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Giving is a question of time: Response times and contributions to a real world public good

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Giving is a question of time: Response times and contributions to a real world public good [a]

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Abstract

Recent experimental research has examined whether contributions to public goods can be traced back to intuitive or deliberative decision-making, using response times in public good games in order to identify the specific decision process at work. In light of conflicting results, this paper reports on an analysis of response time data from an online experiment in which over 3400 subjects from the general population decided whether to contribute to a real world public good. The between-subjects evidence confirms a strong positive link between contributing and deliberation and between free-riding and intuition. The average response time of contributors is 40 percent higher than that of free-riders. A within-subject analysis reveals that for a given individual, contributing significantly increases and free-riding significantly decreases the amount of deliberation required.

Keywords: Public Goods; Cooperation; Dual Process Theories; Response Times; Climate Change; Online Experiment

JEL-Codes: C93; H41; D03;

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1 Introduction

Despite the opportunity to freeride, some individuals are willing to cooperate in the private provision of public goods both in economic experiments (Ledyard, 1994; Zelmer, 2003; Chaudhuri, 2011) and in a significant number of real world situations. This empirical regularity has been ascribed to contributors acting out of motives such as altruism (Andreoni, 1995), warm glow (Andreoni, 1990) or reciprocity (Fischbacher et al., 2001). Heterogeneity in these preferences has been linked to a number of demographic attributes (Andreoni and Vesterlund, 2001; List, 2004), personality traits (Volk et al., 2012) as well as differences in beliefs (Fischbacher and Gächter, 2010). Recent experimental evidence (Piovesan and Wengström, 2009; Kocher et al., 2012; Rand et al., 2012; Duffy and Smith, 2012; Nielsen et al., 2014) suggests that the extent of cooperative behavior is additionally influenced by the type of cognitive system that potential contributors employ when considering their contribution choice. Two principal types of cognitive systems are distinguished by the reigning 'dual process' theories of the mind (Fudenberg and Levine, 2006; Loewenstein and O'Donoghue, 2007; Kahneman, 2011): System I, which arrives at decision through affective or intuitive processes, and System II, which generates decisions based on deliberative or calculated reasoning (Kahneman, 2003; Evans, 2003, 2008; Loewenstein et al., 2008). These theories, and the experiments associated with them, raise the possibility that, everything else equal, individuals might come to a different contribution choice because their decision relied on intuition (System I) or deliberation (System II). If confirmed, this would matter for current attempts to build a unified model of cooperative behavior (Bowles and Gintis, 2011). It would also provide important clues as to how different decision environments can make certain public goods provision outcomes more likely than others, depending on whether that environment favors intuition or deliberation (Thaler et al., 2010).

If contribution decisions are the result of either intuitive or deliberative processes, is there empirical evidence that the type of process makes a systematic difference to contributions? And if so, which of the two cognitive systems, intuition or deliberation, predisposes individuals towards more cooperation? A number of economic experiments have investigated these questions using the public goods game paradigm. While their results jointly support the notion that an empirical link between the cognitive system and the choice to cooperate exists, the direction of the link remains disputed. Rand et al. (2012), for example, find that higher contributions in standard public good games are related to intuitive decision making. Tinghög et al. (2013) fail to replicate this result, as do Duffy and Smith (2012) using a cognitive load design. In the closely related context of general fairness preferences, Piovesan and Wengström (2009) conclude that more generous allocations in dictator games are associated with deliberation. Again, Schulz et al. (2012) find the opposite using a different design. In sum, therefore, the question of how intuition and deliberation relate to cooperative behavior is far from settled.

The present paper brings new empirical evidence from outside the laboratory to bear on the question of a link between cognitive systems and contribution behavior. Methodologically, it follows the common strategy of identifying the cognitive system through response time data (Piovesan and Wengström, 2009; Rand et al., 2012; Tinghög et al., 2013; Nielsen et al., 2014). This strategy relies on the fact that on average, response times (RT) differ between intuitive and deliberative processes. When considering the consequences of a given choice or resolving a moral dilemma, faster decisions are more likely to be the result of intuitive processes while slower decisions are more likely to have involved deliberative reasoning (Rubinstein, 2007, 2013).

The RT data in this paper originates from an extra-laboratory experiment (Charness et al., 2013) run via the internet. There, subjects from the general population faced a choice between receiving a monetary payment or contributing to a real world public good. The real public good exploits the behaviorally rich setting of voluntary actions against climate change (Gowdy, 2008) and takes the form of a guaranteed and verifiable reduction of CO_2 emissions by one metric ton (Diederich and Goeschl, 2013). The public goods nature of such a reduction is not only well understood by economists (Nordhaus, 1991), but also by the subjects of the experiment.[1] This unique dataset of RT observations offers four distinct benefits: First, it is to our knowledge the first set of observations to allow a test of the link between cognitive system and contributions using a real public good. Secondly, with 3483 subjects participating, the number of independent observations is large compared to most datasets that examine this link. This is important in light of Rubinstein's (2007, 2013) dictum that the noisy approximation of mental processes through RT data requires large sample evidence. Third observing a representative sample of subjects from the general population with a broad range of demographic backgrounds increases the generalisability of our results. Fourth the dataset contains two RT observations per subject: Each subject took two choices between different monetary rewards and a public good. Hence, as in Piovesan and Wengström (2009), it is possible to analyze the within-subject relationship between response times and contributions while holding constant unobserved individual attributes or preferences, thus going beyond simple correlation.

