# Type Stability and Response Times: Evidence form a Public Goods Game

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**Abstract**

Experimental economics uses response times as a tool to evaluate the instinctiveness of choices and behaviours. They have been used to define types of subjects, but never to evaluate the stability of such types. This paper defines stability of types in terms of the variability exhibited by the choices made by an individual in a repeated experiment. The analysis of response times and type stability shows that stability is more instinctive than instability, supporting the idea that types exist and that deviations require cognitive effort.

**Keywords: types; stability; response times; public goods experiment**

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## 1. Introduction

Since the seminal work of Rubinstein (2007), the interest for response times in experimental economics has spread. Nowadays the analysis of response times (RTs henceforth) is considered fundamental in experimental economics, and their use in the analysis of experimental results is strongly recommended (Clithero, 2018, and Spiliopoulos and Ortmann, 2018). The information provided by RTs concerns instinctiveness of decisions taken during an experiment: the faster the decision, the more instinctive it is (Rubinstein, 2016). In other words, RTs allow for evaluating how much cognitive effort a decision required to be made. RTs identify "the temporal process of integrating choice and response time during […] decision making."[1] Of course, RTs are subjective, i.e. they differ across individuals and have been found to correlate with some particular behaviours.

The theoretical literature on game theory very often identifies "player types", i.e. players who share some characteristics that allow clustering these individuals in a so-called type (see for example Osborne and Rubinstein, 1994). Rubinstein (2016) empirically identifies some of these types using a set of experiments in economics; other types (co-operators, free-riders, reciprocators, etc.) have been identified by the extant experimental literature in several different articles, books and experiments. Nevertheless, there might be some variability also within types: i.e. a player who *on average* sticks to some well-identifiable strategy may deviate from it when the game presents several rounds (repetitions). In other words, a type's strategy may not be stable over time, and different players may exhibit different degrees of such a strategic stability. This paper takes the average behaviour of a person as the representation of her "type"; in other words, the type is assumed to coincide with the average behaviour revealed by the individual[2].

The extant literature uses the concept of behavioural stability, with particular reference to the field of evolutionary game theory, where stability refers to the probability of type mutations. Often mutation drives from the encounter between individuals of different types, who contaminate each other. In the present paper, a different concept of stability is used. On

[1] Niu et al. (2018), p. 45.
[2] Despite the emphasis placed on types, this paper does not aim at providing any taxonomy of types. Rather, these last are simply assumed to exist, and their number is assumed undefined. For the purpose of this paper, these assumptions are enough.

the one hand, mutations in different ways may occur to the same individual over time. For example one may be reciprocator at time t, free-rider at time t+1 and reciprocator again at time t+2. On the other hand, in addition to these extreme mutations, the extent to which a subject is reciprocator may vary over time, without generating a full mutation (i.e. without transforming an individual of a certain type in an individual of another type). In other words, types may be allowed some degrees of variability, without changing type.

The degree of cooperation is an example of a strategy, which may vary during an experiment: repeated PGGs clearly show that players' contributions decline over time, i.e. degree of cooperativeness of the subjects involved in the game evolves over the rounds. It may be the case, however, that – given the others' strategies – some individual stick more to a given (preferred) degree of cooperativeness than others. The analysis of subjects' contributions in a repeated PGG and of their RTs may shed some light about how instinctive (or thoughtful) sticking to some strategy (partially ignoring the external environment) is. In other words, RTs may help to understand whether people whose contributions do not change much over rounds exhibit such a constant behaviour cognitively or instinctively. Knowing this may help to understand whether stable strategies are the result of a thought or of an instinctive behaviour, and, more in general, if "types" are instinctive or not.

The empirical results presented in this paper are based on a traditional PGG played for five rounds. The focus is on the link between RTs and consistency of individual contributions across rounds, measured as the coefficient of variation of the contributions over the five rounds of the game. Indeed, small variability of contributions between rounds may suggest that the individual follows a precise strategy and is less sensitive to the others' behaviour than a person whose contributions vary much across rounds. Large variability is likely a symptom of context dependency, while the opposite seems to be true in case of small variability of contributions. The results of the paper show a positive link between the two variables, suggesting that people who think more about how much contributing respond to the context more than people who think less. Such a result is consistent with the extant literature, which shows that decisions involving more thinking are also slower than the more instinctive. It is noteworthy than the context to which players respond may be represented by the rules of the game, by the others' behaviour observed in the previous rounds or by both.

## 2. Related literature and hypotheses

The economics literature has already exploited the concept of stability; in particular, in evolutionary game theory, where the behaviour of the experimental subjects has been studied dynamically in repeated games. Güth and Nitzan (1997) proposed two theoretical models of preference stability in the PGG setting. The models proposed consider a population composed of two different types and its evolution over time; the possibility of mutations of one type into the other characterise 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.

Guttman (2000) shows that, under some circumstances, preferences for reciprocity are stable in a sub-sample of the population. Kurzban and Houser (2005) consider the stability of contributions in a PGG, and identify three types of players: reciprocators, co-operators and free-riders, concluding that "our human subject population is in a stable, polymorphic equilibrium of types."[3] However, the analysis of the two authors grounds on the time series profiles of subjects' contributions, without taking into account any specific measure of variability.

The existing theoretical models consider stability as a characteristic of a type and analyse its survival and evolution within a population. In addition, evolutionary game theory takes stability as a fixed condition, to which opposes mutation. In other words, mutation is what hinders stability of types: the definition is thus discrete and dichotomous in the sense that only mutants and non-mutants are allowed. Instead, this paper defines types as "average behaviours" and their instability as variability around this average behaviour to account for the possibility that the main characteristics of a type may appear neater in an individual than in another, while both belong to the same type. As blue eyes of different persons present different nuances, so characterises such as reciprocity and trustworthiness may have different gradations, without losing their intrinsic property of reciprocity and trustworthiness.

