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Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 42(0)

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Publication Date

2020

Peer reviewed

Cooperation, Response Time, and Social Value Orientation: A Meta-Analysis

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Abstract

Recent research at the cross between cognitive and social sciences is investigating the cognitive mechanisms behind cooperative decisions. One debated question is whether cooperative decisions are made faster than non-cooperative ones. Yet empirical evidence is still mixed. In this paper we explore the implications of individual heterogeneity in social value orientation for the effect of response time on cooperation. We conduct a meta-analysis of available experimental studies (n=8; treatments=16; 5,232 subjects). We report two main results: (i) the relation between response time and cooperation is moderated by social value orientation, such that it is positive for individualist subjects and negative for prosocial subjects; (ii) the relation between response time and cooperation is partly mediated by extremity of choice. These results suggest that highly prosocial subjects are fast to cooperate, highly individualist subjects are fast to defect, and subjects with weaker preferences make slower and less extreme decisions. We explain these results in terms of decision-conflict theory.

Keywords: Cooperation; Response Time; Social Value Orientation; Decision Conflict.

Introduction

Cooperation among genetically unrelated individuals is fundamental to large-scale human social life. Yet, there is significant variance in individual behavior. Some people are willing to cooperate, while others try to take advantage of cooperators. Shedding light on the reasons underlying this heterogeneity is important to understand our social behavior (Milinski, Semmann, & Krambeck, 2002; Nowak, 2006; Perc et al., 2017).

Recent research has furthered our understanding of the processes behind cooperative decision-making often relying on response time data. Understanding whether response time is related to cooperative behavior has theoretical and practical implications. Theoretically, it can help us understand the cognitive processes underlying cooperative behavior. Practically, it might help us to better understand the signals sent by people making fast vs slow decisions. Clearly, responding slowly when a drowning swimmer cries for help sends a very different kind of message to onlookers than an instantaneous response does. Such signals may be important in political contexts when electing leaders and in social settings where partner choice is a crucial element of solving cooperation problems. Accordingly, several works have investigated how observers interpret fast vs slow decisions in social contexts (Gambetta, 2009; Jordan, Hoffman, Nowak, & Rand, 2016; Gambetta & Przepiorka, 2014; Evans & Van De Calseyde, 2017). In this paper, we will be concerned with the direct question: Is response time related to cooperative behavior?

The earlier work by Rand, Greene, and Nowak (2012) found that cooperative choices in a one-shot public goods game are made faster than non-cooperative ones. Subsequent work by Krajbich, Bartling, Hare, and Fehr (2015) found that which decision is faster (in a one-shot prisoner's dilemma) depends on the relative attractiveness of the available options: if cooperation is very attractive, such that most people cooperate, then cooperative decisions are made faster than defective decisions; conversely, if defection is very attractive, such that most people defect, then cooperative decisions are made slower than defective ones; in the middle, if cooperation and defection are equally attractive, then neither choice is faster than the other one. The authors explain this finding in terms of strength of preferences: when choices are easy to discriminate, people are fast to make whichever choice is more attractive (Dashiell, 1937). A conceptually similar result was obtained by Evans, Dillon, and Rand (2015), who found that response time (in one-shot public goods games) does not really affect cooperative behavior, but it rather affects decision extremity, such that fast decisions tend to be extreme (towards either full cooperation or full defection), while slow decisions tend to be less extreme. The authors interpret their result also in terms of strength of preferences and decision conflict. According to this explanation, fast decisions are made by people with a strong preference (either for cooperation or for defection); these decisions tend to be extreme (towards full cooperation or full defection). Whereas, slow decisions are made by people whose preference for cooperation conflicts with their preference for defection; these decisions tend to be less extreme. See Evans and Rand (2019) for a review.

