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Cooperators Pay More Attention to the Outcome of Mutual Cooperation in the One-Shot Prisoner's Dilemma Game: Empirical Evidence From an Eye-Tracking Study

Kaede Maeda[1], Hirofumi Hashimoto[2,*], Shigehito Tanida[3]

[1] Rikkyo University, 1-2-26 Kitano, Niiza, Saitama, 352-8558 Japan

[2] Osaka Metropolitan University, 3-3-138 Sugimoto, Sumiyoshi-ku, Osaka-shi, Osaka, 558-8585 Japan

[3] Taisho University, 3-20-1 Nishisugamo, Toshima-ku, Tokyo 170-0001 Japan

[*] Author for correspondence (hirofumihashimoto@outlook.com)

Based on the dual-process theory, we hypothesized that cooperators in the one-shot prisoner's dilemma game would exhibit intuitive decision-making. We also hypothesized that an experimental manipulation that may prevent intuitive cooperation (in this study, inverting the payoff matrix) would result in more protracted decision-making and thus lower cooperation rates. To examine these hypotheses, we designed an experiment using an eye-tracking device. In one condition, the outcome of mutual cooperation in the one-shot prisoner's dilemma game was presented in the upper left-hand corner explaining the result of mutual cooperation first, as in many previous studies (control condition). To suppress the function of intuitive cooperation, we also set the inverted payoff matrix condition in which the positions of the outcomes of mutual cooperation and mutual non-cooperation in the payoff matrix were inverted, explaining the result of mutual non-cooperation first. Although our results did not show the expected differences between the two conditions, it was suggested that cooperators' decision-making time was shorter in the control condition and that cooperators consistently paid more attention to the outcome of mutual cooperation regardless of the conditions. These results are discussed in relation to the intuitive cooperation model and the social exchange heuristic.

Keywords
cooperation, heuristic, prisoner's dilemma game, eye-tracking, intuitive cooperation, social exchange heuristic

Introduction

Recent empirical studies applying the dual-process theory (Evans, 2008; Evans & Stanovich, 2013; Kahneman, 2011; Petty & Cacioppo, 1986) have indicated that the decision-making of a person may differ based on intuition or deliberation (Capraro, 2019). For example, according to the intuitive cooperation model (hereafter, ICM; Rand et al., 2012), it is assumed that the more cooperative a person is, the shorter the time required for their decision-making in an economic game, such as the prisoner's dilemma game (hereafter, PDG). This model is consistent with the "social exchange heuristic hypothesis (hereafter, SEH)" proposed by Kiyonari et al. (2000), and it would be reasonable to assume that people intuitively process information in a way that aims for mutual cooperation in economic games (see also, Yamagishi et al., 1999). Given these studies, we speculate that the length of time allowed for participants to make decisions may influence cooperative behavior in the one-shot PDG. Therefore, the first aim of this study is to examine the primary hypothesis: The decision-making time among cooperators is shorter than that among defectors (*Hypothesis 1*). Theoretically, it is unclear whether cooperators and defectors have different decision-making times under time pressure. Nevertheless, the finding that fast decision-makers tend to cooperate more than slow decision-makers and that people cooperate more under time pressure, as shown by Rand and colleagues (Rand et al., 2012), are sufficient to derive Hypothesis 1. Although the theoretical foundation is not very strong, in the present study, we focus on the time pressure manipulation and test Hypothesis 1 in an exploratory manner.

The second aim of this study is to examine the decision-making process of intuitive cooperators more thoroughly based on the ICM and/or SEH. Kiyonari et al. (2000), who advocate, argued that people intuitively cooperate in one-shot PDG because they *subjectively transform* the PDG in a biased manner. Specifically, humans have a cognitive bias in the information processing of social exchange, according to which they perceive PDG-like situations as an Assurance game (hereafter, AG); in PDG, defection is the dominant choice. That is, defection produces a better outcome for the individual regardless of the choice of the partner. In contrast, there is no dominant choice in AG. Defection produces a better outcome for the individual when the partner is also a defector. However, cooperation produces a better outcome for the individual when the partner cooperates. With this subjective transformation, people intuitively perceive most mixed-motive incentive structures as ones in which mutual cooperation is personally more desirable—that is, produces personally better outcomes—than defection, as the partner also cooperates (Kiyonari et al., 2000). This tendency to consider mutual cooperation as desirable

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in PDG is indicated in the self-rating results among participants who have participated in a one-shot PDG experiment. Kiyonari et al. (2000) demonstrated that a robust pattern of results is shown with most participants rating the outcome of cooperating with each other as the most desirable, rather than the outcome with the highest gain only for themselves.

