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Error Prone Inference from Response Time: The Case of Intuitive Generosity in Public-Good Games

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Error Prone Inference from Response Time: The Case of Intuitive Generosity in Public-Good Games[1]

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Abstract: Higher contributions by fast decision-makers in public-good games may not result from greater generosity but from mistakes. In several public-good games we vary the location of the unique dominant strategy equilibrium. In games with interior equilibria the correlation between response time and contributions is negative when the equilibrium lies below the midpoint of the strategy space, but positive when it lies above the midpoint. Fast decision-makers are also found less generous in simple constant-return public-good games with a full-provision equilibrium. In all investigated public-good games fast decision-makers are largely insensitive to incentives and more often make mistakes.

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1. Introduction

To better understand the choices people make researchers have begun to investigate the decision process that leads to choices. A series of physiological measures, such as brain imaging, eye tracking, and measures of heart rate and skin conductance, have been used to gain better insight into the factors that underlie people's decision making.[2] Response time is another measure that increasingly is used to assess individual decision processes. The time it takes for individuals to make decisions has been used to predict individual choices between products, to predict indifference points, to more broadly draw inference on preferences, and to understand strategic thinking and behavior (see Spiliopoulus and Ortmann 2014 for a review).[3]

The examination of response time has become particularly popular because the software used to elicit individual choices in the experimental laboratory automatically records the time it takes for participants to make decisions. Hence, response-time data is easily and cheaply acquired and researchers have unintentionally been collecting them for many of their past studies. With these data readily available researchers are quickly beginning to examine how response times correlate with individual choices. If we are to embrace this measure for inference on preferences it is, however, essential that we consider the extent to which the observed choices are indeed reflective of individual preferences and are not confounded by decision error. Specifically, the ability to draw valid inference from response times about preferences hinges on the assumption that the frequency of mistakes is not correlated with the time it takes for an individual to make a decision. In this paper we study how response times correlate with mistakes and whether this hinders inference about preferences.

To demonstrate how mistakes may taint the inference from response times we consider the recent literature examining whether individuals are tempted to be generous or to be selfish. In extending the literature on dual selves and dual process reasoning to voluntary public-good provision the questions raised are: Is giving impulsive and intuitive or, is it a deliberate and calculated choice?[4] While it is important to explore whether individuals are predisposed toward generosity or selfishness, it is less clear how we as researchers can answer this question.[5] Existing evidence is scarce and contradictory. Using methods from psychology and neuroscience some studies

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[2] See e.g., Crawford (2008), Rustichini (2008), Smith and Dickhaut (2005), Caplin and Schotter (2008), Camerer, Loewenstein and Prelec (2005).

[3] See also Rubinstein (2007), Chabris, Morris, Taubinsky, Laibson, and Schuldt (2009), Milosavljevic, Malmaud, Huth, Koch, and Rangel (2010), Schotter and Trevino (2012), Agranov, Caplin, and Tergiman (2013), Arad and Rubinstein (2012), and Caplin and Martin (2013).

[4] Central to models of dual selves is that decisions are influenced by an intuitive system which is responsible for automated, rule-based choices, and by a deliberative system, through which calculated reflective decisions are made (see e.g., Evans 2008; Kahneman 2003, 2011; Shefrin and Thaler 1988; Loewenstein and O'Donoghue 2004; Benhabib and Bisin 2005; Bernheim and Rangel 2004; Fudenberg and Levine 2006, 2012). Examples of studies asking whether generosity is intuitive or calculated are Martinsson, Myrseth, and, Wollbrant (2013), Kocher, Martinsson, and Wollbrant (2012), Kinnunen and Windmann (2013), and Kessler and Meier (2014).

[5] For example, inference on motives for giving depends on the extent to which individuals are intuitively generous. Vesterlund (forthcoming) argues that a temptation to give generates the same comparative statics as those attributed to social pressure in DellaVigna, List, and Malmendier (2012).

suggest that generosity is intuitive while others find evidence in favor of the deliberate generosity hypothesis.[6] More recently scholars have begun to use response time and exogenous manipulations of available response time to investigate whether individuals are intuitively generous. The argument is that intuitive decisions can be inferred from decisions that are (or have to be) made quickly, while the more calculated decision can be inferred from those that are made slowly with time. Using constant-return public-good games it has indeed been found that on average participants who make (or have to make) fast decisions contribute more to the public good than those who spend (or can spend) more time making their decisions.[7]

An important concern in using response time or exogenous manipulations of available response time to draw inference on preferences is, however, that it may be correlated with confusion or mistakes.[8] This concern is particularly relevant in the constant-return public-good game where mistakes can be erroneously identified as generosity (Andreoni 1995; Houser and Kurzban 2002). In the classic constant-return public-good game (VCM) n individuals form a group and each allocate an endowment between a private and a group account. While a unit allocation to the private account generates a private payoff of 1, a unit contribution to the group account secures a payoff of r to each group member, where $1/n < r < 1$. To maximize own payoffs, it is a dominant strategy to place the entire endowment in the private account, whereas maximization of the group's aggregate payoff requires the endowment to be placed in the group account.[9] An implication of this particular setting is that each deviation from the equilibrium is beneficial for others and welfare improving and, consequently, any deviation can be interpreted as consistent with generosity. Thus, in this game quick erroneous deviations from the equilibrium will attribute to a negative correlation between contributions and response times and it is therefore important to determine whether error prone participants make fast decisions.

For clean inference on preferences from response time we need to examine environments where error can be identified and where the correlation between response times and error can be evaluated. Therefore, we modify the public-good game such that some deviations from equilibrium simultaneously decrease both the earnings of the individual and of the other group members. Assuming that individuals are either selfish or generous, as in the existing literature, such deviations can be seen as mistakes. Maintaining equilibria in dominant strategies we use a between-subject design to examine two types of public-good games. The first uses piece-wise linear returns to place the dominant strategy equilibrium in the interior of the strategy space, the second instead holds the return from contributing constant and places the dominant strategy at

[6] For example, Ruff, Ugazio, and Fehr (2013), and Kinnunen and Windmann (2013) show evidence consistent with other-regarding behavior being intuitive, while Kocher, Martinsson, Myrseth, and Wollbrandt (2012), Fiedler, Glöckner, Nicklish, and Dickhert (2013) and Strang, Gross, Schuhmann, Riedl, Weber, and Sack (2014) show evidence consistent with other-regarding behavior being a deliberative choice.
[7] See Rand, Greene, Nowak (2012), Lotito, Migheli, and Ortona (2013) and Nielsen, Tyran, and Wengström (2014). Tinghög et al. (2013) and Rand et al. (2014) reexamine the response to time pressure.
[8] For evidence of correlation between response times and error see Rubinstein (2013). Kocher and Sutter (2006), Rubinstein (2007), and Agranov, Caplin, and Tergiman (2013) show that lower frequencies of dominated choices are associated with larger response times in beauty contest games.
[9] Throughout the paper we use the term 'dominant strategy' to refer to selfish payoff maximizing choices.

the upper boundary of the strategy space. Thus, in both types of games there are contributions that simultaneously decrease the payoff to self and others.

In the first type of games the equilibrium and group payoff maximizing outcomes are placed away from the midpoint and boundaries of the strategy space. Using two treatments we vary the location of the dominant strategy. In one treatment, the equilibrium is below the midpoint of the strategy space, and in the other it is above the midpoint of the strategy space. We refer to the first as the “Low” treatment and to the second as the “High” treatment. The welfare maximizing contribution is identical in the two treatments and is placed above the respective dominant strategy. The ability to draw inference on preferences from response times is evaluated by asking whether the correlation between response times and contributions is sensitive to the location of the equilibrium. Specifically, if fast responses are reflective of generous preferences we should find a negative correlation between response times and contributions in both treatments.

We find that behavior in the Low treatment is consistent with the existing literature. When it is a dominant strategy to contribute an amount below the midpoint of the strategy space, response times are negatively correlated with contributions. However, the correlation between response times and contributions is reversed in the High treatment. When the equilibrium is located above the midpoint of the strategy space, fast decision-makers appear less generous than those who take more time to decide.

Intriguingly, in both the Low and High treatments, fast decision-makers are more likely to make mistakes, i.e., choose contributions that decrease both individual and group earnings. By contrast, slow decision-makers are more likely to contribute the equilibrium amount, and when they deviate from the dominant strategy they are more likely to make welfare improving contributions. Comparing the Low and High treatments we find significant differences in the contributions made by slow decision-makers, while those made by fast decision-makers are not distinguishable by treatment. These results show that the payoff differences associated with contributions in the Low and High treatments have little effect on fast decision-makers and are consistent with them being more prone to error.

In both Low and High we also find that fast decision-makers more frequently make the very costly decision of contributing their entire endowment. To assess whether such choices can be seen as mistakes or as very generous contributions we modify the design such that individuals contributing the entire endowment decrease the payoff of all members of the group. In these Modified-Low and Modified-High treatments we replicate all of our initial findings. Importantly, we also find that fast decision-makers contribute the entire endowment more frequently than slow decision-makers even when such contributions are dominated from an individual as well as group perspective. We also show that in repeated interactions contributions quickly converge toward equilibrium. Convergence in average contributions occurs from above in the Low treatment and from below in the High treatment and is slower for participants who make fast decisions in the first round of the experiment.

For the interior equilibrium public-good games we relied on piece-wise linear payoffs, which is a more complicated payoff structure than that of constant return public-good games. One may argue that this could contribute to an increase in the rate of error. Therefore, in the second type of public-good game we ask whether similar results arise when the return to giving is constant as in the standard VCM, but the strategy space includes contributions that are dominated from an individual and group perspective. We secure such an environment by adding a private benefit for contributing, thereby moving the dominant strategy from one of zero provision to one of full provision. That is any contribution below full provision reduces the earnings of both the individual and all other group members. In this High-VCM treatment we replicate our results and find, in contrast to previous VCM results, that fast decision-makers are less generous than slow decision-makers. As in our interior equilibrium designs we examine how sensitive decisions are to the location of the equilibrium by comparing contributions in the High-VCM to those that result in the standard constant return (Low-) VCM with a dominant strategy of zero provision.

We find, for all three variations of our High and Low design, that average choices by slow decision-makers are very sensitive to the location of the equilibrium and easily distinguishable by treatment. By contrast, choices by fast decision-makers are indistinguishable by the respective High and Low treatments. This relative insensitivity to the location of the equilibrium and to the set of allocations that are dominated from a group perspective indicates that choices made by fast decision-makers unlikely reflect solely preferences over payoffs. As in the work on rational inattention and costly information processing by Caplin and Dean (2015) it may instead be that dominated choices (by fast decision makers) result from an unwillingness to trade cognitive effort for monetary reward.

In showing that the correlation between response times and contributions varies with the strategic environment, we argue that a negative correlation between response times and giving seen in the standard public-good game, rather than being evidence of intuitive generosity, likely results from quick erroneous decisions selecting contributions that lie on average above those made by slow participants. Extending beyond the literature on public-good games our results suggest that erroneous behavior must be accounted for if we are to use response time as an indicator of preferences.

2. Related literature

The use of response time to study decision making in economics is relatively recent. It started with the work of Wilcox (1993), who viewed response time as a proxy for decision cost and analyzed choices in risky environments. The subsequent literature has used response time to investigate the decision process employed by individuals, to make inferences about preferences, and to predict choices within and across domains.[10]

Chabris, Morris, Taubinsky, Laibson, and Schuldt (2009), for example, use response time to draw inference on preferences in binary intertemporal choice settings. They show that response time decreases with the difference in net present value between options and use response times to predict discount factors. Milosavljevic, Malmaud, Huth, Koch, Rangel (2010), Krajbich, Armel, Rangel (2010), Krajbich and Rangel (2011), Krajbich, Lu, Camerer, and Rangel (2012) use response time to study drift diffusion models of stochastic choice, which make joint predictions about choices and the time individuals take to make decisions. Their work shows that response time decreases with the strength of preferences between options and can be used together with choice data to predict choices in binary and trinary food consumption settings. Schotter and Trevino (2012) use response times to predict indifference points in repeated binary global game settings. Clithero and Rangel (2013) use them to show that the drift diffusion model of stochastic choice can help improve out of sample predictions in binary food consumption settings. Krajbich, Oud, and Fehr (2014) study inefficiencies in the allocation of time in repeated choice settings and show that the drift diffusion model calibrated with food choice parameters can predict choices in other domains.