Nowadays, one of the main uses of RTs in analysis individual choices relates to selfishness. A number of studies (for a review see Spiliopoulos and Ortmann, 2018) have found that faster decisions mirror self-interested decisions. Piovesan and Wengström (2009) analyse a

[3] Kurzban and Houser (2005), p. 1803.

dictator game and find that egoistic choices are faster than generous offers. Always using a dictator game, Cappelletti et al. (2011) find that strategic thinking requires longer RTs and correlates with higher offers. In a different setting, Rubinstein (2013) shows that the subjects who decide faster are more likely to take mistaken decisions, although such short RTs are uncorrelated with behaviours that conflict with standard theories. In a pure distribution game Ubeda (2014) observes that faster decisions are also more selfish, in the sense that slow deciders are more likely to consider moral trade-offs when choosing how to split the cake. Similar conclusions are reached in an experiment based on value orientation: the decisions of the more individualistic subjects are faster than those of the prosocial participants (Chen and Fischbacher, 2016). Brañas-Garza et al. (2017) use two games to show that decisions involving strategic risks require longer RTs, as risk-aversion generally induces people to tale less instinctive decisions. Finally, Evans and Rand (2019) find that strategic cooperation requires more time to take a decision in payoff-maximising games.

Some extant articles focus on how RTs and contributions to the provision of a public good correlate; these experiments generally use a standard public goods game (PGG). The first study to related RTs and PGG is Lotito et al. (2013), who find that faster decisions about how much contributing to public good are associated with lower contributions than slower decisions are. Lohse et al. (2017) obtain the same result in an experiment on the provision of environmental public goods. Recalde et al. (2018) show two interesting results: on the one hand, individuals who are insensitive to monetary incentives decide faster. On the other hand, when the equilibrium of the PGG is below the mid-point of the available decision set, faster deciders give less than the slow, but the result is reversed when the equilibrium point is above the mid-point of the available decision set. This result is interesting, as highlights that the correlation between RTs and individual behaviour may depend on the context and on the rules of the game. Similarly, Hallsson et al. (2018) show that self-interested behaviours are not always intuitive; in settings where also fairness considerations are involved, there are cases in which selfish decisions are taken more slowly than pro-social choices[4].

The most relevant study for the analysis proposed here is Börger (2016). The author uses an online choice survey on the installation of an offshore windfarm in the Irish Sea (in the UK territorial waters). The survey was on the design of an already approved windfarm; indeed,

[4] On the interpretation of RT as pure measure of instinctiveness, see also Migheli (2017).

different designs were associated with different environmental impacts. In particular, the shape of the windfarm was deemed to affect the degree of biodiversity in the sea neighbouring the farm itself. People were therefore invited to choose between different possible characteristics of the future windfarm, for which the potential impacts on biodiversity were disclosed. The data were then analysed to understand whether the participants expressed consistent choices over the different characteristics of the future windfarm and the RTs were used as one of the control variables. The results show that longer RTs were associated to less randomness in responding the survey. In other words, people with longer RTs were more consistent in expressing their preferences; from a statistical point of view, this suggests lower variance in their decisions than in those of faster deciders. Another article, whose results are very relevant for the present paper is Campbell et al. (2018): Here the authors show that, when measuring preferences for honey characteristics in a sample of Danish consumers through an online survey, the measurement error decreases with RTs; i.e. the longer the RT, the larger the measurement error. However, both works are based on online surveys, i.e. they are not real experiments strictly speaking.

## 3. Methodology

### *3.1. Defining stability*

As mentioned before, the literature defines behavioural stability in terms of absence of type mutation. Instead, this paper allows for some variability of the traits that define a type, within each of them, thus the paper assumes that each type is characterised by a continuous distribution of its distinctive characteristic and that the distribution of types may be continuous, i.e. types may be contiguous (Friedman and Sing, 2009; Cardaliaguet and Rainer, 2012 and Rabanal, 2017). For the purposes of this paper and without loss of generality, types define also the behaviours of the subjects, i.e. their acting according to the categories of behavioural economics (see Camerer, 2003 and Dhami, 2017). According to this definition, each type of player may be defined in function of some trait $\vartheta_i$ so that $p_i = p(\vartheta_i)$, where $\vartheta_i$ is a type-specific trait (or behaviour, in the case of behavioural analysis), which defines type $p_i$ and determines the continuity of the type both between and within individuals. More in general, we may assume that set $P$ contains all the population, and that this set is partitioned in types $p_i, i = 1, \dots, n$ with $n$ finite, for each of which there exists a trait $\vartheta_i$, which defines it. These traits may be treated as random variables, so that each of them follows some random distribution, with mean $\mu_{\vartheta_i}$ (which may be defined as the "central trait" of the type), and finite and bounded variance $var(\vartheta_i) = k, k \in \Xi = \left[\underline{\xi_i}, \overline{\xi_i}\right]$, where $\underline{\xi}$, and $\overline{\xi}$ are two finite real numbers such that $\overline{\xi} > \underline{\xi}$, which define the range of variation of each type $p_i$. Such formulation refers to what we may call "social types", i.e. type $p_i$ characterises a group of individuals who are drawn from the same type. In other words, individuals, who show trait $\vartheta_i$ belong to type $p_i$. So, for example, generous people are all drawn from the generous type. The variability exhibited by this last depends on the fact that different individuals may show different degrees of generosity: charity donations may be assumed as proxies of generosity; yet, while some persons donate large amounts (and shares) of their income, others donate less (both in absolute and relative terms). This between-type variability motivates $var(\vartheta_i)$ in the previous formulation. The size of $var(\vartheta_i)$ provides a measure for the stability of social type $p_i$. It is noteworthy that stability here is taken a synonymous of variability within the type, rather than as a term indicating the (un)likelihood of mutating. In this sense, stability here recalls the idea of business cycle around the trend: the less the cycle oscillates around the trend, the more stable the economic growth is.