Our results are threefold: First, we find a clear difference between contribution decisions depending on whether they are based on intuitive or on deliberative processes. This finding confirms the existing literature that has detected a link between cognitive systems and contribution decisions. Secondly, we find that intuitive decisions are statistically associated with a choice not to contribute to the public good while a choice to contribute is more likely to be observed when the decision is deliberative. This result lends support to earlier findings (Piovesan and Wengström, 2009) that find deliberative processes to favor pro-social choices. In the extra-laboratory experiment that we report on, this effect stands out clearly: The average response time of contributors, controlling

[1] The questionnaire administered to subjects as part of the experiment bears this out. This is unsurprising in light of the fact that German citizens almost universally accept both the empirical veracity of climate change and that anthropogenic greenhouse gas emissions are its cause (European Commission, 2008).

for other factors, is approximately 40% longer than that of non-contributors. Thirdly, this finding carries over to the individual level. Subjects that switch from free riding in their first decision to contributing in their second decision need significantly more time for their second decision and vice versa. We interpret this as evidence in support of the hypothesis that voluntary contributions to the real public good are driven by a deliberative weighting of personal costs and social benefits rather than by affect and intuition. We summarize the experimental procedure in section 2 and present and discuss the results in section 3 before concluding.

2 Experimental Procedures

The RT data analyzed here were collected in the context of an incentivized online experiment. In this experiment, subjects made two consecutive choices, deciding each time between receiving a personal monetary reward and providing a real public good. The real public good took the form of a guaranteed and verifiable reduction of 1 metric ton of CO_2 emissions.[2] From session to session, there were slight variations in the terms of the emissions reduction while retaining the basic design of personal gain versus public goods contribution.[3]

The treatment condition in the online experiment consisted of randomly assigning subjects to different monetary rewards. For each subject and choice, the reward was independently drawn from a uniform distribution of even integers between €2 and €100.[4] As a result, the data set contains significant between-subjects and within-subject variation with respect to the decision. This variation forms the basis of robustness checks, among them a check for the hypothesis that RT is determined by the degree of cognitive difficulty of a decision situation, rather than the cognitive system used (Krajbich et al., 2010; Evans et al., 2014).

The experiment ran between May and July 2010 drawing on a panel of 65,000 members of a large online polling organization. The recruitment of the subjects followed the standard routine in which panel members are invited via an E-mail message to proceed to the poll via a hypertext link. The introductory screen then explained, as common with the pollster's regular surveys, the thematic focus of the poll, the expected duration (ten minutes), and the random incentive

[2]Choices were implemented under a random incentive system (RIS) (Grether and Plott, 1979; Starmer and Sugden, 1991; Lee, 2008). The RIS is between-subjects (BS) (Tversky and Kahneman, 1981; Abdellaoui et al., 2011; Baltussen et al., 2012) with odds of one in fifty that the subject's choice (of either cash or contribution) was realized. This payment procedure decreases overall expected earnings to each subject but ensures that the conditional choice between the two options remained at face value.

[3]There were four variations in total. For example, in some sessions, a contribution decision was made public after the session. Session effects are therefore explicitly included when analyzing pooled data in section 3. The main relationship between response times and contribution behavior is unaffected by the different variations. We therefore pool the data from the different sessions.

[4]For each of the 50 reward categories, there are between 56 and 83 observations.

system.[5] Participants then faced a sequence of 10 to 13 computer screens, two of which were “decision screens” that required a choice between personal monetary payoff and public good contribution. Both decision screens were each preceded by an information screen that introduced the choice situation and the emissions reduction.

The RT data for the present analysis contain, for each of the 3483 subjects, a measure of the time the subject spent on each of the two “decision screens” that were the core of the experiment. Each decision screen presented, through radio buttons, the binary choice between the public goods contribution (”reduction in CO_2 emissions of 1 metric ton”) and the specific monetary reward (e.g. ”€46”) that had been drawn for the subject in this round, with the order of the cash and contribution button randomly assigned. There was no default and subjects clicked on the desired radio button and on a ’proceed’ button directly underneath. For each decision screen, a subject’s RT is defined as the time between entering that decision screen and clicking on the ’proceed’ button. The 3483 subjects are a representative sample of the Internet using population of Germany with respect to sex, age, and federal state of residence.[6]

3 Results

3.1 Response times and behavior

The recent experimental literature hypothesizes that a link exists between an observed contribution decision and the time it took to reach that decision, thus revealing the decision system responsible. For a first look at the data, we follow Rubinstein (2007, 2013) and Piovesan and Wengström (2009) and classify each decision into one of four categories according to its percentile in the RT distributions: very fast (fastest 10%), fast (10%-50%), slow (50% - 90%) and very slow (slowest 10%). Table 1 summarizes, for each of the decision screens, the descriptive statistics of the four RT categories and the associated contribution behavior.

It is evident that RTs vary substantially between the four categories. At the first decision screen (Decision 1), subjects in the fastest category responded on average within 4 seconds, while subjects in the slowest category took more than

[5]The polling company usually incentivizes panel members participating in a poll through either a piece-rate reward of approximately €1 for 20 minutes expected survey time or random (lottery) prizes, e.g. in the form of shopping vouchers.

[6]Compared to the full set of subjects who finished the experiment, we exclude observations with missing values in one or more of the variables. Also, as the data are collected online, it is possible that subjects leave the computer during the experiment and complete their decision form much later. As for these subjects the recorded response time potentially does not coincide with the length of the decision process we exclude all subjects that spent more than 300 seconds on the decision screen from the analysis. The largest RT we exclude is 75 minutes. All major results we present in section 3 are independent from this cutoff criterion. As a robustness check we test this for alternative cutoffs of 60, 120, 180, 240, and 500 sec. With a cutoff of 300 seconds, not more than 20 observations (amounting to 0.3 percent of all complete observations) are excluded from the analysis.

