Experiments on Economic Games

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LEVENT NEYSE

Dissertation of Empirical Economics Doctorate Program

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To my family

Contents

Abstract

This thesis comprises three experimental studies on social preferences. Two of them are analyzing the data gathered from laboratory and the last one is a field experiment.

The first one called “Second-to-Fourth Digit Ratio Has a Non-Monotonic Impact on Altruism” studies the effect of prenatal exposure to testosterone on unconditional generosity. A widely acknowledged technique to observe the testosterone level that the baby is exposed during the gestation is the method called digit ratio. This ratio is calculated by dividing the length of index finger to the length of ring finger on the right hand especially. A smaller ratio indicates a higher level of testosterone exposure and vice-versa. The findings of the study suggest a non-monotonic relationship between unconditional generosity, where individuals with both very high and very low levels of testosterone exposure made less generous decisions comparing to the ones with medium levels.

The second, so called “Heterogeneous Returns from Public Goods”, investigates the impact of receiving unequal benefits in public good provision. In a voluntary contribution mechanism setting we formed diversely formed groups where players receive unequal benefits, so called marginal per capita return, from the public good. On the one hand we make comparisons between homogeneously formed groups, where each member of the group has the same marginal per capita return. On the other hand we compare the contributions of the players in heterogeneously formed groups, where the marginal per capita return of group members are not equal. Results show that the return levels are in

strong positive correlation with the cooperation levels. This effect is even stronger in heterogeneously formed groups.

The last study, “Heterogeneous Motives in Trust Game”, analyzes the motivation behind the first player’s decision in a binary Trust Game. The findings of the experiment point out a duality in the motivation as pro-social and opportunistic. Pro-social players, who choose to trust and also reciprocate, are found to be more generous and more able to shake hands than the ones who only send a positive amount as the first player but do not reciprocate.

Resumen

Esta tesis está formada por tres estudios experimentales sobre preferencias sociales. Los dos primeros analizan datos obtenidos en el laboratorio, mientras que el último utiliza datos de campo.

El primer capítulo, titulado **“Second-to-Fourth Digit Ratio Has a Non-Monotonic Impact on Altruism”**, analiza el efecto sobre la generosidad de la exposición prenatal a la testosterona. Una técnica ampliamente reconocida para determinar el nivel de testosterona al que una persona ha estado expuesta durante su gestación es el método denominado “digit ratio”. Este ratio se calcula dividiendo la longitud del dedo índice por la longitud del dedo anular en general de la mano derecha. Un valor más pequeño de este ratio indica una mayor exposición a la testosterona, y vice-versa. Los resultados de este estudio sugieren una relación no monótona entre la generosidad y el nivel de exposición a la testosterona. Individuos con dos niveles distintos de exposición , uno muy alto y otro muy bajo, toman decisiones menos generosas en comparación con aquellos individuos que tienen niveles medios de exposición.

El segundo capítulo, titulado “**Heterogeneous Returns in Public Good Games**”, investiga cómo afecta la heterogeneidad en los beneficios que los agentes obtienen de la provisión de bienes públicos. En un contexto donde los individuos realizan contribuciones voluntarias al bien público, analizamos el comportamiento de grupos formados por agentes que reciben distintos beneficios, es decir, tienen rendimientos marginales per capita desiguales. Para este análisis por un lado comparamos entre sí grupos formados por agentes que tienen el mismo rendimiento marginal per cápita (homogéneos) pero distinto rendimiento que los agentes de otros grupos. Por otro lado, comparamos la contribución de los distintos agentes dentro de un mismo grupo cuando éstos tienen distinto rendimiento per cápita (heterogéneo). Los resultados muestran que existe una correlación positiva entre el rendimiento marginal per cápita y los niveles de contribución al bien público. Además, este efecto se refuerza en los grupos heterogéneos.

El último capítulo, **"Heterogeneous Motives in Trust Game"**, analiza la motivación de la decisión del primer jugador en tomar la decisión en un Juego de Confianza binario. Los resultados del experimento muestran una dualidad en la motivación como pro-social y oportunista. Jugadores pro-sociales, que optan por confiar en el otro jugador y también corresponderle, son más generosos y más capaces de llegar a un acuerdo que los que sólo envían una cantidad positiva como primer jugador, pero no devuelven ninguna cantidad como segundo.

CHAPTER 1

Introduction

Experiments, measuring social preferences have shown that individuals are not purely self-interested. They are, to some extent, unconditionally generous, reciprocal, cooperative, morally concerned, fair and so on. Levitt & List (2007) sum up the 5 non-monetary factors that influence human decisions as moral and ethical considerations, scrutiny of the others on them, context, subject pool and the stakes of the game. In contrary with game theoretical predictions players send positive amounts in dictator game (Forsythe et al. 1994), which is acknowledged as a tool to measure unconditional generosity (also altruism). Ultimatum Game (Güth et al. 1982) results have proved that people are also concerned about fairness. Subjects punish the unfair actions even if the sanction is costly for them. What is more, individuals can establish economic collaborations with people they do not know and take risky decisions just because they believe that those persons they do not know are trustworthy. Findings of Trust Games (Berg et al. 1995) show that she is indeed. People can also collectively create a public good with others although the dominant strategy is not to contribute. And they do this voluntarily in Public Good Games.[1]

Experimental tools in economics research have been acknowledged by economics literature since mid-20th century. Since then the number of experimental publications increased rapidly in the most respected economics journals. Besides, experimental economics started to develop economic models such as fairness (Rabin 1993) and inequity aversion (Fehr & Schmidt 1999). As result of this rise of experimental (also behavioral) research, experimental economists are now in a position to make policy implications from their data. Several countries, such as United States, United Kingdom, Denmark and also European Union, support experimental research and collaborate with experimental economists for better policymaking. Behavioral Insights Team in UK and Joint Research Center of European Commission are just two examples among the others.

Another interesting contribution of experimental economics is the collaboration between other social and natural sciences. On one hand the distance between economics and the other social sciences such as psychology, sociology, science of morality, linguistics and also anthropology is now reduced (Camerer 1999, Rutherfold 1996, Falk & Szech 2013, Henrich et al. 2004, Chibnik 2005, Selten & Warglien 2007). On the other hand, new connections between economics and natural sciences are now being established. New subfields, such as Neuroeconomics, Genoeconomics and Physioeconomics, have been introduced to economics as a result of those connections. Neuroeconomics studies the neurological basis of economic decisions (Glimcher 2004, Camerer et al. 2005), while Geneoeconomics investigates the hereditary underpinnings of those decisions (Benjamin et al. 2007). Relationship between economic decisions and physiology is in the research area

[1] See Bohm (1972), Bohm (1984) for the first examples and Ledyard (1995) for a survey on Public Good Games

of Physioeconomics (Smith and Dickhaut 2005, Van't Wout et al 2006, Hagenau et al. 2007). Body reactions such blood pressure, pulse and skin conductance are the core apparatuses of Physioeconomics research.

