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Instinctiveness and reflexivity in behavioural type variability

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ABSTRACT

Experimental economics uses response times (RTs) to evaluate the instinctiveness of choices and behaviours. The experiment proposed in this paper seeks to provide further results about the correlation between RTs and behaviours. We use a repeated public goods game with random re-matching to study (1) the relationship between response times and the stability of individual behavioural types and (2) the relationship between RTs and contribution variability. We identify three behavioural types in a public goods game - free-riders, unconditional cooperators, and conditional cooperators. To define RTs in a round, we use two distinct measures: the time the subject takes to review the previous round's results and the time the subject takes to choose the contribution to the public good in that round. Experimental evidence suggests that longer RTs are linked to higher variability in both behavioural types and contributions in a public goods game. The results show that conditional cooperation is the most reflexive choice: 1) the time used to see the results of the previous round correlates positively with behavioural type variation; 2) the subjects switching from free-riding to conditional cooperation spend more time than the others also when choosing the amount of their contribution to the public good.

1. Introduction

Since the seminal work by Rubinstein (2007), experimental economics has considered response times (RTs) with ever-increasing interest, and their use in the analysis of experimental results is often recommended (Clithero, 2018).[1] RTs may provide important information concerning the instinctiveness of the decisions made during experiments: the faster the decision, the more instinctive it is (Rubinstein, 2016). In this respect, RTs allow to evaluate how much cognitive effort a decision requires. RTs identify "the temporal process of integrating choice and response time during […] decision making" (Niu et al., 2018, p. 45). Besides, RTs are subjective, varying between individuals, and have been found to correlate with certain behaviours.

The theoretical literature on game theory often identifies "player types", that is, players who share certain characteristics that allow for their classification into a specific behavioural type (see, for example, Osborne & Rubinstein, 1994). For instance, Rubinstein (2007; 2016), Schotter and Trevino (2021) empirically identify contemplative and instinctive subjects in economic experiments using the RTs of the participants. In repeated games, behavioural types may vary (McDonald et al., 2019; Zhang et al., 2021), especially between subsequent rounds of the same game: behavioural types may not be stable and different players may exhibit different degrees of strategic stability.

Evolutionary game theory uses the concept of behavioural stability, where stability refers to the probability of individuals changing their behavioural types. Within the same public goods game (PGG), a player may either be a free-rider or a conditional or unconditional cooperator (Camerer, 2003). These actions correspond to the three possible behavioural types that may be played in this game. When a player sticks to a given behavioural type during the entire game or most of its rounds, then this behavioural type may be defined as "stable". However, it is often observed that experimental subjects change (i.e. mutate) behavioural type during a repeated game from one round to another. It is important to highlight that the stability of behavioural types does not necessarily coincide with contributing always the same amount to the production of the public good. For example, in repeated PGGs, the average contribution to the common fund may decline with rounds, indicating that at least some participants reduce the amount they

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[1] For an extensive review of the use of RTs' analysis in experiments and its relevance, see Spiliopoulos & Ortmann (2018).

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contribute. However, such a phenomenon may be consistent with conditional cooperation during all the rounds of the game: the behavioural type does not change, but the contributions decrease (i.e. the choices in monetary terms vary).[2]

The experiment proposed in this paper uses a repeated public goods game (PGG) to inquire about the relationship between RTs and behavioural types. The results are the following: 1) the time used to see the results of the past rounds correlates positively with variation in behavioural type; particularly, subjects who switch to or from conditional cooperation spend more time looking at the results of the previous round than the other participants. This suggests that conditional cooperation is the most reflexive choice; 2) the subjects who switch from free-riding to conditional cooperation also spend more time than the others when choosing the amount of their contribution to the public good.[3] In addition, the relationship between RTs and contribution variability is also considered. In this case, subjects who vary their contributions more extensively throughout the game also take more time to decide about their contribution.

The paper is organised as follows: in Section 2, the related literature is reviewed; the definition of behavioural types and stability and the experimental and empirical methodology are described in Section 3; Section 4 gives the results, and Section 5 concludes.

2. Related literature and hypotheses

The economics literature has explored the concept of stability, particularly within evolutionary game theory, examining how subjects' behaviours change dynamically in repeated games. Güth and Nitzan (1997) proposed two theoretical models of preference stability in PGGs. The models consider a population composed of two different behavioural types and its evolution over time. The possibility of mutations of one behavioural type into the other characterises the definition of stability, and the probability of mutation at time t is endogenously determined by the resources earned by the individual in the rounds of the game preceding time t. The authors conclude that, with finite numbers of individuals, the population evolves to a monomorphic one entirely composed of free-riders. However, under certain conditions, preferences for reciprocity remain stable within the population (Guttman, 2000).

Examining the stability of contributions in PGGs allowed Kurzban and Houser (2005) to identify the three player types of conditional and unconditional cooperators and free-riders; the authors concluded that "the human subject population reaches a stable, polymorphic equilibrium of types" (page 1803). However, their analysis focused on subjects' contribution patterns without considering measures of variability. Existing theoretical models consider stability as characteristic of a behavioural type, analysing its survival and evolution within a population. Evolutionary game theory often treats stability as a fixed condition, which opposes mutation: mutation hinders the stability of behavioural types, creating a clear divide between mutants and non-mutants.

One of the main uses of RTs in analysing individual choices has been linked to selfishness. Numerous studies (for a review, see Spiliopoulos & Ortmann, 2018) have found that faster decisions often reflect self-interested choices. This pattern has emerged across various games and contexts. Piovesan and Wengström (2009) find that selfish choices are faster than generous ones in a dictator game. In an ultimatum game, lower RTs are associated with higher offers (Cappelletti et al., 2011). In a pure distribution game, Ubeda (2014) finds that faster decisions are more selfish, with slower subjects more likely to consider moral trade-offs when dividing resources.[4] Similar conclusions were reached in a study on social value orientation, where more individualistic subjects made faster decisions than their prosocial counterparts (Chen & Fischbacher, 2016).

In light of the dual thinking process (Kahneman, 2011), a possible interpretation of RTs can be: fast responses are mostly provided only by system 1 – the intuitive system; RTs are longer when also system 2 – the deliberative system - is activated. Alós-Ferrer and Strack (2014) provide a survey of dual processes in economics and highlight that duality does not mean mutual exclusivity between two processes; rather, it implies continuity between automatic and controlled responses (see also Kruglanski et al., 2006). Nevertheless, Brocas and Carrillo (2014) note that the existence of different processes of decision-making in the human brain and the interaction between them may generate "different selves".

Within the domain of PGGs, empirical investigations have yielded interesting and mixed findings. Lotito et al. (2013) find that faster decisions about how much to contribute to a public good are associated with higher contributions than slower decisions. Lohse et al. (2017), on the contrary, observe a positive relation between RTs and contributions in an experiment about the provision of environmental public goods.

Recalde et al. (2018) show two interesting results: individuals who decide faster are insensitive to monetary incentives, and faster deciders give more than slow ones when the equilibrium of the PGG is below the mid-point of the available decision set, but the result is reversed when the equilibrium point is above the mid-point.[5] This result is interesting, as it highlights that the correlation between RTs and individual behaviour may depend on the context and the rules of the game.

Similarly, Hallsson et al. (2018) show that self-interested behaviours are not always intuitive; in settings where fairness considerations are also involved, there are cases in which selfish decisions are taken more slowly than pro-social choices. Moreover, in repeated games like the PGG, RTs may also decrease because of Bayesian updating. Players may indeed update their beliefs according to what happened in the past rounds, thus reinforcing their heuristics; such a possibility may be mediated by the magnitude of the incentives provided to the players (Alós-Ferrer & Hügelschäfer, 2012).

The most relevant study for the present paper is that of Börger (2016), where the author uses an online choice survey on installing an offshore wind farm in the Irish Sea; participants are asked to choose between different possible designs of the future wind farm, each with different potential impacts on the degree of biodiversity in the sea neighbouring the farm itself. The data were then analysed to understand whether participants expressed consistent choices over the distinct characteristics of the future wind farm, and the RTs were used as one of the control variables. Results show that subjects with longer RTs were more consistent in expressing their preferences, showing a lower variance in their decisions with respect to faster deciders. However, while this study yields relevant insights, it is neither a laboratory nor a field experiment; instead, it is based on an online survey, which extends the field for further exploration within controlled experimental settings.