A similar concept of stability applies here also to individuals: while they may continue belonging to the same type, their behaviour may vary within this type. Indeed, "the human individual is also subject to continuous transformation"[5] and "[h]uman beings, like social systems, are organisations in process."[6] We may refer to this variability as "within-type" variability. Continuing the example of the generous person, she may become more or less generous than she was in the past, without losing her characteristic of generosity. In other words, also each individual, characterised by a type, will exhibit a given behaviour with some variability. Mutations are not excluded by the formulation presented: when the individual variance of $\vartheta_i$ exceeds its upper bound, the individual transitions from a type to another. In this sense, types are fixed (i.e. the population is portioned in sets with immutable characteristics), while their magnitude (i.e. the number of people belonging to some type) are not. This definition allows, for example, some types to be empty sets, when nobody belongs to them, without the type losing its characteristics.

The definition of within-type stability depends on the magnitude of the variance of the individual trait within each type. This variance, although bounded for the type, may differ

[5] Lawson (2015), p. 42.
[6] Ibidem.

between individuals. The smaller the variance at subject level, the more stable the type is for the subject. Formally: taken two individuals $j$ and $k$ belonging to the same type $p_i$ such that $var(\vartheta_i^j) > var(\vartheta_i^k)$ and both variances are within $\Xi$, the behaviour of the latter individual is more stable than that of the former within type $p_i$. In a similar vein, the type of a person is more or less stable over time according to how much the variance of her choices varies over time: stability increases when $var(\vartheta_i)$ decreases and *vice versa*.

*3.2. Experimental methodology*

The data of this study come from a traditional PGG repeated for five rounds with anonymous random re-matching after each round (Andreoni, 1988 and Botelho et al. 2009). 160 subjects participated in the experiment, divided in eight sessions with 20 players each. The subjects were all undergraduate students recruited through advertising; they enrolled on voluntary basis, and played five rounds of a standard PGG in lab. Each participant received an endowment of 60 experimental monetary units (EMU), at the beginning of each round 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 the rounds were not usable in the next. She 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. The subjects also knew that experimenters would then have tripled the sum of the contributions to the fund and the total divided equally between the four members of the group, independently of the individual contributions. The participants also knew that the game would have been repeated five times and at each time, they would have been matched with three other people never met in the previous or in the next rounds. This procedure together with the dimension of the lab (20 PCs) constrained the round to the maximum of five.

The random re-matching procedure allows minimising the interdependence of observations. Indeed, if the subjects played always with the same three people, the probability that the choice of the other members of the group affects one's choice would be very high. Although the subjects may take with them some of what happened in the previous rounds, i.e. what the others did in the previous round(s) may affect one's choices, random re-matching dilutes this effect, rendering it less important. At the end of the game all the players were paid the total amount accumulated during the five rounds.

*3.3 Empirical methodology*

The aim of this paper is to capture the relationship – if any – between RTs and the level of type stability of the individuals. In the context of experimental economics, such a stability is evaluated with respect to the behaviours exhibited by the experimental subjects. To this end, in the framework of a PGG, we construct a set of variables that may capture the variability of the choices of each subject during the experiment. The extant literature led the choice of the game to be used in the inquiry; indeed, PGGs typically involve a number of rounds, where the game repeats identically, the evolution of the subjects' behaviour over time is well known, the protocol is consolidated and easy to understand for the participants, and the interpretation of the results is simple.

To the aforementioned goal, the coefficient of variation (CV) of the contribution over the five round is calculated at individual level. With respect to the standard deviation (SD), the CV has the advantage of expressing the variability in relative than in absolute terms. This property allows for comparing variability, while controlling for differences in average contributions across subjects and has already be applied to study the results of a PGG (Page et al., 2005). The rationale behind this measure is to account for the decreasing utility of money, so that an increase in the contribution of one EMUs is worth more when, for instance, the average contribution is 10 EMUs than when it is 55 EMUs. This measure of variability, however, does not allow exploiting the panel dimension of the data, as it produces one observation per subject.

The panel dimension is exploitable using different measures of variability. In particular, three are the base for the empirical analysis presented in the next section; the first is simply the absolute value of difference of the contribution at each round with respect to the mean individual contribution. Formally: $ADC_{i,t} = \left| c_{i,t} - \frac{1}{5}\sum_{t=1}^{5} c_{i,t} \right|$, where $c_{i,t}$ is the contribution of subject *i* at time *t*. The resulting variable is a sort of "decomposition of the CV" in its each-round components; however, it allows for more in-depth looking at the relationship between RT and difference of a contribution from the mean. Indeed, while the CV is a synthetic measure, this decomposition allows for exploiting the panel dimension and therefore for 1) controlling for individual fixed effects and 2) maximising the quantity of information (i.e. variance) used in the regressions. For the sake of robustness, an analogous measure is computed, using the median contribution instead of the mean as reference for calculating deviations.

Finally, the absolute difference between $c_{i,t}$ and $c_{i,t-1}$ is also computed and regressed against RTs to understand whether larger deviations from the previous choice require more decision time. Positive and negative deviations are then analysed separately with the aim of inquiring whether positive and negative deviations from the previous contribution engender differences also in the times needed to take the decision. Indeed, choosing to be less cooperative may be different from choosing to be more cooperative in terms of instinctiveness. This measure is less representative of the subject's type stability than the other two – at least when the definition of stability given in section 3.1 holds; nevertheless, it serves as robustness check and for exploring a side of stability not directly addressed by the theoretical framework presented in the previous sections.