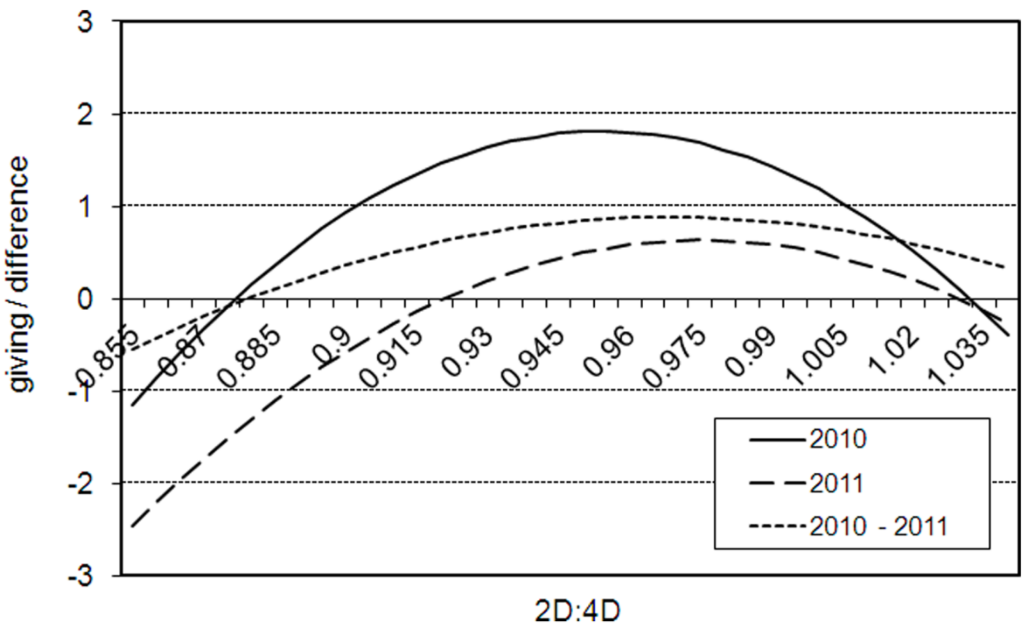
This thesis contains three main chapters. And each of those three focuses on a different social preference. The first one studies the effect of prenatal testosterone exposure on altruism measured by Dictator Game. Second chapter investigates the impact of receiving unequal benefits on the contributions in a Public Good Game, where the third focuses on the motivation behind the first player decisions in a Trust Game.

The first chapter, called "*Non-Monotonic Impact of Digit Ratio on Altruism*", is using the method called "Digit Ratio" to measure the fetal exposure to testosterone levels to explore its association with altruism. The ratio between the index and the ring finger is acknowledged as an indirect measure of prenatal exposure to testosterone, and they are negatively correlated. This is to say that a lower ratio (Index finger/ Ring Finger) points out a higher level of prenatal testosterone. Also, men generally have lower digit ratios which indicate a sexual dimorphism.

Recent research shows negative correlations between digit ratio and various abilities of individuals: Attainment in sports (Manning & Taylor 2001), scores in mental orientation tests (Peters et al. 2007), hierarchical rankings of the elite musicians in the orchestra (Sluming & Manning 2007). Also, some individual characteristics are found to be negatively correlated with digit ratio such as indirect aggression in women (Coyne et al. 2007), sensation seeking in men (Fink et al. 2006). In the recent years the literature on digit ratio has also been connected to economic decisions. Van den Bergh et al (2006) found that men with low digit ratio are more likely to reject unfair Ultimatum Game offers and they are more risk-loving (Brañas-Garza & Rustichini 2011). Besides, people give less in social preference games (Buser 2012).

We use the Dictator Game as a tool to measure altruism, in which subjects decide how to share a 5 Euro pie with an anonymous person. 127 individuals played the Dictator Game in October 2010 and then after 7 months in May 2011. Results show that women have higher digit ratios than men and females send more in the Dictator Game than males. There is a non-monotonic effect of digit ratio on altruism, meaning that the subjects with very high and very low digit ratio contribute less in the Dictator Game than those who have average ratios (See Figure 1).

Figure 1: Digit Ratio and Dictator Giving by sessions



The second chapter is called "*Heterogeneous Returns in Public Good Games*". In many instances people receive different benefits from the public goods due to preference or need differences. Or in some cases they might not have the equal rights to use a certain public good or they might have limited access to it. This chapter studies the contribution behavior of individuals when they are in a society where individuals do not receive the same benefits from the public good.

Previous studies showed that in the public good games players contribute more if they receive higher benefits from the public good in between-group (Ledyard 1995) and also in within group analysis (Reuben & Riedl 2013). We run a more detailed experiment focusing solely on the different group formations those are caused by marginal per capita return heterogeneity with 183 subjects. In our design there is no sanctioning option (Tan 2008, Reuben & Riedl 2009, 2013) or dominant strategy difference (Reuben & Riedl 2009, Kölle 2012). We run between-group analyses with 4 different homogeneously formed societies where each member of a group (n=3 in each group) receives the same return from the public good. Additionally we include 2 heterogeneously formed societies to our analysis in order to make within-group comparisons. In heterogeneously formed societies one of the members of each group receives a different benefit than the other two members in her group.

Our findings show that heterogeneity in benefits matters and contributions are positively correlated with the marginal benefits from the public good. This is to say that individuals contribute to public goods if they receive higher benefits from them (between-group analysis). This effect is stronger in heterogeneously formed groups where group members that receive higher benefits contribute more than the ones who receive lower benefits (within-group analysis).

The last chapter is called "*Heterogeneous Motives in Trust Game*". In this chapter the motivation behind first players' trust game offers are investigated. It can be due to altruism

(Ashraf et al 2006) or risk attitudes (Eckel and Wilson 2004) so on. In our design we disentangle two motives as pro-social or utilitarian. The experiment was run in the field with 795 subjects. They participated in a Dictator Game, an Ultimatum Game a Trust Game and also a questionnaire including questions on socio-demographics. Using strategy method subjects are asked to play a binary Trust Game as the sender and also the responder. The players who send a positive amount but do not reciprocate in Trust Game simply try to maximize their earnings in the game. However, those who both send and reciprocate are pro-social players. The results on Dictator Game and Ultimatum Game support this differentiation in the Trust Game first mover's motives. Those players who choose to send in both roles give more in Dictator Game (See Figure 2); they are also easier to agree with in the Ultimatum Game (See Figure 3), which we observe by subtracting Ultimatum Game minimum acceptable offers from Ultimatum Game offers.