Based on the findings summarized above, we also speculate that intuitive cooperators will subjectively and intuitively understand the PDG as an AG and, as a result, will decide to cooperate quicker. The SEH theoretically promotes a subjective transformation toward the goal of achieving mutual cooperation and generates cooperative behavior by raising the expectation of cooperation from the partner. The operation of this heuristic corresponds to the essential elements for achieving mutual cooperation in social exchange discussed in the Goal Expectancy Theory (Pruitt & Kimmel, 1977). Hence, one potential key to this decision-making process is the expectation of cooperation from the partner. In our experimental manipulation of the one-shot PDG that may encourage intuitive cooperation (in this study, the outcome of mutual cooperation in the PDG was presented in the upper left-hand corner explaining the result of mutual cooperation first, as in many previous studies), participants would pay more attention to the outcome of mutual cooperation, increasing the expectation of cooperation from their partner, and therefore, responding quickly and with higher cooperation rates (*Hypothesis 2a*). Conversely, we hypothesized that an experimental manipulation that may prevent intuitive cooperation (in this study, we inverted the position of the outcome of mutual cooperation and of mutual non-cooperation in the payoff matrix, explaining the result of mutual non-cooperation first) would make participants less likely to expect their partner to cooperate and more likely to be concerned with maximizing their own gain, resulting in longer decision-making times and lower cooperation rates (*Hypothesis 2b*). To examine these hypothesized decision-making processes we use an eye tracker to follow the decision-making process of intuitive cooperators.

In summary, the present study hypothesized that intuitive cooperators would have shorter decision-making times, and even within that shorter decision-making process, they would pay more attention to the outcome of mutual cooperation. To test these hypotheses, we designed an experiment using an eye-tracking device and manipulated the decision time and payoff matrix in the PDG to compare the decision-making process of cooperators and defectors in a one-shot PDG.

Methods

Participants

Forty-eight undergraduate students (16 male and 32 female, mean age 19.96 years) voluntarily participated in this study; it was emphasized that the participants would be given the money determined based on their actual decisions in the study.

Experimental design

Two conditions (control condition and inverted payoff matrix condition) were set up to manipulate the payoff matrix and instructions in the PDG in a one-factor, two-level between-participants experimental design. Twenty-four participants were assigned to the control condition and inverted payoff matrix condition, respectively.

Experimental procedures

When the participants arrived at the laboratory, they were individually escorted to a sound-proof room. After being seated, participants first went through a calibration task in which their eye movements following a white point moving on the screen were tracked. Once this calibration task was completed and it was confirmed that the participants' eye movements could be accurately recorded, they were asked to follow the on-screen instructions to progress through the PDG at their own pace. All instructions presented on the computer screen are in the supplemental material (see, Supplemental Material 1).

The order of explanation for the PDG, or more specifically, how to see the payoff matrix was: 1) top left, 2) top right, 3) bottom left, and 4) bottom right. Thereby, in the control condition, the results of mutual cooperation were manipulated to be checked first. Conversely, in the inverted payoff matrix condition, the results of mutual non-cooperation were manipulated to be always checked first. In the explanations, the words "cooperation" and "defection" were never used, nor were specific amounts of money obtained (yen), only question marks were used.

After reading the entire explanation, participants were asked to make their decision (more specifically, to click either the L or S button) within 15 seconds. The decision was made only once, after completion of which a brief post-questionnaire was given to the participants at the end. The monetary rewards were paid as per their actual decision, as previously emphasized.

Apparatus

The instructions for the PDG and the payoff matrix were displayed on a 23.0" monitor (ThinkVision T23i-20). A screen-based eye-tracking device, Tobii pro fusion (Tobii Technology, Inc), with a sampling rate of 250 Hz, was used to record participants' eye movement. The video data of eye movement was continuously recorded from the calibration period to the end of the experiment.