The literature surveyed above uses RTs either as regressors or dependent variables. In the first case, RTs serve to control for the instinctiveness or reflexivity of decisions taken in the experiment; in the second case, behavioural attributes such as intuitiveness (Artavia-Mora et al., 2017) or speed of cognitive processes (Lohse et al., 2017) are the objects of study and, thus, RTs enter the analyses as the dependent

[2] In a PGG, strategies are used to identify types (Fischbacher et al., 2001). To avoid confusion between behavioural types and strategies, in this paper we will always use the term "behavioural types".

[3] As the next section will highlight, the current state of the art does not allow for a clear hypothesis of whether the link between RTs and behavioural types and switches is causal; therefore, this paper avoids claiming that the results obtained have causal value.

[4] Risk aversion may also play a role; in a "Yes-or-No" game, decisions involving strategic risks require longer RTs, as risk aversion typically leads to less instinctive choices (Brañas-Garza et al., 2017). As payoffs in PGGs depend on the others' decisions, risk aversion may also be present in this context.

[5] It has also been noted that, in different contexts, subjects who make fast decisions are more prone to mistakes, though these fast decisions do not necessarily conflict with standard behavioural theories (Rubinstein, 2013).

variable. The present paper belongs to the second stream of research: RTs are used as the dependent variable, while behavioural types represent the regressors of interest.[6] The existing literature does not provide conclusive evidence about which of these variables should be considered as causing the other(s). On one side, thinking longer may allow people to change their minds more often than reacting instinctively to some stimulus. Conversely, cognitive processes leading to behavioural changes will likely require longer reflection.

In line with the literature, the main hypothesis of this study is that experimental subjects who change their behavioural type spend more time thinking about their contribution in the subsequent round of a PGG than individuals who stick to the same behavioural type.

3. Methodology

3.1. Experimental methodology

The data for this study originate from a traditional PGG repeated over five rounds with anonymous random re-matching after each round (Andreoni, 1988; Botelho et al., 2009). A total of 168 undergraduate students participated in a laboratory experiment divided into eight sessions (six sessions of 20 and two sections of 24 subjects). Participants were recruited online using ORSEE software (Greiner, 2004).[7]

At the beginning of each round, each participant received an endowment of 60 experimental monetary units (EMUs) and was asked how many of these EMUs – between 0 and 60 – she was willing to contribute to a common fund. The EMUs accumulated during one round were not usable in the next. Each participant was also informed that she was part of a group of four people, all sitting in the same room at the same time and that these other three people were asked to make the same choice at the same time as she (i.e. choices were simultaneous and blind with respect to those of the other participants). The subjects were also aware that experimenters would then double the sum of the contributions to the fund and divide the total equally between the four members of the group, independently of the individual contributions. The participants also knew that the game would be repeated five times, and at each time, they would be matched with three other people they had never met in the previous rounds and would not meet in the following ones. This procedure, together with the number of subjects in the sessions, constrained the rounds to a maximum of five. At the end of each round, individuals are shown the value of the common fund and their payoff for the round; however, they are not provided with any information about the individual choices of the other members of the group. At the end of the experiment, all players were paid the total amount they accumulated during the five rounds.

According to these rules, at each round, the individual payoff is equal to

$\pi_{i,n} = e_{i,n} - c_{i,n} + \frac{1}{2}\sum_{j=1}^{4} c_{j,n}$, where $\pi_{i,t}$ is the payoff of the subject at the end of round n, $e_{i,n}$ is the initial endowment of the individual at the beginning of each round, $c_{i,n}$ is her contribution in round n, $c_{j,n}$ are the contributions to the common fund of the other members of the group in round n. The total payoff of the i th participant is, therefore, $\sum_{n=1}^{5} \pi_{i,n}$. Under the assumption that the utility of the subjects depends only on the monetary payoff and all subjects are selfish, aiming at maximising their payoff, the Nash equilibrium of the game is to contribute nothing at each stage. However, the behavioural type that leads to Pareto optimality (i.e., the highest payoff) for all the members of the group is to contribute the entire initial endowment, doubling it.

The random re-matching procedure allows for minimising the interdependence of observations. Although the subjects might be influenced by what the others did in the previous round(s), random re-matching dilutes this effect. Given the purposes of this experiment, random re-matching may substantially reduce conditional cooperation; nevertheless, it allows to make observations as independent as possible, so increasing the dimension of the panel. However, this does not entail the disappearance of conditional cooperation, which may arise because of the existence of self-serving biases (Fischbacher & Gächter, 2010; Boosey, 2017). Indeed, empirical evidence from meta-analyses shows that conditional cooperation also emerges in PGGs with random rematching (Andreoni & Croson, 2008). Consequently, if conditional cooperation emerges in the experimental framework used here, it could be taken as a lower bound for the existence of this behavioural type in PGGs.[8]

3.2. Defining behavioural types and their stability

In the context of a PGG, three behavioural types can be defined: free-riders, who always free-ride (or contribute negligible shares of their initial endowment), no matter the others' contributions; conditional cooperators, who contribute only if the others do and, finally, unconditional cooperators, who contribute, no matter the other participants' contributions.

In the following analysis these three behavioural types are so defined: free riders are those subjects who always contribute 0.[9] Conditional cooperators are those subjects who increase (decrease) their contribution at time t when the value of the common fund has increased (decreased) between time t-2 and t-1. Unconditional cooperators are those subjects whose contributions are strictly positive and barely correlate with the common fund's value in the round before each choice. Such a definition entails some arbitrariness in setting the value of the correlation coefficient under which choices are considered "uncorrelated" with the fund's value in the previous round. We attempted three different thresholds for the empirical analyses: between -0.2 and 0.2, -0.15 and 0.15, and, finally, -0.1 and 0.1. Hence, those individuals for whom correlations between the value of their contributions and the value of the fund lie in one of the intervals stated above were labelled as "unconditional cooperators".

Note that, in the first round, only unconditional free-riders are detectable. Unconditional cooperators and conditional cooperators, who expect others to participate in the provision of the public good, both contribute positive amounts. Instead, they may be disentangled from the second round on, as conditional cooperators will respond to what happened in the first round, modifying contributions accordingly, while unconditional cooperators will not.

Behavioural type stability is defined as the absence of change from one category to another in two subsequent rounds, i.e. a subject who was a (un)conditional cooperator or a free-rider in both rounds *n-1* and *n* is identified as "stable" by a dummy variable taking value 1 if the condition is met and 0 otherwise (i.e. the subject's behavioural type in round n is different from that in round *n-1*). Operationally, this is obtained by subtracting the value of the dummy variable, which identifies the behavioural type of the player in round *n-1* from that in round *n*: if the

[6] However, the analysis in Appendix 1 adopts the other approach and makes behavioural shifts depend on RTs.

[7] The regressions are based on the 160 subjects retained in the most extensive specification. This choice was dictated by homogeneity and comparability between specifications.

[8] The effect of repeating the public goods game on the emergence of conditional cooperation when random rematching is used is debated: according to some studies (e.g., Neugebauer et al., 2009), repeating the game would decrease such behaviour over rounds; instead, according to others (e.g., Chaudhuri et al., 2017) this would not happen. However, a discussion of this issue is outside the scope of the present study.

[9] This may appear to be a very strong definition of free-riders, as, for instance, individuals who always contribute very small amounts may fall in this definition. However, any sum different from 0 would require arbitrary choices, which are, instead, avoided by using such a strong definition of free-riding.

result is equal to 0, the subject did not change her behavioural type from one round to another; if instead, the result is either -1 or 1, she shifted from a behavioural type to another.[10]

An alternative definition of type stability is to consider those subjects stable whose type does not change across all rounds.[11] Under this definition, participants who consistently free-ride or exhibit conditional or unconditional cooperation across all rounds are classified as "stable types". Such a definition is stronger than the one adopted above; therefore, it serves as a lower bound for the results obtained with the previous definition of types. To this end, a dummy variable is created: it takes value 1 if the player adopts the same behavioural type throughout all rounds and 0 if the player changes behavioural type at least once during the game.

As mentioned in the introduction, the empirical analyses presented in the following sections will also provide evidence of the relationship between RTs and contribution variability.

3.3. Empirical methodology

The first aim of this paper is to capture the relationship – if any – between RTs and the stability of individual behavioural types across rounds. To this purpose, in the framework of a PGG, we construct a set of variables that may capture the variability of each subject's choices during the experiment. The use of a PGG for this inquiry presents several advantages, as highlighted by the literature: PGGs typically involve multiple rounds where the game repeats identically, allowing for a clear evolution of subjects' behaviour over time, the rules of the game are easy, and the interpretation of results is relatively simple.