Figure 2: Dictator Giving across Trust Game Decisions

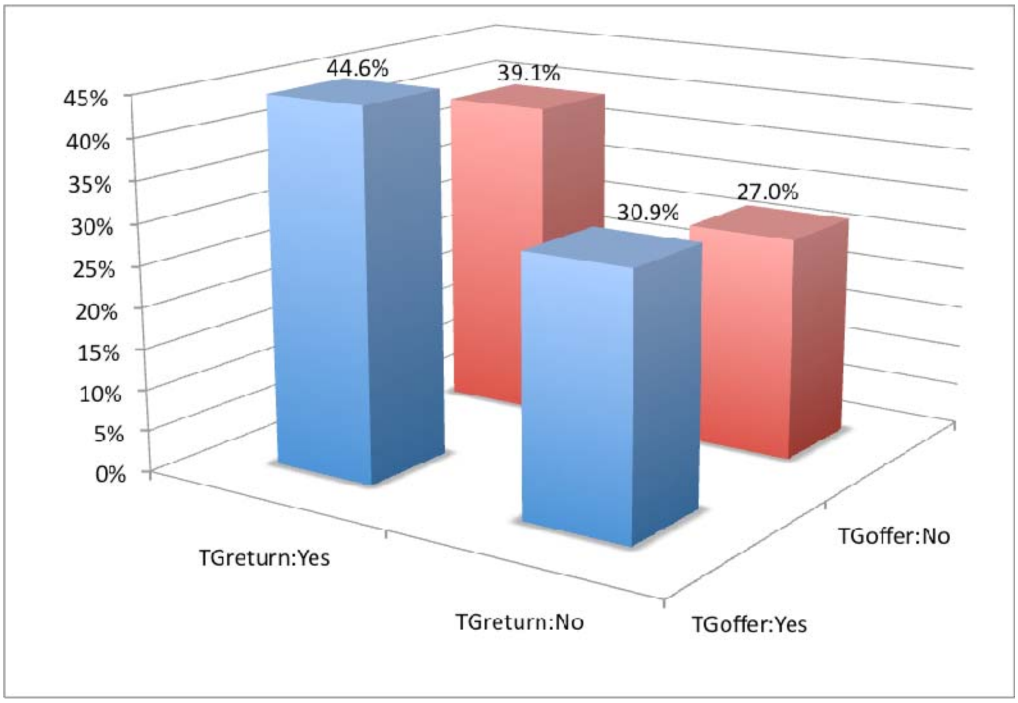
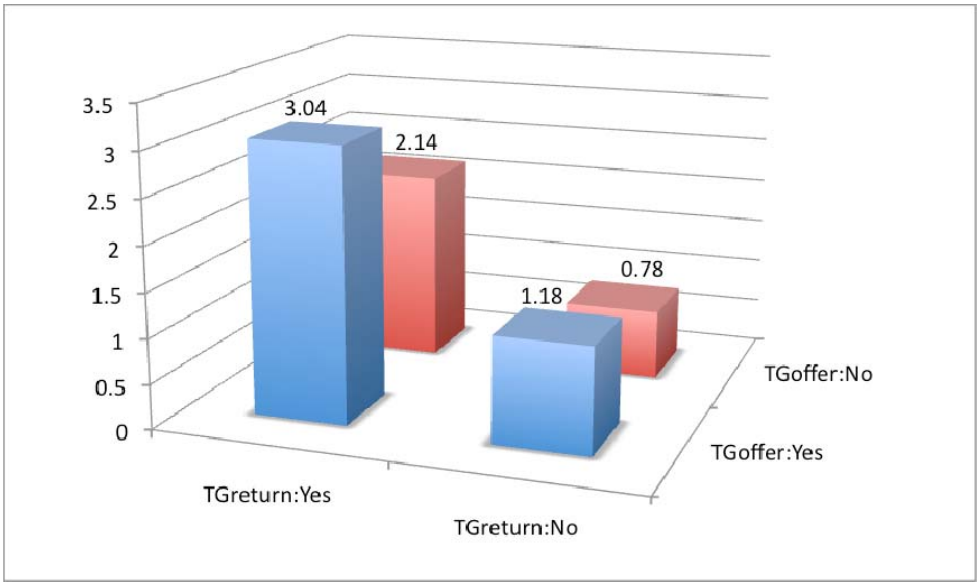


Figure 3: Agreeablity across TG decisions



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CHAPTER 2

Second to Fourth Digit Ratio has a Nonmonotonic Impact on Altruism[2]

ABSTRACT

Gene-culture co-evolution emphasizes the joint role of culture and genes for the emergence of altruistic and cooperative behaviors and behavioral genetics provides estimates of their relative importance. However, these approaches cannot assess which biological traits determine altruism or how. We analyze the association between altruism in adults and the exposure to prenatal sex hormones, using the second-to-fourth digit ratio. We find an inverted U-shaped relation for left and right hands, which is very consistent for men and less systematic for women. Subjects with both high and low digit ratios give less than individuals with intermediate digit ratios. We repeat the exercise with the same subjects seven months later and find a similar association; even though subjects' behavior differs the second time they play the game. We then construct proxies of the median digit ratio in the population (using more than 1000 different subjects), show that subjects' altruism decreases with the distance of their ratio to these proxies. These results provide direct evidence that prenatal events contribute to the variation of altruistic behavior and that the exposure to fetal hormones is one of the relevant biological factors. In addition, the findings suggest that there might be an optimal level of exposure to these hormones from social perspective.

[2] This is a joint work done with Pablo Brañas-Garza and Jaromir Kovarik and it has been published with the following reference: Brañas-Garza, P., Kovářík, J., & Neyse, L. (2013). Second-to-fourth digit ratio has a non-monotonic impact on altruism. *PloS one*, *8*(4), e60419.

Introduction

Human societies are built on cooperation and social norms (Axelrod & Hamilton 1981, Dawkins 1989, Fehr & Fischbacher 2003). It is thus important to understand the origins and determinants of pro-social behavior in humans. Gene-culture co-evolution stresses the joint role of culture and genes for the emergence of altruistic and cooperative traits (Boyd & Richerson 1985, Richerson et al1 2010) and behavioral genetics has recently provided estimates of their relative importance, by comparing monozygotic twins who share 100% of their genes with dizygotic twins who share 50% of genes on average (Cesarini et al. 2008, Cesarini et al. 2009, Benjamin et al. 2012) The limitation of these approaches is that they are unable to disentangle which particular biological traits determine individual differences in prosociality and how they are related (Ebstain et al. 2012). The prominent or at-risk individuals can be those for whom the traits have low or large values, or a non-monotonic association may exist. Non-monotonicity may be particularly important in case of biological traits, since they are shaped by evolutionary forces toward ”optimal” values (Darwin 1871, Alexander 1996, Sutherland 2005)and deviations from these values in any direction might matter. Such an argument is supported by Nye et al. (2012), who find systematic non-monotonic associations between digit ratio and several measures of academic performance.

To determine which traits matter and how is crucial to further understanding of the origins and individual variation of human prosociality, to the interpretation of correlations between prosocial behavior and neural activities in the brain, and to any policy targeting prosociality, cooperation and participation in the commons.

We analyze whether altruism (Camerer 2003, Heinrich et al. 2005, Roth et al 1991) may be shaped by exposure to prenatal sex hormones. The exposure to male and female sex hormones in uterus around the end of the first trimester of pregnancy has large organizing effects on human brain development (Goy & McEwen 1980). Since the neuroeconomic evidence detects that the activity in specific brain areas such as the striatum or insula correlates with altruistic behavior (Lee 2008, Fehr & Camerer 2007, Fehr 2009), different exposure to prenatal hormones, especially testosterone or estrogen, may affect these areas. We thus suspect that exposure to fetal hormones may shed light on why some people are more or less selfish.

We use giving in the Dictator Game (DG) as a measure of altruism and both left-and right-hand second-to-fourth digit ratio (2D:4D) as a biomarker of exposure to fetal sex hormones.

DG is a situation, in which one subject, Dictator, decides the division of a fixed amount of money (5e in our experiment) between herself and another anonymous person, Receiver. The Dictator can hold the whole amount for herself or she can share any part of the money with the Receiver. Since giving is costly for the Dictator and the Receiver cannot affect the proposed distribution, Dictators' giving is interpreted as an act of altruism and the amount given to the Receiver serves as a measure of Dictators' altruism. Since Dictators do not know the identity of Receivers (and vice versa), altruism is therefore interpreted here as the willingness to share voluntarily with unknown individuals at subjects' cost in a reciprocity-free environment.

2D:4D is calculated as the ratio between the lengths of index and ring fingers and it has been documented that 2D:4D is inversely related to high exposure to testosterone and low exposure to estrogen while in uterus (Manning et al. 1998, Lutchmaya et al. 2004, Manning et al. 2012, Zheng et al. 2011).