1 minute. At the second decision screen (Decision 2), average RTs are similar, but hint at a slight acceleration of decision-making relative to decision 1.

Decision 1

Category	N	Reaction Time (Sec.) Mean (S.D.)	Fraction of Contributors Mean (S.D.)
Very Fast	349	4.17 (0.906)	0.088 (0.284)
Fast	1393	10.01 (2.694)	0.128 (0.334)
Slow	1393	26.06 (8.163)	0.203 (0.403)
Very Slow	349	70.02 (31.947)	0.347 (0.476)

Decision 2

Category	N	Reaction Time (Sec.) Mean (S.D.)	Fraction of Contributors Mean (S.D.)
Very Fast	349	4.13 (1.071)	0.140 (0.347)
Fast	1393	10.36 (2.684)	0.234 (0.423)
Slow	1393	24.81 (7.516)	0.234 (0.423)
Very Slow	349	65.67 (34.566)	0.300 (0.459)

Table 1: Categorization of reaction times

Table 1 also reports, for each RT category, the share of contributors. On average 17 percent of subjects chose to contribute in decision 1, 23 percent in decision 2. Comparing, for each decision situation, the share of contributors across the four RT categories, we find a positive relationship between reaction time and contributions that is confirmed by statistical tests. In decision 1, there are significant differences in contribution behavior between all RT categories (Chi^2-Test: Pairwise comparisons, $p < 0.05$). The difference is most pronounced between the fastest and the slowest group of subjects (Chi^2-Test: $p = 0.000$, $\chi^2 = 68.48$): Among the fastest, only 8.8 percent choose to contribute to the public good while among the slowest, a little more than 34 percent of subjects do so. The relationship between RTs and contributions gets weaker in the second decision, as Table 1 shows. The difference between the fastest and the slowest group of subjects (14.0% of contributors vs. 30.0% of contributors) remains highly significant (Chi^2-Test: $p = 0.000$, $\chi^2 = 26.12$). A pairwise comparison of the groups 'Fast' and 'Slow', however, does not yield a significant difference in contribution behavior (Chi^2-Test: $p = 0.973$, $\chi^2 = 0.0012$).[7]

To sum up, basic tests of correlation between RT categories and average contribution shares within each category are supportive of the hypothesis that faster, more intuitive decisions are associated with a lower probability of contributing while slower, more deliberative decisions are associated with a higher probability. The correlation is strong when subjects encounter the choice for the

[7] We show below that part of this moderation can be attributed to those subjects who contribute in the first decision and do not change their behavior in the second decision.

first time and somewhat attenuated when the contribution choice is presented a second time, with different trade-offs.

3.2 Robustness Checks

3.2.1 Categorization

Correlation tests that compare average contribution shares across categories can be sensitive to the method of categorization. The categorization in 3.1 relies on threshold values for the 10th, the 50th, and the 90th RT deciles as introduced by Rubinstein (2007, 2013) and Piovesan and Wengström (2009). Conceivably, a different choice of thresholds between categories could find different results.

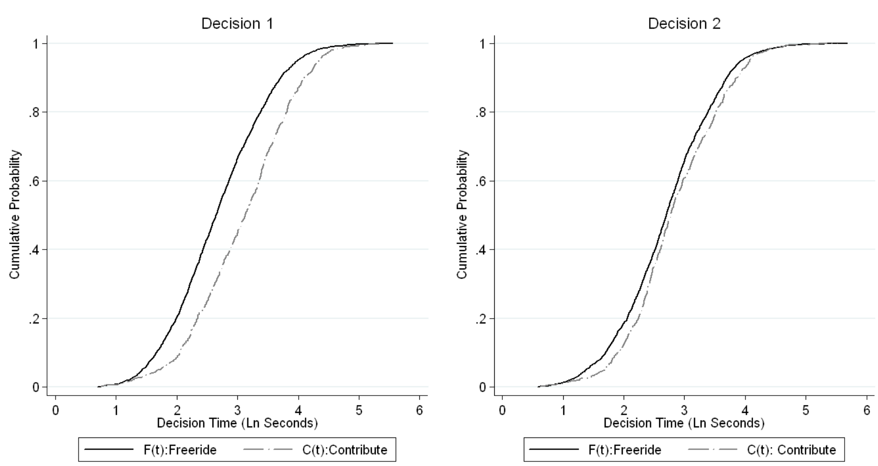

Figure 1: CDF of response times separate for contributors and freeriders

To check for robustness to categorization choice, we examine the entire cumulative distribution function (CDF) of RTs for contributors and non-contributors (Rubinstein, 2013) and find that the results do not depend on the specific categorization. For both decision 1 and 2, figure 1 shows two CDFs of deciding within t seconds, one for contributors $C(t)$ (grey dashed line) and one for those choosing cash $F(t)$ (black solid line). Inspecting the CDFs for decision 1, $C(t)$ is consistently to the right of $F(t)$ over the full range of observed response times (t). This first-order stochastic dominance represents clear evidence (Rubinstein, 2013) that it takes longer for subjects to contribute than to free-ride or - conversely - that deliberate decisions are consistently more likely to result in a contribution decision than intuitive decisions[8]. Inspecting the CDFs for decision 2, free-riding again stochastically dominates contributing, but the difference

[8] A CDF $C(t)$ of the action c is said to stochastically dominate a CDF $F(t)$ of the action f if $F(t) \geq C(t) \forall t$

between the CDFs is smaller. This indicates that the relationship between RTs and contributions, while still present, is weaker in the second decision.