The aforementioned variables will constitute the dependent variables on the analysis. Indeed, if we accept that RTs measure instinctiveness, logically in the neural process the instinctive response precedes the choice or is – at least – contemporaneous to it. In other words, if the RTs are expression of the cognitive process, and the last step of it is the choice, then it is advisable to use RTs as regressors and the variability as dependent variable, even when claims of causality are not raised.

Data are analysed mainly by the means of regression techniques. In particular, when the dependent variable is the CV, multilevel regressions with random effect at individual level are estimated. Standard errors clustered at session level account for possible session fixed effects that may affect the outcomes of the experiment; this strategy contributes to control for the noise induced by interdependence of observations, producing results that are as clean as possible. When differences between contributions constitute the dependent variable, the analysis relies on panel regressions with standard errors clustered at session level for the same reason as before. For the sake of robustness, the analysis presents also estimates from panel multilevel models with random effects calculated at different levels, which include random intercepts at individual level and session level. Some specifications will present estimates obtained with random intercepts at session level and random slopes at individual level. They are another possible way to account for heterogeneity between subjects and allow testing the robustness of the results obtained with other econometric strategies.

Usual controls are part of the regressions. In particular, gender, a trend variable (for panel estimations), lagged values of the common fund, average contributions of the other members of the group in the previous round constitute control variables used in the analyses. Table 1 presents the descriptive statistics of the variables used in the analysis, whose results are shown and discussed in the next section. The table is divided in two panels: the upper reports the descriptive statistics for the collapsed dataset at individual level; the lower shows the same statistics for the full panel data (i.e. not collapsed at individual level). The figures in the table show that there is quite large variability of both RT and CV. The sample is almost balanced in gender terms, although there is some prevalence of males; the negative mean of the difference between one's contribution in round t and that in round t-1 is due to the usual decrease of cooperation over rounds (see Figure 2).

## 4. Results

Figure 1 presents the cumulative density functions (CDFs) of the coefficients of variations for two groups of subjects, identified according to their average RTs being above or equal to or below the average RT of the sample. The figure clearly shows that the CDF of the subjects whose RT is above the mean stochastically dominates the CDF of the other group. A Kolmogorov-Smirnoff test (p-value < 0.001) confirms that the two distributions are statistically different from each other. This graphical representation of the data suggests that the faster the choice about the contribution, the less the latter varies over the rounds of the game. In other words, instinctiveness is associated with less variability in the contributions: this result may suggest that players whose choices are less sensitive to the others' are faster deciders. However, more in-depth analyses are needed to better understand the relationship between RTs and contribution variability.

The first part of the econometric analysis follows directly the graphical evidence just discussed: the CV of each subject over the five rounds of the game is regressed against average RT and other controls. Table 2 reports the results of different specifications of the regression, run using multilevel models with random intercepts at session level and random intercepts at individual level and standard errors clustered at session level. The figures show that, as the RTs increase, so does the CV. The effect is small, as one second more take for deciding reflects in an increase in the CV by something less than 0.005, i.e. a 3.6% increase[7] in RT is associated with a 0.9% increase[8] in CV, suggesting that CV is not much elastic with respect to RT. The coefficient

[7] Calculated on the mean value.
[8] Calculated on the mean value.

of RT is stable and robust to different specifications. The inclusion of the share of times the individual chose to contribute 0 or the whole endowment does not change the magnitude and the statistical significance of the RT coefficient much, but shows that free riding is a less stable behaviour than full cooperation. This result is consistent with the extant evidence provided by the literature showing that cooperation is less instinctive than free riding, which appears to be a well-conscious and thoughtful strategy. The variability of the others' contributions experienced by the subject seems to have no effect on the variability of the contributions of the subject herself.

The likelihood-ratio tests show that estimates from multilevel regressions are preferable to linear estimates only for the first two specifications. Indeed, the logarithms of the standard deviations of the random intercepts are negative and statistically highly significant, suggesting that there is small variability both at individual and session level. This indication from the estimates suggests also that environmental factors and individual fixed effects have little influence on CVs once controlling for RTs, suggesting that choice variability is hardly context dependent and that RTs well represent the individual unobservable that are related to the (in)stability of contributions. Indeed, individual fixed effects regressions confirm this evidence: the addition of individual fixed effects renders the coefficient of RTs statistically non-significant, indicating that RTs capture the individual characteristics, which render the observed behaviours more or less stable.

Table 3 presents regressions on the same specifications of the same model as Table 2 with random intercepts at both individual and session level, with random coefficients for the variable of interest at individual levels. In this case, thus, the analysis assumes that individuals do not to respond differently to different sessions, but that their individual fixed effects are unrelated to session characteristics. The results are qualitatively identical to those presented in Table 2; also quantitatively, the changes are marginal. The logarithms of the standard deviations of the individual intercepts show some small variability between individuals, confirming the partial conclusions derived from the previous table.

The next tables present empirical results that exploit the full panel dimension of the data. In particular, Table 4 shows panel multilevel models with random intercepts at both subject and session levels, where $ADC_{i,t}$ is the dependent variable. Again, the RTs display positive and statistically significant coefficients, which suggest that the longer the subject thought about how much contributing, the more the contribution differed from the subject's mean. Such a result is in line with that already shown in Tables 2 and 3. The random parameters show that, while there is no variability between sessions, there is some between subjects within each session; indeed, the log-likelihood ratio tests suggest that multilevel analysis should be preferred to linear regressions. Evidence stands out about the lack of statistical significance of the coefficient of being full co-operator. Such a result indicates that co-operators' contributions do not diverge much from the means, differently from what happens with the free riders', consistently with what already observed. Free riding presents a positive and statistically significant coefficient; this piece of evidence suggests that the subjects who try this strategy exhibit larger variability in their choices than full co-operators. Perhaps this indicates that co-operators are less sensitive to the environment than free riders are[9]. Table 5 presents figures estimated through the same specifications as those in Table 4, but the fact that random intercepts are both at session and individual level, and random slopes at this last level are allowed with respect to the variable capturing RTs. Qualitatively the results do not change, although some control variables (in particular that capturing the cooperative behaviour) gain statistical significance.