Due to hormone exposure, men have lower 2D:4D's than women (Manning 2002). Many studies thus limit their analysis to one gender only (e.g. Manning & Taylor 2001). Others in turn report that 2D:4D predicts the analyzed behavioral outcomes in men and not women or vice versa (e.g. Brañas-Garza & Rustichini 2011). The interplay of gender and experimental altruism is controversial: evidence exists that women give more than men, but this effect does not seem to be particularly robust (see Croson & Gneezy 2009) for an extensive review). Other papers note that women are more sensitive to the price of altruism (Andreoni & Vesterlund 2001) and are more expected to be fair (Aguiar et al. 2009). In fact, Croson and Gneezy (2009) conclude that women are more "*inequality averse*" and that "*women's decisions are more context-specific*" (p. 458). With these considerations in mind, we carefully analyze gender differences in the analysis below.

As for altruistic behavior, Millet and Dewitte (2009) find both negative and positive relationships between giving and 2D:4D, depending on the mood they induce in their subjects, but they do not compare their results to any neutral control treatment and do not incentivize their subjects. Buser (2012) finds positive correlation between 2D:4D and giving in DG, but he uses a self-reported index of 2D:4D and binary version of DG. This generates an imprecise measure of 2D:4D and precludes from exploiting nonlinearities. Other studies analyze the effects of 2D:4D on strategic behavior in Ultimatum, Public Good and/or Trust Games (Buser 2012, Millet & Devitte 2006, Sanchez-Pages & Turiegano 2010, Ronay & Galinsky 2011, van Honk et al. 2012) The ratio is also negatively related to certain types of asocial behavior such as aggression and some disorders associated with lower socialization such as autism, verbal fluency and depression (see Manning 2012 for a review), suggesting negative association between altruism and 2D:4D. Nevertheless, the differing conclusions across studies emphasize the extreme importance of sampling entire distributions, sufficiently large sample sizes and robustness analysis of reported findings.

In light of the above evidence, we conjecture that 2D:4D may be helpful in predicting individual altruism. In particular, due to above contradictory evidence we suspect that the association between fetal exposure and willingness to give might not be linear but non-monotonic. Moreover, we conjecture that this association will be gender-specific.

Methods

A total of 193 first-year undergraduate students participated in at least one of our experimental sessions during one academic year. The subjects were first-year undergraduate students (freshmen) of Economics at the University of Granada, Spain. The Ethical Committee of the Universidad de Granada approved the study and all subjects provided informed written consent (IC). The IC explains the content of the experiment they will perform and the payoffs attached to their performance. Anonymity was also assured and the Spanish law regarding data protection briefly explained.

The DGs were run twice with the same group of undergraduate students: (i) In the first week of their first academic year (before they get to know their classmates), in October 2010 and (ii) at the end of the academic year (after developing social relationships and after potentially learning from the first DG) in May 2011. Henceforth, we label each session 2010 and 2011, respectively. In both 2010 and 2011, all the four sections of the first year were visited and students were invited to participate in an economic experiment involving money. The participation was voluntary. Any individual who did not want to participate was allowed to leave the class before each session. Those willing to participate were seated separately, each with enough space to preserve anonymity, and they were provided with written instructions.

We followed procedures similar to Brañas-Garza et al. (2010). First, we elicit their within-class social ties (without providing any incentives) and consequently invited them to play the

DG. Each subject played the DG as the Dictator, dividing €5 between herself and another randomly chosen individual from the list of all the participants of the experiment (independently of the attended section). Subjects were informed that each participant would potentially be either a Dictator or Recipient (but not both of them) with one half probability. Giving was expressed in real money up to two decimals.

After the experiment, subjects were invited one by one to an office for the payment and the scanning of their both hands. Both hands were scanned with a high-resolution scanner (Canon Slide 90). To determine 2D:4D, we measured the lengths of the index and ring digits on both hands from basal crease to the finger tip. To ensure the most accurate measurement, we measured the ratio from the scanned pictures twice. The first measurement was made right after the scanning, while the second was performed 14 months later, in January 2012. The data reported in this study use the average of both measures. The correlation between the average and the first (second) measure on the right hand is 0.97 (0.97) ($p < 0.0001$ in both cases). The figures are 0.93 and 0.93, resp. ($p < 0.0001$) for left hands. As a robustness check, all the analysis was repeated using each measure separately and the results were unaffected.

We completed a sample of 173 and 148 participants in 2010 and 2011, respectively; 129 subjects participated in both sessions. Some subjects were excluded from the below analysis though. First, to ensure ethnical homogeneity, three non-Caucasian subjects were excluded from our data set. One of them only participated in 2010, one only in 2011, while the third participated in both. Their inclusion into the data set does not affect any of our results. Second, we do not include other 19 Caucasian subjects who participated in 2011 but not in 2010. They had no previous experience with the game and their behavior would not thus be comparable to the "experienced" subjects. Indeed, these 19 non-experienced Caucasian participants give on average €1.59 more than other Caucasian participants in 2011 ($p < 0.0001$). Third, since one male subject had his left-hand index finger broken in the past, we exclude him from the left-hand analysis. In sum, the analysis of right hands accounts for 171 subjects in 2010 (76 females) and 127 subjects in 2011 (58 females), whereas the left-hand data contain one male subject less. Women represent 44.44% of the sample 2010. 139 (out of 171) subjects reported their age; the average and median age in 2010 were 18.97 and 18 years, respectively (st.dev. 3.79; range between 18 and 60). The composition is similar in 2011.

Each participant was assigned a random identification number prior to the scanning and received a plastic card with an ID number. They were advised to keep it as their identification in future experiments and it served as an ID to record the experimental data and the digit ratios. In May 2011, we again visited the four classes and repeated the same experimental procedure (except the hand scanning). The data on altruism and digit ratios are available upon request from the authors.

The above data were combined with other characteristics of subjects collected in additional sessions. In April 2011, we ran the risk aversion session via an incentivized Holt and Laury's (2002) protocol and at the beginning of June we invited the subjects to fill a questionnaire eliciting other characteristics, such as time preferences, socio-economic status etc., used as controls in the present study (see Econometric Approach). In Discussion, we combine our results with a larger sample of digit ratios elicited one year later to be able to complement the analysis with a representative distribution of digit ratios in the population. The procedure of elicitation was identical as described above and we account for 440 males and 577 females in the sample. See the next section for details.

Econometric Approach

To provide a rigorous statistical analysis of the experimental results, we perform a series of estimations. The dependent variables are all based on Dictators' giving in any of our sessions. Since there is evidence that people take from others in DGs if it is allowed (Bardsley 2008) and giving is restricted to be non-negative in our experiment, our dependent variable is truncated from below by zero and we use censored regression analysis. All reported estimations were also reproduced using simple linear regression and using a logarithmic transformation of the dependent variable. The results are very similar and thus not reported here.

In particular, three types of models are estimated according to the dependent variable:

1. Dictators' giving in 2010 and 2011: continuous dependent variable (2 decimal places) censored from below by 0, cross-section, censored regression analysis, Tables 1 and 2.

2. Dictators' giving in both 2010 and 2011: continuous dependent variable (2 decimal places) censored from below by 0, cross-section and two periods, censored random-effect panel-data analysis, Table 3.

3. The change of behavior from 2010 to 2011, calculated as Dictators' giving in 2010 minus Dictators' giving in 2011: continuous dependent variable (2 decimal places) censored from below by −5 and above by 5, censored regression analysis (no censored observation in the data), Table 4.