3.2.2 Individual Heterogeneity

RTs are a noisy proxy for identifying intuitive and deliberative decision systems (Rubinstein, 2007, 2013). The present experiment responds to the resultant sample size requirement with observations from almost 3500 subjects. However, this large subject pool is highly diverse in terms of its demographic background and is exposed to variations in price and contribution characteristics within the experiment. This requires refining the simple analysis above in order to check whether differences in RTs are perhaps driven by differences in certain subject characteristics (such as age) and treatment conditions (such as a high price) rather than differences in the use of decision systems. Table 2 reports the results of a multivariate OLS regression analysis of RT data in which we control for the presence of potential confounding factors in subjects' decision 1. Table 3 reports the same for decision 2. Summarizing ahead of a more detailed discussion, the positive relationship between RT and contribution behavior turns out to be robust to the potential confounds examined here.

	(1)		(2)		(3)	
	Ln(RT1)		Ln(RT1)		Ln(RT1)	
Contributor (1=Yes; 0=No)	0.393****	(11.02)	0.371****	(10.34)	0.306****	(8.96)
Price (Euro)	0.0000192	(0.04)	-0.000126	(-0.27)	-0.000346	(-0.80)
Age (Years)			0.00627****	(6.57)	0.00495****	(5.46)
Education (Cat. 1-11)			-0.0146**	(-2.15)	-0.0123*	(-1.92)
Income (Cat. 1-11)			-0.0204****	(-3.75)	-0.0168***	(-3.26)
Female (1=Yes; 0=No)			-0.0283	(-1.03)	-0.0274	(-1.05)
Time Introduction Screen (Sec.)			0.0000118	(0.35)	-0.000266**	(-1.96)
Time Information Screen (Sec.)			0.000358****	(4.88)	0.00699****	(21.53)
Personal Benefit (Cat. 1- 4)			-0.0483***	(-2.67)	-0.0327*	(-1.92)
Next Generation Benefit (Cat. 1- 4)			0.0768****	(4.20)	0.0550***	(3.18)
Constant	2.617****	(83.37)	2.440****	(29.00)	2.294****	(28.58)
Observations	3483		3483		3456	
R^2	0.053		0.081		0.185	
Prob> F	0.000		0.000		0.000	

t statistics in parentheses. Robust standard errors.
session dummies included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 2: Decision 1: Regression of reaction times on contribution dummy and demographic covariates.

For decision 1, table 2 reports the regression results for three different specifications. Specification (1) regresses the logarithm of reaction time[9] as a function of the binary contribution decision and the treatment conditions under which the decision was taken. These conditions are given by the monetary reward

[9]As the distribution of reaction times is close to an exponential distribution, a logarithmic transformation is applied to normalize the dependent variable and give less weight to observations with large decision times. The results presented here hold also with untransformed variables.

(price) that subjects forewent when choosing to contribute and one of four variations of the public good characteristics. An inspection of the coefficient for the contribution variable shows that a contributor took on average approximately 40 percent more time to reach a decision than a non-contributor.

Specification (2) adds demographic controls to the analysis, but finds little change in the fundamental relationship between RTs and contribution behavior. As expected, RT increases with age and decreases with education status and income. To proxy for individual variations in general reading and computer handling speed, we use the time spent on the relatively text-intensive introduction screen of the experiment, but find no evidence of a significant relationship with the RT at the decision screen. As a further control variable, we also use the time spent on the information screen. Since this screen contained some details that would become actionable on the decision screen, subjects could conceivably start the decision process before reaching the decision screen, resulting in a negative correlation with our RT measure. Testing this possibility, we indeed find a significant relationship, but it is both quantitatively small[10] and works in the opposite direction: Subjects who spent more time on the information screen tend to also spend more time on the actual decision screen.[11]

Specification (2) also includes two variables from the post experimental survey measuring subjects' attitudes regarding the benefits of CO_2 reductions for themselves and for future generations. We find that these variables relate to RT in a significant way. The relationship mirrors the observed relationship between RTs and the decision to contribute: RT decreases with the strength with which subjects believe that a contribution generates personal benefits, but increases with the strength with which subjects believe that a contribution generates benefits to the next generation. In other words, the more a subject believes that the consequences of the decision affect others, the more likely it is that deliberative processes are involved in the decision.

Specification (3) checks how sensitive the coefficient estimates are to outliers. It excludes observations that display a high leverage[12] when running regression diagnostics after specification (2). The high leverage is mainly driven by a few observations that stand out for the long time spent on the introduction or information screen. Overall 27 observations are discarded. The main relationship between RT and contributions is robust to this change, with an increase in contributors' response time of 31 percent. The coefficients for time spent on introduction or information screen gain both in magnitude and significance.

Table 3 contains the corresponding analysis of RT data from decision 2.

[10] One additional second spent on the information screen increases RT by an average of 0.04 percent.

[11] As a further robustness check instead of controlling for the time spent on the information screen within the regression, we use the total time spent on both information and decision screen as a dependent variable. We still find a significant difference between contributors and defectors. One interpretation is that subjects who are more oriented towards pro-social goals spent more time acquiring information on how their decision could affect others. Fiedler et al. (2013) provide evidence along these lines.