Tables 6 and 7 present the outcomes of regressions where the absolute change between $c_t$ and $c_{t-1}$ is the dependent variable. The estimation strategy is the same as before: panel multilevel models nested either at session and individual level or at session and individual level with random coefficients at individual level for the RT variable. The tables report estimates, taking the natural logarithm, of $|c_t - c_{t-1}|$ as dependent variable. In fact, the use of the natural value of the difference provides results that are not statistically significant. However, the use of the logarithmic transformation leads to results that are both statistically significant and in line with the previous evidence. This result suggests that the link between RTs and $ln(\Delta c_t)$ is not linear but exponential; in other words, as the RT increases, so does $\Delta c_t$ with increasing absolute speed, as there is a positive association between the individual RT and the difference between two contributions in two immediately subsequent rounds. The variability at the level of sessions and individuals is very small, and in some cases so close to zero to be statistically non-different from this value. This piece of information suggests that there are few individual characteristics non-included in the regression, which influence the observed results.

[9] However further research is needed to shed more light on this point.

Splitting the sample between contributions higher than and lower than the mean does not provide any interesting result. Indeed, the coefficients of RTs are statistically significant and of equal magnitude in both cases, indicating that what matters is not the direction of the deviation of contribution in a round with respect to the individual mean, but only the magnitude of such a difference. In other words, what requires more time for deciding is the magnitude, but not the direction of the deviation from the mean. This result may suggest that small differences from the average may be random (or, at least, less thoughtful) more likely than large differences are. In addition, the statistical significance of the coefficient of RTs is not stable across different specifications, and the loss of significance is larger when the difference between $c_t$ and $c_{t-1}$ is negative. This last result suggests that choosing to deviate positively from the previous choice requires more time than the opposite choice, in line with the evidence observed about free-riding (which results to be more instinctive than cooperation).

It is noteworthy that – for the sake of robustness – tobit and panel tobit estimates were also computed for the specifications presented in this section and analysed through multilevel regressions. The results are not qualitative different from those presented here. The tobit strategy was chosen following Moffatt (2016): the contributions to the public fund are constrained between 0 and 60 EMUs by the experimenters. Consequently, there cannot be any variation outside the range [-60, 60], and the CVs are constrained in [0, 45]; such constraints may engender masses of probability on the two extremes, what may require tobit estimation. However, the masses on density on the extremes are not big enough to render tobit estimates much different from multilevel estimates, on which, as a consequence, this paper relies.

## 5. Conclusions

Starting from the consolidated interpretation of RTs in experiment as a measure of instinctiveness in decision-making, this paper has presented evidence in favour of longer RTs to be linked to higher variability in the contributions in a PGG game. While several articles on the link between RTs and the outcomes of different experiments in economics exist, RTs had never been used in relationship with the variability of decisions in repeated games. Here, the assumption is that subjects who follow a given strategy belong to a given "type" in the meaning of theoretical game theory. The aim of the empirical analysis was to understand if the stability of these types is the result of instinctive or thoughtful responses to the environment in an experimental framework. The results of the paper suggest that types are instinctive, as the magnitude of the contribution variability in a PGG is positively associated with RTs: to deviate from own instinctive strategy requires cognitive efforts, which translate in observable RTs. Of course, such an evidence does not mean that instinctive subjects are irrational, or that strategies are necessarily not well pondered. Nevertheless, the empirical evidence offered in this paper suggests that the degree of perseverance in playing a strategy in a PGG does not necessarily respond to the others' contributions made in the previous round (indeed, all the variables included in the regressions that try to capture such an effect present coefficients that are not statistically significant)[10]. In other words, the magnitude of the deviation from the average individual behaviour does not seem to depend on the absolute behaviour of the other players in the past.

The results of the paper show that type (behavioural) stability is more instinctive than instability and therefore suggests that types generate spontaneous behaviours, while deviations from the central trait of the type requires cognitive effort.

[10] Ancillary panel regressions of RTs in round t on the contributions of the other members of the group in the past rounds never provide statistically significant evidence of the existence of such a link. Although there is evidence that the higher the average contribution of the other members of the group at time t-1, the higher the contribution of the subject in round t, this evidence does not automatically imply that a link between one's contribution variability and the level of the others' contributions exists. Indeed, the empirical results of the paper do not provide any support for such a link.

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Figure 1. CDF of coefficients of variation