Each model is reported under eight different specifications: six models with the complete data set, (a) - (f), one model for the subsample of men, and one for women, (male) and (female). The structure of the independent variables is the same in the four specifications.The regressions are mainly focused on the role of 2D:4D, $2D{:}4D^2$, gender and risk aversion (Brañas-Garza & Rustichini 2011, Sapienza et al. 2009, Garbarino et al. 2011,Stenstrom et al. 2011, Apicella et al. 2008). In estimations (f), we also control for other variables that have been documented to influence either the 2D:4D and/or giving in the DG: intelligence (Brañas-Garza & Rustichini 2011), academic performance (Hopp et al. 2012), time preferences (Fehr & Leibbrant 2011), position in the class network (Brañas-Garza et al. 2010, Kovarik et al 2012) and socioeconomic status.

As mentioned above, we combine our data with a different data set (see Discussion), where each gender-specific median $\widehat{2D:4D}$ is used as a proxy for the population median. These medians are 0.954 for males' and 0.967 for females' right hands; the corresponding left-hand counterparts are 0.961 and 0.969, respectively. We used these numbers as proxies for the median 2D:4D in the population and relate giving in the DG to the deviation, in absolute terms, of individual 2D:4D from gender-specific population median 2D:4D's. The deviation variable in the estimated models in Table 5 is $\left(2D:4D \quad \widehat{2D:4D}\right)$ and $\left|(2D:4D) - \widehat{2D:4D}\right|^2$ is the deviation squared. There are three types of models depending on the way the deviation variable enter the regression and whether controls are included or not: (i) linear term alone (a-b) (ii) both linear and quadratic terms (c-d), (c) quadratic term alone (e-f). We also report the best estimations separated for men and women. The other regressors coincide with Tables 1-4. In all regressions, we report p-values based on estimated robust standard errors corrected for possible correlations within students from the same sections, as these individuals may have been under the influence of common factors and are more likely to know each other. In case of 2010 results (Table 1), the standard errors are robust but assumed uncorrelated (as people did not have time to know each other), but controlling for possible intra-section correlations has no effect on the regressions.

Results

Dictators' giving: Figure 1 summarizes Dictators' giving in the experiment in 2010 (left, N = 171) and 2011 (right, N = 127). In 2010, the average Dictators' giving is 32.4% out of 5e, while they give on average 17.8% in 2011. Subjects are more selfish in 2011 than in 2010 (Wilcoxon signed-rank test: ZW =6.14, $p < 0.0001$; any other test leads to the same conclusion). On average, people gave 0.71e (44.2%) less in 2011 than in 2010.

The pair wise correlation between the behavior of subjects who participated in both games is 0.327 ($p < 0.0002$), positive but far from 1. These differences may suggest that any relation found in one of the periods should disappear in the other one. As we shall see below, this is not the case.

Concerning gender, we observe no effect in 2010 ($p > 0.600$ using t-and Wilcoxon unpaired rank-sum tests), but there seems to be marginal gender effects in 2011 ($p = 0.126$, and 0.082 for the same tests, respectively). Men gave 0.79e less (50.4%), while women passed 0.61e less to the Recipients (37.1%). Women change the behavior slightly less, but this difference is not statistically significant ($p > 0.230$ for any test).

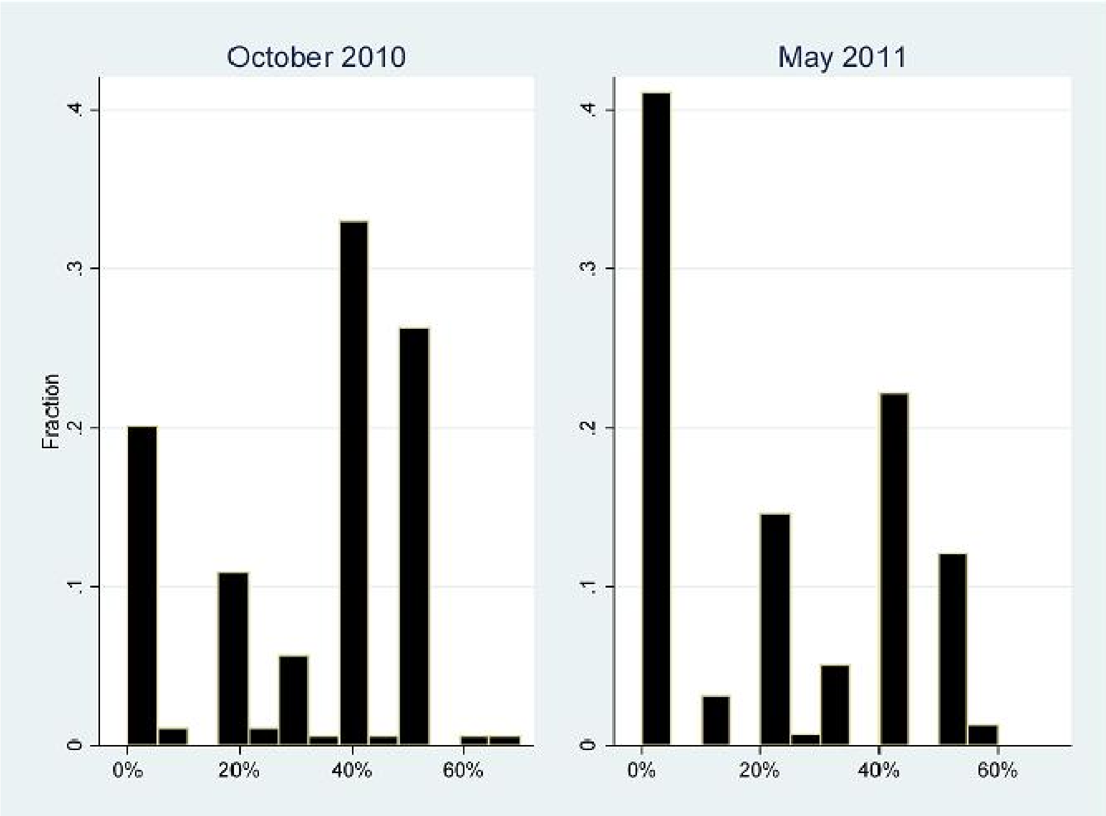

Figure 1: Dictator Giving in October 2010 and May 2011. Left: 2010. Mean: 1.62, St.Dev.: 0.99, Median: 2, N = 171 (76 females). Right: 2011. Mean: 0.89, St.Dev.: 0.97, Median: 1, N = 127 (58 females).

Digit ratios: Males exhibit lower right-hand digit ratios (Male -Mean: 0.950; St.Dev.: 0.031; Female -Mean: 0.966; St.Dev.: 0.033). This gender effect is supported by any statistical test ($p< 0.002$ for the t-and Wilcoxon unpaired rank-sum tests). The average 2D:4D's are 0.950 and 0.965 for men and women if we only consider participants in both Dictator Games. This difference is again significant ($p< 0.020$). The reported distributions are statistically indistinguishable from (Brañas-Garza & Rustichini 2011) for men, women and the pooled data. This makes us confident that the observed population constitutes a representative sample.

