD=1.78)) was significantly higher than that among participants in the rational group ((M=1.91, SD=1.66, p<0.01)).

The interaction effect between facial expression and decision mode was significant, (F(2,179)=5.28), (p=0.006), (_p^2=0.056). Further simple-effects analyses showed that, under the intuitive decision mode, there were significant differences in participants' level of cooperation across the different expression groups, (F(2,179)=18.23), (p<0.001), (_p^2=0.17). The level of cooperation among participants in the happy-expression group ((M=3.50, SD=1.43)) and the neutral-expression group ((M=3.27, SD=1.57)) was significantly higher than that among participants in the angry-expression group ((M=1.27, SD=1.44)), (ps<0.001); the level of cooperation in the happy-expression group did not differ significantly from that in the neutral-expression group, (p=0.872). Under the rational decision mode, there were no significant differences in participants' level of cooperation across the different expression groups, (F(2,179)=1.48), (p=0.230).

Figure 3 Cooperation of participants facing opponents with different facial

Figure 4. Expected cooperation of opponents with different facial expressions under different decision-making modes.

Figure 3: Figure 4. Expected cooperation of opponents with different facial expressions under different decision-making modes.

expressions under different decision modes

Note: Error bars indicate standard errors; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

3.2.3 Effects of Facial Expression and Decision Mode on Expected Cooperation by the Opponent

Using facial expression and decision mode as independent variables, an analysis of variance was conducted on the level of cooperation participants expected from the opponent. The results showed that the main effect of facial expression was significant, $F(2, 179) = 15.82$, $p < 0.001$, $\eta_p^2 = 0.15$. Participants expected opponents with happy ($M = 3.19$, $SD = 1.60$) and neutral ($M = 3.19$, $SD = 1.77$) expressions to cooperate significantly more than opponents with angry expressions ($M = 1.78$, $SD = 1.47$), $ps < 0.001$; there was no significant difference between the expected cooperation level of happy-expression opponents and that of neutral-expression opponents, $p = 0.981$. The main effect of decision mode was not significant, $F(1, 179) = 0.73$, $p = 0.395$.

The interaction effect between facial expression and decision mode was significant, $F(2, 179) = 3.64$, $p = 0.028$, $\eta_p^2 = 0.039$. Further simple-effects analyses showed that, under the intuitive decision mode, there were significant differences in the cooperation levels that participants expected from opponents with different expressions, $F(2, 179) = 17.22$, $p < 0.001$, $\eta_p^2 = 0.16$. Participants expected opponents with happy ($M = 3.56$, $SD = 1.38$) and neutral ($M = 3.50$, $SD = 1.55$) expressions to cooperate significantly more than opponents with angry expressions ($M = 1.43$, $SD = 1.52$), $ps < 0.001$; there was no significant difference between the expected cooperation level of happy-expression opponents and that of neutral-expression opponents, $p = 0.872$. Under the rational decision mode, there were no significant differences in the cooperation levels that participants expected from opponents with different expressions, $F(2, 179) = 2.17$, $p = 0.118$.

Figure 4 Cooperation expected from opponents with different facial expressions under different decision-making modes

Note. Error bars represent standard errors; (* $p < 0.05$), (** $p < 0.01$), (*** $p < 0.001$).

3.2.4 Analysis of the Moderated Mediation Effect

To test whether the expected level of cooperation from the opponent mediated the effects of the opponent' s facial expression, decision-making mode, and their interaction on individuals' level of cooperation, Model 8 in the PROCESS 3.3 macro was used to conduct a moderated mediation analysis of the above variables (Hayes, 2018). The percentile bootstrap method was used to compute the 95% confidence interval (CI) for the indirect effect based on 10,000 bootstrapped samples. Regression analysis was conducted with the dummy-coded opponent facial expression (with the neutral-expression group as the reference condition), decision-making mode, and their interaction as independent variables, the expected cooperation of the opponent as the mediator, and participants' cooperation as the dependent variable.

The results showed that the six predictors explained 64.38% of the variance in individuals' cooperative behavior, ($F(6, 178) = 53.63$), ($p < 0.001$). Analysis of the relative conditional direct effects found that the direct effects under all conditions were nonsignificant. Analysis of the relative conditional indirect effects found that, under the intuitive decision-making mode, the relative indirect effect of the opponent' s happy expression (vs. neutral expression) on individuals' cooperative behavior was nonsignificant, (= 0.05), 95% CI ([-0.4952, 0.5967]); under the rational decision-making mode, the relative indirect effect of the opponent' s happy expression (vs. neutral expression) on individuals' cooperative behavior was also nonsignificant, (= -0.04), 95% CI ([-0.7011, 0.6043]); the moderated indirect effect was nonsignificant (the confidence interval included 0), (a_4*b* = *0.09), 95% CI ([-0.7501, 0.9438]). In addition, under the intuitive decision-making mode, the relative indirect effect of the opponent' s angry expression (vs. neutral expression) on individuals' cooperative behavior was significant, (= -1.50), 95% CI ([-2.1290, -0.8958]); under the rational decision-making mode, the relative indirect effect of the opponent' s angry expression (vs. neutral expression) on individuals' cooperative behavior was nonsignificant, (= -0.56), 95% CI ([-1.1767, 0.0605]); the moderated indirect effect was significant (the confidence interval did not include 0), (a_5*b = -0.94), 95% CI ([-1.8390, -0.1256]). This indicates that, under the intuitive decision-making mode, compared with a neutral expression, participants expected peers with angry expressions to be less cooperative, and consequently were less cooperative in the prisoner' s dilemma.