These findings suggest that the effect of response time on cooperation may be: (i) moderated by people' Social Value Orientation (SVO), that is the concern people have for others (Liebrand, 1984; Murphy, Ackermann, & Handgraaf, 2011), and (ii) mediated by extremity of choice. Specifically, on the

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one hand, highly prosocial subjects should be fast to fully cooperate, whereas highly individualist subjects should be fast to fully defect, because they have strong preferences for cooperation and defection, respectively. On the other hand, subjects closer to the SVO's threshold between individualism and prosociality should be more conflicted between cooperation and defection, therefore they should take more time to make a decision, and their decision should be less extreme; not full cooperation, nor full defection, but something in between.

To the best of our knowledge, only two papers explored whether the effect of response time on cooperation is moderated by the social value orientation. Mischkowski and Glöckner (2016) found, in a one-shot public goods game, a significantly negative interaction between response time and social value orientation. Splitting the sample in individualist and prosocial subjects (using the standard threshold value of SVO = 22.50), they found that response time correlates negatively with cooperation among prosocial subjects; however, they found no effect among individualist subjects. Yamagishi et al. (2017) used a public goods game and a prisoner's dilemma and replicated the finding that response time decreases cooperation among prosocial subjects; but they also found that response time increases cooperation among individualist subjects. They do not report the interaction analysis with the continuous SVO. So, these works agree that response time has a negative effect on cooperation among prosocial subjects (SVO > 22.50), but they disagree on the effect among individualist subjects (SVO < 22.50). Moreover, none of these two studies tested whether their effects were mediated by choice extremity. Thus, the following two questions remain unanswered:

Research Question 1 (RQ1). Is the relation between response time and cooperation moderated by social value orientation?

Research Question 2 (RQ2). Is the relation between response time and cooperation mediated by choice extremity?

To address RQ1, we conduct a meta-analysis of available studies that measured one-shot cooperation, response time, and SVO. To measure cooperation, we consider one-shot, simultaneous-move, economic games in which each subject can pay a monetary cost to increase the payoff of the other subject(s). The selected games are the Prisoner's Dilemma (PD) and the Public Goods Game (PGG). The SVO (Liebrand, 1984; Murphy et al., 2011) consists of a series of resource allocation tasks where subjects choose between options that offer points to the self and another person. This measure takes the form of an angle that ranges from -16.25 to 61.39. In general, higher values denote greater prosociality, and lower values denote greater individualism. Decision time was measured via the programs used for data collection (e.g., z-tree for the laboratory studies and Qualtrics for the on-line studies), and it was log transformed to account for a highly skewed distribution (Rand et al., 2012; Evans et al., 2015). In doing so, we collected a total of $N = 5,232$ independent observations, from 16 experimental studies. By employing a meta-regression using the data available, we show that subjects' SVO moderates the relation between response time and cooperation in the hypothesized direction. Following previous work, we will also discretize the SVO, by definining two classes of subjects: prosocial subjects, corresponding to SVO > 22.50, and individualist subjects, corresponding to SVO < 22.50. In doing so, we will show that response time is negatively (positively) correlated to cooperation among prosocial (individualist) subjects. Note that this result should not be interpreted as a within-subject result: it is not the same prosocial (individualist) subject who, when time passes, becomes less (more) cooperative. Rather, when time passes, different types of subjects make a decision: those prosocial (individualist) subjects who make a decision are less (more) prosocial, than the subjects who make faster decisions, that is, they are more conflicted.

To shed light on RQ2, we conduct a mediation analysis, as follows. We explore whether extremity of choice, defined as the distance between participant's choice in the cooperation game and the midpoint between full cooperation and full defection, mediates the effect of response time on cooperation. In doing so, we find some evidence that extremity of choice mediates the effect of response time on cooperation. We elaborate on the interpretation of these results in the Discussion section.