To define RT in round n we use two distinct measures:

1. The time taken by the subject to review the results of round $n-1$ is measured as the number of seconds between the appearance of the results on the screen and the input given by the subject to proceed to the following screen (the decision screen).
2. The time taken to choose the contribution is measured as the time between the appearance of the choice box on the screen and the subject's confirmation of the choice made by clicking the confirmation button.[12]

The rationale for using these two separate measures, rather than only the second one as other authors do (e.g., Lotito et al., 2013; Migheli, 2017; Menietti et al., 2018), lies in the possibility that participants may decide their behavioural type either when they receive information about the previous round or when they make their contribution choice in the new round. By considering both measures of RTs, we aim to explain when individuals are likely to make a decision on the strategy to adopt. Analysing these two distinct RTs allows us to understand the decision-making process in PGGs better.

Another primary aim of this paper is to investigate the relationship between contribution variability and RTs. While previous studies have focused on the stability of contributions, this paper analyses more in detail the cognitive mechanisms underlying the separate choices of behavioural types and contributions in a PGG. To achieve this, measurements of contribution variability are necessary.

1. A simple measure for contribution variability, which allows exploiting the panel dimension of the data, is the absolute difference between $c_{i,t}$ and $c_{i,t-1}$. RTs are regressed against the calculated difference to determine whether larger deviations from the previous choice require more decision time.[13]
2. An alternative measure of contribution variability is the standard deviation of contributions at an individual level. This statistic has the advantage of being widely used and immediately interpretable; however, as each subject is associated with a unique standard deviation, the panel dimension is not exploitable. Nevertheless, the standard deviation has merits in the framework of a PGG. Consider the following cases: an individual who free-rides in four rounds and contributes all the EMUs in the fifth; another who contributes 30 EMUs for four rounds and 0 in the fifth; and yet another who contributes 60 EMUs over four rounds and 0 in the last. Assuming that, in the case of the last two individuals, the contributions of the other members of their groups varied over rounds, they can be classified as unconditional cooperators who free-ride in one round. The respective mean contributions are 12, 24 and 48; the respective standard deviations are 53.67, 26.83 and 53.67. Therefore, the standard deviation allows us to evaluate the same dispersion of contributions equally, independently of the chosen behavioural type. For this reason, in the following analyses, we will also present regressions, where the standard deviation of individual contributions is used as the dependent variable. However, as panel regressions with individual fixed effects cannot be employed, to account for subjective observable and unobservable characteristics, we base estimates on multilevel regressions with random intercepts at session and individual levels (Moffatt, 2016).

A definition of the different behavioural types was given in Section 3.2 above. Note that an individual is classified as a conditional cooperator if she increases her contribution when this is below the mean of the others' contributions in the previous round and decreases it when it is above. While using the mean as a threshold is an arbitrary choice, it is practical, given the information provided to the subjects at the end of each round—namely, the fund's value—which allows a reasonably accurate calculation of the mean of others' contributions.[14]

In the analyses, we use panel multilevel regressions with standard errors clustered at the session level.[15] This approach is particularly advantageous in handling the panel structure of the data, as it accommodates the repeated measures design of PGG. It also enhances the

[10] While it is true that the distribution of behavioural types may be continuous, i.e. behavioural types may be contiguous (Friedman & Sing, 2009; Cardaliaguet & Rainer, 2012 and Rabanal, 2017), this paper relies on the traditional discrete categorisation for PGGs.

[11] We wish to thank an anonymous referee for suggesting this definition of stability.

[12] Although these two measures of RT are positively correlated (correlation coefficient: 0.36, p-value < 0.001), they are not identical. Therefore, they will be used as separate dependent variables in the econometric analyses.

[13] The absolute value of this deviation is considered, since participants may increase or decrease their contributions from one round to the next. The same variable enters the regressions in its original (i.e., non-transformed) value too. This measure is less representative of the subject's behavioural type stability than the other measure which follows – at least when the definition of stability in section 3.2 holds.

[14] Given these definitions, the classification of individuals whose contributions equal the mean contributions of other group members remains ambiguous. To minimise arbitrariness and adhere to the established methodology, such cases are classified as conditional cooperators in the regressions. To account for the possibility that contributions exactly equal to the mean of others' contributions were unattainable (because they were non-integer numbers), all integer contributions that represented an upper or lower rounding of the mean were classified as representing conditional cooperators.

[15] The random effects are calculated as random intercepts at the session level and random slopes at the individual level. The random intercepts at the session level capture the overall effect of being in a particular session, while the random slopes at the individual level account for the variability in responses within the same individual across different rounds. This methodological choice ensures that the variability in contributions is examined across individuals and within individuals over different sessions. By clustering standard errors at the session level, we mitigate the potential bias that might arise from session-specific influences.

Table 1
Descriptive statistics.

	Mean	Standard deviation	Minimum	Maximum
Panel A: data collapsed at individual level				
Time used to see the results of the previous round	79.847	14.103	12.00	100.00
Time to choose the contribution	27.722	20.441	3.4	116.4
Average individual contribution	32.939	17.484	0	60
Standard deviation of individual contributions	17.484	10.668	0	32.863
Mean value of the fund	135.26	36.377	55.6	355.2
Males (as percentage of the sample)	57.50			
Free riders (as percentage of the sample)	16.75			
Conditional co-operators (as percentage of the sample)	52.38			
Full co-operators (as percentage of the sample)	30.87			
Number of observations:	160			
Panel B: full panel dataset				
Difference of individual's contribution from her mean	0	15.947	-48	48
Difference of individual's contribution from the group's mean	-1.168	27.171	-60	60
Difference of individual contribution from her median	2.939	23.331	-30	30
Difference of individual's contribution from her contribution in the previous round	-2.880	22.335	-60	60
Number of observations:	800			

Note: the values of the dummy variables do not change from one sample definition to the other, by construction.

Table 2
Number of subjects by behavioural type and round.

<table>
<tr><th></th><th colspan="5">Round</th></tr>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>Free riders</td><td>14</td><td>20</td><td>30</td><td>32</td><td>39</td></tr>
<tr><td>Conditional cooperators</td><td rowspan="2">154</td><td>131</td><td>122</td><td>118</td><td>112</td></tr>
<tr><td>Unconditional cooperators</td><td>17</td><td>16</td><td>18</td><td>17</td></tr>
<tr><td>Subjects always free riding</td><td colspan="5">8 (5 %)</td></tr>
<tr><td>Subjects always conditionally cooperating</td><td colspan="5">90 (53.6 %)</td></tr>
<tr><td>Subjects always unconditionally cooperating</td><td colspan="5">0</td></tr>
</table>

reliability of the findings by addressing potential within-subject correlations and session-level dependencies. Moreover, these multilevel models enable a detailed analysis of contribution variability, providing insights into how individual behaviours change over time and under varying experimental conditions. This is crucial for understanding the cognitive processes underlying decision-making in PGGs and identifying patterns of conditional and unconditional cooperation and free-riding tendencies. Compared to regressions with individual fixed effects, these techniques offer an alternative approach to account for heterogeneity between subjects, thereby allowing for a robust testing of the results. In the analyses, gender along with a trend variable, the lagged values of the common fund, and the average contributions of other group members in the previous round serve as control variables.

Table 1 presents the descriptive statistics and the results discussed in the following section. The table is divided into two panels: the upper panel reports descriptive statistics for the dataset collapsed at the individual level, while the lower panel displays the same statistics for the full panel data, uncollapsed. The figures reveal a large variability in both RTs. The sample is nearly gender-balanced (males are slightly more prevalent). The negative mean of the difference between an individual's contribution in round n and that in round n-1 reflects the typical decrease of cooperation over rounds.

Table 2 presents the distribution of subjects by behavioural type and round.[16] Consistent with typical patterns observed in PGGs, the frequency of free riders increases over time while the total number of cooperators decreases. Specifically, the number of conditional cooperators decreases continuously. The overall decline in cooperators is almost entirely due to a decrease in the number of this type of player. Notably, conditional and unconditional cooperators cannot be distinguished in the first round.

Table 3 proposes the transition probabilities from one type to another in the three last rounds of the game. The decimal numbers in the tables represent shares, while the corresponding absolute numbers are in parentheses.[17]

Table 3
Transition matrix of behavioural types.