As for the left hands, the gender effects are weaker but in the same direction. Males have lower 2D:4D's if we consider the whole sample at 6% ($p< 0.059$ for the same tests; Male -Mean: 0.959; St.Dev.: 0.036; Female -Mean: 0.969; St.Dev.: 0.031). However, they are not significant for the participants in both DG sessions ($0.20 <p< 0.23$). The averages are 0.961for males and 0.969 for females. The correlations between the left and right 2D:4D are 0.657 in 2010 (N = 170) and 0.661 (N = 125); highly significant ($p< 0.0001$) but far from one. These correlations are the same for males and females separately up to two decimals. Hence, the asymmetry does not seem to be gender-specific.

Regression Analysis: Tables 1 -3 show the estimation results of the 2010, 2011 and the aggregated data for both right (top) and left hands (bottom), while Table 4 provides results for the change of behavior from 2010 to 2011. Figure 2 summarizes the right-hand results associating 2D:4D with giving in the two DGs and the change of behavior.

Right-hand digit ratio								
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(male)**	**(female)**
2D:4D	3.17 (0.27)	408.03 (0.00)	417.57 (0.00)	433.1 (0.00)	573.13 (0.00)	659.72 (0.00)	539.00 (0.03)	609.28 (0.00)
2D:4D^2		−211.57 (0.00)	−216.9 (0.00)	−225.82 (0.00)	−300.3 (0.00)	−342.00 (0.00)	−282.38 (0.03)	−316.99 (0.00)
Female			0.18 (0.33)	−2.76 (0.63)	−3.77 (0.56)	−0.27 (0.96)		
Fem.*2D:4D				3.08 (0.61)	4.16 (0.53)	0.5 (0.93)		
Risk Aver.					0.08 (0.26)	1.18 (0.25)	0.04 (0.74)	0.12 (0.14)
Other Heterogen.	No	No	No	No	No	Yes	No	No
N	171	171	171	171	149	107	88	61
Pseudo-R^2	0.002	0.023	0.024	0.025	0.036	0.065	0.019	0.087
p (model)	0.263	0.003	0.006	0.012	0.006	0.000	0.113	0.003
Left-hand digit ratio								
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(male)**	**(female)**
2D:4D	0.21 (0.94)	278.88 (0.02)	269.04 (0.02)	320.07 (0.01)	337.79 (0.01)	400.38 (0.00)	602.52 (0.00)	−326.10 (0.11)
2D:4D^2		−143.96 (0.02)	−139.03 (0.02)	−167.82 (0.01)	−177.63 (0.01)	−211.02 (0.00)	−315.46 (0.00)	169.71 (0.11)
Female			0.14 (0.47)	−11.36 (0.05)	−12.56 (0.06)	−11.25 (0.01)		
Fem.*2D:4D				11.91 (0.04)	13.15 (0.05)	11.80 (0.01)		
Risk Aver.					0.03 (0.67)	0.60 (0.52)	−0.02 (0.84)	0.15 (0.11)
Other Heterogen.	No	No	No	No	No	Yes	No	No
N	170	170	170	170	148	106	87	61
Pseudo-R^2	0	0.012	0.012	0.020	0.023	0.044	0.046	0.033
p (model)	0.939	0.056	0.098	0.034	0.063	-	0.005	0.137

p-values in parentheses. Constants non-reported: non-significant in (top a) (p = 0.58), in (bottom a) and (bottom f) (p>0.12), significant otherwise.
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Table 1: Dictator giving and digit ratio (2010), censored regression.

The linear relationship is positive but non-significant in 2010 for both hands (p> 0.27), but once we introduce the squared 2D:4D the estimates reveal a non-monotonic, concave association between giving and 2D:4D: the most generous subjects have intermediate 2D:4D. These results remain for both left and right hands, if we estimate the models separately for men and women, and are robust to inclusion of controls that have shown to be related to altruism and/or the digit ratio in other studies. The unique exception is the model for female left hands where we find no significant association. In sum, the results are fairly robust to different specifications, different subsamples, and left/right hands. Since weaker left-hand effects are commonly observed in the literature, it serves as an indication of the robustness of our findings.

Since the behavior in DGs is generally sensitive to many details (Camerer 2013), we further test these findings. We repeated the experiment in 2011 with the same subject pool and the findings are qualitatively similar (Table 2), even though the subjects are significantly more selfish (see Figure 1). The differences we find are: (i) the linear relationship between giving and right-hand 2D:4D becomes significant in 2011 ($p < 0.0001$); (ii) the association gives up being non-monotonic for male right-hand 2D:4D and turns out to be linear ($p = 0.025$; pseudo$R^2 = 0.012$; model $p = 0.025$); and (iii) the left-hand estimates are statistically weaker in 2011 than in 2010.

The conclusions are reinforced if we treat the data as a panel as shown in Table 3. Hence, there is a robust non-monotonic association between altruism and 2D:4D in our data.

Another interesting result is associated to learning; that is, how subjects update their behavior. As illustrated in Table 4, the 2D:4D also exerts nonmonotonic influence on the change of behavior from 2010 to 2011 if we control for individual heterogeneity. The linear relation is never significant, but adding the squared 2D:4D results in lower p-values of the linear term. In case of right hands, the linear and quadratic terms are jointly significant at 10% in Model (d) and at 1% in Model (f), in which we control for individual heterogeneity more systematically. Subjects with intermediate right-hand 2D:4D, i.e. the most generous subjects, tend to adjust their giving downwards more that individuals with low and high 2D:4D's. These results have to be enjoyed with care though as 2D:4D does not exert influence on giving in several of our model specifications.

Right-hand digit ratio								
	(a)	(b)	(c)	(d)	(e)	(f)	(male)	(female)
2D:4D	9.91 (0.00)	301.18 (0.00)	308.74 (0.00)	302.71 (0.00)	416.4 (0.00)	449.83 (0.00)	114.59 (0.63)	672.5 (0.03)
2D:4D^2		−151.97 (0.00)	−156.7 (0.00)	−152.96 (0.00)	−213.5 (0.00)	−236.86 (0.00)	−54.94 (0.65)	−346.8 (0.03)
Female			0.42 (0.39)	2.6 (0.8)	−0.48 (0.95)	−1.59 (0.86)		
Fem.*2D:4D				−2.27 (0.83)	0.84 (0.92)	2.24 (0.82)		
Risk Aver.					0.32 (0.00)	−1.86 (0.41)	0.23 (0.28)	0.38 (0.00)
Other Heterogen.	No	No	No	No	No	Yes	No	No
N	127	127	127	127	122	107	69	53
Pseudo-R^2	0.013	0.018	0.024	0.024	0.054	0.091	0.023	0.116
p (model)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Left-hand digit ratio								
	(a)	(b)	(c)	(d)	(e)	(f)	(male)	(female)
2D:4D	4.62 (0.28)	210.82 (0.06)	176.52 (0.20)	174.24 (0.23)	227.01 (0.04)	215.54 (0.20)	102.02 (0.66)	477.13 (0.14)
2D:4D^2		−106.33 (0.06)	−89.03 (0.21)	−87.67 (0.24)	−115.02 (0.04)	−115.65 (0.18)	−50.24 (0.67)	−244.0 (0.14)
Female			0.45 (0.38)	1.28 (0.86)	−1.00 (0.83)	1.03 (0.82)		
Fem.*2D:4D				−0.86 (0.91)	0.70 (0.89)	−0.49 (0.92)		
Risk Aver.					0.31 (0.00)	−2.56 (0.27)	0.24 (0.25)	0.34 (0.00)
Other Heterogen.	No	No	No	No	No	Yes	No	No
N	126	126	126	126	121	106	68	53
Pseudo-R^2	0.003	0.006	0.067	0.013	0.040	0.075	0.016	0.077
p (model)	0.281	0.121	0.000	–	–	–	0.030	0.000

p-values in parentheses. Constants non-significant in (top male)($p = 0.6$), (bottom a), (bottom c–d), (bottom f), (bottom male), (female) ($p > 0.19$), significant otherwise.
doi:10.1371/journal.pone.0060419.t002

Table 2: Dictator giving and digit ratio (2011), censored regression.