Methods

Meta-analysis: inclusion criteria and data collection

To make studies comparable in our analyses, we define a set of inclusion criteria:

- Incentivized experiments in a controlled environment using experimental subjects – as opposed to experiments in which counterparts are hypothetical or computers;
- Social dilemmas measuring cooperation (namely, Public Goods Games and Prisoner's Dilemma);
- One-shot or repeated games with random re-matching after every interaction
- Studies administering the SVO;
- Studies measuring subjects' decision time in the social dilemma choice;
- Studies with treatments that do not manipulate response time using time constraints - as we want to keep reaction times endogenous in order to study decision conflict.

To find qualifying studies, we conducted an online search using relevant keywords (e.g. Public Goods, Prisoner's Dilemma, SVO, Cooperation, Social Dilemmas, Reaction Time), and contacted authors of the papers to ask the raw data. Additionally, we posted a message on the ESA Google group asking scholars to contact us in case they had conducted studies that fit the inclusion criteria.

We collected 8 studies, for a total of 16 experimental treatments and 5,232 independent observations at the individual level (table 1).

	Papers	N. of Treatments	Individuals	Game
1	Andrighetto, Szekeley, Zhang, et al. (2020)	2	725	PGG
2	Andrighetto, Szekeley, Bruner, and Steinmo (2020)	2	331	PGG
3	Andrighetto, Szekeley, Bruner, Steinmo, Todor, and Volintiru (2020)	2	319	PGG
4	Mischkowski and Glöckner (2016)	3	743	PGG
5	Andrighetto, Szekeley, Zhang, et al. (2020)	3	378	PGG
6	Yamagishi et al. (2017)	1	443	PGG, PD
7	Zhang, Andrighetto, Ottone, Ponzano, and Steinmo (2016)	2	1948	PGG
8	Andrighetto et al. (2016)	1	345	PGG
	Tot.	16	5232	

Table 1: Studies included in the analysis

Models	***Parameters***					
	β_k	β_1	β_2	β_3	μ_k	σ_k
Model 1	$N(\mu_k, \sigma_k)$	$N(0,10)$	$N(0,10)$	$N(0,10)$	$N(50,10)$	$Exp(1)$
Model 2	$N(\mu_k, \sigma_k)$	$N(0,10)$	—	—	$N(50,10)$	$Exp(1)$
Model 3	$N(\mu_k, \sigma_k)$	$N(0,10)$	—	—	$N(0,10)$	$Exp(1)$
Model 4a-b	$N(\mu_k, \sigma_k)$	$N(0,10)$	$N(0,10)$	—	$N(50,10)$	$Exp(1)$
Model 5	$N(\mu_k, \sigma_k)$	$N(0,10)$	—	—	$N(0,10)$	$Exp(1)$
Model 6a-b	$N(\mu_k, \sigma_k)$	$N(0,10)$	$N(0,10)$	—	$N(50,10)$	$Exp(1)$

Table 2: Priors of the models implemented.

Analyses and hypotheses

In this section, we formalize the research questions above and we derive the methods and the analyses to address them.

Regarding RQ1 (whether the relation between response time and cooperation is moderated by subjects' SVO), we use a multi-level model (Model 1 below) with varying intercept at the study level, where Cooperation levels (C) are predicted by SVO, the logarithm of response time centered to the mean (RT), and their interaction.

Model 1

$$C_{ik} = \beta_k^{(1)} + \beta_1^{(1)} * RT_{ik} + \beta_2^{(1)} * SVO_{ik} + \beta_3^{(1)} * SVO_{ik} * RT_{ik}.$$

Here, and in all the subsequent models, $i \in \{1, \ldots, 4789\}$ denotes the subject and $k \in \{1, \ldots, 15\}$ the study.[5]

With this model, the hypothesis that SVO moderates the relation between response time and cooperation, such that more prosocial (individualist) subjects take less time to make cooperative (defective) choices, corresponds to:

H1: $\beta_3^{(1)} < 0$.

To test the robustness of the results, we also estimate a simpler model:

Model 2

$$C_{ik} = \beta_k^{(2)} + \beta_1^{(2)} * RT_{ik}.$$

We then compute model fit measures (Weighted Aikake Information Criteria and AIC weight) for each model specification and compare such measures to understand whether the inclusion of our variables of interest (SVO and $SVO * RT$) brings about a significant improvement in the overall model fit.