	Free rider	Conditional cooperator	Unconditional cooperator
Share in round 3			
Free rider	0.80 (16)	0.15 (3)	0.05 (1)
Conditional cooperator	0.11 (13)	0.90 (112)	0.06 (7)
Unconditional cooperator	0.06 (1)	0.44 (7)	0.50 (8)
Share in round 4			
Free rider	0.57 (17)	0.33 (10)	0.10 (3)
Conditional cooperator	0.11 (14)	0.84 (102)	0.05 (6)
Unconditional cooperator	0.06 (1)	0.37 (6)	0.56 (9)
Share in round 5			
Free rider	0.63 (20)	0.31 (10)	0.06 (2)
Conditional cooperator	0.14 (16)	0.82 (97)	0.04 (5)
Unconditional cooperator	0.17 (3)	0.28 (5)	0.56 (10)

Decimal figures in cells are shares, integers in parentheses are absolute numbers. Initial behaviours are listed in the first column, so that each cell contains the share of individuals, who either kept the initial behaviour or switched to one of the other two. Transitions from round 1 to round 2 are not calculable, because of the impossibility of disentangling conditional and unconditional cooperators in round 1.

The matrix shows that, in general, most of the subjects did not switch from one behavioural type to another between two subsequent rounds.

[16] As explained above, all the players contributing the average contribution to the common fund in the previous round are classified as conditional cooperators.

[17] For the sake of presenting a clear transition matrix, players who contributed exactly the average value of the common fund in the previous round are univocally classified as conditional cooperators. However, to minimise arbitrariness in the regression analyses, a slightly looser definition was adopted.

Table 4
Time spent to choose the contribution to the common fund and contribution difference between two subsequent rounds.

	(1)	(2)	(3)	(4)	(5)	(6)
Absolute difference between the contributions in two subsequent rounds	0.0957 (0.0642)	0.0999 (0.0656)	0.0962 (0.0633)	0.0987 (0.0660)	0.106** -0.0537	0.108** -0.0532
Time spent looking at the results of the previous round					-0.593*** (0.0778)	-0.593*** (0.0778)
Value of the common fund in the previous round			-0.0123 (0.0277)	-0.0232 (0.0265)	-0.0185 (0.0253)	-0.0193 (0.0245)
Round		-2.055* (1.050)		-2.265** (1.087)	0.0859 (1.087)	0.0597 (1.095)
Male						2.827 (3.406)
Constant	23.99*** (2.472)	31.13*** (4.681)	25.60*** (5.288)	35.03*** (6.948)	72.69*** (5.346)	71.23*** (5.297)
Standard deviation of the intercepts (by session)	3 × 10e-5	3 × 10e-5	5.3–10e-6	2.5 × 10e-6	0.0036	0.0017
Standard deviation of the intercepts (by subject)	5.286	5.290	5.210	5.176	3.253	3.389
Standard deviation of the residuals	25.15	25.05	24.96	24.84	23.66	23.62
Log-pseudolikelihood	-2973.55	-2970.88	-2964.00	-2960.88	-2927.54	-2926.47
Number of subjects	160	160	160	160	160	160

Multilevel panel OLS estimates: coefficients and standard errors between brackets.
Dependent variable: seconds spent to choose the contribution to the common fund.
*** p-value ≤ 0.01.
** $0.01 < p$-value ≤ 0.05.
* $0.05 < p$-value ≤ 0.1.

Consistently with what is generally observed in PGGs, the share of (conditional or unconditional) cooperators switching to free-riding is higher in the last round.

4. Results

This section presents the regressions of the two partial decision times either on contribution variability or behavioural switches between types in each round.

4.1. RTs and contribution variability

The first part of the analysis explores the relationship between the contribution variability and the time subjects spend deciding their contribution. Specifically, we regress the time spent to choose the contribution on the absolute difference between contributions in successive rounds. The tables relative to multilevel regressions report also the standard deviation of intercepts and residuals: the first two are measures of intra-session and subject variability. In particular, the standard deviation of intercepts by session shows whether people in different sessions behaved in a significant different way. The smaller its size, the more similar the average subjects' behaviour, suggesting that the participants' relevant traits were identically distributed across sessions. Finally, the standard deviation of the residuals represents the dispersion of the error term of the regression. Table 4 reports the results of the multilevel panel estimates, with random slopes for individuals and random intercepts at the session level.

Differences in contribution and decision times are positively correlated, though the relationship is not consistently robust across all specifications. However, the coefficients are statistically significant in the more complete specifications, suggesting that in specifications (1)-(4), the effect of the variation in the contribution also includes the influence of some other control variable. The data suggests that significant changes in contributions from one round to the following one require a more extended reflection, suggesting that behavioural variability is more thought-out than instinctive.

Table 5 extends the same analysis by using the standard deviation of individual contributions. Given that there is only one value of the standard deviation of the individual contributions, the estimates are derived from multilevel pooled OLS. The results confirm the previous findings: the coefficient for the standard deviation of the contributions is statistically significant in all specifications. This clearcut result shows that subjects who varied their contributions more extensively throughout the game also took more time to make their decisions, reinforcing the notion that such behaviour is reasoned rather than instinctive.

The second component of the total decision time is the time spent in front of the screen presenting the results of the previous round. In this phase, subjects see the total value of the fund, resulting from the contributions of all the members of the group, and think about whether they wish to change their behaviour. As above, we examine as regressors the absolute difference between the contributions in two subsequent rounds (Table 6) and the standard deviation of the individual contributions (Table 7).

In this case, no statistically significant coefficient for the variable of interest is found. Hence, it seems that the size of the change in the subjects' contributions does not correlate with the time spent looking at the round results. This finding suggests that decisions regarding contribution amounts are taken in front of the decision screen when subjects are asked to choose. An interesting result is that the time spent reviewing the results increases with the rounds (Table 6). This trend may suggest that subjects make an effort to compare the just-ended round with the preceding one, which increases as the game proceeds.

4.2. RTs and behavioural type changes

Our analyses have so far focused on one way to look at the possible behavioural changes: the variability in the contributions to the public good. Although it provides useful information, this approach overlooks behavioural types and the potential switches between them (see 3.2 for a definition of the three different behavioural types in a PGG). The variability in the contributions may derive either from the choices of conditional cooperators or from changes from one behavioural type to another.

If behavioural changes correlate with decision times and are thought-out rather than instinctive, subjects who change their behavioural type should spend more time deciding their contributions compared to those who maintain the behavioural type of the previous round. Hence, comparing the decision times of switchers with those of

Table 5
Time spent to choose the contribution to the common fund and standard deviation of the individual contributions during the game.

	(1)	(2)	(3)	(4)	(5)	(6)
Standard deviation of the individual contributions	0.243***	0.242***	0.236*	0.233*	0.211*	0.221**
	(0.0907)	(0.0908)	(0.129)	(0.130)	(0.116)	(0.103)
Average time spent looking at the results					-0.586***	-0.549***
					(0.0777)	(0.0784)
Average value of the common fund			-0.0126	-0.0232	-0.0187	-0.0228
			(0.0262)	(0.0248)	(0.0239)	(0.0232)
Male						3.540
						(3.176)
Constant	24.30***	34.38***	23.70***	32.97***	70.59***	78.17***
	(3.036)	(4.012)	(5.100)	(6.971)	(6.228)	(7.461)
Standard deviation of the intercepts (by session)	1 × 10e-5	8.6 × 10e-6	1.3 × 10e-6	1.4 × 10e-6	4.4 × 10e-7	2.3 × 10e-8
Standard deviation of the intercepts (by subject)	5.023	5.046	5.025	5.005	3.187	3.391
Standard deviation of the residuals	25.90	25.46	24.92	24.80	23.64	23.39
Log-pseudolikelihood	-3735.49	-3721.94	-2962.56	-2959.59	-2926.92	-2920.40
Number of subjects	160	160	160	160	160	160

Multilevel OLS estimates: coefficients and standard errors between brackets.
Dependent variable: average seconds spent to choose the contribution during the game.
*** p-value ≤ 0.01.
** $0.01 < p$-value ≤ 0.05.
* $0.05 < p$-value ≤ 0.1.

non-switchers should result in positive coefficients for the dummy variables representing behavioural changes.[18]

The following analyses employ a dummy variable for each potential behavioural type switch, taking the absence of any switch as the reference category. This approach enables us to explore the impact of behavioural switches on decision times in the context of the PGG. As above, the analysis first considers the time spent in deciding the contribution; Table 8 provides the results of multilevel panel estimations.

The results here show that subjects who switched from free-riding to conditional cooperation spent a longer time in front of the decision screen (in one specification, the coefficient for subjects who switched from conditional cooperation to free-riding is also statistically significant and positive). Apparently, abandoning purely selfish behaviour to adopt a cooperative attitude, though conditioned to others' choices, takes longer. The size of this effect, measured by the increase in decision time (in seconds), varies across specifications, particularly in response to the time spent looking at the results of the previous round: a positive and statistically significant correlation exists. This suggests that when the time spent looking at the previous round's results is not present in the analysis, the coefficient for the transition dummy partly reflects the additional time allocated to this process. However, the sign and statistical significance of the transition dummy across specifications shows that subjects switching from free-riding to conditional cooperation consistently require more time to make their decisions, confirming the stronger cognitive effort during decision-making that this shift requires.