Rubinstein (2007) used response time to study the deliberation process employed by individuals and used response time to identify intuitive responses. He put forward the idea that fast choices are instinctive while slow choices are cognitive and analyzed the correlation between response times and choices in seven different strategic environments.[11] His work together with subsequent studies (Rubinstein 2013, 2014) documents large variation in the types of choices associated with fast response times.[12]

Rand, Greene, and Nowak (2012) use response times and exogenous manipulations of available response time to identify intuitive and deliberate actions in public-good games. They analyze the correlation between choices and the time individuals take to make decisions in a series of constant-return public-good games (and binary prisoner dilemma games).[13] Consistent with generosity on average being an intuitive response and greed on average being a calculated

[10] See Spiliopoulus and Ortmann (2014) for a review. Further examining the decision process researchers have also investigated the effect of time pressure on choices (see e.g., Ibanez, Czermak and Sutter, 2009; Cappeletti, Güth, and Ploner, 2011; Kocher, Pahlke, and Trautmann, 2013; Reutskaja, Nagel, Camerer, and Rangel, 2011).

[11] See also Kahneman (2011).

[12] In Rubinstein (2007, 2014) fast decisions are associated with fair outcomes in some settings, with equilibrium and efficiency maximizing choices in others, and with the use of strictly dominated choices in yet other environments. In many of the strategic settings investigated, however, focal choices coincide with fair, equilibrium, efficiency maximizing, and strictly dominated strategies.

[13] Analysis of non-strategic environments such as the dictator game and actual donation decisions has also been conducted and shows mixed results. Piovesan and Wengrström (2009) find a positive correlation between offers in the dictator game and the time individuals take to make choices within and across subjects. Cappelen, Nielsen, Tungodden, Tyran, and Wengström (2014) show instead that equal split offers are associated with faster response times than selfish choices in the dictator game. Lohse, Goeschl, and Diederich (2014), on the other hand, show that response times are positively correlated with monetary contributions to CO_2 emission reduction in a large online experiment with 3,483 participants.

response they find a negative correlation between contributions and response times which is robust to exogenously manipulating time pressure.[14] Lotito, Migheli, and Ortona (2013) replicate the negative correlation between response times and contributions when endowments are asymmetric, and Nielsen, Tyran, and Wengström (2013) do so when the strategy method is employed.[15] Brañas, Garza, Meloso and Miller (2013) document a negative correlation between offers to responders and the proposers' decision times in the ultimatum game.[16]

In examining the correlation between response times and generosity the literature has given limited attention to the role of error.[17] Specifically, the inference on preferences has not taken into account the possible correlation between mistakes and the time individuals take to make choices. Such correlation is of particular concern in the standard constant-return public-good game where all deviations from the equilibrium are welfare improving and can thus be rationalized by generosity.[18] If errors are uncorrelated with response times this is, of course, not an issue. However, it becomes an important confound if error is correlated with the time individuals take to make choices. If fast or slow decision-makers more frequently are confused or inattentive, then response time will be a poor measure of preferences.

Existing evidence exploring whether mistakes are correlated with the time individuals take to make choices is mixed. Rubinstein (2013) studies the correlation between response times and mistakes in 10 decision tasks. He finds that mistakes are negatively correlated with the time

[14] Tinghög et al. (2013), however, note that the time pressure analysis presented in Rand, Greene, and Nowak (2012) is problematic because it excludes half of the observations from the sample. Tinghög et al. (2013) conduct a series of binary public-good game experiments in three different countries to reexamine the effect of time pressure on cooperation, and do not find a robust relationship. Rand et al. (2014) reanalyze data from 15 experiments that manipulate time pressure and show that the effect of time pressure is positive and statistically significant in the pooled sample of studies. They also note that time pressure is never found to have a statistically significant negative effect on contributions.

[15] Nielsen et al. (2014) use the strategy method to classify participants as free–riders, conditional cooperators, and other cooperator types. They show that free-riders are slower to make choices than other cooperator types. We note that their results could be driven by error if confused participants make fast choices that are arbitrarily coherent and increase with the contribution of others. See Ariely, Loewenstein, and Prelec (2003) for evidence of coherent arbitrariness in other settings.

[16] Rubinstein's (2007) analysis of response times and ultimatum game offers shows a negative correlation between response times and offers only when offers above the 50-50 threshold are excluded. Offers in excess of 60 percent of the endowment are associated with short response times, while offers between 50 and 60 percent of the endowment are associated with long response times.

[17] While drift diffusion models acknowledge that mistakes occur as part of the choice process, existing studies cannot identify mistakes explicitly and do not attribute the correlation between response times and choices to mistakes, but rather to the difficulty of choices measured through the differences in payoffs. For example, Krajbich, Bartling, Hare, and Fehr (2014) examine how changes in the MPCR affect the correlation between generosity and response times. They have subjects make repeated choices in constant-return VCMs with various MPCRs and show that contributions are positively correlated with response times when the MPCR equals 0.3 and 0.5, but are negatively correlated with response times when the MPCR equals 0.9.

[18] Similarly all deviations from equilibrium in the dictator and ultimatum games can also be seen as generous behavior. While it is tempting to argue that offers in excess of 50 percent of the endowment are mistakes in these settings, response time data indicates that such generous choices are sometimes associated with slow response times and thus indicative of deliberation (see e.g., Rubinstein 2007, 2014; and Piovesan and Wengström 2009). Furthermore, in such settings the midpoint of the strategy space is focal and coincides with the fair outcome, making it impossible to distinguish between focal, generous or fair choices, and mistakes.

individuals take to make choices when questions have a definitive right answer. Mistakes defined as violations of transitivity, however, are positively correlated with response times. Finally, mistakes defined as violations of consistency are not correlated with the time individuals take to make choices. Other studies have shown that the frequency of dominated choices decreases with individuals' response times in strategic settings. Sutter, Kocher, and Strauß (2003), for example, show that forcing subjects to make decisions quickly increases the rates of rejection in the first round of a repeated ultimatum game. Kocher and Sutter (2006) show that guesses in the beauty contest game increase with time pressure. Rubinstein (2007) shows that choices equal to or above the midpoint of the strategy space in the 2/3 beauty contest game are associated with faster response times than any other strategy. Agranov, Caplin, and Tergiman (2013) use a strategy-type method that maps choices over response time in the beauty contest game and show that while the guesses of strategic players decrease with response time, non-strategic players make average guesses that coincide with the midpoint of the strategy space and do not change with time.

Our study contributes to the literature by asking whether response time is a reliable indicator of individual preferences in social dilemma situations. We develop a strategic setting that allows us to distinguish quick mistakes from intuitively generous behavior and examine the extent to which error affects the observed correlation between response times and choices. While our study focuses on public goods games, our results are also informative of inference from response time in other settings. Mistakes are likely to play a prominent role in many strategic environments, hence inference on preferences from such settings require that mistakes and their distribution over time are accounted for.

3. Identifying mistakes

In the standard constant-return public-good game (aka voluntary contribution mechanism, VCM) an individual's private monetary payoff is maximized by contributing nothing irrespective of the contributions made by others. That is, contributions of zero are from a narrow selfish perspective a dominant strategy and deviation toward higher contributions could be mistakes. While it is costly for the individual to contribute, doing so increases the payoffs of the other group members, and the group's aggregate earnings are maximized when the entire endowment is contributed. Hence positive contributions need not be mistakes but could instead result from generosity. As all deviations from equilibrium increase the earnings of others it is not possible to determine whether positive contributions are made in error, are due to concern for others, or both.[19]

[19] Social or other-regarding preferences models transform the VCM into a coordination game where any contribution vector may be supported as a Nash equilibrium (see e.g., Fehr and Schmidt (1999) Proposition 4, p.839). In the following whenever we refer to Nash equilibrium we mean a Nash equilibrium under narrow material selfishness.

If we are to understand what causes VCM contributions by fast decision-makers to exceed those by slow decision-makers, then the rate of mistakes must be accounted for. We therefore modify the standard public-good game design to secure that some deviations from equilibrium are dominated in the sense that they simultaneously decrease both the payoffs of the individual and the payoffs of the other group members. That is, we examine games where some contributions can be seen as mistakes for individuals aiming to increase the earnings to self and/or others.

We implement two types of public goods games both with a unique Nash equilibrium in dominant strategies (as in the VCM). The first type uses piece-wise linear returns to place both the equilibrium and the group-payoff maximizing contributions in the interior of the strategy space. Importantly, in contrast to the VCM a subset of contributions in the strategy space are dominated from an individual and group perspective. To understand the role of mistakes we implement two treatments of the game where we keep constant the group payoff maximizing outcome, but vary the location of the dominant strategy equilibrium. The equilibrium in one treatment (Low) lies below the midpoint of the strategy space and the equilibrium in the other treatment (High) lies above the midpoint. In both treatments the Nash equilibria lie below the group payoff maximizing outcome. These two treatments allow us to use comparative statics analysis to determine whether the location of the equilibrium affects the correlation between response time and contributions.

The payoff structure of the second type of public-good game is similar to the standard VCM. Holding the return from contributing constant we secure the group-payoff maximizing contribution at full provision. However, by increasing the individual's return from contributing the dominant strategy is moved from zero to full provision. In this High-VCM, full provision is thus not only dominant from a group perspective, but also from a selfish individual payoff maximizing perspective. While error cannot be separated from generous contributions in the standard VCM with a dominant strategy of zero provision, it can be identified when instead the dominant strategy is one of full provision. To secure comparative statics we compare the contributions and response times of this High-VCM treatment to those seen in a standard Low-VCM. We first describe the design and results of the interior equilibrium public good experiments (Section 4) and then proceed to report on the public good experiments where the equilibria are at the boundary of the strategy space (Section 5).

4. Public-good games with interior equilibria

Holding constant the interior contributions that maximize the group's earnings we vary in two public-good games the location of an interior dominant strategy equilibrium. In a Low treatment the equilibrium is below the midpoint of the strategy space and in a High treatment the equilibrium is above the midpoint of the strategy space. Using these treatments we assess whether mistakes vary with response times, and whether fast decisions are more generous in both strategic settings.

4.1. Payoffs

To secure an interior equilibrium we use a piece-wise linear payoff structure. Specifically, we extend the two-person framework of Bracha, Menietti, and Vesterlund (2011) to a four-person group. Participants are given a \$10 endowment, which they can contribute in \$1 increments to a group account. Contributions to the group account generate a constant and equal benefit to the other group members. The private benefit of contributing, however, is concave using a linear approximation. The participant's payoffs are given by the following function:

$$\pi_i(g_i, G_{-i}) = \begin{cases} 10 + \alpha g_i + \sigma G_{-i} & if \quad 0 \leq g_i \leq g^L \\ 10 + \alpha g^L + \beta(g_i - g^L) + \sigma G_{-i} & if \quad g^L < g_i \leq g^H \\ 10 + \alpha g^L + \beta(g^H - g^L) + \gamma(g_i - g^H) + \sigma G_{-i} & if \quad g^H < g_i \leq g^P \\ 10 + \alpha g^L + \beta(g^H - g^L) + \gamma(g^P - g^H) + \delta(g_i - g^P) + \sigma G_{-i} & if \quad g^P < g_i \leq 10 \end{cases} \tag{1}$$

where π_i denotes the monetary payoff individual i receives from his or her contribution g_i to the group account and the sum of contributions G_{-i} made by the three other group members. Threshold contributions $g^L$and g^H denote respectively the individual equilibrium contribution in the Low and High treatments, and g^P denotes the individual contribution associated with the unique group-payoff maximizing outcome. Parameter σ remains constant across the Low and High treatments, while α, β, γ, and δ vary. That is, across treatments we hold constant the benefit others get from an individual's contribution, while varying the individual's private return from contributing. The specific parameters used in each treatment are shown in Table 1.

Table 1. Payoff function parameters by treatment

Treatment	Parameter							
	α	β	γ	δ	σ	g^L	g^H	g^P
Low	1.45	-0.25	-0.5	-3.25	0.25	3	7	9
High	0.116	0.25	-0.5	-1.25	0.25	3	7	9

Parameters were chosen to secure that the strategic settings fulfilled four requirements. First, there is an interior Nash equilibrium in dominant strategies, which varies by treatment. In our Low treatment the equilibrium contribution is \$3 and, thus, located below the midpoint of the strategy space. In our High treatment the equilibrium contribution is \$7 and, thus, located above the midpoint of the strategy space. Second, there is a unique interior group-payoff maximizing contribution of \$9, which is the same in both treatments. Third, equilibrium payoffs as well as the boundary payoffs associated with contributing \$0 and \$10 are held constant across treatments. Payoffs are chosen such that individually costly but group welfare improving contributions range from \$4 to \$9 in the Low treatment, and from \$8 to \$9 in the High treatment. Fourth, the cost of deviating from the equilibrium contribution toward the middle of the strategy space (between \$3 and \$7) is held constant in the two treatments. The strategic environments thus separate Nash equilibrium and group-payoff maximizing contributions from both the boundaries and the midpoint of the strategy space, while holding key features of the environment constant across treatments.