[12] We employ the conventional cutoff of Leverage $> (2 * k + 2)/N$

	(1) (LN RT 2)		(2) (LN RT 2)	
Contributor (1=Yes; 0=No)	0.131****	(4.38)	0.124****	(4.00)
Price (Euro)	0.00108**	(2.32)	0.00106**	(2.33)
Age (Years)			0.00930****	(9.90)
Education (Cat. 1-11)			0.00642	(0.98)
Income (Cat. 1-11)			-0.0215****	(-4.02)
Female (1=Yes; 0=No)			-0.0215	(-0.80)
Time Introduction Screen (Sec.)			-0.0000538*	(-1.66)
Time Information Screen (Sec.)			0.000361***	(2.71)
Personal Benefits (Cat. 1- 4)			-0.125****	(-7.38)
Benefits Next Gen (Cat. 1- 4)			0.125****	(7.09)
Constant	2.605****	(135.64)	2.136****	(26.98)
Observations	3483		3483	
R^2	0.04		0.09	
Prob> F	0.000		0.000	

t statistics in parentheses. Robust standard errors.
Session dummies included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 3: Decision 2: Regression of reaction times on contribution dummy and demographic covariates.

Specification (1) is identical to that in table 2 and reaffirms a highly significant and positive relationship between the contribution decision and RT. In contrast to table 2, the RT differences are now smaller, but a decision to contribute still leads to an average increase of 13 percent in the RT. Also, decisions are slower when a higher monetary award is at stake. Specification (2) demonstrates that the link between RT and the second contribution decision is also robust to the inclusion of the controls considered in the first decision.

The evidence on a positive relationship between RT and contribution decision reported in table 3 contains one obvious complication: In decision 2, subjects have already taken a decision once, have greater familiarity with the public good offered and have seen a specific monetary award. Table 4 reports on the results of further analysis of the link between RT and contributions that includes behavior and prices from decision 1 and therefore explicitly accounts for the possible dependence of decision 2 on decision 1. Again, the main result is that the link between RT and contributions remains robust, as we explain in detail.

Specification (1) in table 4 contains the same controls of specification (1) in table 3, but includes robustness checks vis-a-vis decision 1. One pair of variables captures the effect of having contributed in decision 1 and of contributing in both decisions (through the interaction term), relative to a baseline of contributing in neither. A second pair measures by how much the cost of contributing has increased or decreased relative to the first decision, allowing for a possible asymmetry in the magnitude of the response. On the contribution decision, we find

	(1) (LN RT 2)		(2) (LN RT 2)	
Contributor Decision 2 (1 = Yes; 0 = No)	0.265****	(5.74)	0.191***	(3.02)
Contributor Decision 1 (1 = Yes; 0 = No)	0.189**	(2.57)	-0.0792*	(-1.70)
Interaction(Contrib1*Contrib2)	-0.407****	(-4.52)		
Negative Difference Price (p2-p1<0)	-0.000601	(-1.07)	-0.00114*	(-1.74)
Positive Difference Price (p2-p1>0)	0.00263****	(3.57)	0.00278****	(3.38)
Interaction(Neg Price Diff*Contrib2)			0.00126	(1.03)
Interaction(Positive Price Diff*Contrib2)			0.000379	(0.21)
Demographic Controls	YES		YES	
Session Dummies	YES		YES	
Constant	2.112****	(26.46)	2.111****	(26.21)
Observations	3483		3483	
R^2	0.10		0.09	
Prob> F	0.000		0.000	

t statistics in parentheses. Robust standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 4: Decision 2: Regression of reaction times including interaction terms for price differences and decision 1 contribution dummy

that average RT is 26% higher for those who contribute in decision 2 for the first time and 4.7% higher for those who contribute in both decisions [13]. Adhering to the same choice in decision 2 as in decision 1 is therefore associated with lower average RT, with a slightly higher RT if decision 1 was to contribute. For those subjects that change their choice from decision 1 to decision 2, the average increase in RT is higher for those subjects that change from defecting to contributing than for those that change from contributing to defecting. This provides additional support for the general finding that the decision to free-ride requires less deliberation. On the cost of contributing, we find that exogenously changing the contribution cost has an asymmetric effect on RT. While increases in contribution costs from decision 1 to decision 2 are associated with significantly higher RTs, decreasing costs are not associated with lower RTs.

Specification (2) in table 4 examines the possibility of an interaction between the change in price and contribution behavior in the second decision. While the effect of an increase in the announced price of the contribution does not change in size or significance, a falling price produces a (weakly) significant negative effect on RT. The insignificant interaction terms show that these effects affect contributors and non contributors in a uniform way.

3.2.3 Indecision by indifference

The result that RT and contribution behavior is linked lends support to the conjecture that underlying decision processes matter for determining outcomes in social dilemmas. However, there is also an alternative interpretation of our results. Rather than reflecting the underlying decision process, RTs could simply reflect the cognitive difficulty of coming to a binary decision when the two

[13]This estimate is the sum of coefficients from contribution decisions 1 and 2 minus the coefficient of the interaction term.

options on offer are of similar value to the subject or subjects are genuinely indifferent. In this interpretation, those that have a strong preference for one of the options should on average be able to make a faster decision for the preferred option than those subjects who are close to indifference between the two options (Krajbich et al., 2010; Evans et al., 2014).

In the context of the present experiment, the conjecture of 'indecision by indifference' would imply that subjects that are quoted a monetary reward that is sufficiently close to their maximum willingness to contribute would find the decision more difficult and therefore require more time for a decision. Those, on the other hand, for whom the reward and the reservation price of contributing are far apart would find it easier and be able to make a fast decision. Which decision is easy depends, under this conjecture, on the reward: If the reward offered is low, the decision to contribute is easy and vice versa. By implication, the RT for contributors is predicted to be low when offered a low price and high when offered a high price while the RT of defectors is predicted to be high for low prices and low for high prices.