Note that the relation is gender-specific in case of left hands. The association remains inverted U-shaped for men, but for women we find a highly significant U-shaped (rather than inverted U-shaped) relation. This explains why we never observe significant effects in the pooled estimations. As the dependent variable is not statistically different across genders and women exhibit inverted U-shaped association using right hands, we suspect that this result has to do with the difference between left and right hands. However, since it is not well understood how fetal hormones manifest through left vs. right hands, we cannot interpret this finding.

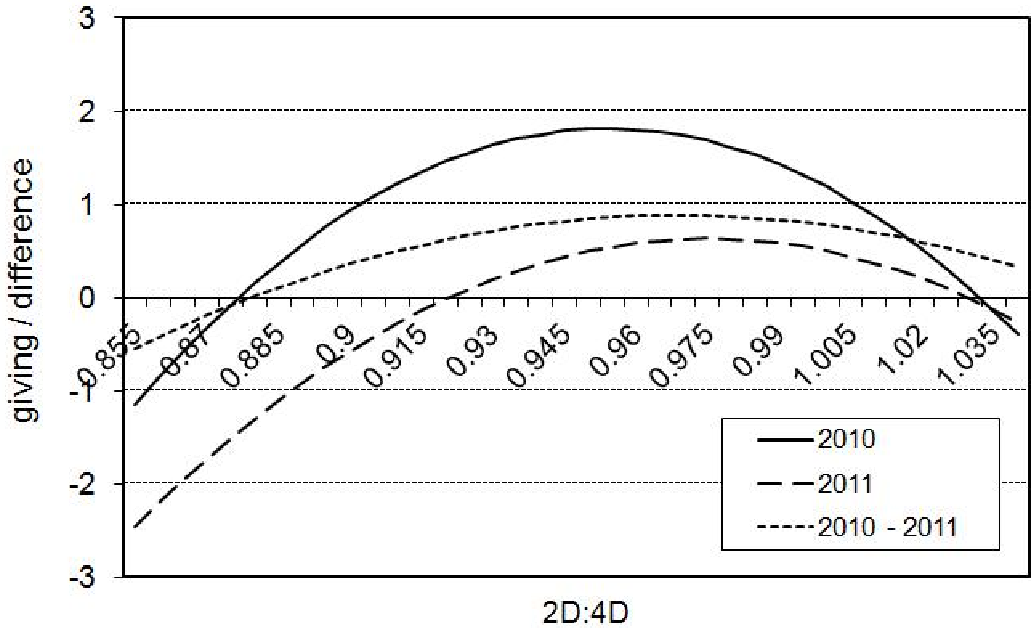

Figure 2: The estimated relation. Dictator's giving in 2010 (solid), 2011 (dashed) and updating of behavior from 2010 to 2011 (dotted) on y-axis and 2D:4D (x-axis); censored regression analysis; right hands. Estimated results: (i) 2010: $y = 300.3x^2 - 573.1x$, (ii) 2011: $y = 213.5x^2 - 416.4x$, (iii) 2011-2010: $y = 109.63x^2 - 212.47x$. The reported estimations control for heterogeneity; control variables are held at their averages.

One may argue that an inverted U-shaped association can potentially be an artifact of low sharing of subjects with high and low 2D:4D's in 2010 who simply might not be allowed to give any less in 2011 given the design. Nevertheless, such an explanation can be contrasted with the U-shaped association observed using female left hands, even though female left-hand 2D:4D does not seem to predict giving in the DG.

In addition, note that there are only 125 observations in Table 4. We removed two male subjects with extremely much higher giving in 2010 than in 2011, as their inclusion dramatically improves the estimates. Nevertheless, since these results are highly sensitive to the removal of these two outliers, we report the conservative and more robust estimates in Table 4, which are robust to further removals.

Males receive more prenatal testosterone and less estrogen than females, reflected in lower 2D:4D's in men (Manning 2002). Hence, the relation between 2D:4D and giving might potentially explain gender effects observed in Dictator Games (Croson & Gneezy 2009). Regressing Dictator giving in 2011 only on female dummy (and the constant term) never leads to statistically significant effects of gender on giving in our data (regressions not reported).

Thus, the influence of 2D:4D on giving behavior is orthogonal to these gender effects documented elsewhere and scholars cannot capture the detected biological predisposition by controlling for gender.

Discussion

We provide support for the hypothesis that 2D:4D may predict altruistic behavior. This is implied by the non-monotonic association we find between 2D:4D and giving in Dictator Game. In contrast to the 2D:4D literature that reports important differences between men and women and between right and left hands, our findings are for the most part robust to these issues. Our results corroborate the idea that part of the variation of human altruism is already determined by prenatal events. This suggests that biological and genetic factors play an important role in social norm transmission (as much as cultural transmission and socialization). Our results are in line with the analysis of Benjamin et al. (Benjamin et al. 2012) who conclude that the genetic variation in behavioral traits will most likely be explained by many factors with each having a small effect. The McFadden's pseudo-R^2 from the 2010 estimations suggest that 2D:4D alone explains 2.3% of the individual variation in giving, while gender improves the fit by 0.2% and controlling for heterogeneity more systematically leads to final 6.5%. The absolute numbers should be treated with caution and interpreted relatively, due to the general difficulties of interpreting the pseudo-R^2 (Long 1997). For comparison, 2D:4D has relatively similar effects in ordinary least-squares estimations of the same models. The R^2's are 0.059 (compared to 0.023 in the censored regressions), 0.064 (compared to 0.025 while controlling for gender) and 0.1658 (compared to 0.065 while controlling for heterogeneity more systematically).

Right-hand digit ratio								
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(male)**	**(female)**
2D:4D	5.69 (0.05)	362.96 (0.01)	373.74 (0.01)	377.9 (0.01)	497.01 (0.00)	547.92 (0.00)	355.1 (0.10)	633.25 (0.00)
$2D:4D^2$		−186.65 (0.01)	−192.76 (0.01)	−195.18 (0.01)	−258.59 (0.00)	−286.19 (0.00)	−183.84 (0.10)	−328.35 (0.00)
Female			0.25 (0.17)	−0.68 (0.90)	−2.4 (0.69)	−0.19 (0.98)		
Fem.*2D:4D				−0.97 (0.87)	2.74 (0.66)	0.57 (0.93)		
Risk Aver.					0.17 (0.01)	−0.45 (0.81)	0.1 (0.29)	0.24 (0.00)
Other Heterogen.	No	No	No	No	No	Yes	No	No
N	171	171	171	171	149	107	88	61
p (model)	0.042	0.002	0.003	0.007	0.001	0.025	0.208	0.000
Left-hand digit ratio								
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(male)**	**(female)**
2D:4D	0.97 (0.30)	141.79 (0.00)	122.87 (0.00)	137.83 (0.00)	139.84 (0.00)	176.91 (0.00)	371.54 (0.03)	−2..61 (0.99)
$2D:4D^2$		−72.71 (0.00)	−63.14 (0.00)	−71.79 (0.00)	−72.69 (0.00)	−92.41 (0.01)	−193.56 (0.03)	3.23 (0.98)
Female			0.19 (0.18)	−4.58 (0.11)	−4.1 (0.02)	−3.06 (0.26)		
Fem.*2D:4D				4.93 (0.10)	4.42 (0.03)	3.45 (0.24)		
Risk Aver.					0.09 (0)	−0.37 (0.80)	0.08 (0.40)	0.24 (0.01)
Other Heterogen.	No	No	No	No	No	Yes	No	No
N	170	170	170	170	148	106	87	61
p (model)	0.3	0.001	0.001	0	-	-	0.117	0.039

p-values in parentheses. Constants non-reported: non-significant in (bottom a, top/bottom male) ($p > 0.18$), significant otherwise.