Within each treatment, our design allows us to assess whether fast or slow deciding participants more frequently make choices that decrease both the individual and the group's total earnings. Such an assessment would not be possible in a standard VCM. Moreover, by comparing the pattern of contributions of fast and slow decision-makers between treatments we can assess whether fast or slow decisions result in larger contributions and whether the correlation between response times and contributions depends on the strategic environment. If mistakes are more frequently made by fast decision-makers and if these mistakes do not respond to changes in the strategic environment, then we would expect to find a negative correlation between response times and contributions in the Low treatment but to find the reverse correlation in the High treatment.[20]

4.2. Experimental procedures

The experiment was conducted at the Pittsburgh Experimental Economics Laboratory (PEEL) at the University of Pittsburgh. Using a between-subject design we conducted four sessions of each of the two treatments. With 20 participants per session a total of 160 undergraduate students participated in these public-good games with interior equilibria. Each session lasted approximately 45 minutes with average payments being $22.50 per subject (including a $6 show up fee).

Upon entering the lab, participants were seated in a pre-marked cubicle, and were asked to provide informed consent to participate in the study. We then distributed instructions and read them out loud. The instructions provided a general description of the strategic setting.

Participants were informed that they would be matched in groups of four and that they would each be given an endowment of $10, which they could invest in $1 increments in a group account. Participants knew that investment decisions would affect their payoffs and the payoffs of other group members, but were given no details on the actual payoff structure. They were told that payoff information would be presented to them via payoff tables displayed on the computer screen. The instructions explained to participants how they should read the payoff table and informed them that they would have to complete a tutorial before proceeding.[21]

After completion of the instructions participants proceeded with a tutorial. Interfaces for the tutorial and for the decision making part of the experiment were programmed using z-Tree (Fischbacher 2007). The tutorial used an abstract payoff table in which participants had two

[20] We hypothesize a negative correlation in the Low treatment due to the results documented in the literature. The correlation between response times and contributions in the Low treatment could, nevertheless, be null or positive given that the set of welfare improving contributions constitute a large subset of the strategy space and carefully deliberated choices not reflective of error may fall anywhere in this set. Note that fast choices that reflect mistakes need not coincide on average with the midpoint of the strategy space in this and other experiments as experimental procedures and focal points may easily change the distribution of error.

[21] For the instructions see the online Appendix.

investment options. The payoffs in each cell were denoted using matrix notation. That is, no monetary payoffs were presented but rather combinations of letters and numbers (e.g., $A11). Participants had to answer six questions in the tutorial, which asked them to identify the abstract payoffs associated with different investment choices made by all group members. The tutorial allowed participants to enter incorrect answers, but presented solutions to ensure proper understanding.

The decision-making phase began after the tutorial. Individual computer screens displayed the payoff table and asked participants to make a contribution decision.[22] For a given average contribution made by the other three group members, the payoff table listed, for each possible contribution decision between $0 and $10, the individual's payoffs and the average payoffs of the other group members. Time was recorded as the number of seconds it took participants to make a decision after seeing the payoff table. Time was not displayed on the decision screen. Once all contribution decisions had been made participants were shown a payoff screen informing them of their own contribution, the total and average contribution made by other group members, their own payoff and the average payoff of the other group members.

This ended Part 1 of the experiment and participants received instructions for Part 2. They were informed that Part 2 consisted of 10 periods of the same decision scenario as Part 1. They were also informed that in each period they would be randomly re-matched with other group members, and that they could not be re-matched with the same group members twice in a row. Participants were at the beginning of the session informed that the experiment would consist of two parts and that only one of the two parts would count for payment. If Part 2 was selected for payment only one randomly selected period would be paid. At the end of each period participants received the same feedback as in Part 1.

For the analysis of the relation between response times and contributions we emphasize the Part-1 results, and use the Part-2 results to assess convergence. After completing the decision phase all participants were given a brief demographic questionnaire to determine their age, gender, nationality, year in college, and college major.

4.3. Results

We start with a description of contributions, then report on the correlation between contributions and response time, and proceed to examine the robustness of the results. As a further reflection of the role of mistakes we conclude the section by examining how behavior changes in repeated interactions, and by reporting on behavior in a slightly modified version of the experiment where full provision decreases both individual and group payoffs.

[22] The payoff tables used in the experiment are presented in the online Appendix Tables A1 and A2.

4.3.1 Contributions

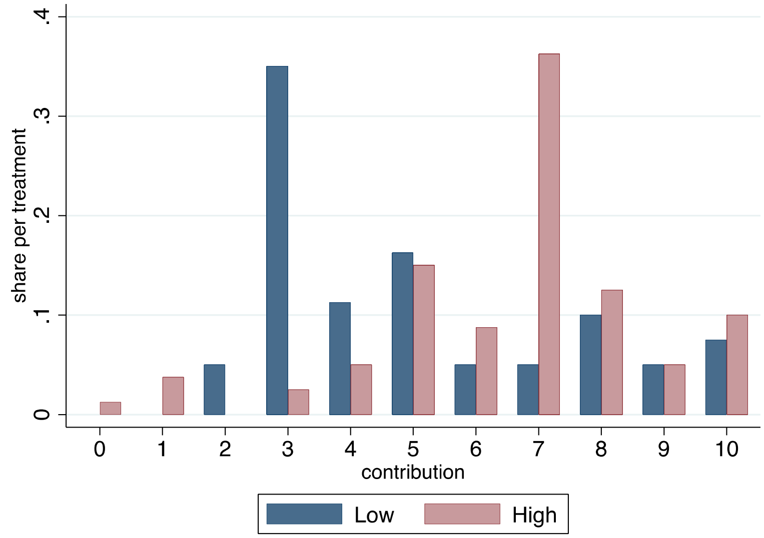
Participants respond to the different incentives in the Low and High treatments. Figure 1 presents a histogram of contributions by treatment. It shows that the modal contribution in the Low and High treatment is precisely the equilibrium prediction ($3 and $7, respectively). 35 percent of participants in the Low treatment contribute $3 and 36 percent of participants in the High treatment contribute $7.[23]

In the Low treatment the average contribution exceeds the equilibrium prediction of $3 (mean = $5.06, p<0.01), whereas in the High treatment it falls short of the equilibrium prediction of $7 (mean = $6.57, p<0.10).[24] Hence, relative to the equilibrium prediction, on average, participants overcontribute in the Low treatment and undercontribute in the High treatment. Participants in the Low treatment also contribute, on average, less than participants in the High treatment (p<0.01).[25]

Importantly, in both the Low and High treatments we see deviations from equilibrium that decrease both individual and group payoffs. Furthermore, some choices exceed the group-payoff maximizing contribution of $9. Although contributions of $10 benefit others, the individual marginal cost of giving $10 rather than $9 is so large that the group's aggregate payoff decreases. To better understand such contributions we report in Section 4.4 on experiments with a slightly modified payoff structure which helps determine whether contributions of $10 represent very generous choices or mistakes.

[23] This frequency of equilibrium play is higher than that usually documented for VCMs, which suggests that our setting is not more difficult for participants to understand. Isaac, Walker, and Thomas (1984) document a frequency of equilibrium play of 30 percent (across 10 rounds) in constant-return VCMs with various group sizes and various marginal per capita returns (19 percent in the first round of play when group size is four). For a general description of contribution behavior in the standard VCM see Ledyard (1995) and Chaudhuri (2011).
[24] Unless otherwise noted all tests are two-sided t-tests.
[25] The differences in the distribution of contributions across treatments are statistically significant (Kolmogorov-Smirnov p<0.01).

Figure 1. Histogram of contributions by treatment, Part 1



Note: The equilibrium contribution is 3 in the Low treatment and 7 in the High treatment. The group payoff maximizing contribution is 9 in both treatments.

Interestingly, when disregarding equilibrium play, the distributions of contributions appear rather insensitive to treatment. Absent contributions of $3 and $7 we cannot reject the null hypothesis that the average of the remaining contributions are the same across treatments (the mean contribution in the Low treatment is $6.10 and the mean contribution in the High treatment is $6.47; p=0.479). We can also not reject the null hypothesis that (absent contributions of $3 and $7) the two samples come from the same underlying distribution (Kolmogorov-Smirnov p=0.714). The similarity in contributions is particularly striking when considering contributions of $4, $5, and $6. While these contributions may be seen as generous in the Low treatment, they are dominated from a group (and individual) perspective in the High treatment. The similarity in frequency of $10 contributions is also surprising given the substantial differences in cost associated with contributing $10 in the two treatments.

Despite substantial differences in incentives the frequencies of non-equilibrium contributions do not appear to respond to the treatments. We classify contributions as mistakes only when they are dominated from an individual and group perspective. We note however that the similarity in distributions of off-equilibrium contributions across treatments with vastly different incentive structures suggests that costly welfare improving contributions in the Low treatment may not be reflective of generous contributions but rather of mistakes.

Next we examine how long it takes participants to make a contribution and how these response times correlate with contributions and mistakes. We are particularly interested in whether overcontributions in the Low treatment and undercontributions in the High treatment result from error, and whether such errors are correlated with participants' response times.

4.3.2. Response times and contributions

The time it takes to make a contribution decision varies substantially across participants. Some participants spend as little as 4 seconds making a decision whereas others spend more than 3 minutes deciding. There is, however, no evidence that response times differ by treatment (Kolmogorov-Smirnov p=0.490). The mean and median response times of 50.61 and 41 seconds in the Low treatment and of 46.78 and 42.5 seconds in the High treatment are very similar and do not differ statistically significantly between treatments (p=0.497; Wilcoxon Mann-Whitney rank-sum test p=0.452).

To explore the correlation between response times and contributions we use OLS regressions with contributions as the dependent variable.[26] Column 1 of Table 2 shows the results for participants in the Low treatment and reports a negative and statistically significant coefficient on response time. That is, when the equilibrium is located below the midpoint of the strategy space fast decision-makers contribute more than slow decision-makers. Thus, consistent with the existing evidence from the constant-return VCM literature, faster decision-makers select larger contributions. The size of the coefficient indicates that participants who delay their decision by 1 minute on average contribute $1.14 less than those who make a contribution decision right away.

The correlation between contributions and response times is, however, sensitive to treatment. Column 2 of Table 2 shows that in the High treatment the correlation is reversed: it is positive and statistically significant. Thus, in this treatment it is slow decision-makers who tend to choose larger contributions. The coefficient on response time is of similar magnitude as the one estimated in the Low treatment. A participant who delays the decision by 1 minute will on average contribute $0.96 more than someone who makes a contribution right away. Column 3 of Table 2 pools the data from the two treatments to test whether treatment effects are statistically different. Using a difference-in-difference regression of contributions on response time and treatment, column 3 shows two things. First, the insignificant coefficient of the dummy variable High (1 if treatment is High, 0 otherwise) indicates that, when controlling for response time, there is no overall difference in contributions between treatments. Second, the positive and statistically significant coefficient of the interaction between the dummy High and response time (High x response time) shows that the correlation between contributions and response times significantly differs between treatments. Hence, while for fast decision-makers there is little difference in contributions between the Low and High treatments, the difference increases with response time. Therefore, the treatment differences seen in Figure 1 are a result of the slower decisions.[27]

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[26] Tobit regressions that take into account the censoring at $0 and $10 are presented in the Appendix and provide similar results.

[27] In Table A2 of the appendix we show that the correlations between response times and contributions documented in Table 2 are robust to controlling for age, gender, the number of tutorial questions answered correctly, training in economics, and experience with laboratory experiments. The results are also robust to excluding outlier observations. Specifically, eliminating observations with response times in excess of 150 seconds does not alter the

Table 2. OLS regression of contributions on response time

Dep. Var.: Contribution to group account	Treatments		
	Low	High	All
	(1)	(2)	(3)
Response time	-0.019**	0.016**	-0.019***
	(0.008)	(0.006)	(0.007)
High			-0.205
			(0.598)
High x response time			0.035***
			(0.010)
Constant	6.024***	5.819***	6.024***
	(0.469)	(0.376)	(0.443)
Total effect response time: High			0.016**
			(0.007)
N	80	80	160

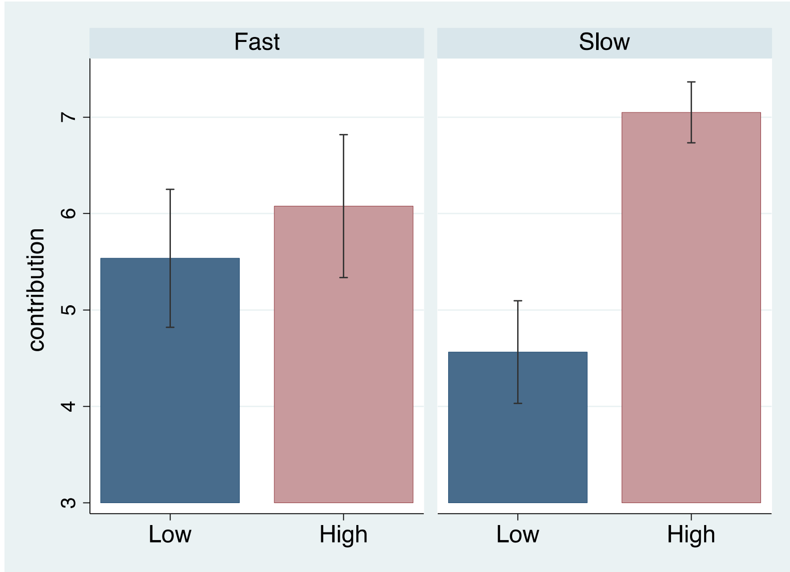
Note: Standard errors in parentheses. *p<0.10, **p<0.05, ***p<0.01.