Analysing the time spent looking at the results may help better understand the results in Table 8. On the one hand, the effect of this time on the coefficient of the behavioural switch from free-riding to conditional cooperation suggests that part of the decision to change behaviour is also taken in front of the screen that presents the results of the past round.[19] On the other hand, a correlation between the two RTs may affect the analysis of decision times.[20]

Table 9 presents the regression results using the time spent to look at the result. Interestingly, for three specific behavioural type switches, changing requires more time than sticking to the current behavioural type or undergoing any other change: free riders who become conditional cooperators and viceversa, and unconditional cooperators who become conditional cooperators.

In all these three cases, conditional cooperation is involved, suggesting that: 1) the statistically significant results depend on these three switches in behavioural type; 2) conditional cooperation is the most reflexive behaviour; and 3) this may derive from the need to think of the others' contributions (i.e., performing mental calculations) before choosing one's own. Moreover, in the case of subjects switching from free-riding to conditional cooperation, the decision also requires spending time in front of the decision screen.[21] This means that this behavioural change is the most reflexive among all of those involved in a PGG.[22]

Results in Tables 8 and Table 9 also suggest that the decision to switch from free-riding to conditional cooperation is taken in two steps: first in front of the screen summarising the results and then in front of the decision screen. A possible interpretation could be that people first decide to change their behaviour and then think about the amount of their contribution.

4.3. A stronger definition of type stability

Tables 10 and Table 11 present the results of regressions using the strong definition of type stability provided at the end of Section 3.2: the

[18] It is worth noting that some behavioural changes of types may be more radical than others; for example, switching from free riding to unconditional cooperation signifies a more pronounced decision shift than switching from free riding to conditional cooperation. Unfortunately, the existing literature does not provide a ranking of behavioural switches in terms of RTs.

[19] Appendix 2 provides some additional inquiry into this aspect.

[20] Given the experimental setup, where the screen with the results of the previous round precedes the contribution decision screen, the time spent making the decision cannot affect the time spent looking at the results.

[21] In addition, while not robust in two out of three specifications, free riding after conditionally cooperating also requires some more additional time to choose the contribution.

[22] Krajbich et al. (2015) caution against using response times (RTs) to infer the reflexiveness or intuitiveness of behaviours in Public Goods Games (PGGs) due to potential changes in the attractiveness of given choices and the speed of their adoption, which may arise from different parameters within the game setup. While acknowledging the relevance of this methodological issue, we note that our study focuses on examining the relationship between RTs and the stability of behavioural types within a PGG, using a standard set of parameters in a given experimental game setting.

Table 6
Time spent looking at the results of the previous round and contribution difference between two subsequent rounds.

	(1)	(2)	(3)	(4)	(5)	(6)
Absolute difference between the contributions in two subsequent rounds	-0.0389	-0.0425	-0.0412	-0.0435	-0.0268	-0.0259
	(0.0368)	(0.0389)	(0.0360)	(0.0383)	(0.0299)	(0.0303)
Time spent to choose the contribution					0.154***	0.155***
					(0.0400)	(0.0402)
Value of the common fund in the previous round			-0.0124	-0.00563	-0.00812	-0.00862
			(0.00793)	(0.00715)	(0.00738)	(0.00715)
Round		1.643***		1.586***	1.239***	1.227***
		(0.293)		(0.293)	(0.303)	(0.308)
Male						0.918
						(0.839)
Constant	82.62***	77.02**	84.42***	78.03***	64.74***	64.23***
	(1.547)	(1.722)	(1.786)	(1.879)	(3.624)	(3.736)
Standard deviation of the intercepts (by session)	7.2 × 10e-7*	1.7 × 10e-6	1.7 × 10e-6	2.8 × 10e-6	1.6 × 10e-9	1.5 × 10e-10
Standard deviation of the intercepts (by subject)	3.610	3.478	3.607	3.481	2.691	2.697
Standard deviation of the residuals	12.35	12.22	12.34	12.23	11.65	11.65
Log-pseudolikelihood	-2442.28	-2435.68	-2437.96	-2432.06	-2401.07	-2400.62
Number of subjects	160	160	160	160	160	160

Multilevel panel OLS estimates: coefficients and standard errors between brackets.
Dependent variable: seconds spent looking at the results of the previous round.
*** p-value ≤ 0.01.
** $0.01 < p$-value ≤ 0.05.
* $0.05 < p$-value ≤ 0.1.

Table 7
Time spent looking at the results of each round and standard deviation of individual contributions.

	(1)	(2)	(3)	(4)	(5)	(6)
Standard deviation of individual contributions	-0.0326	-0.0302	-0.0465	-0.0448	-0.0116	-0.0114
	(0.0612)	(0.0611)	(0.0522)	(0.0531)	(0.0395)	(0.0418)
Average time used to choose the contribution					0.155***	0.156***
					(0.0405)	(0.0408)
Average value of the fund			-0.0118	-0.00506	-0.00771	-0.00824
			(0.00804)	(0.00732)	(0.00763)	(0.00739)
Male						0.950
						(0.846)
Constant	80.16**	70.71***	84.42***	78.05***	64.43***	63.91***
	(1.819)	(2.083)	(1.793)	(1.968)	(3.677)	(3.785)
Standard deviation of the intercepts (by session)	3.5 × 10e-8*	8.6 × 10e-8	1.8 × 10e-6	2.1 × 10e-6	7.4 × 10e-10	2.7 × 10e-7
Standard deviation of the intercepts (by subject)	3.440	3.187	3.579	3.459	2.694	2.700
Standard deviation of the residuals	13.66	12.93	12.35	12.24	11.66	11.65
Wald chi-squared	0.28	113.64	5.30	40.47	158.03	317.63
Log-pseudolikelihood	-3146.14	-3102.74	-2438.59	-2432.86	-2401.55	-2401.07
LR-test chi-squared	0.594	0.000	0.071	0.000	0.000	0.000
Number of subjects	160	160	160	160	160	160

Multilevel OLS estimates: coefficients and standard errors between brackets.
Dependent variable: average seconds spent looking at the results of the round.
*** p-value ≤ 0.01.
** $0.01 < p$-value ≤ 0.05.
* $0.05 < p$-value ≤ 0.1.

dependent variables are the time spent choosing the contribution in each round and the spent looking at the results of the previous round, respectively. Instead, the main regressor of interest is the dummy identifying type stability. The analysis is again based on multilevel panel regressions.

Table 10 shows that stable behavioural types were, on average, faster than unstable types in making their decision about how much to contribute to the public good. The coefficient for the dummy is always negative and statistically significant, although the magnitude decreases when more controls are added.

Table 11 presents the results of the regressions where the time spent looking at the results of the previous round is the dependent variable. In this case, the coefficient for the dummy capturing behavioural stability is never statistically different from zero, indicating that stable types do not spend an amount of time different from the other types in front of the screen reporting the results. Therefore, while the figures in Table 10 confirm the earlier results, those in Table 11 do not. However, such a difference may depend on the stronger definition of type stability adopted in the regressions in Table 11.

5. Conclusions

Starting from the well-established interpretation of RTs in experiments as a measure of instinctiveness in decision-making, this paper presents evidence that longer RTs are linked to higher variability in behavioural types and contributions in a PGG game. While the existing literature has examined RTs in relation to various experimental outcomes in economics, RTs have rarely been used to study the stability of behavioural types in repeated games. The empirical analysis undertaken in this study seeks to fill this gap by investigating whether the stability of behavioural types arises from instinctive or deliberate responses within the experimental setting of a repeated PGG.

Table 8
Time spent to choose the contribution to the public good and behavioural switches from the previous round.