Regarding RQ2 (whether the effect of response time is mediated by choice extremity), we proceed as follows. First of all, following Evans et al. (2015), we define the extremity of a decision to be $E = |C - 0.5|$. This value is maximum when the decision is maximally extreme (i.e., full cooperation or full defection). Having defined this variable, we test whether response time is positively correlated with extremity of choice.

Model 3

$$E_{ik} = \beta_k^{(3)} + \beta_1^{(3)} * RT_{ik}.$$

Then, we test whether extremity of choice mediates the positive effect of response time on cooperation.

Model 4

$$C_{ik} = \beta_k^{(4)} + \beta_1^{(4)} * RT_{ik} + \beta_2^{(4)} * SVO_{ik} + \beta_3^{(4)} * SVO_{ik} * RT_{ik} + \beta_4^{(4)} * E_{ik} + \beta_5^{(4)} * SVO_{ik} * E_{ik}$$

With this model, the hypothesis that extremity of decision is negatively correlated with response time and mediates the relation between response time and cooperation corresponds formally to:

H2: $\beta_1^{(3)} < 0, \beta_4^{(4)} \neq 0, \beta_5^{(4)} \neq 0, |\beta_1^{(4)}| < |\beta_1^{(1)}|, |\beta_3^{(4)}| < |\beta_3^{(1)}|$.

Finally, we repeat the mediation analysis for individualist subjects (Model 5a) and prosocial subjects (Model 5b). In these models prosocials and individualist types are defined using SVO values and a threshold of 22.50. We indicate prosocial subjects with $P = 1$, and individualist with $P = 0$.

Model 5a

$$C_{ik} = \beta_k^{(5a)} + \beta_1^{(5a)} * RT_{ik} + \beta_2^{(5a)} * E_{ik}, \qquad \text{if } P = 0$$

Model 5b

$$C_{ik} = \beta_k^{(5b)} + \beta_1^{(5b)} * RT_{ik} + \beta_2^{(5b)} * E_{ik}, \qquad \text{if } P = 1$$

In doing so, the hypothesis that extremity of choice mediates the negative effect of response time on cooperation among individualist subjects corresponds formally to:

H3a: $\beta_1^{(3)} < 0, \beta_2^{(5a)} \neq 0$, and $|\beta_1^{(5a)}| - |\beta_1^{(1)}| < 0$.

Similarly, the hypothesis that extremity of choice mediates the positive effect of response time on cooperation among prosocial subjects correspond to:

H3b: $\beta_1^{(3)} < 0, \beta_2^{(5b)} \neq 0$, and $|\beta_1^{(5b)}| - |\beta_1^{(1)} + \beta_3^{(1)}| < 0$.

Results

We estimate all our regression models under the Bayesian framework using the R package Rethinking (McElreath, 2016). Priors for each model specification are reported in table 2.

For each model, we report the 95% Highest Probability Density Interval (HPDI, henceforth) of estimated parameters.

[5] Yamagishi et al.'s (2017) dataset reports only discretized values for SVO to indicate prosocial and selfish subjects. Hence, this study cannot be included in the analysis with continuous SVO. Yet, we include it in the analyses using discretized SVO that follow in this section.

We assess null values using a cut-off value of 0. If the 95% HPDI does not include the cut-off, we will consider this an evidence against the null hypothesis of no effect (Kruschke & Liddell, 2016).

Results from our estimates of Model 1 are reported in table 3. The first column reports the mean posterior estimates, the second column reports the standard deviations of the estimates, while the third column the 95% HPDI.

	Mean	SD	95% HPDI
β_1	14.95	2.51	[10.10; 19.90]
β_2	0.92	0.04	[0.85 ; 0.99]
β_3	-0.83	0.10	[-1.02 ; -0.63]

Table 3: Posteriors estimates of Model 1.