Table 3
Test of the mediating-effect model of facial expression and decision mode influencing individual cooperative behavior

Variable		Equation 1Dependent variable: participant's cooperation (Y)				Equation 2Dependent variable: expected opponent cooperation (M)				Equation 3Dependent variable: participant's cooperation (Y)		
		β	SE	t		β	SE	t		β	SE	t
Opponent's facial expression (D_1)	c_1	0.36	0.39	0.93	a_1	-0.05	0.39	-0.14	c_1'	0.40	0.26	1.52
Opponent's facial expression (D_2)	c_2	-0.32	0.40	-0.80	a_2	-0.77	0.41	-1.87	c_2'	0.23	0.28	0.85
Decision mode (W)	c_3	1.39**	0.40	3.48	a_3	0.59	0.41	1.46	c_3'	0.96**	0.27	3.52
$D_1 \times W$	c_4	-0.13	0.56	-0.23	a_4	0.12	0.57	0.21	c_4'	-0.21	0.38	-0.56
$D_2 \times W$	c_5	−1.68**	0.57	-2.92	a_5	−1.30*	0.58	-2.23	c_5'	-0.74	0.39	-1.88

Variable	Equation 1Dependent variable: participant's cooperation (Y)			Equation 2Dependent variable: expected opponent cooperation (M)			Equation 3Dependent variable: participant's cooperation (Y)		
Expected opponent cooperation (M)						b	0.73***	0.05	14.55
Constant	i_y 1.88***	0.28	6.73	i_m 2.91***	0.28	10.27	i_y -0.23	0.24	-0.98
	$R^2 = 0.22$ $F(5, 179) = 10.11, p < 0.001$			$R^2 = 0.18$ $F(5, 179) = 7.87, p < 0.001$			$R^2 = 0.64$ $F(6, 178) = 53.63, p < 0.001$		

Note: D_1: neutral = 0, happy = 1, angry = 0; D_2: neutral = 0, happy = 0, angry = 1; W: rational = 0, intuitive = 1; $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

4 Experiment 3

4.1 Method

4.1.1 Participants

A total of 218 adult participants were recruited (148 women), with a mean age of 23.74 years ($SD = 3.11$). All were physically and mentally healthy and had

normal or corrected-to-normal vision. There were 37 participants in the happy-expression–time-delay group, 35 in the happy-expression–time-constraint group, 47 in the neutral-expression–time-delay group, 31 in the neutral-expression–time-constraint group, 32 in the angry-expression–time-delay group, and 36 in the angry-expression–time-constraint group. After the experiment, participants received a cash reward of 10 yuan.

4.1.2 Experimental design

A 3 (opponent' s facial expression: happy/neutral/angry) × 2 (time pressure: time constraint/time delay) fully between-subjects design was adopted. The independent variables were the opponent' s facial expression and time pressure; the dependent variables were the same as in Experiments 1 and 2.

4.1.3 Experimental materials

(1) Facial-expression images. The same as in Experiments 1 and 2.

(2) Prisoner' s dilemma task. The same as in Experiments 1 and 2.

4.1.4 Experimental procedure

After participants agreed to take part in the experiment, the experimenter welcomed and thanked them, and then explained the contents of the participant information sheet and the informed-consent form. The specific experimental procedure was as follows:

(1) Comprehension of the game task. Same as in Experiments 1 and 2.

(2) Decision-mode manipulation. Following the time-pressure manipulation paradigm of Rand et al. (2012), participants were required either to make decisions quickly within a specified time limit (i.e., the time-constraint condition) or to make decisions only after thinking for a period of time (i.e., the time-delay condition). The maximum time allowed in the former condition is typically 10 seconds or less. Their studies further demonstrated that, under the time-constraint condition, decisions are more strongly influenced by intuition, whereas under the time-delay condition, decisions are more strongly influenced by deliberation or rational analysis (Rand, 2016). In the time-constraint group: "You will complete five rounds of the game in total, and each round must be completed within 10 seconds. After 10 seconds, the interface will automatically submit your response. Missing any round of decisions will affect your final experimental payment. To remind you of the time remaining, the interface will display a countdown of the remaining time." In the time-delay group: "You will complete five rounds of the game in total, and each round must be completed after 10 seconds. The interface will remain on screen for 10 s before you are allowed to fill in and submit your response. Missing any round of

decisions will affect your final experimental payment. To remind you of the time, the interface will display a timer."