The treatment insensitivity of fast decision-makers is summarized in Figure 2. We use the median response time of the pooled sample (41.5 seconds) to define fast and slow decision-makers. Figure 2 shows that while there are no significant treatment differences in the average contributions made by fast decision-makers (Mean Low = $5.54, Mean High = $6.08, p=0.380), there are substantial and statistically significant differences in the average contributions made by slow decision-makers (Mean Low = $4.56, Mean High = $7.05, p<0.01). Consistent with the results presented in Table 2 we find in the Low treatment that slow decision-makers contribute less than fast decision-makers, but that the reverse holds true in the High treatment (p=0.072 and 0.042 in each treatment respectively). We also note that in both treatments standard deviations are smaller for slow decision-makers.[28]

coefficients on response time reported in Table 2 (irrespective of whether or not the full set of additional controls is included in the regressions). See online Appendix Table A3.

[28] Tests for differences in the standard deviation of contributions reject the null hypothesis that the variance of the contributions is the same for fast and slow decision-makers (Brown - Forsythe robust test p<0.05 in both treatments).

Figure 2. Mean contribution by fast and slow decision-makers, Part 1

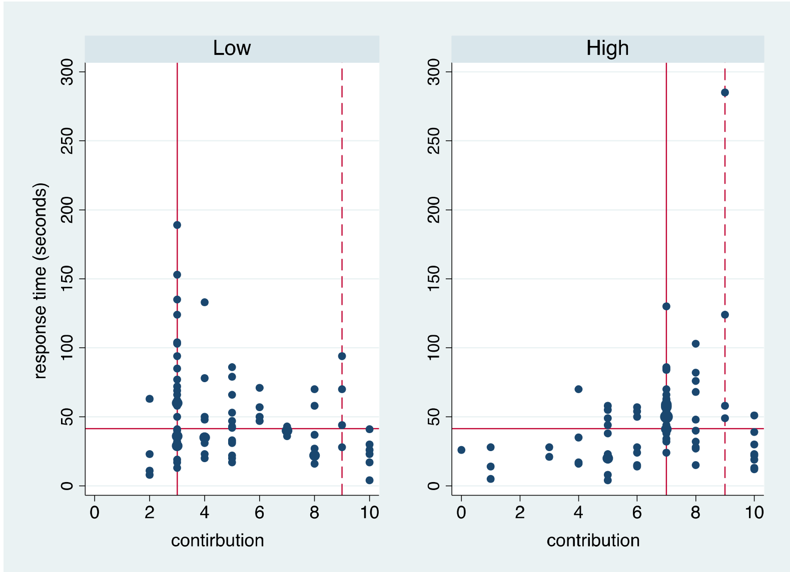


Note: Fast indicates that choices were made in less than the median response time, and slow indicates that choices were made in the median response time or more.

The results reported in Table 2 and Figure 2 clearly demonstrate that whether fast decision-makers contribute more than slow decision-makers depends on the strategic environment. Looking at the distribution of contributions by response time it becomes clear why the comparative statics reverse with treatment. Figure 3 presents a scatterplot of response times and contributions by treatment. The solid vertical line indicates the location of the equilibrium contribution ($3 and $7 in the Low and High treatment, respectively) and the dashed vertical line indicates the location of the contribution that maximizes the group's total earnings ($9 in both treatments). The horizontal line indicates the median response time of the pooled sample, separating fast decision-makers below the horizontal line, from slow decision-makers above the horizontal line. Inspecting the segments below the median response time in the two panels of Figure 3, we see that despite the different incentives fast contributions are similarly distributed in both treatments. In contrast, slow contributions, depicted in the segments of Figure 3 above the median response time, show clear treatment differences.[29]

[29] For fast decision-makers, the distributions of contributions do not differ significantly by treatment (Wilcoxon Mann-Whitney rank-sum test yields p=0.232, and Kolmogorov-Smirnov p=0.167), whereas those for slow decision-makers do (p<0.01 for both Wilcoxon Mann-Whitney rank-sum and Kolmogorov-Smirnov tests).

Figure 3. Scatterplot of contributions and response time by treatment, Part 1



Note: The solid vertical line indicates the Nash contribution, the dashed vertical line indicates the group payoff maximizing contribution, and the solid horizontal line indicates the median response time of the pooled sample (41.5 seconds).

Table 3 summarizes the information contained in Figure 3 and indicates the types of choices that are associated with fast response times in each treatment. Mistakes are defined as contributions that simultaneously decrease the payoff to the individual and to all other group members, that is, contributions that fall below \$3 and \$7 in the Low and High treatments respectively. The first row in Table 3 shows that mistakes are overwhelmingly associated with fast response times in both treatments. Overall 72 percent of subjects who make mistakes do so in less than the median response time. Hence we reject the null hypothesis that slow and fast decision-makers are equally likely to make mistakes (2-sided Fisher's exact test $p<0.01$ in the pooled sample).[30] Moreover, contributions of \$10, which are dominated from a group payoff maximizing perspective are also associated with fast responses (2-sided Fisher's exact test $p<0.01$ in the pooled sample). By contrast, both equilibrium and group payoff maximizing contributions are more likely to be made by slow decision-makers (2-sided Fisher's exact test $p<0.01$ and $p=0.064$ for equilibrium and payoff maximizing contributions in the pooled sample).[31]

[30] Using response times rather than the fast-slow partition to analyze whether mistakes are associated with fast response times yields similar results. A probit regression of mistakes on response time returns statistically significant marginal effects in the pooled sample (-0.00494; $p=0.001$); the Low treatment (-0.00134; $p=0.0001$) and the High treatment (-0.0107; $p=0.003$).

[31] We report pooled data statistics because by treatment the number of observations in some bins is very small. The 2-sided Fisher's exact test statistics for the Low and High treatment separately are for mistakes (Low: $p=0.616$; High: $p<0.01$), equilibrium contributions (Low: $p=0.160$; High: $p<0.01$), group payoff maximizing contributions (Low: $p=0.353$; High: $p=0.116$) and contributions of \$10 ($p<0.05$ in both treatments). The extent to which a \$10 contribution is also a mistake is examined in a modified treatment where both the lower and upper boundary of the strategy space are dominated from an individual and group perspective (see section 4.4).

Table 3. Contributions by treatment

Choices	Low # obs.	Low % fast	High # obs.	High % fast	All # obs.	All % fast
Mistakes (dominated from individual and group perspective)	4	75	29	72	33	72
Nash equilibrium	28	39	29	21	57	30
Above Nash & below group payoff max.	38	53	10	50	48	52
Group payoff maximizing	4	25	4	0	8	13
Full provision (reducing group payoff)	6	100	8	88	14	93
Midpoint of strategy space	13	46	12	67	25	56
All	80	51	80	49	160	50

Note: "fast" indicates that contribution decisions were made in less than the median response time.

Our results show that the correlation between response times and contributions is sensitive to the strategic environment. While fast decision-makers do not generally contribute more than slow decision-makers, they are more likely to select a contribution that simultaneously lowers individual and group payoffs, and their average contribution appears to be independent of the treatment. This is consistent with the interpretation that fast decision-makers are more prone to errors than slow decision-makers, rather than that fast decision-makers tend to be more generous.

4.4. Robustness

To further examine the role of mistakes we conduct two additional sets of analyses. First we examine how contributions change in Part 2 of the experiment. Second, we conduct an additional set of experiments where we alter the payoff structure to secure that full-provision choices simultaneously decrease the payoff of all members of the group and thus can be seen as a mistake. Using this modified design we ask whether the frequency of full-provision contributions responds to this change in incentives.

One way of assessing the extent to which choices are reflective of preferences is to look at how choices change in Part 2 of the experiment, where participants make decisions in a ten-period version of Part 1 with random re-matching of group members in each period. We find that the frequency of equilibrium play increases substantially with repeated interaction. In the Low and High treatments the share of equilibrium contributions increases from one third to two thirds from Part 1 to period 10 of Part 2.[32] With repetition contributions decrease on average in the Low treatment, while they increase on average in the High treatment. That is, contributions converge to the equilibrium prediction from above in the Low treatment and from below in the High treatment. The opposing directions of convergence in Part 2 are consistent with the interpretation that overcontribution in the Low treatment and undercontribution in the High treatment in part can be attributed to mistakes. In fact, using Part 1 response times to classify participants as fast and slow decision-makers shows that fast decision-makers contribute significantly more than slow decision-makers in Part 2 of the Low treatment and significantly less than slow decision-

[32] The share of equilibrium play increases from 35 to 69 percent in the Low treatment and from 36 to 79 percent in the High treatment when moving from Part 1 to period 10 of Part 2.

makers in Part 2 of the High treatment. They thus converge more slowly toward the equilibrium.[33] By period 4, the median contribution of each of the two treatments equals the respective equilibrium predictions. Convergence from above in the Low treatment could in principle be indicative of both generous types becoming selfish with deliberation and of them correcting initial mistakes. However, convergence from below in the High treatment lends support to the latter explanation as it clearly shows that subjects learn not to play a dominated strategy. Hence, overall the behavioral pattern observed in Part 2 is consistent with contributions of fast decision-makers being due to mistakes, rather than being reflective of (generous) preferences over payoffs.

An interesting result in the Part-1 decisions was that contributions of \$10 were predominantly made by fast decision-makers. The individual cost of contributing \$10 rather than \$9 is substantial and results in a decrease of group welfare. It does, however, increase the earnings of other group members. Therefore, contributions of \$10 may be rationalized by very generous preferences.[34] In this second robustness analysis we ask whether the frequency of full-provision contributions changes when an increase in contributions from \$9 to \$10 lowers both an individual's own payoff and the payoffs of every other member of the group.[35] Keeping the payoffs of all other combinations of contributions the same as in the initial interior equilibrium experiments, this ensures that both the lower and upper boundary of the strategy space are dominated from an individual as well as group perspective. We conduct four sessions of these treatments, two with the Modified-Low treatment and two with the Modified-High treatment. With 40 participants in each treatment, a total of 80 individuals participated in these modified treatments. The experimental procedures were the same as in our initial interior equilibrium design.

Results from these modified treatments show that the frequency of \$10 contributions is even slightly higher than what we find in the initial interior equilibrium treatments. 10 percent of participants contribute \$10 in the Modified-Low treatment and 15 percent contribute \$10 in the Modified-High treatment.[36] These \$10 contributions are primarily made by fast decision-makers. As in the interior equilibrium treatments a vast majority of the dominated \$10 choices is made by fast decision-makers. In the Modified-Low and Modified-High treatments, fast decisions account

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[33] Random effects regressions show that for both the Low and High treatment the Part-1 classification as a fast decision-maker is predictive of the individual's Part-2 contributions. Controlling for period the coefficient on fast decision-makers is 0.232 (s.e. = 0.102, $p<0.05$) in the Low treatment, and -0.745 (s.e. = 0.283, $p<0.01$) in the High treatment. While being a fast decision-maker in Part 1 is predictive of contributions, it is essential to note that inconsistent with this being reflective of a preference type contributions in the Low and High treatments converge from opposite directions.

[34] In the initial treatments (with piece-wise linear returns) the marginal cost of contributing \$10 rather than \$9 is \$3.25 in the Low treatment and \$1.25 the High treatment. The marginal benefit to others from contributing is \$0.75, or \$0.25 per group member. Contributions of \$10 rather than \$9 thus decrease total group payoffs by \$2.50 and \$0.50 in the Low and High treatments, respectively.

[35] The payoff tables used in these Modified treatments are shown in online Appendix Table A3 and A4. δ is set to -2.25 and -0.25 in the Modified-Low and High treatments, respectively, and σ=-0.15 in both treatments when $g_i > 9$.