Posterior estimates from Model 1 provide evidence in support of H1. The average posterior of $\beta_3^{(1)}$ is negative (average posterior $\beta_3 = -0.83$) and its 95% HPDI does not overlap with zero (95% HPDI [-1.02, -0.63]). From model estimates, we can notice that to an increase of 1 point of RT with respect to its mean, it is associated an increase in cooperation of about 15%. This relation is however modulated by SVO scores. The net marginal effect of RT on cooperation is $\beta_1 + \beta_3 * SVO$ which equals zero in correspondence of a SVO = 18.01 using our model estimates. This implies that the net marginal effect of RT on cooperation is positive when considering subjects with an SVO score higher than that threshold level, and negative for those below that threshold. Figure 1 depicts the average marginal effect of RT, by splitting subjects into prosocial and individualist using a threshold value of 22.5, which is mostly used in the extant literature ((Mischkowski & Glöckner, 2016; Yamagishi et al., 2017)) and very close to our estimated threshold. It seems clear that opposite patterns are drawn whether one consider prosocial or individualist types.

To test the robustness of the model, we estimate Model 2 and compare it to Model 1 in their predictive accuracy measures. Table 4 reports the WAIC and AIC Weights for each model specification.

	WAIC	SE	dWAIC	dSE	weight
MODEL 1	48611.4	68.07	0.00		1.00
MODEL 2	49224.9	49.32	613.5	51.45	0.00

Table 4: WAIC and Akaike weights for MODEL 1 and MODEL 2

A lower WAIC value is indication of a better predictive accuracy of the model. Accordingly, Aikake weights are estimates of the probability that a model will make the best predictions on hypothetical new data, conditional on the set of models considered (McElreath, 2016). Results from our analyses reports a higher predictive accuracy for MODEL 1 than that of MODEL 2. Therefore, the inclusion of *SVO* and its interaction with *RT* improves predictive accuracy. The difference between models in terms of WAIC is substantial and the related standard error is smaller than the difference itself (dWAIC=613.5, dSE=51.45). Further, MODEL 1 gets all the Aikake weight, providing additional evidence in support to our results robustness.

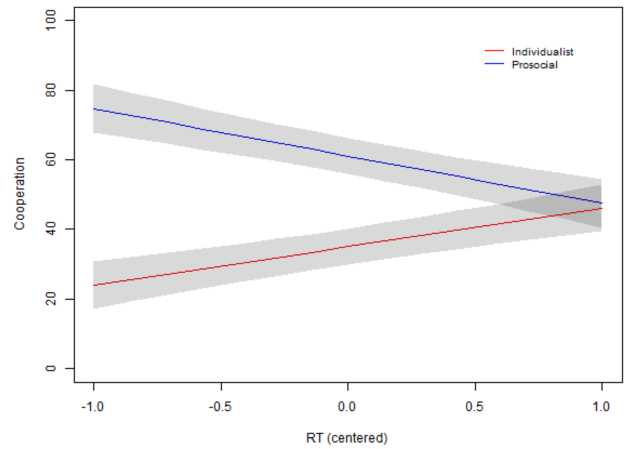

Figure 1: Relation between RT and cooperation levels broken down by type. Shaded area depicts the 95% confidence interval.

Next, we test H2. Consistently to H2, estimates from Model 3 show a negative relation between RT and E ($\beta_1^{(3)} = .10, 95\%$ HPDI $= [-0.11; -0.08]$). Results are depicted in Figure 2. Moreover, we find strong support for $\beta_4^{(4)} \neq 0$ ($\beta_4^{(4)} = -29.79, 95\%$ HPDI $= [-37.77; -21.26]$) and for $\beta_5^{(4)} \neq 0$ ($\beta_5^{(4)} = 2.12, 95\%$ HPDI $= [1.79; 2.44]$). However, we only find mild support for the remaining two hypotheses: $|\beta_1^{(4)}| - |\beta_1^{(1)}| = -2.68, 95\%$ HPDI $= [-9.56; 4.41]$, Prob$(|\beta_1^{(4)}| - |\beta_1^{(1)}| < 0) = 0.52$; $|\beta_3^{(4)}| - |\beta_3^{(1)}| = -0.2, 95\%$ HPDI $= [-0.40; 0.08]$, Prob$(|\beta_3^{(4)}| - |\beta_3^{(1)}| < 0) = 0.85$