(3) Formal game task. Same as in Experiments 1 and 2. The only difference was that, when the decision interface appeared in each round, a countdown or count-up timer was presented.

(4) Time-pressure manipulation check. After completing the decision-making task, participants answered two manipulation-check items (Gao et al., 2020): "When I made the decision, I did not have time to think," and "I thought carefully when making the decision" (1 = strongly disagree, 5 = strongly agree).

(5) Facial-expression manipulation check. Same as in Experiments 1 and 2.

4.2 Results

4.2.1 Experimental manipulation checks

Time-pressure manipulation check. With time-pressure group as the independent variable and participants' scores on the time-pressure manipulation-check items as the dependent variable, independent-samples t tests were conducted. The results showed that the different time-pressure groups differed significantly in their scores on "When I made the decision, I did not have time to think," $t(216) = 11.32$, $p < 0.001$, Cohen' s $d = 1.54$: the time-constraint group ($M = 3.76$, $SD = 0.90$) reported greater decision-time pressure and less time to think than the time-delay group ($M = 2.25$, $SD = 1.05$). The different time-pressure groups also differed significantly in their scores on "I thought carefully when making the decision," $t(216) = -7.55$, $p < 0.001$, Cohen' s $d = 1.02$: the time-constraint group ($M = 2.66$, $SD = 1.06$) deliberated less when making decisions than the time-delay group ($M = 3.64$, $SD = 0.86$). These results indicate that the time-pressure manipulation was effective.

Facial-expression manipulation check. The three items used to assess happy expressions had a Cronbach' s $\alpha = 0.94$; the three items used to assess angry expressions···

The items had Cronbach' s $\alpha = 0.95$; the mean scores of the three items for happiness and anger were taken, respectively, as participants' evaluations of the opponent' s facial expression. With facial expression as the independent variable, a one-way analysis of variance was conducted on the evaluation scores for the opponent' s facial expression. The results showed that the between-group main effect for ratings of happy expressions was significant, $F(2, 215) = 69.26$, $p < 0.01$, $\eta_p^2 = 0.39$. Post hoc multiple comparisons indicated that participants in the happy-expression group rated the opponent' s happy expression significantly higher ($M = 3.83$, $SD = 0.93$) than did those in the angry-expression group ($M = 1.97$, $SD = 1.07$) and the neutral-expression group ($M = 2.91$, $SD = 0.76$). The between-group main effect for ratings of angry expressions was significant, $F(2, 215) = 131.30$, $p < 0.01$, $\eta_p^2 =$

0.55. Post hoc multiple comparisons indicated that participants in the angry-expression group rated the opponent' s angry expression significantly higher ($M = 3.87,\ SD = 0.91$) than did those in the happy-expression group ($M = 1.80,\ SD = 0.90$) and the neutral-expression group ($M = 2.11,\ SD = 0.62$). The between-group main effect for ratings of neutral expressions was significant, $F(2, 215) = 74.52,\ p < 0.001,\ \eta_p^2 = 0.41$. Post hoc multiple comparisons indicated that participants in the neutral-expression group rated the opponent' s neutral expression significantly higher ($M = 3.91,\ SD = 0.93$) than did those in the angry-expression group ($M = 1.94,\ SD = 1.08$) and the happy-expression group ($M = 2.40,\ SD = 1.08$). This indicates that the facial-expression manipulation was effective.

4.2.2 Effects of Facial Expression and Time Pressure on Cooperative Behavior

Using facial expression and time pressure as independent variables, an analysis of variance was conducted on participants' level of cooperation. The results showed that the main effect of facial expression was significant, $F(2, 212) = 4.39,\ p = 0.014,\ \eta_p^2 = 0.040$. The level of cooperation among participants in the happy-expression group ($M = 2.63,\ SD = 1.78$) was significantly higher than that of participants in the angry-expression group ($M = 1.84,\ SD = 1.70,\ p = 0.003$), but did not differ significantly from that of participants in the neutral-expression group ($M = 2.39,\ SD = 1.82,\ p = 0.123$). The level of cooperation in the neutral-expression group did not differ significantly from that in the angry-expression group ($p = 0.144$). The main effect of time pressure was significant, $F(1, 212) = 15.15,\ p < 0.001,\ \eta_p^2 = 0.067$; the level of cooperation among participants in the time-constraint group ($M = 2.68,\ SD = 1.71$) was significantly higher than that among participants in the time-delay group ($M = 1.83,\ SD = 1.69$).