[36] In the initial Low (High) treatment 8 (10) percent contribute \$10.

for respectively 75 percent and 83 percent of the $10 contributions.[37] Importantly, the modification of the payoffs resulting from a $10 contribution does not alter the comparative statics in comparison to the initial interior equilibrium treatments.

In summary, the results from the modified treatments along with the evidence from Part 2 are consistent with our initial interpretation of the results from Part 1. Fast decision-makers appear to be less sensitive to individual and group incentives and are more prone to making mistakes. Depending on the strategic environment, these characteristics make fast decision-makers appear more generous in some circumstances and less generous in others. This calls for caution when interpreting fast decisions as being reflective of generosity or, more general, (social) preferences over payoffs. Rather, the evidence from our four treatments indicates that the negative correlation between response times and contributions is likely the result of a positive correlation between fast decisions and mistakes.

5. Public-good games with equilibria at the boundary

In order, to disentangle mistakes from generosity, we implemented public-good games that are arguably more complex than the standard constant-return VCM. It might be argued that the more complex payoff structure contributed to the results. First, because it might have increased confusion and caused a higher frequency of mistakes, and second because the more complicated payoff structure implied that payoffs were presented in a payoff table, which along with the required tutorial may have triggered a cognitive mind state without regard for others (e.g., Charness, Frechette, and Kagel, 2004).

To explore whether the correlation between response times and contributions remains sensitive to the location of the equilibrium in simple payoff environments similar to the standard VCM, we conducted another set of experiments. In these experiments we kept the return to contributing constant (as in the standard VCM), which implies that the dominant strategy equilibrium will be on the boundary of the strategy space. We examine two public good environments where we modify the return to the individual from contributing: one where the dominant strategy Nash equilibrium is to contribute nothing (Low-VCM) and one where the dominant strategy Nash equilibrium is to contribute everything (High-VCM). The implementation of the Low- and High-VCM mirrors that of the standard VCM. Members of a four-person group can contribute none, parts, or all of an $8 endowment to a group account, where every contributed dollar is doubled and split equally between group members.[38] Hence, across treatments we keep constant the

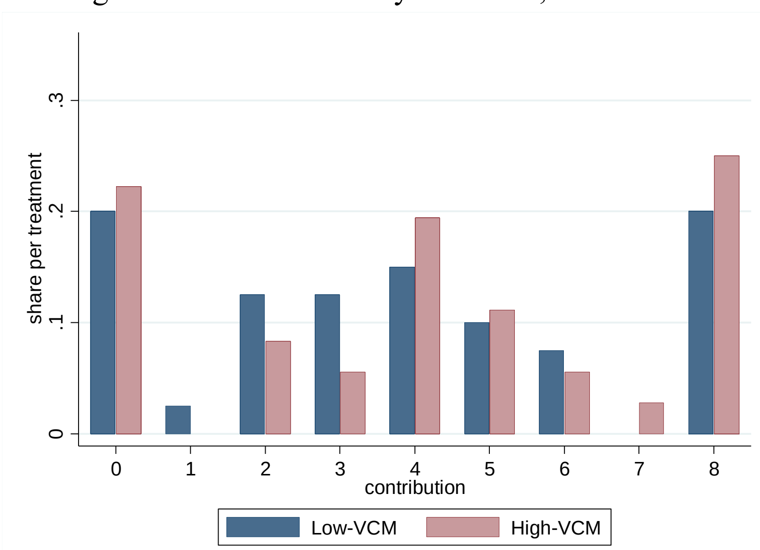
[37] With the smaller sample size some results are, however, not statistically significant. The correlation between response times and contributions is negative in the Modified-Low treatment and positive in the Modified-High treatment. Mean contributions are not distinguishable for fast decision-makers (Mean Modified-Low = $6.22, Mean Modified-High = $6.00, p=0.599), but are distinguishable for slow decision-makers (Mean Modified-Low = $5.00, Mean Modified-High = $6.88, p<0.01).

[38] To secure payoff ranges similar to that in our other experiments we provide each participant with an $8 endowment. This secures comparable maximum group payoffs across treatments. See the Appendix for instructions and payoff descriptions. Payoff descriptions were provided on the same screen used to make contribution decisions. Response time was measured from the moment the decision screen was shown.

marginal benefit to others from contributing. This marginal per capita return (MPCR) is \$0.50, and the equilibrium contribution is zero in the Low-VCM treatment. For the High-VCM we secure an equilibrium with full provision by adding to the \$0.50 MPCR an individual contribution bonus of \$0.60 per dollar contributed. Only the individual contributing receives the contribution bonus. Importantly, as in the standard VCM, instructions are simple and payoffs are characterized without the use of a payoff table and the associated tutorial. The rest of the procedures are as in our initial experiments.

We conducted four sessions of the VCM treatments, two sessions of the Low-VCM treatment and two sessions of the High-VCM treatment. 40 individuals participated in the Low-VCM and 36 participated in the High-VCM. Figure 4 shows the distribution of contributions by treatment. We first ignore the dominant strategies of 0 in the Low-VCM and 8 in the High-VCM and examine instead contributions in the range of 1 through 7. Contributions in this range are welfare improving in the Low-VCM but are dominated from a group perspective in the High-VCM. Despite these very different payoff consequences the contribution distributions are very similar (Kolmogorov-Smirnov p=0.732). Equally striking is the similarities in the frequency by which contributions of 0 and 8 are chosen. In the following we look at how choices by fast and slow decision-makers contribute to the similarities in contribution distributions across treatments.

Figure 4. Histogram of contributions by treatment, VCM treatments (Part 1)



Note: The equilibrium contribution is 0 in the Low treatment and 8 in the High treatment. The group payoff maximizing contribution is 8 in both treatments.

The median response time of 35.5 seconds in the pooled VCM is only slightly shorter than the one documented in the interior equilibrium experiments. Using this median time to distinguish between fast and slow decision-makers, we find that the high frequency of non-equilibrium play is largely due to fast decision-makers. Table 4 presents the frequency of choices made by fast decision-makers in each treatment. Mistakes, which can only be identified in the High-VCM treatment, are associated overwhelmingly with fast response times (70 percent of such dominated contributions are made by fast decision-makers, 2-sided Fisher's exact test p=0.019).[39] Interestingly only fast decision-makers select contributions of 0 in the High-VCM. Equilibrium and full provision choices, on the other hand, are associated with slow response times in both treatments (2-sided Fisher's exact test p=0.097 for the pooled sample for each of these two provision choices). Choices in the middle of the strategy space (i.e., providing half of the endowment), which are welfare improving relative to the dominant strategy in the Low-VCM but are dominated from an individual and group perspective in the High-VCM are also more frequently selected by fast decision-makers.

Table 4. Contributions by VCM treatment

Choices	Treatment					
	Low-VCM		High-VCM		All VCM	
	# obs.	% fast	# obs.	% fast	# obs.	% fast
Mistakes (dominated from individual and group perspective)	n.a.	n.a.	27	70	27	70
Nash equilibrium	8	38	9	22	17	30
Above Nash & below welfare max.	24	46	n.a.	n.a.	24	46
Group payoff maximizing (full provision)	8	38	9	22	17	29
Midpoint of strategy space	6	67	7	71	13	69
All	40	43	36	58	76	50

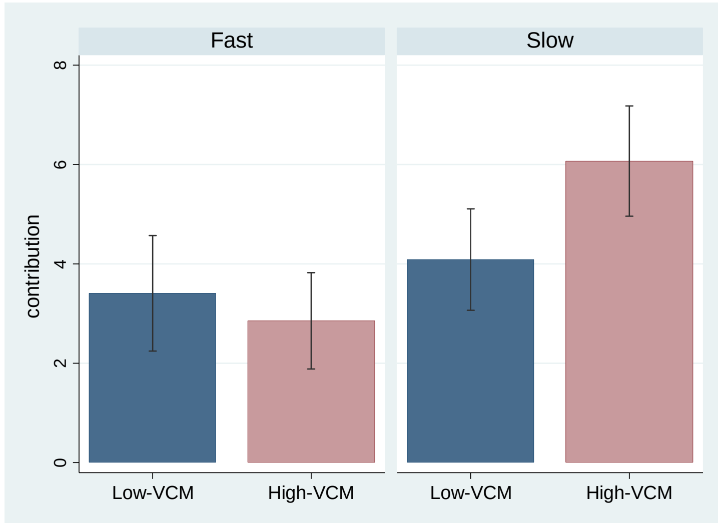
Note: "fast" indicates that contribution decisions were made in less than the median response time.

Finally looking at the correlation between contributions and decision times Figure 5 shows for fast and slow decision-makers the mean contributions by treatment. For the High-VCM we replicate the results from the initial High treatment. Rather than being more generous we find that average contributions by fast decision-makers are smaller than those by slow decision-makers ($2.86 vs. $6.07, p<0.01). Ignoring an outlier, the results reported in Table 2 replicate and we find that contributions in the High-VCM increase significantly with response time.[40]

[39] A probit regression of mistakes on a dummy for fast decision-maker provides a marginal effect of 0.3714 (s.e. 0.1439) with p=0.014.

[40] One participant in the High-VCM had a response time of 277 seconds and contributed nothing, by comparison the second slowest response time was 103 seconds. Eliminating this outlier and regressing contributions on response time yields a coefficient of 0.103 (s.e. 0.019). Similar results are obtained from a Tobit regression where the coefficient on response time is 0.159 (s.e. 0.037). Regressions that do not exclude the outlier show a positive and statistically insignificant coefficient on response time: OLS 0.004 (s.e. 0.011), Tobit 0.005 (s.e. 0.022).

Figure 5. Mean contribution by fast and slow decision-makers, Part 1 VCM treatments



The negative correlation between response time and giving is, however, not replicated in the Low-VCM, and there is no significant difference in average contributions by fast and slow decision-makers ($3.41 vs. $4.09, p=0.467).[41] While inconsistent with the interpretation that fast decision-makers are more generous this result need not be inconsistent with fast decisions being more prone to error. Indeed the reason for looking at environments with an interior equilibrium was precisely that in the Low-VCM all equilibrium deviations are welfare improving, thus making it impossible to separate mistakes and/or generosity. Indeed, consistent with fast decisions being more prone to error it continues to be the case that for fast decision-makers we cannot distinguish the mean contributions by treatment (Mean Low = $3.41, Mean High=$2.86, p=0.53). By contrast mean contributions by slow decision-makers are easily distinguishable by treatment (Mean Low = $4.09, Mean High=$6.07, p=0.03).

Analysis of repeated interaction in Part 2 shows convergence to equilibrium in the Low-VCM treatment but not in the High-VCM treatment.[42] An explanation for these different dynamics lies in the behavior of those who undercontribute (relative to the equilibrium prediction in the High-VCM treatment) by mistake in the High-VCM treatment. In the Low-VCM treatment, those who contribute closest to the equilibrium always earn most, reinforcing convergence towards the low equilibrium contributions. In contrast, in the High-VCM differences in payoffs between those who undercontribute and those who provide equilibrium contributions likely reinforces mistakenly low contributions and hinder learning.[43] Consistent with this interpretation we find in

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[41] A regression of contributions on response time in the Low-VCM yields a coefficient of 0.015 (s.e. 0.024).Similar results are obtained in a Tobit regression where the coefficient on response time is 0.019 (s.e. 0.040).

[42] The frequency of equilibrium play increases from 20 to 70 percent from Part 1 to period 10 of Part 2 in the Low-VCM treatment. In contrast, the frequency of equilibrium play is 25 percent in Part 1 and period 10 of Part 2 in the High-VCM treatment.

[43] For example in four person groups with contributions (8,0,0,0) earnings are (8.8, 16.8, 16.8, 16.8)) thus reinforcing non-equilibrium play.

a questionnaire administered at the end of the experiment that participants in the High-VCM are less able to identify the individual payoff-maximizing choice.[44]

The results from these simple constant-return public-good games are thus consistent with the results for our interior public-good games. Fast decision-makers appear less sensitive to incentives and more prone to selecting contributions that are dominated from an individual and group perspective.

6. Conclusion

Response times are increasingly used to draw inference on individual preferences. We argue that such inference can be misleading when mistakes are correlated with response time. To demonstrate we revisit the finding that response times are negatively correlated with contributions in constant-return public-good games. While this finding has been seen as evidence that individuals are intuitively generous, we argue that large fast contributions instead may result from individuals making mistakes.