Finally, we test H3a and H3b. Results from model 5a estimates show a significant positive association between RT and C for individualist subjects ($\beta_1^{(5a)} = 8.17$, 95% HPDI = [4.56 ; 11.85]). However, we find only mild evidence for $|\beta_1^{(5a)}| - |\beta_1^{(1)}| < 0$ (mean of the difference = -2.97, 95% HPDI = [-9.00 ; 2.91], Prob($|\beta_1^{(5a)}| - |\beta_1^{(1)}| < 0$) = .66) In a similar vein, estimates from model 5b support our hypothesis ($\beta_2^{(5b)} = -8.15$, 95% HPDI = [-11.93 ; -4.50]), but we can only provide mild evidence that $|\beta_1^{(5b)}| - |\beta_1^{(1)} + \beta_1^{(3)}| < 0$ (mean of the difference = -5.47, 95% HPDI = [-11.95 ; 0.87], Prob($|\beta_1^{(5b)}| - |\beta_1^{(1)} + \beta_3^{1}| < 0$) = .88)

Discussion

In the past decade, there has been increasing interest in understanding the relationship between response time and cooperation in one-shot social dilemmas. Previous research suggests that this relationship might be moderated by sub-

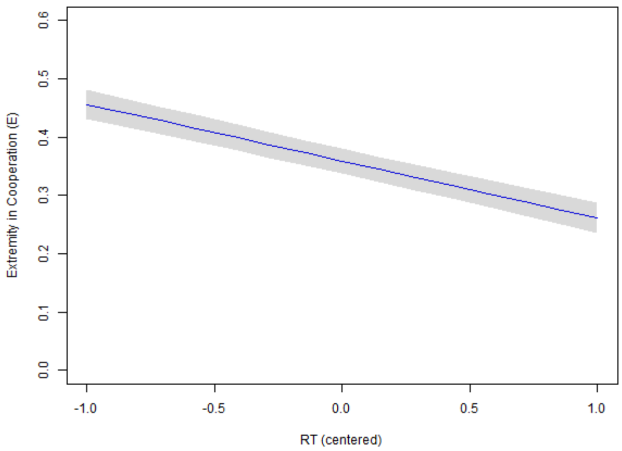

Figure 2: Estimated relation between extremity of choice and reaction time.

jects' social value orientation. However, the evidence is mixed. Mischkowski and Glöckner (2016) found a negative interaction between SVO and response time; moreover, splitting the sample by individualist and prosocial subjects, they found that response time is negatively correlated with cooperation among prosocial subjects, but they found no effect among individualist subjects. Yamagishi et al. (2017) replicated the finding that response time is negatively correlated with cooperation among prosocial subjects, but, in contrast to Mischkowski and Glöckner (2016), they found a significantly positive correlation between response time and cooperation among individualist subjects. The first goal of our paper was to shed light on these relationships. We do so by conducting a meta-analysis of the available studies that have collected individual measures of cooperative behavior, response time, and SVO. This consists of a large dataset of over 5,200 independent observations, divided into sixteen treatments. The analysis of this dataset clearly shows that: (i) the relation between response time and cooperation is moderated by SVO, and (ii) splitting the sample by individualist and prosocial subjects, response time is positively correlated with cooperation among individualist subjects and negatively correlated with cooperation among prosocial subjects. Next, we explored the mechanisms driving these relationships. We did so by building on previous work on the relationship between response time and decision conflict (Evans et al., 2015; Krajbich et al., 2015). We operationalized decision conflict using extremity of decision. We showed that response times is positively correlated with extremity of decision. This suggests that the effects of response times on cooperation might be mediated by extremity of decision. We tested this hypothesis through a standard mediation analysis. We found mild evidence that extremity of decision partially mediates the effect of response time on cooperation, especially among pro-self subjects.