The interaction effect between facial expression and time pressure was significant, $F(2, 212) = 3.32,\ p = 0.038,\ \eta_p^2 = 0.030$. Further simple-effects analyses showed that, under the time-constraint condition, there were significant differences in cooperation levels among participants in the different expression groups, $F(2, 212) = 6.58,\ p = 0.002,\ \eta_p^2 = 0.058$. The cooperation level of participants in the happy-expression group ($M = 3.49,\ SD = 1.56$) was significantly higher than that of participants in the neutral-expression group ($M = 2.39,\ SD = 1.82,\ p = 0.008$) and the angry-expression group ($M = 2.14,\ SD = 1.48,\ p = 0.001$); the cooperation level of participants in the neutral-expression group did not differ significantly from that of participants in the angry-expression group, $p = 0.541$. Under the time-delay condition, there were no significant differences in cooperation levels among participants in the different expression groups, $F(2, 212) = 1.11,\ p = 0.331$.

Legend: Time constraint Time delay

Y-axis: Participants' cooperation

X-axis: Opponent' s facial expression
Categories: Happy; Neutral; Angry

Figure 5. Participants' cooperation toward opponents with different facial expressions under different time-pressure conditions

Note: Error bars indicate standard errors; * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$).

4.2.3 Effects of Facial Expression and Time Pressure on Expected Opponent Cooperation

An analysis of variance was conducted with facial expression and time pressure as independent variables and the expected level of opponent cooperation as the dependent variable. The results showed that the main effect of facial expression was significant, ($F(2, 212) = 6.90$), ($p = 0.001$), (_p^2 = 0.061). Participants' expected cooperation level for happy opponents (($M = 2.87$, $SD = 1.73$)) and neutral opponents (($M = 2.64$, $SD = 1.70$)) was significantly higher than that for angry opponents (($M = 1.85$, $SD = 1.84$, p_1 < 0.001, p_2 = 0.006)). There was no significant difference between the expected cooperation levels for happy and neutral opponents, ($p = 0.404$). The main effect of time pressure was significant, ($F(1, 212) = 12.13$), ($p = 0.001$), (_p^2 = 0.054). The expected cooperation level of opponents in the time-constraint group (($M = 2.85$, $SD = 1.76$)) was significantly higher than that in the time-delay group (($M = 2.04$, $SD = 1.76$, $p = 0.001$)).

The interaction effect between facial expression and time pressure was significant, ($F(2, 212) = 3.10$), ($p = 0.047$), (_p^2 = 0.028). Further simple-effects analyses showed that under the time-constraint condition, there were significant differences in participants' expected cooperation levels for opponents with different expressions, ($F(2, 212) = 6.96$), ($p = 0.001$), (_p^2 = 0.062). Participants' expected cooperation level for happy opponents (($M = 3.66$, $SD = 1.45$)) was significantly higher than that for neutral (($M = 2.74$, $SD = 1.86$, $p = 0.030$)) and angry (($M = 2.17$, $SD = 1.67$, $p < 0.001$)) opponents. The expected cooperation level for neutral opponents did not differ significantly from that for angry opponents, ($p = 0.168$). Under the time-delay condition, there were significant differences in participants' expected cooperation levels for opponents with different expressions, ($F(2, 212) = 3.33$), ($p = 0.038$), (_p^2 = 0.030). Participants' expected cooperation level for happy opponents (($M = 2.08$, $SD = 1.64$)) did not differ significantly from that for neutral (($M = 2.53$, $SD = 1.60$, $p = 0.228$)) or angry (($M = 1.53$, $SD = 1.98$, $p = 0.181$)) opponents. The expected cooperation level for neutral opponents was significantly higher than that for angry opponents, ($p = 0.011$).

[Bar chart: y-axis, "Participant' s expected cooperation from the opponent" ; x-axis, "Opponent' s facial expression" with categories Happy, Neutral, Angry; legend: gray bars = Time constraint, white bars = Time delay. Significance brackets are marked with , **.]

Figure 6 Cooperation expected by participants from opponents with different facial expressions under different time pressures

Note: Error bars indicate standard errors; ({}^{}*p < 0.05), ({}^{}**p < 0.01), ({}^{}**p** < 0.001).

4.2.4 Analysis of moderated mediation effects To examine whether expected cooperation from the opponent mediated the effects of the opponent' s facial expression, time pressure, and their interaction on individuals' cooperative behavior, Model 8 in the PROCESS 3.3 macro was used to conduct a moderated mediation analysis of the above variables (Hayes, 2018). The percentile bootstrap method was used to compute the 95% confidence intervals (CIs) for the indirect effects based on 10,000 bootstrapped samples. A regression analysis was conducted with dummy-coded opponent facial expression (with the neutral-expression group as the reference condition), time pressure, and their interaction as independent variables; expected cooperation from the opponent as the mediator; and participants' cooperation as the outcome variable.

The results showed that the six predictors explained 61.00% of the variance in individuals' cooperative behavior, ($F(6, 211) = 55.00$), ($p < 0.001$).