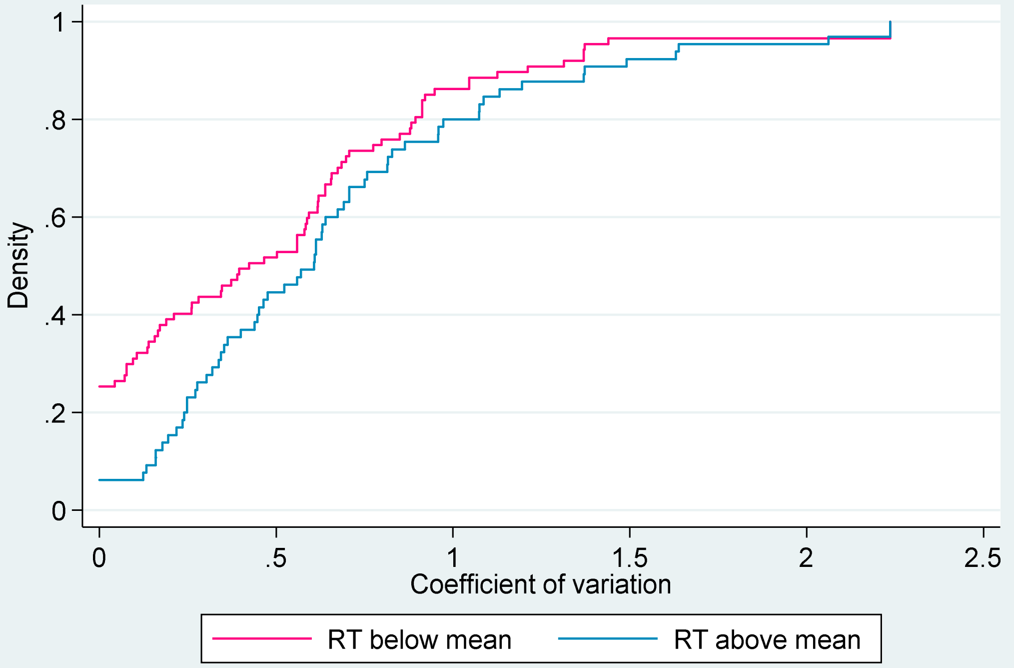


Figure 2. Average contributions to the PG over rounds

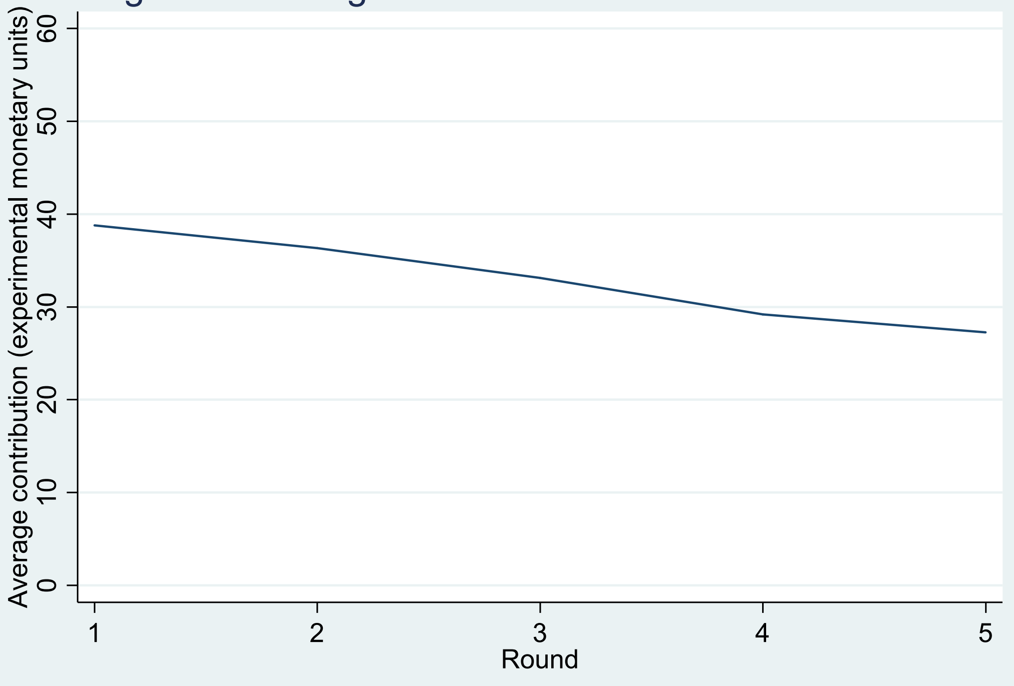

**Table 1. Descriptive statistics**

| | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| *Panel A: data collapsed at individual level* | | | | |
| Coefficient of variation of contributions | 0.579 | 0.528 | 0 | 2.236 |
| Response time (seconds) | 27.722 | 20.441 | 3.4 | 116.4 |
| Average individual contribution | 32.939 | 17.484 | 0 | 60 |
| CV of the contributions other members of the group | 0.573 | 0.191 | 0 | 2.137 |
| 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 | | | |
| Full cooperators (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. Variability of contributions and response times** | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Response time | 0.00485 | 0.00485 | 0.00346 | |
| | (0.00196)** | (0.00191)** | (0.00125)*** | |
| Logarithm of response time | | | | 0.113 |
| | | | | (0.0420)*** |
| Male | 0.114 | 0.118 | 0.0377 | 0.0411 |
| | (0.0489)** | (0.0432)*** | (0.0481) | (0.0501) |
| Coefficient of variation of the contributions of the other memebrs of the group | | -0.0977 | | |
| | | (0.360) | | |
| Free rider | | | 1.880 | 1.887 |
| | | | (0.105)*** | (0.114)*** |
| Full cooperator | | | -0.270 | -0.253 |
| | | | (0.0473)*** | (0.0477)*** |
| Constant | 0.377 | 0.422 | 0.314 | 0.0530 |
| | (0.0834)*** | (0.182)** | (0.0630)*** | (0.139) |
| Log of the s.d. of random slope (by subject) | -7.124 | -7.057 | -27.39 | -25.65 |
| | (1.373)*** | (1.186)*** | (71.75) | (107.7) |
| Log of the s.d. of intercepts (by session) | -2.266 | -2.221 | -2.858 | -2.954 |
| | (0.530)*** | (0.506)*** | (0.443)*** | (0.489)*** |
| Log of the variance of the residuals | -0.705 | -0.707 | -1.287 | -1.290 |
| | (0.0859)*** | (0.0881)*** | (0.126)*** | (0.125)*** |
| Wald chi-squared | 7.70 | 14.34 | 1,141.81 | 1,075.14 |
| Log-pseudolikelihhod | -111.73 | -111.66 | -22.49 | -21.69 |
| LR test chi-squared | 3.53 | 3.53 | 1.60 | 1.16 |
| Number of observations | 160 | 160 | 160 | 160 |

**Notes**

Dependent variable: coefficient of variation of contributions over the five rounds. Robust standard errors in parentheses. Mixed effects model estimates; random intercepts at session level, random slopes at individual level. The RTs are in seconds. Free rider and Full cooperator record the share of rounds in which the individual chose to contribute zero EMUs (free rider) or the entire endowment (full cooperator).