Area of interest (AOI) settings

We focused on and analyzed the decision time that the participants' eyes were fixated on each of the four or eight divisions of the payoff matrix (see, Supplemental Material 2). Regarding the four outcomes in the payoff matrix, we first set the four divisions as CC, CD, DC, and DD for each. These were a combination of acronyms, with CC as the result of mutual cooperation. DD, on the contrary, was the result of mutual non-cooperation. The AOI made was the combined rate of gazing at each payoff matrix (e.g., CC area) and the rate of gazing at the corresponding option (e.g., L and K buttons). For example, the gazing rate of AOI for CC was calculated by dividing the gazing time for CC and the corresponding option by the total gazing time (the gazing time to the corresponding option was doubled for convenience). The eight divisions, rather than four, were based on making a distinction between gazing time to one's own gain and that of the partner's for each area, and the AOI and the gazing rate were calculated in the same way.

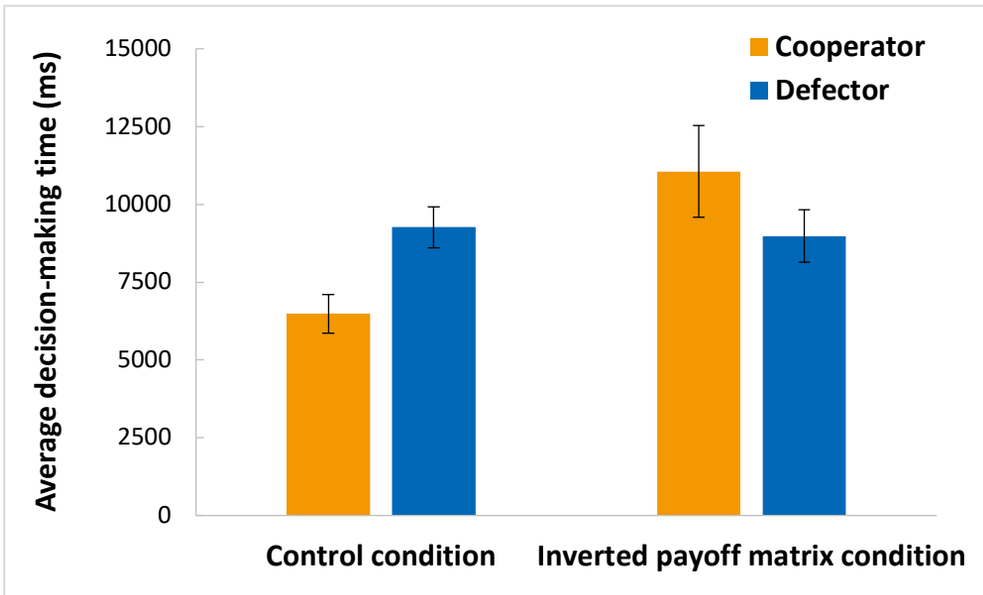

Figure 1. Average decision-making time per condition and participants' decisions (cooperators vs. defectors)

Note. Error bars represent standard errors.

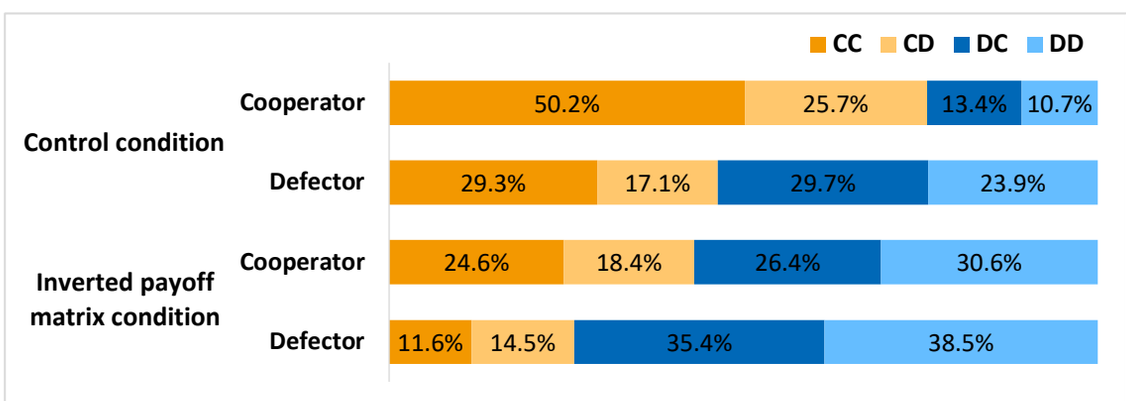

Figure 2. Percentage of eye gaze directed toward the four payoff matrices per condition and participants' decisions