Analysis of relative conditional direct effects showed that the direct effects under all conditions were nonsignificant. Analysis of relative conditional indirect effects showed that, under the time-constraint condition, the relative indirect effect of the opponent' s happy expression (vs. neutral expression) on individuals' cooperative behavior was significant, (= 0.66), 95% CI ([0.0732, 1.2889]); under the time-delay condition, the relative indirect effect of the opponent' s happy expression (vs. neutral expression) on individuals' cooperative behavior was nonsignificant, (= -0.33), 95% CI ([-0.8395, 0.1975]). The moderated indirect effect was significant (the confidence interval did not include 0), (a_4*b = 0.99), 95% CI ([0.1962, 1.8178]). In addition, under the time-constraint condition, the relative indirect effect of the opponent' s angry facial expression (vs. neutral expression) on individuals' cooperative behavior was nonsignificant, (= -0.42), 95% CI ([-1.0330, 0.2137]); under the time-delay condition, the relative indirect effect of the opponent' s angry expression (vs. neutral expression) on individuals' cooperative behavior was significant, (= -0.73), 95% CI ([-1.3405, -0.1204]). The moderated indirect effect was nonsignificant (the confidence interval included 0), (a_5b = 0.31), 95% CI ([-0.5588, 1.1938]). This indicates that, under the time-constraint condition, compared with a neutral expression, participants expected partners with happy expressions to be more cooperative, and consequently cooperated more in the prisoner' s dilemma.

Table 4
Test of the mediation-effect model for the influence of facial expression and time pressure on individual cooperative behavior

Variable

Equation 1

Equation 2

Equation 3

Dependent variable: participant’ s cooperation (Y)

Dependent variable: expected opponent cooperation (M)

Dependent variable: participant’ s cooperation (Y)

β

SE

t

β

SE

t

β

SE

t

Opponent’ s facial expression (D1)

c1

-0.25

0.36

-0.70

a1

-0.45

0.37

-1.21

c′1

0.07

0.24

0.31

Opponent’ s facial expression (D2)

c2

-0.56

0.38

-1.49

a2

-1.00

0.39

-2.58

c′2

0.16

0.26

0.63

Time pressure (W)

c3

0.32

0.38

0.85

a3

0.21

0.39

0.54

c′3

0.17

0.26

0.67

D1 × W

c4

1.35*

0.54

2.48

a4

1.37*

0.56

2.44

c′4

0.36

0.37

0.97

D2 × W

c5

0.32

0.55

0.57

a5

0.43

0.57

0.75

c′5

0.01

0.37

0.02

Expected opponent cooperation (M)

b

0.73***

0.04

16.23

Constant

iy

2.06

0.24

8.56

im

2.53

0.25

10.24

iy

0.23

0.20

1.14

R2 = 0.12

R2 = 0.13

R2 = 0.61

F(5, 212) = 5.94, p < 0.001

F(5, 212) = 6.19, p < 0.001

F(6, 211) = 55.00, p < 0.001

Note: D1: neutral = 0, happy = 1, anger = 0; D2: neutral = 0, happy = 0, anger = 1; W: time delay = 0, time constraint = 1; *p < 0.05,* ***p < 0.01,*** p < 0.001.

5 Discussion

Experiment 1 showed that, in the prisoner's dilemma game, the opponent's facial expression not only directly influenced participants' cooperative behavior, but also influenced cooperative behavior by affecting participants'expectations of the opponent's cooperative behavior, supporting Hypothesis 1. By manipulating decision mode through instructions, Experiment 2 not only verified the findings of Experiment 1, but also showed that decision mode had a dual moderating effect on the two pathways whereby facial expressions influence cooperative behavior and expectations of the opponent' s cooperative behavior, further supporting Hypothesis 1 and also supporting Hypothesis 2. Experiment 3 manipulated participants' decision mode through a time-pressure task and essentially replicated the results of Experiment 2, again supporting Hypothesis 1 and further supporting Hypothesis 2. Experiments 2 and 3 also found that individuals making relatively intuitive decisions were more cooperative than individuals making relatively rational decisions.

5.1 The influence of facial expressions on individuals' cooperative behavior

Across the three experiments in this study, we consistently found that, in the prisoner's dilemma game, the opponent's incidental facial expressions influenced participants' cooperative behavior, and that different types of facial expressions had different effects on participants' cooperative behavior. That is, when participants faced opponents with different facial expressions, they showed a tendency

toward cooperative decision-making, supporting the social-functional theory of emotion (Erickson & Schulkin, 2003; Fischer & Manstead, 2008; Keltner et al., 1999; Van Kleef et al., 2010). In addition, the results of the present study are to some extent consistent with evidence from related research (e.g., Alguacil et al., 2015; Raoul et al., 2017; Tortosa et al., 2013), indicating that people are not always completely rational when making cooperative decisions (Wang et al., 2018).