As mistakes cannot be uniquely identified with standard constant-return public-good games, we examine contributions in public-good games with unique interior equilibria. In these games, we show that the correlation between response times and contributions reverses with the location of the equilibrium. The correlation is negative when the equilibrium is located below the midpoint of the strategy space, and it is positive when the equilibrium is located above the midpoint of the strategy space. Despite the fact that incentives change with the location of the equilibrium, we find that mean contributions for fast decision-makers are independent of the location of the equilibrium. In our study we use public-good games where a subset of the strategy space is dominated from both an individual and group earnings perspective. Assuming that participants are selfish or generously inclined, as in the past literature, these dominated contributions can be interpreted as mistakes. We can thus identify mistakes and show that the frequency of mistakes decreases with response time in our public-good games. The pattern of contributions suggests that fast responses rather than being reflective of an intuitively generous action result from fast decision-makers quickly selecting erroneous contributions.[45]

Our evidence that mistakes confound the inference on preferences from response times suggests that caution is warranted when considering other experimental manipulations that also interact

[44] Looking at understanding in all six treatments we find that that participants who are classified as fast decision-makers in Part 1 are less able to identify the dominant strategy at the end of the experiment, than are those classified as slow decision-makers in Part 1.

[45] Our study offers an explanation for the mixed results on the correlation between response times and generosity that has been documented across strategic settings. Error may play a smaller role in simple settings and a larger role in more complex ones. This may explain why in the simple dictator game and in donation experiments a positive correlation has been documented between kindness and response times (Piovesan and Wengström, 2009; Fiedler, Glöckner, Nicklish and Dickhert, 2013; Lohse et al. 2014), while a negative correlation has been found in the constant-return public-good game (Rand et al. 2012, Lotito et al. 2013, Nielsen et al. 2014) and in the ultimatum game (Brañas-Garza et al. 2013).

with mistakes. For example, to determine whether giving is intuitive we may ask whether giving increases when participants are put under time pressure when making a decision. Note, however, that such a manipulation should yield similar results as those obtained without time pressure as lower available response time will likely increase the rate of error. Similarly, giving participants an option to revise an initial decision to determine whether fast decisions are impulsive will not only result in corrections for those who in the heat of the moment opted to contribute, but also cause those who made a mistake to correct their decision. Just as response times are correlated with error, experimental manipulations that influence error will make inference on preferences difficult.

The results of our paper extend beyond the study of response times and intuitive choices in social dilemmas. In particular, it suggests that independent of the environment caution is warranted when trying to draw inferences about preferences from response times. While we found fast decision-makers to be insensitive to the payoffs associated with their choices, slow decision-makers were instead very sensitive to changes in payoffs. Our results thus suggest that, compared to fast decision-makers, the choices made by slow decision-makers better reflect individual preferences over payoffs.

The concern for error raised here is likely to be greater when examining one-shot interactions. Response times may better reflect preferences in environments, such as those recently used to study drift diffusion, where individuals are presented with choices between familiar products and asked to repeatedly make decisions in comparable environments.

Finally, our study suggests that theoretical models of decision making may need to take into account not only the possibility of dual processes and response times but also how errors relate to response times (see e.g., Caplin and Martin 2014). Only with such models at hand will empirical researchers be able to use response times for unbiased inference on individual preferences.

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Appendix (for publication)

Table A1. Tobit regression of contribution, Part 1

Dep. Var.: Contribution to group account	Treatments		
	Low	High	All
	(1)	(2)	(3)
Response time	-0.021**	0.015**	-0.021***
	(0.008)	(0.007)	(0.008)
High			-0.199
			(0.650)
High x response time			0.035***
			(0.011)
Constant	6.190***	5.970***	6.180***
	(0.501)	(0.418)	(0.481)
Total effect response time: High			0.015**
			(0.007)
N	80	80	160

Note: Standard errors in parentheses. * p<0.10, **p<0.05, ***p<0.01.

Table A2. OLS regression of response time and contributions, Part 1

Dependent Variable:	Response time (seconds)			Contribution to group account		
	Low	High	All	Low	High	All
	(1)	(2)	(3)	(4)	(5)	(6)
Response time				-0.018**	0.011*	-0.018**
				(0.008)	(0.007)	(0.008)
% tutorial correct	22.121	30.526	22.121	-0.756	3.504***	-0.756
	(22.471)	(21.749)	(22.666)	(1.607)	(1.283)	(1.479)
Experiments	-0.824	-0.948	-0.824	-0.021	0.003	-0.021
	(0.531)	(0.648)	(0.536)	(0.038)	(0.038)	(0.035)
Econ courses	1.175	5.763***	1.175	-0.105	0.038	-0.105
	(1.375)	(1.937)	(1.387)	(0.098)	(0.119)	(0.090)
Age	2.353	2.094	2.353	0.091	0.256	0.091
	(3.085)	(3.272)	(3.112)	(0.220)	(0.191)	(0.203)
Female	-13.854*	5.358	-13.854*	0.034	0.423	0.034
	(7.672)	(7.916)	(7.738)	(0.557)	(0.462)	(0.513)
High			-25.062			-7.571
			(89.289)			(5.793)
High X response time						0.029***
						(0.011)
High X % tutorial correct			8.404			4.260**
			(31.286)			(2.048)
High X experiments			-0.123			0.024
			(0.836)			(0.055)
High X econ courses			4.588*			0.143
			(2.369)			(0.160)
High X age			-0.259			0.165
			(4.495)			(0.292)
High X female			19.212*			0.389
			(11.022)			(0.724)
Constant	-2.218	-27.280	-2.218	5.234	-2.337	5.234
	(63.195)	(63.058)	(63.744)	(4.490)	(3.676)	(4.133)
Total effect response time: High						0.011
						(0.007)
Total effect % tutorial correct: High			30.526			3.504**
			(21.565)			(1.417)
Total effect experiments: High			-0.948			0.003
			(0.642)			(0.042)
Total effect econ courses: High			5.763***			0.038
			(1.921)			(0.132)
Total effect age: High			2.094			0.256
			(3.244)			(0.211)
Total effect female: High			5.358			0.423
			(7.849)			(0.510)
N	80	80	160	80	80	160

Note: Standard errors reported in parentheses. * p<0.10, **p<0.05, ***p<0.01.

Online Appendix (not for publication)

Instructions

[Piece-wise linear payoff structure]

This is an experiment on decision making. The earnings you receive today will depend on the decisions made by you and by other participants in this room. Please do not talk or communicate with others in any way. If you have a question please raise your hand and an experimenter will come to where you are sitting to answer you in private.

Earnings

There will be two parts of the experiment. Only one of the two parts will count for payment. Once part 1 and 2 are completed we will flip a coin to determine which part counts for payment. Your earnings in the experiment will be the sum of a $6 payment for showing up on time and your earnings from either part 1 or part 2. We will first explain how earnings are determined in part 1. Once part 1 is completed we will explain how earnings in part 2 are determined. Decisions in part 1 only affect possible earnings in part 1, and decisions in part 2 only affect possible earnings in part 2. Your total earnings will be paid to you in cash and in private at the end of the experiment.

Part 1

In part 1 you will be matched in groups of four. That is the computer will randomly match you with three other participants.

You will each have to make one decision, and earnings will depend on the decision made by you and the decisions made by other members of your group. Neither during nor after the experiment will you get to know who the other members of your group are or what decisions they make. Likewise, no one in your group will know who you are and what decision you make.

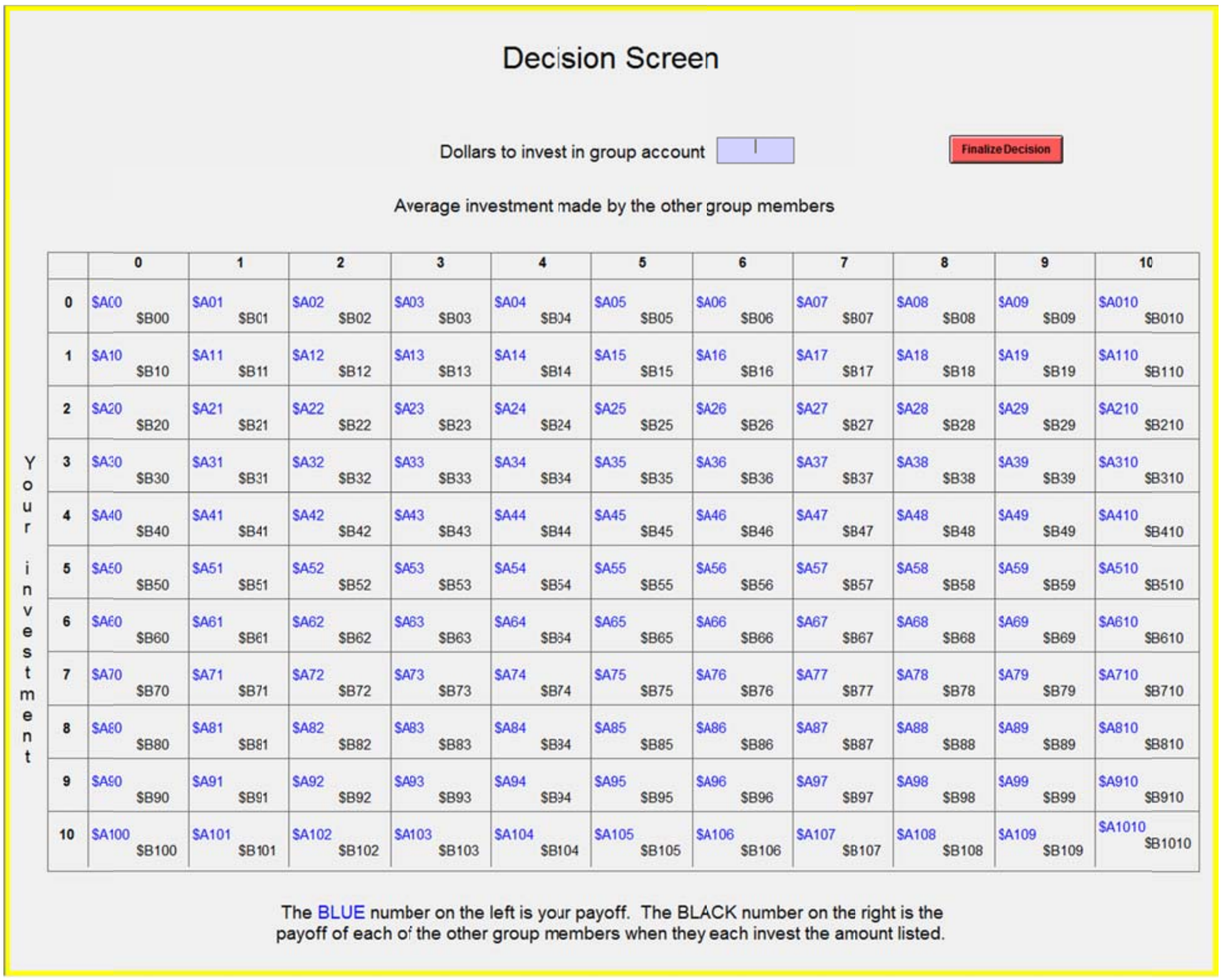
You and each of the other group members will be given $10 and asked to make an investment decision. You may select to invest any dollar amount between $0 and $10 in a group account. Investments in the group account affect both your earnings and those of the other members of the group. That is, individual earnings depend on the individual investment in the group account and the investment by the other group members.

Decision Screen

Your investment decision will be made using a decision screen. You make a decision by entering the number of dollars you wish to invest in the group account in the area labeled: *Dollars to invest in group account*. Once you have made your investment decision, please click the red

Finalize Decision button. You will not be able to modify your decision once your choice is finalized.

A decision screen is shown below. The actual decision screen will include a payoff table with the earnings that result from the investments made by you and the three other group members. We will use the screenshot below to demonstrate how to read the table. The first column shows all possible investments by you. The first row shows all possible average investments by the other group members. If the average investment by the other group members is say $2, then it may result from each investing $2, or from one member investing $0, another investing $2, and a third investing $4.