**Table 3. Variability of contributions and response times**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Response time | 0.00611 | 0.00617 | 0.00506 | |
| | (0.00245)** | (0.00244)** | (0.00160)*** | |
| Logarithm of response time | | | | 0.112 |
| | | | | (0.0390)*** |
| Male | 0.114 | 0.120 | 0.0271 | 0.0308 |
| | (0.0562)** | (0.0528)** | (0.0485) | (0.0490) |
| Coefficient of variation of the contributions of the other memebrs of the group | | -0.168 | | |
| | | (0.336) | | |
| Free rider | | | 1.980 | 1.994 |
| | | | (0.115)*** | (0.123)*** |
| Full cooperator | | | -0.254 | -0.248 |
| | | | (0.0495)*** | (0.0515)*** |
| Constant | 0.345 | 0.418 | 0.263 | 0.0450 |
| | (0.0937)*** | (0.190)** | (0.0606)*** | (0.127) |
| Log of the s.d. of random intercepts (by session) | -2.070 | -1.981 | -3.385 | -3.581 |
| | (0.397)*** | (0.404)*** | (0.634)*** | (0.822)*** |
| Log of the s.d. of random intercepts (by subject) | -0.811 | -0.879 | -1.848 | -1.785 |
| | (0.152)*** | (0.166)*** | (0.176)*** | (0.180)*** |
| Log of the s.d. of random slopes of RTs (by subject) | -5.314 | -5.259 | -5.052 | -5.064 |
| | (0.612)*** | (0.608)*** | (0.206)*** | (0.235)*** |
| Log of the s.d. of the residuals | -2.024 | -1.640 | -2.423 | -2.615 |
| | (0.160)*** | (0.165)*** | (0.184)*** | (0.180)*** |
| Wald chi-squared | 6.66 | 14.66 | 1,834.81 | 1,947.16 |
| Log-pseudolikelihhod | -110.88 | -110.66 | -9.48 | -9.41 |
| LR test chi-squared | 5.24 | 5.53 | 27.62 | 25.72 |
| Number of observations | 160 | 160 | 160 | 160 |

**Notes**

Dependent variable: coefficient of variation of contributions over the five rounds. Robust standard errors in parentheses. Mixed effects model estimates; random intercepts at session level and individual level.
The RTs are in seconds. Free rider and Full cooperator record the share of rounds in which the individual chose to contribute zero EMUs (free rider) or the entire endowment (full cooperator).

| **Table 4. Absolute difference with respect to own mean 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) | | | | |
| Free rider | | | 6.617 | 6.641 | 6.522 | 6.563 |
| | | | (1.515)*** | (1.557)*** | (1.549)*** | (1.568)*** |
| Full cooperator | | | 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 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 | -3,058.96 | -2,440.96 | -3,040.45 | -3,043.15 | -3,040.06 | -3,042.34 |
| 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 average individual contribution over the five rounds.
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 dummies recording whether the individual chose to contribute zero EMUs (free rider) or the entire endowment (full cooperator).

**Table 5. Absolute difference with respect to own mean and response times**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Response time | 0.0470 | 0.0450 | 0.0605 | | 0.0686 | |
| | (0.0171)*** | (0.0168)*** | (0.0167)*** | | (0.0184)*** | |
| Logarithm of response time | | | | 0.962 | | 1.234 |
| | | | | (0.433)** | | (0.524)** |
| Male | 0.259 | 0.462 | -0.780 | -0.696 | -0.825 | -0.720 |
| | (1.344) | (1.392) | (1.467) | (1.499) | (1.435) | (1.475) |
| Value of common fund lagged one period | | -0.00981 | | | | |
| | | (0.00715) | | | | |
| Free rider | | | 9.173 | 9.220 | 8.930 | 9.019 |
| | | | (1.363)*** | (1.348)*** | (1.291)*** | (1.280)*** |
| Full cooperator | | | 5.876 | 5.804 | 6.193 | 6.117 |
| | | | (2.115)*** | (2.117)*** | (2.146)*** | (2.135)*** |
| Round (trend variable) | | | | | 0.375 | 0.378 |
| | | | | | (0.157)** | (0.201)* |
| Constant | 9.104 | 10.36 | 5.963 | 4.672 | 4.596 | 2.725 |
| | (1.369)*** | (2.060)*** | (1.348)*** | (1.135)*** | (1.548)*** | (1.805) |
| Log of the s.d. of random intercepts (by session) | 0.801 | 0.554 | 0.779 | 0.780 | 0.785 | 0.780 |
| | (0.278)*** | (0.396) | (0.306)** | (0.319)** | (0.297)*** | (0.313)** |
| Log of the s.d. of random intercepts (by subject) | 1.982 | 2.028 | 2.037 | 2.040 | 2.038 | 2.041 |
| | (0.0639)*** | (0.0589)*** | (0.0792)*** | (0.0807)*** | (0.0787)*** | (0.0802)*** |
| Log of the s.d. of random slopes of RTs (by subject) | -3.053 | -3.274 | -2.766 | -2.631 | -2.787 | -2.658 |
| | (0.405)*** | (0.687)*** | (0.318)*** | (0.332)*** | (0.330)*** | (0.349)*** |
| Log of the s.d. of the residuals | 2.108 | 2.058 | 2.031 | 2.031 | 2.029 | 2.030 |
| | (0.0600)*** | (0.0588)*** | (0.0691)*** | (0.0686)*** | (0.0703)*** | (0.0695)*** |
| Wald chi-squared | 7.57 | 13.58 | 59.44 | 54.67 | 106.61 | 99.92 |
| Log-pseudolikelihhod | -2,958.63 | -2,355.64 | -2,918.58 | -2,921.99 | -2,916.95 | -2,920.44 |
| LR test chi-squared | 230.83 | 186.45 | 272.47 | 269.75 | 274.77 | 271.33 |
| Number of observations | 800 | 640 | 800 | 800 | 800 | 800 |