Specifically, the level of cooperation in the anger, neutral, and happy facial-expression groups showed a gradually increasing trend. However, a stable significant difference appeared only between the anger and happy facial-expression groups; the cooperation levels of participants in the happy and neutral facial-expression groups showed a stable nonsignificant difference; and the difference in cooperation levels between participants in the anger and neutral facial-expression groups was not highly consistent across experiments: in Experiments 1 and 3, the difference in cooperation levels between the anger and neutral facial-expression groups was nonsignificant, whereas in Experiment 2, the difference between the two groups was significant. According to the negativity bias (Rozin & Royzman, 2001) and the asymmetrical effects of bad and good (Baumeister et al., 2001), negative information, events, and emotions have a greater impact than positive information, events, and emotions (bad is stronger than good), and also exert a stronger effect on impression formation. Therefore, the effect of positive interaction information (such as happy expressions) may be more similar to that of neutral interaction information (such as neutral expressions), whereas the effect of negative interaction information (such as angry expressions) may be markedly different. Evolutionary theory and classical conditioning theory also hold that, compared with happy and neutral expressions, angry expressions are associated with negative consequences and are more salient (Tortosa et al., 2013). Thus, compared with happy or neutral expressions, angry expressions will produce stronger effects; that is, cooperation levels are lowest when facing an opponent with an angry expression.

From the perspective of the social function of emotion, the social signals released by smiling expressions (happy expressions) are relatively complex, such as reward smiles, affiliative smiles, and dominance smiles (Martin et al., 2017), as well as genuine smiles and polite smiles (Johnston et al., 2010; Reed et al., 2012; Shore & Heerey, 2011), among others. Whether the recipient of such emotional signals can correctly interpret the meaning of another person' s smiling signal is the key to whether it can play a positive social function. Although in the present study participants were randomly assigned to groups, standardized facial-expression images were used, and the results of the manipulation check also showed that participants were able to recognize them accurately, individual differences may nevertheless have existed in participants' interpretations of smiling expressions. For example, some participants may have regarded them as sincere smiles, whereas others may not have done so, ultimately leading to no significant difference in the effects of happy and neutral expressions. Future research should attempt to use more refined experimental designs and control

or measure relevant individual-difference variables, so as to further examine the effects of happy facial expressions of different natures on individuals' cooperative behavior.

5.2 The Mediating Role of Expectations

Across the three experiments, the present study consistently found that, in the prisoner' s dilemma game, others' facial expressions influenced participants' expectations regarding their opponents' cooperative behavior, and that different types of facial expressions had different effects on cooperation expectations. This is consistent with the view that facial expressions function to externalize intentions as social signals (Darwin, 1872/1962), and that emotional expression functions to guide interpersonal interaction (Erickson & Schulkin, 2003; Frith & Frith, 2006; Horstmann, 2003). Specifically, participants expected the cooperation levels of angry-, neutral-, and happy-faced opponents to show a gradually increasing trend. However, stable significant differences appeared only between participants in the happy and neutral facial-expression groups and those in the anger facial-expression group, whereas participants in the happy and neutral facial-expression groups showed a stable nonsignificant difference. This indicates that people can consciously or intuitively interpret the latent psychological meanings contained in the social signals of others' facial expressions, thereby helping them form expectations about others' behavior.

Mediation-effect analyses showed that expectations about others' cooperative behavior mediated the relationship between facial expressions and individuals' cooperative behavior.

Specifically, Experiment 1 found that participants' expectations about the opponent' s cooperative behavior mediated the effect of the opponent' s angry expression (vs. neutral expression) on individuals' cooperative behavior. Experiment 2 found that the mediation effect observed in Experiment 1 appeared only under the intuitive decision-making mode. Experiment 3 found that, under time constraints, participants' expectations about the opponent' s cooperative behavior mediated the effect of a happy expression (vs. neutral expression) on individuals'cooperative behavior. These results are consistent with findings from related studies (Ruz et al., 2011; Ng & Au, 2016; Pletzer et al., 2018), and also support the aforementioned goal–expectation theory (Pruitt & Kimmel, 1977). They indicate that when explicit information about whether the other party will cooperate is unavailable, people use indirect information such as the other party' s facial expression to form expectations about that person' s cooperative behavior, thereby deciding whether to cooperate with them. The mediation model established and verified in the present study helps further deepen our understanding of the potential psychological processes through which facial expressions influence cooperative behavior.