	0	1	2	3	4	5	6	7	8	9	10
0	$A00 $B00	$A01 $B01	$A02 $B02	$A03 $B03	$A04 $B04	$A05 $B05	$A06 $B06	$A07 $B07	$A08 $B08	$A09 $B09	$A010 $B010
1	$A10 $B10	$A11 $B11	$A12 $B12	$A13 $B13	$A14 $B14	$A15 $B15	$A16 $B16	$A17 $B17	$A18 $B18	$A19 $B19	$A110 $B110
2	$A20 $B20	$A21 $B21	$A22 $B22	$A23 $B23	$A24 $B24	$A25 $B25	$A26 $B26	$A27 $B27	$A28 $B28	$A29 $B29	$A210 $B210
3	$A30 $B30	$A31 $B31	$A32 $B32	$A33 $B33	$A34 $B34	$A35 $B35	$A36 $B36	$A37 $B37	$A38 $B38	$A39 $B39	$A310 $B310
4	$A40 $B40	$A41 $B41	$A42 $B42	$A43 $B43	$A44 $B44	$A45 $B45	$A46 $B46	$A47 $B47	$A48 $B48	$A49 $B49	$A410 $B410
5	$A50 $B50	$A51 $B51	$A52 $B52	$A53 $B53	$A54 $B54	$A55 $B55	$A56 $B56	$A57 $B57	$A58 $B58	$A59 $B59	$A510 $B510
6	$A60 $B60	$A61 $B61	$A62 $B62	$A63 $B63	$A64 $B64	$A65 $B65	$A66 $B66	$A67 $B67	$A68 $B68	$A69 $B69	$A610 $B610
7	$A70 $B70	$A71 $B71	$A72 $B72	$A73 $B73	$A74 $B74	$A75 $B75	$A76 $B76	$A77 $B77	$A78 $B78	$A79 $B79	$A710 $B710
8	$A80 $B80	$A81 $B81	$A82 $B82	$A83 $B83	$A84 $B84	$A85 $B85	$A86 $B86	$A87 $B87	$A88 $B88	$A89 $B89	$A810 $B810
9	$A90 $B90	$A91 $B91	$A92 $B92	$A93 $B93	$A94 $B94	$A95 $B95	$A96 $B96	$A97 $B97	$A98 $B98	$A99 $B99	$A910 $B910
10	$A100 $B100	$A101 $B101	$A102 $B102	$A103 $B103	$A104 $B104	$A105 $B105	$A106 $B106	$A107 $B107	$A108 $B108	$A109 $B109	$A1010 $B1010

Each cell reports the payoff you and the other group members receive given your investment and the average investment by the other group members. Your payoff will be depicted in blue and located in the upper left corner of each cell. The average payoff of the other group members will be depicted in black and located in the bottom right corner of each cell. To determine the payoffs from a specific combination of investments you look at the cell where the row of your investment crosses the column of the average investment by the other group members. In this cell you will see your payoff on the left (in blue) and the average payoff of the other group members on the right (in black). The average payoff for the other group members refers to the payoff they each get when they invest the same amount in the group account.

Consider an example where you invest $1 and the average investment by the other group members is $4. Your earnings from this investment decision will be $A14, where the first number refers to your $1 investment and the second to the $4 average investment by the other group members. Similarly the earnings of each of the three other group members will be $B14. If you were to increase your investment to $2 you move down one row to see that your earnings would become $A24 and the average earnings of the other group members would become $B24. Likewise if the average investment of the other group members increased by $1, such that you invest $2 and the other group members on average invest $5, you move over one column to see that your earnings would become $A25 and the average payoff to the other group members would be $B25. Before we begin we will give you a tutorial on how to read the payoff table.

Results Screen

After everyone has made an investment decision you will see a results screen. The results screen will indicate the investments made by you and the other group members and will summarize the earnings you and the other group members receive if part 1 counts for payment. The average earnings for the other group members reported in the payoff table refer to the earnings that result when the three other group members make the same investment decision. In the event that they do not invest the same amount their actual average earnings may differ slightly from that reported in the table. Your own payoff from the listed investment combination will be precisely that listed in the payoff table.

Instructions Part 2

Part 2 is very similar to part 1. The only difference is that you now must make investment decisions over a sequence of ten rounds. At the beginning of each round you will be randomly matched with three other people to form a new group of four. You will never be matched with the same three people twice in a row. It is also unlikely that you will meet the same set of three other group members twice. You will not get to know who the other members of your group are nor will you be informed of their past investment. Likewise, no one will know who you are and what investments you made in the past.

Just as for part 1 you will be presented with a decision screen which reports the earnings that you and the other group members get from the different investments. The decision screen will be the same in each round. That is, the earnings are the same for each of the ten rounds and are identical to those seen in part 1.

After each round is complete you will be shown a result screen which reports the investments made by you and the other group members in that round, as well as the earnings you and the other group members made in that round.

If part 2 is selected for payment we will randomly select a number between one and ten. The earnings for the corresponding round will be paid to the participants along with the $6 show up fee. The part that counts for payment will be determined by the flip of a coin. The round that counts in part 2 will be determined by having a participant draw a number between 1 and 10.

Table A1. Payoff table Low treatment

Average investment made by the other group members

Your Investment	0	1	2	3	4	5	6	7	8	9	10
0	10.00 / 10.00	10.75 / 11.95	11.50 / 13.90	12.25 / 15.85	13.00 / 16.10	13.75 / 16.35	14.50 / 16.60	15.25 / 16.85	16.00 / 16.85	16.75 / 16.85	17.50 / 14.10
1	11.45 / 10.25	12.20 / 12.20	12.95 / 14.15	13.70 / 16.10	14.45 / 16.35	15.20 / 16.60	15.95 / 16.85	16.70 / 17.10	17.45 / 17.10	18.20 / 17.10	18.95 / 14.35
2	12.90 / 10.50	13.65 / 12.45	14.40 / 14.40	15.15 / 16.35	15.90 / 16.60	16.65 / 16.85	17.40 / 17.10	18.15 / 17.35	18.90 / 17.35	19.65 / 17.35	20.40 / 14.60
3	14.35 / 10.75	15.10 / 12.70	15.85 / 14.65	16.60 / 16.60	17.35 / 16.85	18.10 / 17.10	18.85 / 17.35	19.60 / 17.60	20.35 / 17.60	21.10 / 17.60	21.85 / 14.85
4	14.10 / 11.00	14.85 / 12.95	15.60 / 14.90	16.35 / 16.85	17.10 / 17.10	17.85 / 17.35	18.60 / 17.60	19.35 / 17.85	20.10 / 17.85	20.85 / 17.85	21.60 / 15.10
5	13.85 / 11.25	14.60 / 13.20	15.35 / 15.15	16.10 / 17.10	16.85 / 17.35	17.60 / 17.60	18.35 / 17.85	19.10 / 18.10	19.85 / 18.10	20.60 / 18.10	21.35 / 15.35
6	13.60 / 11.50	14.35 / 13.45	15.10 / 15.40	15.85 / 17.35	16.60 / 17.60	17.35 / 17.85	18.10 / 18.10	18.85 / 18.35	19.60 / 18.35	20.35 / 18.35	21.10 / 15.60
7	13.35 / 11.75	14.10 / 13.70	14.85 / 15.65	15.60 / 17.60	16.35 / 17.85	17.10 / 18.10	17.85 / 18.35	18.60 / 18.60	19.35 / 18.60	20.10 / 18.60	20.85 / 15.85
8	12.85 / 12.00	13.60 / 13.95	14.35 / 15.90	15.10 / 17.85	15.85 / 18.10	16.60 / 18.35	17.35 / 18.60	18.10 / 18.85	18.85 / 18.85	19.60 / 18.85	20.35 / 16.10
9	12.35 / 12.25	13.10 / 14.20	13.85 / 16.15	14.60 / 18.10	15.35 / 18.35	16.10 / 18.60	16.85 / 18.85	17.60 / 19.10	18.35 / 19.10	19.10 / 19.10	19.85 / 16.35
10	9.10 / 12.50	9.85 / 14.45	10.60 / 16.40	11.35 / 18.35	12.10 / 18.60	12.85 / 18.85	13.60 / 19.10	14.35 / 19.35	15.10 / 19.35	15.85 / 19.35	16.60 / 16.60

The BLUE number on the left is your payoff. The BLACK number on the right is the payoff of each of the other group members when they each invest the amount listed.

Table A2. Payoff table High treatment

Average investment made by the other group members

Your Investment	0	1	2	3	4	5	6	7	8	9	10
0	10.00 / 10.00	10.75 / 10.62	11.50 / 11.23	12.25 / 11.85	13.00 / 12.60	13.75 / 13.35	14.50 / 14.10	15.25 / 14.85	16.00 / 14.85	16.75 / 14.85	17.50 / 14.10
1	10.12 / 10.25	10.87 / 10.87	11.62 / 11.48	12.37 / 12.10	13.12 / 12.85	13.87 / 13.60	14.62 / 14.35	15.37 / 15.10	16.12 / 15.10	16.87 / 15.10	17.62 / 14.35
2	10.23 / 10.50	10.98 / 11.12	11.73 / 11.73	12.48 / 12.35	13.23 / 13.10	13.98 / 13.85	14.73 / 14.60	15.48 / 15.35	16.23 / 15.35	16.98 / 15.35	17.73 / 14.60
3	10.35 / 10.75	11.10 / 11.37	11.85 / 11.98	12.60 / 12.60	13.35 / 13.35	14.10 / 14.10	14.85 / 14.85	15.60 / 15.60	16.35 / 15.60	17.10 / 15.60	17.85 / 14.85
4	10.60 / 11.00	11.35 / 11.62	12.10 / 12.23	12.85 / 12.85	13.60 / 13.60	14.35 / 14.35	15.10 / 15.10	15.85 / 15.85	16.60 / 15.85	17.35 / 15.85	18.10 / 15.10
5	10.85 / 11.25	11.60 / 11.87	12.35 / 12.48	13.10 / 13.10	13.85 / 13.85	14.60 / 14.60	15.35 / 15.35	16.10 / 16.10	16.85 / 16.10	17.60 / 16.10	18.35 / 15.35
6	11.10 / 11.50	11.85 / 12.12	12.60 / 12.73	13.35 / 13.35	14.10 / 14.10	14.85 / 14.85	15.60 / 15.60	16.35 / 16.35	17.10 / 16.35	17.85 / 16.35	18.60 / 15.60
7	11.35 / 11.75	12.10 / 12.37	12.85 / 12.98	13.60 / 13.60	14.35 / 14.35	15.10 / 15.10	15.85 / 15.85	16.60 / 16.60	17.35 / 16.60	18.10 / 16.60	18.85 / 15.85
8	10.85 / 12.00	11.60 / 12.62	12.35 / 13.23	13.10 / 13.85	13.85 / 14.60	14.60 / 15.35	15.35 / 16.10	16.10 / 16.85	16.85 / 16.85	17.60 / 16.85	18.35 / 16.10
9	10.35 / 12.25	11.10 / 12.87	11.85 / 13.48	12.60 / 14.10	13.35 / 14.85	14.10 / 15.60	14.85 / 16.35	15.60 / 17.10	16.35 / 17.10	17.10 / 17.10	17.85 / 16.35
10	9.10 / 12.50	9.85 / 13.12	10.60 / 13.73	11.35 / 14.35	12.10 / 15.10	12.85 / 15.85	13.60 / 16.60	14.35 / 17.35	15.10 / 17.35	15.85 / 17.35	16.60 / 16.60

The BLUE number on the left is your payoff. The BLACK number on the right is the payoff of each of the other group members when they each invest the amount listed.

Table A3. OLS regression of contributions on response time, outliers excluded Part 1

Dependent Variable:	Low		High		All	
	(1)	(2)	(3)	(4)	(5)	(6)
Response time	-0.020**	-0.020**	0.023**	0.016	-0.020**	-0.020**
	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)	(0.009)
High					-0.536	-7.296
					(0.704)	(5.925)
High X response time					0.043***	0.036**
					(0.013)	(0.014)
% tutorial correct		-0.726		3.378**		-0.726
		(1.631)		(1.301)		(1.496)
Experiments		-0.026		0.004		-0.026
		(0.040)		(0.038)		(0.036)
Econ courses		-0.120		0.038		-0.120
		(0.102)		(0.120)		(0.094)
Age		0.114		0.251		0.114
		(0.228)		(0.192)		(0.210)
Female		0.030		0.479		0.030
		(0.564)		(0.471)		(0.517)
High X % tutorial correct						4.104*
						(2.078)
High X experiments						0.030
						(0.056)
High X econ courses						0.158
						(0.162)
High X age						0.138
						(0.298)
High X female						0.449
						(0.735)
Constant	6.070***	4.917	5.534***	-2.379	6.070***	4.917
	(0.524)	(4.673)	(0.469)	(3.690)	(0.492)	(4.287)
Total effect response time: High					0.023**	0.016
					(0.010)	(0.011)
Total effect % tutorial correct: High						3.378**
						(1.442)
Total effect experiments: High						0.004
						(0.043)
Total effect econ courses: High						0.038
						(0.133)
Total effect age: High						0.251
						(0.213)
Total effect female: High						0.479
						(0.522)
N	78	78	79	79	157	157

Note: Choices made in more than 150 seconds excluded from the sample. Standard errors reported in parentheses.
* p<0.10, **p<0.05, ***p<0.01.