To test this prediction, we exploit the fact that in decision 1, each subject faced a randomly drawn contribution cost in the range of €2 to 100. Given this random assignment, the testable hypothesis is that all other things equal, contributors should be faster than free-riders at the lower end of the range while free-riders should be faster than contributors at the upper end of the range. We implement this test by running specification (2) of the multivariate regression model (table 2) separately for five equally spaced subsets of the reward range between €2 and 100. This provides, for each of the five reward bands, a coefficient estimate of how the decision to contribute influences RT. As we discuss below, the prediction that the RT coefficients of a positive contribution decision are negative at low prices and positive at high prices, is not fulfilled. Even a weaker prediction, namely that RT coefficients are higher for higher monetary rewards, is not fulfilled. We therefore find no support for the conjecture of 'indecision by indifference'.

Price Range	N	Coefficient (S.D.)
EUR 2-20	607	0.224 (0.0733)
EUR 20-40	713	0.409 (0.0843)
EUR 40-60	668	0.350 (0.0856)
EUR 60-80	739	0.351 (0.0831)
EUR 80-100	690	0.404 (0.0779)

Table 5: Contribution dummy coefficient for five ascending price ranges

In each of the five reward bands, there is a significantly positive relationship between being a contributor and longer RTs. Strikingly, the effect is also quantitatively comparable across reward ranges. To add robustness, we re-run specification (2) (table 2), including an interaction term between the contribution dummy and the reward variable. We find that the main effect of the contribution dummy remains highly significant (Coeff. = 0.347; p = 0.000). The interaction term, predicted to be negative, is not significantly different from zero (Coeff. =0.0004833; p=0.673). The alternative interpretation that the difficulty of the decision situation rather than the underlying cognitive processes generates the evidence has therefore little support in the data.

3.3 Within-subject differences

The cross-sectional evidence in section 3.1 points to a strong relationship between the decision system employed and contribution behavior. On average, subjects that are more likely to be relying on intuitive processes choose the monetary reward while those that are more likely to be relying on deliberative processes choose to contribute to the public good. This finding holds irrespective of RT categorization and controlling for a variety of confounds. The finding can also not be explained by variations in RT resulting from 'indecision by indifference'. Cross-sectional evidence, however, cannot rule out the possibility that the identified correlation is driven by unobserved individual characteristics.

We address the possible role of unobserved individual characteristics in the link between decision system and contribution choice by exploiting the fact that the online experiment recorded for each subject two consecutive contribution decisions and the corresponding RTs. As all characteristics (observed and unobserved) are constant for the same individual, a within-subject change in RT that is related to a within-subject change in contribution behavior would provide strong evidence for the existence of a true relationship.

As a first step, table 6 compares the changes in decision times for those 428 subjects (12%) who change their contribution decision from decision 1 to decision 2 with those subjects who do not. The results shows that we can recover the cross-sectional correlation between contribution decision and RTs also at the individual level: Subjects that switch from contributing to free-riding require on average 4.20 seconds less time for their second choice. In contrast, subjects that switch from free-riding to contributing require on average 1.52 seconds more to come to that decision. The difference is (weakly) significant at the ten percent level (Man-Whitney-Test: $p = 0.072$).

Decision 1	Decision 2	RT2 - RT1	Observation
Contributor	Defector	-4.20	117
Defector	Contributor	1.52	309
	No switch	-0.889	3057

Table 6: Switching behavior and reaction times

Table 7 presents the results of an analysis with full controls for changes in the incentive structure at the subject level. There, we estimate the effect of changing contribution behavior on reaction time in a first-difference estimation framework. This within-subject framework captures the potential effects of all time varying factors during the experiment while eliminating potential biases due to observed and unobserved individual time-constant characteristics. Specification (1) reports the coefficient estimates for regressing a change in RT on a change in contribution behavior and a change in price. Table 7 shows that on average, the same subject takes 8.2% more time for a contribution decision than for a free-riding decision, compared to a baseline of subjects that do not change their contribution behavior. Changing the monetary reward does not affect a change in reaction times. Under the premise that this analysis includes all time-varying factors between the two decisions,[14] this evidence can be restated to say that on average, more deliberative decision-making leads to more cooperative behavior.

	(1) OLS		(2) IV	
First Diff. Contrib. (contrib2 - contrib1)	0.0822**	(1.99)	0.423**	(2.11)
First Diff. Price (p2 - p1)	0.0000863	(0.23)		
Constant			-0.0366**	(-1.98)
Observations	3483		3483	
R^2	0.10		-	
Prob> F	0.000		0.0350	

t statistics in parentheses; session dummies included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

Table 7: Decision Times First Difference Equation

As an additional robustness check, specification (2) accounts for the possible omission of unobserved time varying factors that conceivably bias the results of specification (1). The strategy is to employ an IV estimation framework in which the exogenous variation in the monetary rewards through random assignment is used as a instrument for changes in the contribution behavior. The randomly drawn rewards are uncorrelated with any unobserved time-varying factors and, under the validity of the exclusion restriction, valid instruments by design (Smith, 2013).[15] In this framework, the coefficient estimate reports a positive within-subjects relationship between switching to cooperation and RT that confirms the previous results at the individual level.

4 Discussion and conclusion

In this paper, we examined evidence from an online experiment in which subjects faced two consecutive decisions between a monetary reward and a real public good contribution, and where response time data is available for each decision. This allows the evidence to speak to a current discussion on the link between cognitive systems and cooperative behavior that exploits response times as an

[14]Potential candidates for unobserved time-varying factors could be boredom or fatigue by the subjects. Their role can be considered minor in light of the fact that the median subject completed the experiment within 6 minutes.