5.3 The Moderating Role of Decision-Making Mode

According to dual-system theories of decision making (Evans & Stanovich, 2013; Kahneman, 2011), if people make decisions using a relatively rational decision-making mode that is slow, deliberative, and analytical, they are relatively less influenced by superficial emotional information such as facial expressions. If, however, people make decisions using a relatively intuitive decision-making mode that is fast, automatic, and heuristic, they are more sensitive to emotional information such as facial expressions. In addition, the perspective of heuristic decision-making holds that people are usually unable or unwilling to consider all available information, and instead prefer to use heuristic strategies to reduce cognitive effort—that is, to make decisions by relying on only part of the available information (Gigerenzer et al., 2011). In Experiments 2 and 3 of the present study, participants' decision-making modes were directly manipulated using two paradigms, namely instructions and time pressure, respectively. Both experiments found that decision-making mode moderated the influence of the opponent' s facial expression on cooperative behavior and expectations of cooperation. In Experiment 2, under the intuitive decision-making mode, the cooperation levels of the happy- and neutral-expression groups were significantly higher than that of the angry-facial-expression group; participants expected the cooperation levels of opponents with happy and neutral expressions to be significantly higher than those of opponents with angry facial expressions; and only under the intuitive decision-making mode did participants' expectations about the opponent' s cooperative behavior mediate the effect of an angry expression (vs. neutral expression) on individuals' cooperative behavior. In Experiment 3, under the time-constraint condition, the cooperation level of the happy-facial-expression group was significantly higher than those of the neutral- and angry-facial-expression groups; participants expected the cooperation level of opponents with happy facial expressions to be significantly higher than those of opponents with neutral and angry facial expressions; and only under the time-constraint condition did participants' expectations about the opponent' s cooperation mediate the effect of a happy facial expression (vs. neutral expression) on individuals' cooperative behavior. These results not only support dual-system theories of decision making, but also clarify the boundary conditions under which others' facial expressions influence individuals' expectations of cooperation and, in turn, their cooperative behavior. Theoretically, they supplement and advance existing related research to a certain extent; practically, they help people better understand under what conditions, or for what kinds of individuals, it is appropriate to influence cooperative behavior through facial expressions.

Interestingly, the results of Experiments 2 and 3 also showed a significant main effect of decision-making mode on participants' level of cooperation; that is, a relatively intuitive decision-making mode led people to be more cooperative than did a relatively rational decision-making mode. A series of studies by Rand and colleagues found that, in one-shot anonymous interactions in which self-interest

is the optimal choice, intuitive responses tend to be more cooperative than deliberative responses (Bear &

Rand, 2016; Jordan et al., 2016; Levine et al., 2018; Rand, 2016; Rand et al., 2012; Rand et al., 2014). On this basis, they proposed the social heuristics hypothesis (SHH), revising the "human nature is selfish" assumption of most prosocial theoretical models—that is, that humans are essentially selfish and that prosocial behavior requires reflection on and control over these basic instincts. They argued that, in many situations, prosocial behavior is itself an intuitive impulse rather than a rational choice made after controlling impulses. The findings of the present study provide some evidence for the SHH.

5.4 Limitations and Prospects

The present study shows that an opponent' s incidental facial expression influences an actor' s immediate cooperative behavior in short-term social interactions. But can this influence be extended to subsequent long-term behavior? Or, what is the relationship between an opponent' s incidental expressions in specific situations and the actor' s later long-term cooperative behavior? People' s understanding of an opponent' s incidental emotional signals may be more complex. As Knutson (1996) pointed out, facial expressions can be used not only to predict an opponent' s immediate behavior during an interaction, but may also be interpreted as related to the opponent' s stable traits and long-term behavioral tendencies. This view has been supported by relevant experimental evidence (Wang et al., 2018). Future research could incorporate people' s trait inferences based on an opponent's facial expressions into experimental designs as a potential mediating variable, so as to gain a deeper understanding of whether and how facial expressions affect individuals' long-term cooperative behavior.

The present study mainly focused on whether and how the social signal of an opponent' s facial expression influences the actor' s cooperative behavior. However, some incidental emotional responses generated during the cooperative decision-making process may also influence the actor' s cooperative behavior. Although researchers have shown that, in prisoner' s dilemma games, the reverse appraisal mechanism can fully explain the effect of incidental emotional signals on cooperative behavior, and that the role of incidental affective responses can therefore be ignored (de Melo et al., 2014), the results of the present study suggest that even in non-face-to-face communication contexts, the possibility that incidental emotional responses play a role still cannot be completely ruled out. As indicated by the emotions as social information theory (Van Kleef, 2016; Van Kleef et al., 2010), emotion-based inference processes cannot explain or replace incidental affective responses; in some cases, these mechanisms may occur simultaneously and may also interfere with one another. Research on cognitive neural mechanisms has shown that, in dictator-game contexts, compared with recipients who were happy or disappointed, participants interacting with angry recipients more often displayed anger themselves and made selfish offers; moreover, the expression of anger (vs. disappointment) increased activation in brain

regions related to self-referential thinking (Lelieveld et al., 2013). This provides a path for future work using neuroeconomic techniques to integratively examine the relative effects of inference processes and affective-response processes, in order to reveal the neural mechanisms by which facial expressions influence cooperative decision-making.