This suggests that our results are *partly* driven by the following mechanism. Fast responders tend to have non-conflicting preferences, either for full cooperation or for full defection, and thus they quickly choose either full cooperation or full defection, depending on their dominant preference; slow responders have more conflicting preferences and therefore they move away from the extreme choices: prosocial subjects become less prosocial, and individualist subjects become less individualist. However, at the same time, the mediation analysis shows that extremity of decision (and extremity of SVO) does not fully mediate the effect of response time on cooperation. This suggests that the positive (negative) effect of response time on cooperation among individualist (prosocial) subjects is not entirely driven by decision conflict, but it is partly driven by some other factor. What could this factor be?

At this stage of the research, we can only speculate. Previous work has explored whether cooperative choices in one-shot social dilemmas tend to be more intuitive or deliberative. This research builds on the dual-process framework, according to which people's decisions result from the interplay between two cognitive processes, System 1, that is fast, automatic, and intuitive, and System 2, that is slow, controlled, and deliberative (Shiffrin & Schneider, 1977; Fodor, 1983; Sloman, 1996; Kahneman, 2011). Several works have explored the cognitive basis of cooperation using cognitive manipulations such as time constraints (Rand et al., 2012; Tinghög et al., 2013; Verkoeijen & Bouwmeester, 2014; Capraro & Cococcioni, 2015, 2016; Bouwmeester et al., 2017). See Capraro (2019) for a review. This research suggests that intuition favors cooperation (Rand, 2016), especially among subjects who trust the society in which they live (Rand, 2016; Capraro & Cococcioni, 2015). A potential explanation for these findings is the Social Heuristics Hypothesis (SHH), proposed by Rand and colleagues (Rand et al., 2014; Rand, Brescoll, Everett, Capraro, & Barcelo, 2016; Bear & Rand, 2016). The SHH posits that people's intuitive responses are shaped primarily by prior experience, so that people from cooperation-supporting milieux develop heuristics for cooperative behavior and therefore cooperate fast and intuitively, and people from non-cooperation-supporting settings have non-cooperation as action sustained by intuition. Deliberation, in contrast, involves the consideration of payoff-maximizing actions, which, in one-shot, anonymous, cooperation dilemmas, leads to self-interested behavior. Therefore, to the extent to which people with prosocial orientations correspond to subjects that live in cooperative societies, the SHH predicts that deliberation should decrease cooperation among these subjects. Similarly, to the extent to which people with individualist orientation correspond to subjects that live in non-cooperative societies, the SHH predicts that deliberation should have no effect among individualist subjects.

Earlier work considered response time as a proxy for whether the decision maker acts intuitively or deliberatively (Rubinstein, 2007; Piovesan & Wengström, 2009; Rand et al., 2012). Although more recent research showed that response time primarily measures decision conflict, rather than deliberation (Evans et al., 2015; Krajbich et al., 2015), it is still possible that response time is *also* a measure of deliberation. In this light, our first result corresponds to a negative effect of deliberation on cooperation among prosocial subjects. Therefore, assuming that response time is also a measure of deliberation, our first result is in line with the predictions of the SHH. However, our second result would correspond to a positive effect of deliberation on cooperation among individualist subjects. While this interpretation pairs well with a recent working paper finding that time delay has a positive effect on cooperation among individualist subjects (Alós-Ferrer & Garagnani, 2020), it goes against the prediction of the SHH that deliberation should have no effect on cooperation among individualist. This observation suggests that future work is needed, on both the empirical and the theoretical grounds, shedding light on what other factors - in addition to decision conflict - may explain the relationship between response time and cooperation.

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