[15]The first stage regression F statistic returns $F = 28.60$. This indicates that the instruments are not weak.

observable proxy for cognitive processes. One strand in this discussion holds that in social dilemma situations in which the decision to cooperate is costly for individuals, subjects employing intuitive processes are more likely to cooperate while those employing deliberative processes are more likely to act selfishly (e.g.Rand et al. 2012, 2014; Zaki and Mitchell, 2013; Nielsen et al. 2014). The evidence used to support this claim comes from experimental studies, some of them involving the exogenous application of time pressure. While some fail to replicate these findings (Tinghög et al., 2013), another strand in the discussion arrives at the opposite conclusion: In dictator games, cooperative behavior is associated with deliberative reasoning, and selfish behavior with intuitive processes (Piovesan and Wengström, 2009; Fiedler et al., 2013).[16]

The context of the online experiment analyzed here is ostensibly one of public goods. Yet, the results fall squarely into the second strand: We find that cooperative behavior in an online experiment on contributions to a real public good is associated with deliberative processes, both at the cross-sectional level and at the individual level. There are at last two explanations for this. One reason are design differences: Suter and Hertwig (2011) highlight that the decision context is essential for triggering different mental processes. This is one explanation why the correlation between behavior in the standard public good game and contribution towards real public goods is modest (Laury and Taylor, 2008) to non-existent (Voors et al., 2012), depending on the kind and context of the real public good offered to experimental subjects. The real public good used in the present experiment differs from public good contributions in standard experiments along several important dimensions. The marginal per capita return (MPCR) for climate protection is low on account of the large number of potential beneficiaries and the temporal structure of climate change.

This leads to second candidate explanation. Subjects in a standard public goods game face strategic uncertainty (e.g. Gangadharan and Nemes, 2009) as their own payoff depends on the strategic behavior of others. Subjects in our experiment have complete control over their own monetary payoff. This means that the appropriate experimental paradigm among laboratory experiments to compare our results to may well turn out to be the standard dictator game experiment where the dictator's private return of contributing a token is zero. This makes our findings consistent with this part of the literature.

To conclude, this paper establishes a robust relationship between reaction times, deliberative and intuitive decision making and contributions to a real public good. As such, it adds to the emerging evidence base that the list of factors that determine behavior in social dilemmas may have to be expanded to include participants' decision system. To the economist, who has traditionally focused on outcomes rather than underlying decision processes, our finding raises the question to what degree observed preferences of the same individual depend on extraneous factors that favor either one of the decision systems. In contexts such as the present one, decision environments that favor a reliance on intuition will result in lower levels of observed contributions compared to

[16] For a deviating result, see Schulz et al. (2012)

decision environments that favor a reliance on deliberative reasoning. Thus, our findings strengthen recent developments towards an increased consciousness about controlling for the presence of different decision environments and for thinking about their active design.

Furthermore for those interested in the question, if the willingness to cooperate is ingrained in human biology or rather driven by cultural evolution our results are in line with the 'social brain' hypothesis (Dunbar, 2003). Intuitive processes rely on older parts of the brain in evolutionary terms, while deliberative processes rely on parts of the brain that are of much more recent evolutionary origin (Evans, 2008; Rakic, 2009). Findings such as ours can be seen as support for the idea that brain physiology and societal institutions have to be understood in co-evolutionary terms.

References

M. Abdellaoui, A. Baillon, L. Placido, and P. P. Wakker. The rich domain of uncertainty: Source functions and their experimental implementation. *The American Economic Review*, 101(2):695–723, 2011.

J. Andreoni. Impure altruism and donations to public goods: a theory of warm-glow giving. *The Economic Journal*, 100(401):464–477, 1990.

J. Andreoni. Cooperation in public-goods experiments: kindness or confusion? *The American Economic Review*, pages 891–904, 1995.

J. Andreoni and L. Vesterlund. Which is the fair sex? gender differences in altruism. *The Quarterly Journal of Economics*, 116(1):293, 2001.

G. Baltussen, G. T. Post, M. J. Van Den Assem, and P. P. Wakker. Random incentive systems in a dynamic choice experiment. *Experimental Economics*, 15(3):418–443, 2012.

Samuel Bowles and Herbert Gintis. *A cooperative species: Human reciprocity and its evolution*. Princeton University Press, 2011.

G. Charness, U. Gneezy, and M. A. Kuhn. Experimental methods: Extra-laboratory experiments-extending the reach of experimental economics. *Journal of Economic Behavior & Organization*, 91(0):93–100, 2013.

A. Chaudhuri. Sustaining cooperation in laboratory public goods experiments: a selective survey of the literature. *Experimental Economics*, 14(1):47–83, 2011.

J. Diederich and T. Goeschl. Willingness to pay for voluntary climate action and its determinants: Field-experimental evidence. *Environmental and Resource Economics*, pages 1–25, 2013.

S. Duffy and J. Smith. Cognitive load in the multi-player prisoner's dilemma game: Are there brains in games? *Working Paper*, 2012.

R. Dunbar. The social brain: mind, language, and society in evolutionary perspective. *Annual Review of Anthropology*, pages 163–181, 2003.

European Commission. Europeans' attitudes towards climate change. *Special Eurobarometer*, 300, 2008. European Parliament / European Commission.

A. M Evans, K. D. Dillon, and D. G. Rand. Reaction times and reflection in social dilemmas: Extreme responses are fast, but not intuitive. *Working Paper*, 2014.

J. S. B. T. Evans. In two minds: dual-process accounts of reasoning. *Trends in cognitive sciences*, 7(10):454–459, 2003.