**Notes**

Dependent variable: difference between individual contribution at time t and average individual contribution over the five rounds.
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 dummies recording whether the individual chose to contribute zero EMUs (free rider) or the entire endowment (full cooperator).

**Table 6. Absolute difference between contribution at time t and time t-1 and response times**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Response time | 0.00689 | 0.0463 | 0.00343 | 0.00360 |
| | (0.00240)*** | (0.0164)*** | (0.00195)* | (0.00217)* |
| Time used to see the results of the previous round | | | | 0.00111 |
| | | | | (0.00519) |
| Male | -0.201 | 0.419 | -0.150 | -0.150 |
| | (0.188) | (1.381) | (0.162) | (0.161) |
| Contribution (one period lagged) | | -0.00950 | 0.00343 | 0.00944 |
| | | (0.00714) | (0.00195)* | (0.00594) |
| Free rider | | | 0.0986 | 0.0975 |
| | | | (0.121) | (0.124) |
| Full cooperator | | | -1.408 | -1.403 |
| | | | (0.278)*** | (0.277)*** |
| Round (trend variable) | | | | -0.000536 |
| | | | | (0.0733) |
| Constant | 1.596 | 1.507 | 1.705 | 1.616 |
| | (0.203)*** | (0.202)*** | (0.244)*** | (0.383)*** |
| Log of the s.d. of random intercepts (by session) | -1.867 | -1.767 | -2.397 | -2.381 |
| | (0.942)** | (0.819)** | (1.799) | (1.743) |
| Log of the s.d. of intercepts (by subject) | -0.0795 | 2.034 | -0.228 | -0.224 |
| | (0.0915) | (0.0558)*** | (0.0855)*** | (0.0887)** |
| Log of the variance of the residuals | 0.193 | 2.063 | 0.140 | 0.139 |
| | (0.0580)*** | (0.0546)*** | (0.0523)*** | (0.0526)*** |
| Wald chi-squared | 9.13 | 15.30 | 159.83 | 492.98 |
| Log-pseudolikelihhod | -1,129.12 | -2,355.86 | -1,084.12 | -1,084.08 |
| LR test chi-squared | 100.70 | 186.02 | 72.66 | 70.40 |
| Number of observations | 640 | 640 | 640 | 640 |

**Notes**

Dependent variable: difference between individual contribution at time t and at 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 dummies recording whether the individual chose to contribute zero EMUs (free rider) or the entire endowment (full cooperator).

| Table 7. Absolute difference between contribution at time t and time t-1 and response times | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Response time | 0.00689 | 0.00681 | 0.00343 | 0.00360 |
| | (0.00240)*** | (0.00231)*** | (0.00195)* | (0.00217)* |
| Time used to see the results of the previous round | | | | 0.00111 |
| | | | | (0.00519) |
| Male | -0.201 | -0.193 | -0.150 | -0.150 |
| | (0.188) | (0.183) | (0.162) | (0.161) |
| Contribution (one period lagged) | | 0.00253 | 0.00946 | 0.00944 |
| | | (0.00632) | (0.00539)* | (0.00594) |
| Free rider | | | 0.0986 | 0.0975 |
| | | | (0.121) | (0.124) |
| Full cooperator | | | -1.408 | -1.403 |
| | | | (0.278)*** | (0.277)*** |
| Round (trend variable) | | | | -0.000536 |
| | | | | (0.0733) |
| Constant | 1.596 | 1.507 | 1.705 | 1.616 |
| | (0.203)*** | (0.202)*** | (0.244)*** | (0.383)*** |
| Log of the s.d. of random intercepts (by session) | -1.867 | -1.767 | -2.397 | -2.381 |
| | (0.942)** | (0.819)** | (1.802) | (1.744) |
| Log of the s.d. of intercepts (by subject) | -0.0795 | -0.0679 | -0.228 | -0.224 |
| | (0.0916) | (0.0986) | (0.0856)*** | (0.0888)** |
| Log of the s.d. of slopes of RTs (by subject) | -28.76 | -29.69 | -26.17 | -25.52 |
| | (108.5) | (115.8) | (117.4) | (109.2) |
| Log of the s.d. of the residuals | 0.193 | 0.190 | 0.140 | 0.139 |
| | (0.0580)*** | (0.0563)*** | (0.0523)*** | (0.0526)*** |
| Wald chi-squared | 9.13 | 11.95 | 159.83 | 492.99 |
| Log-pseudolikelihhod | -1,129.12 | -1,128.73 | -1,084.12 | -1,084.08 |
| LR test chi-squared | 100.70 | 99.65 | 72.66 | 70.40 |
| Number of observations | 640 | 640 | 640 | 640 |

**Notes**

Dependent variable: difference between individual contribution at time t and at 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 dummies recording whether the individual chose to contribute zero EMUs (free rider) or the entire endowment (full cooperator).