The present study used static pictures of emotional facial expressions, which differ markedly from emotional facial expressions in real situations. Studies have shown that when an interaction partner (the signal sender) smiles in a responsive and rapid manner, the individual (the signal receiver) is more likely to cooperate; conversely, when the signal sender smiles in an unresponsive and slow manner, the signal receiver' s likelihood of cooperating decreases (Danvers & Shiota, 2018). This indicates, to some extent, that in real life, the way emotional facial expressions are presented also affects individuals' level of cooperation. Future research could examine dynamic emotional

···facial expressions on individuals' cooperative behavior, thereby increasing the ecological validity of the research conclusions. In addition, human emotions are rich and varied, and the ways in which emotions are expressed are also diverse, such as through voice, posture, text, video, and so forth. Studies have shown that emotions conveyed by voice influence cooperative behavior: compared with voices expressing negative emotions, voices expressing positive emotions elicit higher levels of cooperation (Caballero et al., 2017). Future research may examine the effects of more types and more forms of emotional signals on individuals' cooperative behavior, with the aim of further enriching, improving, and constructing an overall theoretical framework for how emotional information influences individual cooperative behavior.

6 Conclusion

(1) Happy facial expressions elicited higher levels of cooperation than angry facial expressions.

(2) Expectations regarding the cooperative behavior of opponents with different facial expressions mediated the relationship between facial expressions and cooperative behavior.

(3) Individuals' decision-making mode both moderated the effect of facial expressions on cooperative behavior and indirectly influenced cooperative behavior by moderating cooperation expectations.

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The effect of opponent' s emotional facial expressions on individuals' cooperation and underlying mechanism in prisoner' s dilemma game

XIONG Chengqing1, 2, XU Jiaying1, MA Danyang1, LIU Yongfang1

(1 Shanghai Key Laboratory of Mental Health and Psychological Crisis Intervention, School of Psychology and Cognitive Science, East China Normal University, Shanghai 200062, China)

(2 School of Educational Science, Xinyang Normal University, Xinyang 464000, China)

Abstract

Previous research suggested that emotional facial expressions significantly influence perceivers' behaviors in interactive decision-making. Although emotional facial expressions of opponents could bias participants' behaviors, little was known about the reason for this effect. Based on the social functions of emotions and dual-process theories of decision-making, the present study aimed to explore the effect of three emotional facial expressions, i.e. happiness, neutral and anger, on individuals' cooperative behaviors in prisoner' s dilemma game

and the underlying mechanism, i.e. the mediating role of expectations of others' cooperation and the moderating role of individuals' decision modes.

Three experiments were designed to test the hypothesis. The emotional facial expressions were manipulated by grey-scale images of emotionally expressive faces (3 males and 3 females, 260 × 300 pixels) taken from a standard set of Chinese Affective Picture System (CAPS; Bai, Ma, Huang & Luo, 2005) in three experiments. Experiment 1 investigated the effects of emotional facial expressions (happiness/neutral/anger) on participants' cooperation, as well as the mediating role of expectations of partner' cooperation with a one-factor between-subjects design. A total of 180 adult participants were recruited for this experiment (109 females; mean age 22.36 ± 4.10 years) and were randomly assigned to happy, neutral or angry conditions. Experiment 2 adopted a 3(facial expressions: happiness/neutral/anger) × 2(decision modes: intuitive/deliberative) between-subjects design to examine moderating role of decision modes, as well as the mediating role of expectations of partner' cooperation. A total of 185 adult participants were recruited for this experiment (130 females; mean age 21.48 ± 2.71 years). And the decision modes were manipulated by instructions (Levine, Barasch, Rand, Berman & Small, 2018). Experiment 3

adopted a (3) (facial expressions: happiness/neutral/anger) (×2) (time pressure: time constraint/time delay) between-subjects design to examine the moderating role of time pressure, as well as the mediating role of expectations of partners' cooperation. A total of 218 adult participants were recruited for this experiment (148 females; mean age (23.74 ±3.11) years). Time pressure was manipulated by imposing a time constraint (Rand, Greene & Nowak, 2012).

The results of the three experiments showed: (1) participants were more cooperative toward happy partners than toward angry ones, and expectations of partners' cooperation mediated the relationship between emotional facial expressions and participants' cooperative behaviors (Experiment 1); (2) only under the condition of intuitive decision mode were participants more cooperative toward happy and neutral partners than toward angry ones, and expectations of partners' cooperation mediated the relationship between emotional facial expressions and participants' cooperative behaviors (Experiment 2); (3) only under the condition of time constraint were participants more cooperative toward happy partners than toward angry and neutral ones, and expectations of partners' cooperation mediated the relationship between emotional facial expressions and participants' cooperative behaviors (Experiment 3).

Our findings contribute to the literature in two ways. First, the study extends our understanding of the phenomenon that emotional facial expressions influence individuals' cooperative behaviors. Second, our findings further enrich and extend the evidence and field of the interpersonal effect of emotional facial expressions in interactive decision-making. These findings therefore have important implications for understanding the mechanism underlying the effect of different emotional facial expressions on individuals' cooperative decision-making.

Key words facial expressions, expectations of cooperation, cooperative behaviors, decision modes, social functions of emotions

Appendix 1: Facial-Expression Images

[Six grayscale facial-expression images are shown in a 2 × 3 arrangement: the top row shows a male face with happy, neutral, and angry expressions; the bottom row shows a female face with happy, neutral, and angry expressions.]

Note: Figure translations are in progress. See original paper for figures.