J. S. B. T. Evans. Dual-processing accounts of reasoning, judgment, and social cognition. *Annu. Rev. Psychol.*, 59:255–278, 2008.

Susann Fiedler, Andreas Glöckner, Andreas Nicklisch, and Stephan Dickert. Social value orientation and information search in social dilemmas: An eye-tracking analysis. *Organizational Behavior and Human Decision Processes*, 120(2):272–284, 2013.

U. Fischbacher and S. Gächter. Social preferences, beliefs, and the dynamics of free riding in public goods experiments. *American Economic Review*, 100(1): 541–556, 2010.

U. Fischbacher, S. Gächter, and E. Fehr. Are people conditionally cooperative? evidence from a public goods experiment. *Economics Letters*, 71(3):397–404, 2001.

D. Fudenberg and D. K. Levine. A dual-self model of impulse control. *The American Economic Review*, pages 1449–1476, 2006.

L. Gangadharan and V. Nemes. Experimental analysis of risk and uncertainty in provisioning private and public goods. *Economic Inquiry*, 47(1):146–164, 2009.

J. M. Gowdy. Behavioral economics and climate change policy. *Journal of Economic Behavior & Organization*, 68(3):632–644, 2008.

D. M. Grether and C. R. Plott. Economic theory of choice and the preference reversal phenomenon. *The American Economic Review*, pages 623–638, 1979.

D. Kahneman. Maps of bounded rationality: Psychology for behavioral economics. *The American Economic Review*, 93(5):1449–1475, 2003.

D. Kahneman. *Thinking, fast and slow.* Farrar, Straus and Giroux, 2011.

M. Kocher, K. Myrseth, P. Martinsson, and C. Wollbrant. Strong, bold, and kind: Self-control and cooperation in social dilemmas. *Working Paper*, 2012.

I. Krajbich, C. Armel, and A. Rangel. Visual fixations and the computation and comparison of value in simple choice. *Nature Neuroscience*, 13(10):1292–1298, 2010.

S. K Laury and L. O Taylor. Altruism spillovers: Are behaviors in context-free experiments predictive of altruism toward a naturally occurring public good? *Journal of Economic Behavior & Organization*, 65(1):9–29, 2008.

J. O Ledyard. Public goods: A survey of experimental research. *Public Economics*, 1994.

J. Lee. The effect of the background risk in a simple chance improving decision model. *Journal of Risk and Uncertainty*, 36(1):19–41, 2008.

J. A List. Young, selfish and male: Field evidence of social preferences. *The Economic Journal*, 114(492):121–149, 2004.

G. Loewenstein and T. O'Donoghue. Animal spirits: Affective and deliberative processes in economic behavior. *Available at SSRN 539843*, 2007.

G. Loewenstein, S. Rick, and J. D. Cohen. Neuroeconomics. *Annu. Rev. Psychol.*, 59:647–672, 2008.

U. H. Nielsen, J.-R. Tyran, and E. Wengström. Second thoughts on free riding. *Economics Letters*, 122(2):136–139, February 2014.

W. D. Nordhaus. To slow or not to slow: the economics of the greenhouse effect. *The Economic Journal*, pages 920–937, 1991.

M. Piovesan and E. Wengström. Fast or fair? a study of response times. *Economics Letters*, 105(2):193–196, 2009.

P. Rakic. Evolution of the neocortex: a perspective from developmental biology. *Nature Reviews Neuroscience*, 10(10):724–735, 2009.

D. G. Rand, J. D. Greene, and M. A. Nowak. Spontaneous giving and calculated greed. *Nature*, 489(7416):427–430, 2012.

A. Rubinstein. Instinctive and cognitive reasoning: A study of response times. *The Economic Journal*, 117(523):1243–1259, 2007.

A. Rubinstein. Response time and decision making: An experimental study. *Judgment and Decision Making*, 8(5):540–551, 2013.

J. F. Schulz, U. Fischbacher, C. Thöni, and V. Utikal. Affect and fairness: Dictator games under cognitive load. *Journal of Economic Psychology*, 2012.

C. Starmer and R. Sugden. Does the random-lottery incentive system elicit true preferences? an experimental investigation. *American Economic Review*, 81 (4):971–78, 1991.

R. S. Suter and R. Hertwig. Time and moral judgment. *Cognition*, 119(3): 454–458, 2011.

Richard H Thaler, Cass R Sunstein, and John P Balz. Choice architecture. *Working Paper*, 2010.

G. Tinghög, D. Andersson, C. Bonn, H. Böttiger, C. Josephson, G. Lundgren, D. Västfjäll, M. Kirchler, and M. Johannesson. Intuition and cooperation reconsidered. *Nature*, 498(7452):E1–E2, 2013.

A. Tversky and D. Kahneman. The framing of decisions and the psychology of choice. *Science*, 211(4481):453–458, 1981.

S. Volk, C. Thöni, and W. Ruigrok. Temporal stability and psychological foundations of cooperation preferences. *Journal of Economic Behavior & Organization*, 81(2):664–676, 2012.

M. Voors, T. Turley, A. Kontoleon, E. Bulte, and John A. List. Exploring whether behavior in context-free experiments is predictive of behavior in the field: Evidence from lab and field experiments in rural sierra leone. *Economics Letters*, 114(3):308–311, 2012.

J. Zaki and J. P. Mitchell. Intuitive prosociality. *Current Directions in Psychological Science*, 22(6):466–470, 2013.

J. Zelmer. Linear public goods experiments: A meta-analysis. *Experimental Economics*, 6(3):299–310, 2003.