	(1)	(2)	(3)
Male		-4.076	-3.325
		(3.311)	(3.364)
Time to look at the results of the previous round			0.546***
			(0.0801)
Behavioural switches between rounds (reference category: no switch)			
from free rider to unconditional cooperator	-0.388	-0.723	-7.391
	(13.84)	(13.75)	(15.49)
from free rider to conditional cooperator	8.810***	11.38***	5.517**
	(3.069)	(3.269)	(2.617)
from unconditional cooperator to free rider	3.358	3.015	2.466
	(7.151)	(6.958)	(5.841)
from conditional cooperator to free rider	2.325	4.729**	0.281
	(1.936)	(2.283)	(2.817)
from conditional cooperator to unconditional cooperator	-6.061	-4.895	-3.600
	(10.34)	(10.38)	(10.86)
from unconditional cooperator to conditional cooperator	0.547	2.255	-3.539
	(7.976)	(8.287)	(7.709)
Constant	92.13***	98.02***	46.22***
	(2.341)	(2.974)	(8.101)
Standard deviation of the intercepts (by session)	7.4 × 10e-5*	6.26×10e-6	2.11×10e-7
Standard deviation of the intercepts (by subject)	5.160	5.021	3.426
Standard deviation of the residuals	25.94	25.72	23.36
Log-pseudolikelihood	-3736.78	-3729.76	-2919.74
Number of subjects	160	160	160

Multilevel panel OLS estimates: coefficients and standard errors between brackets.
Dependent variable: seconds spent to choose the contribution in each round.
*** p-value ≤ 0.01.
** $0.01 < p$-value ≤ 0.05.
* $0.05 < p$-value ≤ 0.1.

The results suggest that the decision to switch from free-riding to conditional cooperation requires more reflection than any other switch in behavioural type. In any case, whenever the decision involves conditional cooperation, the total decision time is longer than in all the other scenarios. Moreover, type stability generally correlates with shorter decision times, suggesting that changing behaviour between rounds requires more reflection than sticking to a particular choice.

The evidence suggests that decisions involving conditional cooperation may be influenced by insights gathered from reviewing the outcomes of the previous round, indicating a multi-stage decision-making process. In the case of change from free-riding to conditional cooperation, the decision to switch is apparently taken when looking at the previous round's results and choosing the contribution in the present round. Free-riding after conditionally cooperating correlates positively with the time spent looking at the results of the previous round; only in one specification out of three the positive correlation with the time spent to choose the contribution is statistically significant. Finally, the subjects make the decision to switch from unconditional to conditional cooperation when looking at the results of the previous round. These results suggest that people tend to form their decisions more often when information about what happened is disclosed than when they have to choose the contribution. However, such a result could depend on the fact that individuals in a repeated PGG know that the decision task follows the informative screen. In other words, they may anticipate the decision they will have to take immediately after because they know the steps required for the decision process.

Table 9
Time spent looking at the results of the previous round and behavioural switches from the previous round.

	(1)	(2)	(3)
Male		0.376	0.741
		(0.599)	(0.517)
Time to choose the contribution			0.170***
			(0.0323)
Behavioural switches between rounds (reference category: no switch)			
from free rider to unconditional cooperator	2.445	1.961	2.219
	(5.068)	(5.138)	(3.906)
from free rider to conditional cooperator	8.306***	9.149***	7.308***
	(1.777)	(1.224)	(1.388)
from unconditional cooperator to free rider	2.568	2.539	0.788
	(4.133)	(4.208)	(3.031)
from conditional cooperator to free rider	4.844***	5.310***	4.335***
	(1.049)	(1.067)	(1.279)
from conditional cooperator to unconditional cooperator	-3.710	-3.454	-2.415
	(3.447)	(3.284)	(3.216)
from unconditional cooperator to conditional cooperator	4.493**	4.900**	5.105***
	(1.894)	(2.048)	(1.174)
Constant	79.11***	79.93***	57.96***
	(1.420)	(1.980)	(2.930)
Standard deviation of the intercepts (by session)	1.81×10e-9*	2.59×10e-8	6.62×10e-10
Standard deviation of the intercepts (by subject)	3.403	3.268	2.716
Standard deviation of the residuals	13.51	13.48	12.63
Log-pseudolikelihood	-3137.21	-3135.83	-3083.84
Number of subjects	160	160	160

Multilevel panel OLS estimates: coefficients and standard errors between brackets.
Dependent variable: seconds spent looking at the results of the previous round.
*** p-value ≤ 0.01.
** $0.01 < p$-value ≤ 0.05.
* $0.05 < p$-value ≤ 0.1.

These behavioural changes are responsible for the results (presented in the first part of the empirical analysis) which highlight that deviating from the behavioural type previously adopted requires cognitive efforts, which relate to longer RTs observed.

Overall, the results indicate that behavioural type stability is more instinctive than behavioural type switching, suggesting that behavioural types generate spontaneous behaviours, while deviations require cognitive effort. Moreover, the experiment's results also show that decisions on the behavioural type to adopt in a round and the amount to contribute in the same round are taken in two different game moments. This suggests that, while correlated, the two decisions are (at least partially) independent. Further research should investigate the relationship between RTs and behavioural types in other decision contexts. In addition, given the lack of robustness of the results concerning the time spent looking at the results of the past round, additional theoretical and empirical efforts are needed to define behavioural stability better and to design experiments to identify and measure it.

CRediT authorship contribution statement

Gianna Lotito: Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Matteo Migheli:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Guido Ortona:** Writing – original draft, Methodology, Funding acquisition, Conceptualization.

Table 10
Time spent to choose the contribution and strong type stability.

	(1)	(2)	(3)	(4)
Stable type	-6.110***	-6.645***	-4.629**	-4.563**
	(1.928)	(1.881)	(2.231)	(2.217)
Time spent looking at the results of the previous round			-0.592***	-0.592***
			(0.0777)	(0.0775)
Value of the common fund in the previous round		-0.0191	-0.0226	-0.0232
		(0.0276)	(0.0254)	(0.0248)
Male				2.733
				(3.513)
Constant	25.72***	28.33***	73.85***	72.49***
	(2.250)	(5.390)	(5.176)	(5.359)
Standard deviation of the intercepts (by session)	2.2 × 10e-4*	2.6 × 10e-6	0.007	8.0 × 10e-7
Standard deviation of the intercepts (by subject)	5.21	5.09	3.12	3.36
Standard deviation of the residuals	25.17	24.97	23.72	23.48
Log-pseudolikelihood	-2973.77	-2964.04	-2928.85	-2922.72
Number of subjects	160	160	160	160

Multilevel panel OLS estimates: coefficients and robust standard errors between brackets.
Dependent variable: seconds spent to choose the contribution during the game.
*** p-value ≤ 0.01.
** 0.01 < p-value ≤ 0.05.
* 0.05 < p-value ≤ 0.1.

Table 11
Time spent looking at the results of the previous round and strong type stability.

	(1)	(2)	(3)	(4)
Stable type	2.392	2.114	-0.380	-0.351
	(1.882)	(1.878)	(1.819)	(1.801)
Time spent choosing the contribution in the same round			-0.156***	-0.157***
			(0.0406)	(0.0409)
Value of the common fund in the previous round		-0.0102	-0.00779	-0.00831
		(0.00818)	(0.00737)	(0.00715)
Male				0.949
				(0.833)
Constant	81.93***	83.41**	82.87***	82.48***
	(1.495)	(1.845)	(2.037)	(2.203)
Standard deviation of the intercepts (by session)	1.3 × 10e-7*	1.1 × 10e-6	1.6*e10–6	1.6 × 10e-11
Standard deviation of the intercepts (by subject)	3.58	3.52	2.72	2.99
Standard deviation of the residuals	12.35	12.25	11.65	11.58
Log-pseudolikelihood	-2442.49	-2433.27	-2401.08	-2397.98
Number of subjects	160	160	160	160

Multilevel panel OLS estimates: coefficients and robust standard errors between brackets.
Dependent variable: seconds spent to choose the contribution during the game.
*** p-value ≤ 0.01.
** 0.01 < p-value ≤ 0.05.
* 0.05 < p-value ≤ 0.1.

Appendix 1: Another way to consider the relationship between behavioural types and RTs

In this appendix, an alternative approach is explored to analyse the relationship between Reaction Times (RTs) and behavioural switches, as well as contribution variability. Rather than RTs serving as the dependent variable, the focus shifts to using measures of contribution variability or dummies capturing behavioural changes as dependent variables, with RTs as the regressors of interest.

To operationalize behavioural type stability, we generate dummies capturing shifts in behavioural types from one round to another. These changes are captured through two approaches: firstly, dummies denote shifts to specific behavioural types from other types in the previous round; secondly, they indicate any change in behavioural type between consecutive rounds. The subsequent tables present regression estimates obtained using various specifications to ensure robustness. To account for different decision time scales, RTs are included in absolute or logarithmic terms. The logarithmic specification particularly adjusts for variations in time differences, weighting them differently based on decision times.

Table A1 shows regression estimates where the dependent variable is a dummy, taking value 1 when the subject changes behavioural type from round *n-1* to round *n*, no matter the behavioural type chosen in the latter round.

Table A1
Response times and changes from any behavioural type to another.