Note. The four outcomes of the payoff matrix are represented by the combinations of two characters, C and D, the first character indicating the choice of the participant and the second, the choice of the partner. (CC: mutual cooperation; CD: participant's choice is C and partner's choice is D; DC: participant's choice is D and partner's choice is C; DD: mutual non-cooperation)

Results

We first compared the rates of cooperation in the PDG between conditions. The cooperation rate in the control condition was 37.5% (9/24), while that in the inverted payoff matrix condition was 33.3% (8/24), $\chi^2(1) = 0.09$, $p = .76$; hence Hypothesis 2a and 2b, stating that there would be a difference in cooperation rates with the inverted payoff matrix, were not supported.

Figure 1 shows the decision-making time of the cooperators and defectors in each condition. We log-transformed the decision-making time and performed an analysis of variance for the log-transformed decision-making time, with conditions (control/inverted payoff matrix) and participants' decisions (cooperator/defector) as independent variables. The results showed a main effect of the conditions, $F(1, 44) = 5.38$, $p = .03$, partial $\eta^2 = .11$, and an interaction effect, $F(1, 44) = 6.91$, $p = .01$, partial $\eta^2 = .14$. To clarify the interaction effect, we performed an additional multiple comparison analysis and found significant differences in the decision-making time between cooperators and defectors in control condition [$t(44) = 2.16$, $p = .04$]. However, no significant differences were observed in the inverted payoff matrix condition [$t(44) = 1.57$, *ns*]. These results partially supported Hypothesis 1.

Figure 2 demonstrates how the gazing rates for the four outcomes differed in each condition and between cooperators and defectors. An analysis of variance was conducted on the gazing rates, with conditions and participants' decisions as independent variables. The results showed that for the area of mutual cooperation (CC), the main effects of condition, $F(1, 44) = 74.72$, $p < .001$, partial $\eta^2 = .63$ and participants' decision, $F(1, 44) = 45.80$, $p < .001$, partial $\eta^2 = .51$ were significant, suggesting that cooperators paid more attention to CC than defectors did in both conditions. In the area of mutual non-cooperation (DD), the main effects of condition, $F(1, 44) = 52.04$, $p < .001$, partial $\eta^2 = .54$ and participants' decision, $F(1, 44) = 19.68$, $p < .001$, partial $\eta^2 = .31$ were significant, suggesting

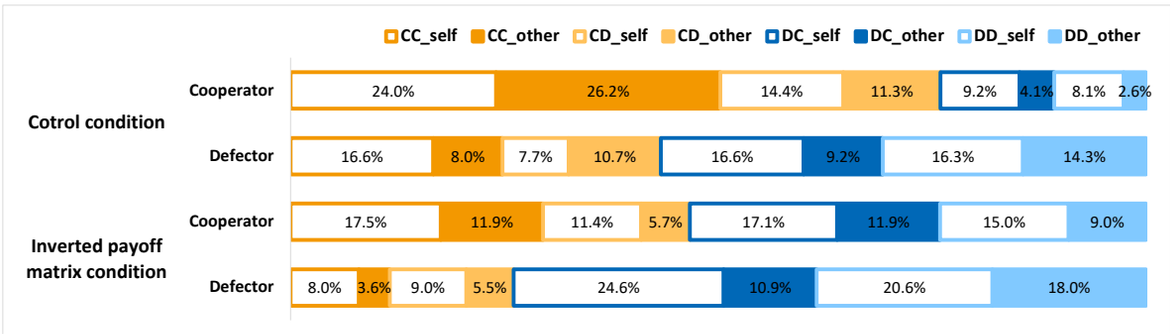

Figure 3. Eye gaze percentage directed toward the eight areas (with distinction between the participants' own gains and those of their partners) per condition and participants' decisions

Note. The participant's gains in each of the four outcomes are represented by filled bars and their partner's gains by the bars outlined in color and white inside.

that defectors paid more attention to DD than cooperators did in both conditions.