Table A4 Payoff table Modified-Low treatment

Average investment made by the other group members

Your Investment	0	1	2	3	4	5	6	7	8	9	10
0	10.00 10.00	10.75 11.95	11.50 13.90	12.25 15.85	13.00 16.10	13.75 16.35	14.50 16.60	15.25 16.85	16.00 16.85	16.75 16.85	16.30 14.30
1	11.45 10.25	12.20 12.20	12.95 14.15	13.70 16.10	14.45 16.35	15.20 16.60	15.95 16.85	16.70 17.10	17.45 17.10	18.20 17.10	17.75 14.55
2	12.90 10.50	13.65 12.45	14.40 14.40	15.15 16.35	15.90 16.60	16.65 16.85	17.40 17.10	18.15 17.35	18.90 17.35	19.65 17.35	19.20 14.80
3	14.35 10.75	15.10 12.70	15.85 14.65	16.60 16.60	17.35 16.85	18.10 17.10	18.85 17.35	19.60 17.60	20.35 17.60	21.10 17.60	20.65 15.05
4	14.10 11.00	14.85 12.95	15.60 14.90	16.35 16.85	17.10 17.10	17.85 17.35	18.60 17.60	19.35 17.85	20.10 17.85	20.85 17.85	20.40 15.30
5	13.85 11.25	14.60 13.20	15.35 15.15	16.10 17.10	16.85 17.35	17.60 17.60	18.35 17.85	19.10 18.10	19.85 18.10	20.60 18.10	20.15 15.55
6	13.60 11.50	14.35 13.45	15.10 15.40	15.85 17.35	16.60 17.60	17.35 17.85	18.10 18.10	18.85 18.35	19.60 18.35	20.35 18.35	19.90 15.80
7	13.35 11.75	14.10 13.70	14.85 15.65	15.60 17.60	16.35 17.85	17.10 18.10	17.85 18.35	18.60 18.60	19.35 18.60	20.10 18.60	19.65 16.05
8	12.85 12.00	13.60 13.95	14.35 15.90	15.10 17.85	15.85 18.10	16.60 18.35	17.35 18.60	18.10 18.85	18.85 18.85	19.60 18.85	19.15 16.30
9	12.35 12.25	13.10 14.20	13.85 16.15	14.60 18.10	15.35 18.35	16.10 18.60	16.85 18.85	17.60 19.10	18.35 19.10	19.10 19.10	18.65 16.55
10	10.10 12.10	10.85 14.05	11.60 16.00	12.35 17.95	13.10 18.20	13.85 18.45	14.60 18.70	15.35 18.95	16.10 18.95	16.85 18.95	16.40 16.40

The BLUE number on the left is your payoff. The BLACK number on the right is the payoff of each of the other group members when they each invest the amount listed.

Table A5. Payoff table Modified-High treatment

Average investment made by the other group members

Your Investment	0	1	2	3	4	5	6	7	8	9	10
0	10.00 10.00	10.75 10.62	11.50 11.23	12.25 11.85	13.00 12.60	13.75 13.35	14.50 14.10	15.25 14.85	16.00 14.85	16.75 14.85	16.30 14.30
1	10.12 10.25	10.87 10.87	11.62 11.48	12.37 12.10	13.12 12.85	13.87 13.60	14.62 14.35	15.37 15.10	16.12 15.10	16.87 15.10	16.42 14.55
2	10.23 10.50	10.98 11.12	11.73 11.73	12.48 12.35	13.23 13.10	13.98 13.85	14.73 14.60	15.48 15.35	16.23 15.35	16.98 15.35	16.53 14.80
3	10.35 10.75	11.10 11.37	11.85 11.98	12.60 12.60	13.35 13.35	14.10 14.10	14.85 14.85	15.60 15.60	16.35 15.60	17.10 15.60	16.65 15.05
4	10.60 11.00	11.35 11.62	12.10 12.23	12.85 12.85	13.60 13.60	14.35 14.35	15.10 15.10	15.85 15.85	16.60 15.85	17.35 15.85	16.90 15.30
5	10.85 11.25	11.60 11.87	12.35 12.48	13.10 13.10	13.85 13.85	14.60 14.60	15.35 15.35	16.10 16.10	16.85 16.10	17.60 16.10	17.15 15.55
6	11.10 11.50	11.85 12.12	12.60 12.73	13.35 13.35	14.10 14.10	14.85 14.85	15.60 15.60	16.35 16.35	17.10 16.35	17.85 16.35	17.40 15.80
7	11.35 11.75	12.10 12.37	12.85 12.98	13.60 13.60	14.35 14.35	15.10 15.10	15.85 15.85	16.60 16.60	17.35 16.60	18.10 16.60	17.65 16.05
8	10.85 12.00	11.60 12.62	12.35 13.23	13.10 13.85	13.85 14.60	14.60 15.35	15.35 16.10	16.10 16.85	16.85 16.85	17.60 16.85	17.15 16.30
9	10.35 12.25	11.10 12.87	11.85 13.48	12.60 14.10	13.35 14.85	14.10 15.60	14.85 16.35	15.60 17.10	16.35 17.10	17.10 17.10	16.65 16.55
10	10.10 12.10	10.85 12.72	11.60 13.33	12.35 13.95	13.10 14.70	13.85 15.45	14.60 16.20	15.35 16.95	16.10 16.95	16.85 16.95	16.40 16.40

The BLUE number on the left is your payoff. The BLACK number on the right is the payoff of each of the other group members when they each invest the amount listed.

Instructions

[VCM treatments]

This is an experiment on decision making. The earnings you receive today will depend on the decisions made by you and by other participants in this room. Please do not talk or communicate with others in any way. If you have a question please raise your hand and an experimenter will come to where you are sitting to answer you in private.

Earnings

There will be two parts of the experiment. Only one of the two parts will count for payment. Once part 1 and 2 are completed we will flip a coin to determine which part counts for payment. Your earnings in the experiment will be the sum of a $6 payment for showing up on time and your earnings from either part 1 or part 2. We will first explain how earnings are determined in part 1. Once part 1 is completed we will explain how earnings in part 2 are determined. Decisions in part 1 only affect possible earnings in part 1, and decisions in part 2 only affect possible earnings in part 2. Your total earnings will be paid to you in cash and in private at the end of the experiment.

Part 1

In part 1 you will be matched in groups of four. That is, the computer will randomly match you with three other participants.

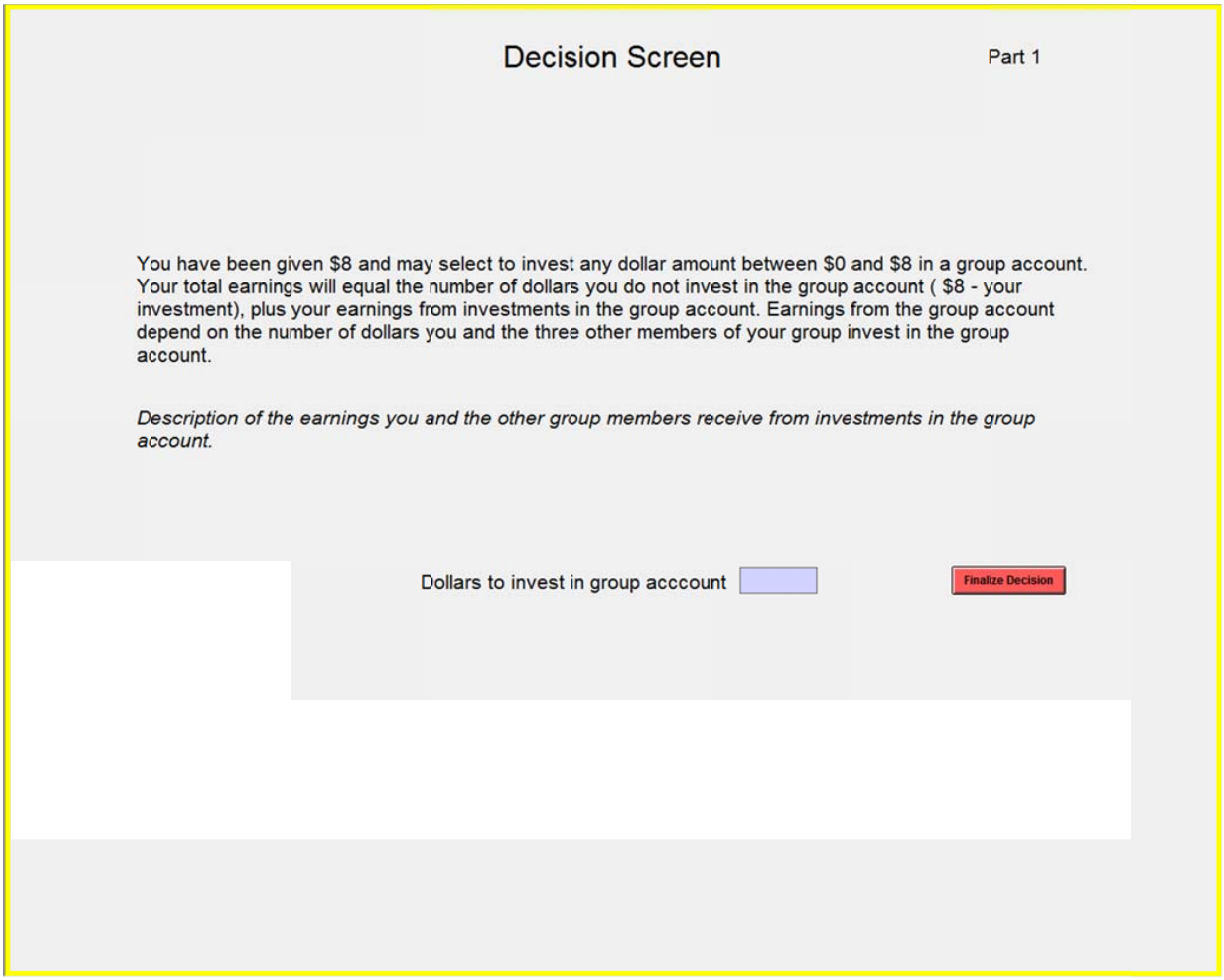
You will each have to make one decision, and earnings will depend on the decision made by you and the decisions made by other members of your group. Neither during nor after the experiment will you get to know who the other members of your group are or what decisions they make. Likewise, no one in your group will know who you are and what decision you make.

You and each of the other group members will be given $8 and asked to make an investment decision. You may select to invest any dollar amount between $0 and $8 in a group account. Investments in the group account affect both your earnings and those of the other members of the group. That is, individual earnings depend on the individual investment in the group account and the investment by the other group members.

Decision Screen

Your investment decision will be made using a decision screen. You make a decision by entering the number of dollars you wish to invest in the group account in the area labeled: *Dollars to invest in group account*. Once you have made your investment decision, please click the red *Finalize Decision* button. You will not be able to modify your decision once your choice is finalized.

A decision screen is shown below. The actual decision screen will include a description of the earnings you and the other group members receive from investing in the group account. Your total earnings will equal the number of dollars you do not invest in the group account ($8 – your investment) plus your earnings from investments in the group account. Earnings from the group account depend on the number of dollars you and the three other members of your group invest in the group account.



Results Screen

After everyone has made an investment decision you will see a results screen. The results screen will indicate the investments made by you and the other group members and will summarize the earnings you and the other group members receive if part 1 counts for payment.

Instructions Part 2

Part 2 is very similar to part 1. The only difference is that you now must make investment decisions over a sequence of ten rounds. At the beginning of each round you will be randomly matched with three other people to form a new group of four. You will never be matched with the same three people twice in a row. It is also unlikely that you will meet the same set of three other group members twice. You will not get to know who the other members of your group are nor will you be informed of their past investment. Likewise, no one will know who you are and what investments you made in the past.

Just as for part 1 you will be presented with a decision screen, which reports the earnings that you and the other group members get from investing in the group account. The decision screen will be the same in each round. That is, the earnings are the same for each of the ten rounds and are identical to those seen in part 1.

After each round is complete you will be shown a result screen which reports the investments made by you and the other group members in that round, as well as the earnings you and the other group members made in that round.

If part 2 is selected for payment we will randomly select a number between one and ten. The earnings for the corresponding round will be paid to the participants along with the $6 show up fee. The part that counts for payment will be determined by the flip of a coin. The round that counts in part 2 will be determined by having a participant draw a number between 1 and 10.

Description of payoffs: Low- and High-VCM treatments

Low-VCM treatment:

"Every dollar invested in the group account by you or any other member of your group will secure the group a payoff of $2 which is divided equally between you and the three other group members. Thus, for every dollar any group member invests in the group account you and each of the other group members will receive 50 cents."

High-VCM treatment:

Same as Low-VCM treatment + "In addition, you will get a bonus of 60 cents for every dollar you personally invest in the group account."