Specifications	(1)	(2)	(3)	(4)	(5)
Time to choose the contribution	0.992	0.999	0.997	0.997	
	(0.00603)	(0.00700)	(0.00699)	(0.00700)	
Time used to see the results of the previous round	1.041***	1.060***	1.054***	1.037**	
	(0.0119)	(0.0141)	(0.0147)	(0.0153)	
Logarithm of the time to choose the contribution					0.853
					(0.156)
Logarithm of the time used to see the results of the previous round					11.88**
					(11.86)
Fund increased in the previous round (dummy = 1 if yes)			0.271***	0.418***	0.417***
			(0.0744)	(0.121)	(0.121)
Free rider in the previous round (dummy = 1 if yes)		0.0437***	0.0229***	0.00950***	0.00991***
		(0.0290)	(0.0162)	(0.00810)	(0.00842)
Unconditional co-operator in the previous round (dummy = 1 if yes)		0.0269***	0.0141***	0.00415***	0.00360***
		(0.0236)	(0.0125)	(0.00430)	(0.00374)
Round fixed effects	NO	NO	NO	YES	YES
Likelihood ratio chi-squared	14.28	72.35	97.84	109.78	111.45
Log-likelihood	-142.15	-113.13	-100.37	-94.90	-93.57
Observations	398	398	398	398	398
Number of subjects	100	100	100*	100	100

Notes: Dependent variable: changing type (dummy = 1 if the individual changed from a type to another). Odds ratios after panel logit estmates with fixed effects at individual level. Standard errors in brackets. Times are recorded in seconds.
*** p-value $\leq$ 0.01.
** 0.01 < p-value $\leq$ 0.05.
* 0.05 < p-value $\leq$ 0.1.

The results presented in Table A1 show that the likelihood of changing behavioural type is positively correlated to the time spent reviewing the results of the previous round while it does not depend on the time spent to decide the amount of the contribution. Notably, even with the logarithmic transformation of the regressor of interest, this finding persists, suggesting that subjects who spend more time reflecting upon the preceding round's outcomes are more inclined to adjust their behavioural type accordingly. However, given that three distinct behavioural types are possible in a PGG, this analysis does not delineate potential heterogeneity in how reaction times influence the selection of different behavioural types.

Table A2 presents the panel regressions, which use dummies that capture changes from one behavioural type to another specific behavioural type as dependent variables.

Table A2
Response times and changes from a behavioural type to another.

Specifications	(1)			(2)			(3)		
Change from another strategy to	Freeriding	Conditional co-operator	Unconditional co-operator	Free riding	Conditional co-operator	Unconditional co-operator	Free riding	Conditional co-operator	Unconditional co-operator
Time to choose the contribution	1.005	0.991	0.986	1.003	0.993	1.003			
	(0.00915)	(0.00566)	(0.0171)	(0.00947)	(0.00573)	(0.0227)			
Time used to see the results of the previous round	1.056***	0.971***	0.955	1.046**	0.974***	1.021			
	(0.0189)	(0.00805)	(0.0290)	(0.0185)	(0.00840)	(0.0337)			
Logarithm of the time to choose the contribution							0.688*	1.489***	0.895
							(0.143)	(0.219)	(0.565)
Logarithm of the time used to see the results of the previous round							18.72**	0.299**	3.004
							(24.21)	(0.150)	(6.186)
Fund increased in the previous round (dummy = 1 if yes)				0.455**	1.197	0.266	0.431**	1.210	0.255
				(0.151)	(0.226)	(0.231)	(0.145)	(0.228)	(0.220)
Free rider in the previous round (dummy = 1 if yes)				0.961	0.774	0.00842***	0.919	0.758	0.00872**
				(0.399)	(0.300)	(0.0155)	(0.375)	(0.290)	(0.0164)
Unconditional co-operator in the previous round (dummy = 1 if yes)				1.400	0.351	0.00770***	1.271	0.368	0.00765***
				(1.217)	(0.232)	(0.0113)	(1.081)	(0.242)	(0.0119)
Likelihood ratio chi-squared	12.12	17.52	4.09	18.76	21.89	28.17	22.22	24.97	28.04

(continued on next page)

Table A2 (*continued*)

Specifications	(1)			(2)			(3)		
Change from another strategy to	Freeriding	Conditional co-operator	Unconditional co-operator	Free riding	Conditional co-operator	Unconditional co-operator	Free riding	Conditional co-operator	Unconditional co-operator
Log-likelihood	-69.68	-205.81	-23.15	-65.85	-203.63	-11.10	-64.12	-202.09	-11.17
Observations	196	570	68	196	570	68	196	570	196
Number of subjects	49	143	17	49	143	17*	49	143	17

Notes: Dependent variable: changing strategy from a strategy to that indicated in column. Odds ratios after panel logit estimates with fixed effects at individual level. Standard errors in brackets. Times are recorded in seconds.
*** p-value ≤ 0.01.
** 0.01 < *p*-value ≤ 0.05.
* 0.05 < *p*-value ≤ 0.1.

The results show that subjects who spend more time looking at the results of the previous round are more likely to change from cooperation to free-riding. Conversely, the likelihood of switching from either free-riding or unconditional cooperation to conditional cooperation diminishes with longer observation periods. The choice of being an unconditional cooperator, instead, does not seem to depend on the length of either component of the RT. While linear modelling of decision time reveals no statistically significant effect on the choice of the contribution amount, the logarithmic form shows interesting results. Specifically, longer decision times are associated with higher probabilities of switching to conditional cooperation, yet lower probabilities of switching to free-riding. However, this latter result is less robust across different specifications of the regressor of interest.

In what follows, we present the estimates where contribution variability is the dependent variable. To ensure robustness, fixed effects at the individual level are used to mitigate the influence of unobservable characteristics across individuals and sessions.

Table A3 presents the estimates for the first measure of contribution variability: the absolute difference between the contributions in two consecutive rounds. Although the estimation procedure employs OLS panel regressions, odds ratios are reported to facilitate comparison with outcomes from other tables.

Table A3
Contribution variability (absolute difference between contributions in two contiguous rounds) and response times.

Specifications	(1)	(2)	(3)	(4)
Time to choose the contribution	0.671**	0.691**	0.688**	0.704**
	(0.109)	(0.111)	(0.111)	(0.114)
Time to choose the contribution squared	1.003**	1.003**	1.003**	1.002**
	(0.00109)	(0.00108)	(0.00108)	(0.00108)
Time used to see the results of the previous round	1.213***	1.220***	1.215***	1.188***
	(0.0749)	(0.0749)	(0.0748)	(0.0753)
Free rider in the previous round (dummy = 1 if yes)		8.77e-05***	5.01e-05***	4.06e-05***
		(0.000235)	(0.000138)	(0.000110)
Unconditional co-operator in the previous round (dummy = 1 if yes)		28.76	18.15	10.87
		(120.6)	(76.70)	(45.95)
Value of the fund in the previous round			0.987	
			(0.0139)	
Fund increased in the previous round (dummy = 1 if yes)				-9.431
				(12.93)
Constant	14,007	6966	93,043	16,534
	(107,022)	(52,778)	(753,160)	(125,356)*
Number of observations	638	638	638	638
R-squared	0.036	0.064	0.066	0.070
Number of subjects	160	160	160	160

Notes: Dependent variable: difference between individual contribution in round n and n-1. Panel OLS estimates with fixed effects at individual.
level. The reported figures are odds ratios. Standard errors in brackets. The RTs are in seconds.
*** p-value ≤ 0.01.
** 0.01 < *p*-value ≤ 0.05.
* 0.05 < *p*-value ≤ 0.1.

The analysis reveals a significant and robust association between the time spent choosing the contribution and the difference in contributions in two contiguous rounds: deviations from the previous contribution increase with the time spent choosing how much to contribute. The association between the two variables is not linear: a quadratic form, indeed, captures the positive link, while no linear relationship is detectable.[23] The functional form associated with the relationship between the two variables is a parabola, which decreases up to a choice time of 71.13 s and increases then. The parabola is increasing at both the average (92.37) and median (101) points.[24] Therefore, on average, the results suggest that the more time the subject spends deciding the contribution, the larger its variation between rounds *n* and *n-1*.

Moreover, the time spent looking at the results of the previous round features a positive and statistically significant effect. This finding suggests that subjects tend to decide whether to change their behavioural type when seeing the results of the previous round. As the choice of changing behavioural type is likely to involve larger changes in contributions than the choice to keep the behavioural type unchanged, a positive association between this component of the decision time and the magnitude of contribution variation emerges.