Figure 3 illustrates the case of eight divisions. One additional interpretation is that, although the cooperators in the control condition had a shorter gazing time, they still gazed closely not only at their own gains in the CC area, but also at their partner's gains.

Discussion

Although we hypothesized that the cooperation rate would decrease when the payoff matrix was inverted and the explanation of the outcome of DD (mutual non-cooperation), rather than CC (mutual cooperation), was started by first explaining and attempting to guide the participants' gaze, there was no difference in the cooperation rate between the two conditions and the cooperation rates were below 40% for both conditions. Table S1 in the Supplemental Material presents the results of the post hoc analysis of the self-reported desirability ratings from the questionnaire. The results suggest that, overall, the participants strongly preferred the desirability of CC (mutual cooperation), and that although inverting the payoff matrix seemed to make participants more likely to perceive DD (mutual non-cooperation) as desirable over CC (mutual cooperation), the conditional difference was not as significant as we had assumed. Thus, it must be said that the hypothesized decision-making process was not confirmed in this study. The study concludes that our experimental manipulation was also a failure in terms of the manipulation of participants' goals and expectations regarding mutual (non-)cooperation. However, our results regarding the participants' decision-making time and gazing rates are worth discussing in relation to the ICM and/or SEH. Our results suggest that under the 15-second constraint, cooperators are more likely to gaze at the outcome of mutual cooperation (i.e., CC), and exhibit faster decision-making. We also found that cooperators in the inverted payoff matrix condition had a longer decision-making time, but simultaneously, they gazed longer at the outcome (CC, CD) obtained by their own cooperation than the defectors did. These results suggest that even if presented with a mutual non-cooperation outcome first, cooperators subjectively transformed the PDG into an AG and then showed cooperative decision-making. Although the details of the decision-making process require thorough exploration in future studies, our findings have certainly indicated that cooperators pay more attention to the outcome of mutual cooperation in the one-shot PDG.

Our findings need to be extended in future research. First, this study was conducted under a 15-second time constraint; from the perspective of dual process theory, useful findings could be obtained by comparing conditions with and without a time constraint. In particular, as shown in this study, it is difficult to determine whether the decision-making process of the cooperators in the inverted payoff matrix condition was based on intuition or deliberation. Although utilizing self-paced decision-making time could be related to decision conflict (Evans & Rand, 2019), it is necessary to investigate how robust the results of the present study are without time constraints in the form of a comparison between the time pressure and time delay conditions. Second, future research should focus on the people they cooperate with, or what kind of social exchange is assumed by the decision-makers. The possibility that people intuitively process information in a way that aims for mutual cooperation has been pointed out before: the possibility that intuitive mutual cooperation may work as an adaptive strategy to the general exchange system within a group (e.g., Yamagishi et al., 2007) or that intuitive cooperation may work only for members of an in-group (Maeda & Hashimoto, 2020). Finally, the present study examined the difference in cooperation rates through experimental manipulations with a transformed matrix, and although the results did not support our hypothesis, the robustness of our results needs to be confirmed by simultaneous manipulation of decision time and interaction partners.

Despite these limitations, the present study potentially points a way forward in studying the decision-making process of intuitive cooperation. Future research should carefully examine the cooperators' tendency to pay attention to the outcome of mutual cooperation, such as those found in this study, by manipulating the salience of social exchange situations. We believe that the accumulation of such findings can provide theoretical implications not only for social psychologists, but also for evolutionary game-theory oriented social scientists.

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Author contribution

All authors contributed to the study design and the writing of the manuscript. KM and HH conducted data collection and data analysis. All authors approved the final version of the manuscript for submission.

Ethical statement

This study was reviewed and approved by the Ethical Review Committee of the Graduate School of Literature and Human Sciences at Osaka Metropolitan University (No. 3–6).

Supplementary material

Electronic supplementary materials are available online.

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