Table A4 shows the relationship between RTs and the standard deviation of individual contributions, reporting the odds ratios of the estimates of a multilevel model with random intercepts at session level and random slopes at individual levels, to control for unobservable characteristics at these levels. Given that the dependent variable is observed only once for each subject, the controls in the model represent the mean values of the variables at

[23] The linear regressions modelling the choice time are available upon request.
[24] Calculations were made on the coefficients of the fourth specification.

the individual level. The odds ratios of the estimates show interesting results. Firstly, the results indicate a statistically significant association between the time spent choosing the contribution and the standard deviation of the contributions, suggesting that individuals with longer decision times tend to exhibit greater variability in their contributions (remember that the parabola is increasing at both median and mean points).

This relationship persists across various model specifications, underscoring its robustness.

Table A4
Contribution variability (standard deviation of individual contributions) and response times.

Specifications	(1)	(2)	(3)	(4)
Time to choose the contribution	0.963**	0.963**	0.963**	0.963**
	(0.0161)	(0.0161)	(0.0161)	(0.0161)
Time used to see the results of the previous round	1.002	0.993	0.993	0.990
	(0.0299)	(0.0299)	(0.0299)	(0.0302)
Share of free-riding choices		4.647	4.245	4.390
		(5.311)	(5.101)	(5.037)
Share of unconditional-cooperation choices		46.88**	44.83	42.60**
		(75.99)	(73.13)**	(69.42)
Average value of the fund			0.998	
			(0.00773)	
Percentage of times the value of the fund increased				1.587
				(1.302)
Constant	2.798e+07***	3.565e+07***	4.656e+07***	3.644e+07***
	(7.588e+07)	(9.606e+07)	(1.350e+08)	(9.803e+07)
Log of the s.d. of random intercepts (by session)	2.17e-10*	3.26e-09**	1.48e-09***	3.17e-09**
	(1.98e-09)	(2.58e-08)	(1.06e-08)	(2.52e-08)
Log of the s.d. of slopes (by subject)	3.490***	3.387***	3.371***	3.362***
	(0.963)	(0.940)	(0.939)	(0.936)
Log of the variance of the residuals	10.00***	9.954***	9.954***	9.953***
	(0.282)	(0.280)	(0.280)	(0.280)
Wald chi-squared	5.62	12.42	12.49	12.75
Log-pseudolikelihhod	-2384.05	-2380.71	-2380.68	-2380.55
LR test chi-squared	53.70	50.14	48.49	48.69
Number of subjects	160	160	160	160

Notes: Dependent variable: standard deviation of individual contributions. The figures in the table are odds ratios. Standard errors in brackets. Multilevel model estimates; random intercepts at session level and individual level. The RTs are in seconds.

*** p-value $\leq$ 0.01.

** 0.01 $< p$-value $\leq$ 0.05.

* 0.05 $< p$-value $\leq$ 0.1.

The analysis reveals a nuanced relationship between decision time and contribution variability as measured by the standard deviation. Surprisingly, while a negative correlation emerges between the average time spent on contribution decisions and contribution variability, no statistically significant association is found between contribution variability and the average time spent reviewing results from the previous round.

This inconsistency could stem from several factors: firstly, the use of average values may induce less accuracy compared to individual-level observations employed in panel regression; secondly, the variability of behavioural types, could generate both positive and negative correlations with time when considered at the individual level (as shown in Table A2), but these effects may cancel out when means are considered, resulting in an overall effect that is not statistically different from zero. A third possibility is that the two variables are simply unrelated. Unfortunately, the dataset does not provide sufficient information to discern among these possibilities. Additionally, unlike the previous analysis, the relationship between time spent choosing the contribution and contribution variability appears linear rather than quadratic, possibly due to information loss due to the use of cross-sectional instead of panel data. The values of the standard deviations of the random intercepts reveal the role played by individual unobservable characteristics in determining contributions.[25]

From the previous analysis two key results emerge. Firstly, behavioural type variations in a round correlate to the time spent looking at the results of the previous round. Secondly, contribution variations correlate to the time spent in deciding the amount to put in the common fund, at least in the panel analysis, where they are measured as differences between the amounts contributed in two subsequent rounds. These results are interesting, as they suggest that the subjects decide whether to change their behavioural type when receiving information and analysing what happened in the previous round, while subjects decide variations in the amount to contribute in front of the contribution decision screen. In other words, a sort of duality seems to exist. In addition, unconditional cooperation appears to be unaffected by these reflections, as its nature would suggest.

Appendix 2: Robustness checks

This section presents additional regressions, using the variability of contributions to the PGG as the dependent variable and total response times as the primary regressor, consistent with Appendix 1. This total response time includes the time spent reviewing the previous round's results and the time allocated to choose the contribution for each round. As discussed in the paper, the experimental design does not allow to determine with certainty whether the decision regarding the amount of the contribution is formulated during the review of the previous round's results, during the act of choosing the contribution, or both.

[25] It is worth mentioning that – for the sake of robustness – tobit and panel tobit estimates were also computed for the specifications presented in this section and analysed through panel OLS regressions. The results are not qualitatively different from those presented. The tobit behavioural type was chosen following Moffatt (2016): the contributions to the public fund in the experiment are constrained between 0 and 60 EMUs. Consequently, there cannot be any variation outside the range [-60, 60]; such constraints may engender masses of probability on the two extremes, which may require tobit estimation. However, the masses on density on the extremes are not big enough to render tobit estimates much different from panel OLS estimates, on which, therefore, this paper relies.

As in Appendix 1, the data are analysed through multinomial regressions with fixed intercepts at the session level and random slopes at the individual level. Table A5 presents the results where the dependent variable is the absolute difference between contributions in two consecutive rounds.

Table A5
Contribution variability (absolute difference between contributions in two contiguous rounds) and response times.

	(1)	(2)	(3)	(4)	(5)	(6)
Response time	0.0449**	0.0363	0.0622***		0.0656***	
	(0.0190)	(0.0236)	(0.0168)		(0.0183)	
Logarithm of response time				1.394**		1.551**
				(0.576)		(0.671)
Male	0.0972	0.251	-0.726	-0.530	-0.739	-0.539
	(1.329)	(1.395)	(1.386)	(1.438)	(1.374)	(1.427)
Value of common fund lagged one period		-0.00709				
		(0.0124)				
Share of free-riding choices			6.617***	6.641***	6.522***	6.563***
			(1.515)	(1.557)	(1.549)	(1.568)
Share of unconditional-cooperation choices			2.676	2.568	2.835	2.785
			(3.153)	(3.195)	(3.250)	(3.321)
Round (trend variable)					0.303	0.365
					(0.273)	(0.328)
Constant	9.223***	10.29***	7.273***	4.908***	6.244***	3.312
	(1.509)	(2.729)	(1.163)	(1.829)	(1.773)	(3.000)
Log of the s.d. of random intercepts (by session)	-20.59	-21.92	-20.94	-22.15	-20.63	-21.82
	(68.35)	(109.2)	(93.05)	(118.4)	(70.47)	(83.20)
Log of the s.d. of random slopes (by subject)	0.978**	0.841***	0.936***	0.927***	0.938***	0.928***
	(0.177)	(0.209)	(0.182)	(0.191)	(0.180)	(0.189)
Log of the variance of the residuals	2.395***	2.385***	2.372***	2.376***	2.372***	2.375***
	(0.0426)	(0.0400)	(0.0376)	(0.0356)	(0.0371)	(0.0347)
Wald chi-squared	5.56	3.45	34.45	23.62	167.81	138.97
Log-pseudolikelihhod	-3058.96	-2440.96	-3040.45	-3043.15	-3040.06	-3042.34
LR test chi-squared	30.16	15.81	28.32	27.43	28.54	43.50
Number of observations	800	640	800	800	800	800

Notes: Dependent variable: difference between individual contribution at time t and time t-1. Robust standard errors in parentheses. Panel multilevel model estimates; random intercepts at session level and individual level.
The RTs are in seconds. Free rider and Full cooperator are dummy variables defined as explained in the paper.
EMUs (free rider) or the entire endowment (full cooperator).

The figures in the table confirm the conclusions of the analyses presented in the paper. The coefficients are smaller than those observed in the other tables; this is likely due to individuals taking the “largest part” of their decision when either looking at the results of the previous round or choosing the contribution. Indeed, in such a case, subtracting one time from the other lets the full correlation emerge; instead, using the total response time as a regressor dilutes the magnitude of the statistically significant correlation. However, the overall correlation remains positive, indicating that adopting a different behavioural type necessitates longer deliberation.

Data availability

Data will be made available on request.

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