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Table 3: Dictator giving and 2D:4D, panel-data random-effects censored regression.

Note that our analysis differs from other studies relating prosocial behavior and biological factors such as circulating hormones (Burnham 2007) or oxytocin (Carsten et al. 2010). Their levels are endogenous, complicating causality assessments. That is why we chose to work with the exposure to prenatal sex hormones, since they are not systematically related to their circulating counterparts (Hönekopp et al. 2007).

Right-hand digit ratio								
	(a)	(b)	(c)	(d)	(e)	(f)	(male)	(female)
2D:4D	−1.92 (0.64)	134.96 (0.13)	120.44 (0.13)	126.98 (0.09)	114.60 (0.17)	212.47 (0.01)	154.32 (0.15)	62.56 (0.79)
$2D{:}4D^2$		−71.78 (0.13)	−63.71 (0.14)	−67.42 (0.10)	−60.90 (0.18)	−109.63 (0.00)	−81.88 (0.14)	−33.5 (0.79)
Female			−.23 (0.38)	−1.25 (0.48)	−.25 (0.93)	1.88 (0.72)		
Fem. *2D:4D				1.07 (0.56)	0.04 (0.99)	−2.27 (0.68)		
Risk Aver.					−0.08 (0.10)	0.81 (0.74)	−0.01 (0.82)	−0.18 (0.00)
Other Heterogen.	No	No	No	No	No	Yes	No	No
N	125	125	125	125	120	105	67	53
Pseudo-R^2	0.001	0.004	0.008	0.008	0.013	0.040	0.003	0.031
p (model)	0.636	0.274	0.142	-	-	-	0.246	0.000
Left-hand digit ratio								
	(a)	(b)	(c)	(d)	(e)	(f)	(male)	(female)
2D:4D	−1.59 (0.74)	3.40 (0.97)	14.69 (0.88)	40.46 (0.72)	47.06 (0.67)	122.12 (0.53)	295.94 (0.00)	−544.86 (0.00)
$2D{:}4D^2$		−2.58 (0.96)	−8.21 (0.87)	−22.76 (0.71)	−26.56 (0.65)	−67.19 (0.49)	−155.53 (0.00)	280.95 (0.00)
Female			−0.20 (0.48)	−5.81 (0.18)	−7.68 (0.17)	−7.19 (0.33)		
Fem. *2D:4D				5.82 (0.20)	7.76 (0.18)	7.17 (0.35)		
Risk Aver.					−0.11 (0.07)	0.60 (0.78)	−0.06 (0.32)	−0.13 (0.06)
Other Heterogen.	No	No	No	No	No	Yes	No	No
N	125	125	125	125	120	105	67	53
Pseudo-R^2	0.001	0.001	0.003	0.005	0.013	0.037	0.018	0.078
p (model)	0.744	0.947	0.889	-	-	-	0.000	0.000

p-values in parentheses. Constants non-reported: significant at 2% in all models except (top a) ($p = 0.09$), $p > 0.58$ in (bottom a–f); $p < 0.0001$ in (bottom male/female).
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Table 4: The change of behavior ($giving_{2010} - giving_{2011}$) and digit ratio, censored regressions.

We would like to emphasize that the degree of exposure to prenatal sex hormones and thus 2D:4D ratio, as much as any other biological traits in humans and non-humans (Darwin 1871, Alexander 1996, Sutherland 2005), has most likely been tuned by thousands years of evolution till it has reached an “optimal” level. Does the distance from the mean predict a subjects’ adherence to a desirable sharing norm? We address this question in the following manner. We combine our data with a large distribution of digit ratios of individuals from another study. This is gives us a total of 1017 observations (577 females) (see Methods). The right-hand 2D:4D’s that maximize giving in 2010 (before subjects learn and may know the other participants) are 0.956 and 0.961 for men and women, respectively (see Figure 2). These figures are very close to 0.957 and 0.969, the proxies for the median 2D:4D’s in the population.

We further provide a more rigorous test. We estimate the relation between giving and (the absolute value of) the deviation from the above population medians. The linear term is significant on its own in Table 5. However, the best model in terms of model significance, adjusted-R^2, and p-values associated to 2D:4D variables ($p< 0.02$) turns out to be regressing giving over the quadratic term for both hands. Controlling for heterogeneity in this model reinforces this conclusion. With one exception, we observe a decreasing concave association, suggesting that the higher the distance from the optimal value the lower the giving, but at a decreasing rate. Hence, the distance from the median 2D:4D relates negatively to the observed sharing behavior. We find the contrary increasing convex association -for deviations of female left-hand 2D:4D's from the population median.

One possible interpretation of the above findings comes from stabilizing selection. Since sharing with others is socially beneficial, selfish individuals are socially excluded and their fitness affected negatively. If individuals who are exposed too much or too little do not share with others, there is an evolutionary pressure on these non-altruistic individuals, which in turn generates an indirect evolutionary pressure on the degree of exposure to prenatal sex hormones by raising survival probabilities of individuals with intermediate levels of exposure. This hypothesis is supported by observed distributions of 2D:4D in the literature, which are universally concentrated around the median values (Manning 2001). Even though the previous paragraphs provide certain support for our hypothesis, a word of caution is in place here. First, our results are rather suggestive. They only provide one piece of evidence to support such argument and cannot be taken as conclusive evidence of stabilizing selection. Other explanations are obviously possible. Second, we know that exposure to fetal testosterone and estrogen conditions many behavioral and physical traits in humans (not only sharing behavior). The 2D:4D optimal from the evolutionary perspective (if it exists) could thus be confounded with effects on these traits and potential trade-offs have to be taken into account. Therefore, we have to be wary of making general conclusions based on our exercise. On the other hand, some studies have already suggested non-monotonic impacts of 2D:4D on some behavioral outcomes (e.g. Nye et al. 2012, Sapienza et al. 2009, Sanders et al. 2002, McFadden 2002).

Right-hand digit ratio

	(a)	(b)	(c)	(d)	(e)	(f)	(male)	(female)
$2D{:}4D-\widetilde{2D{:}4D}$	−12.91 (0.02)	−17.66 (0.01)	23.04 (0.11)	23.28 (0.15)				
$(2D{:}4D-\widetilde{2D{:}4D})^2$			−520.14 (0.01)	−614.27 (0.01)	−221.62 (0.00)	−300.43 (0.00)	−283.26 (0.01)	−280.78 (0.01)
Female		2.75 (0.55)		5.05 (0.27)		4.28 (0.34)		
Fem. *2D:4D		−2.64 (0.58)		−5.01 (0.29)		−4.22 (0.37)		
Risk Aver.		0.07 (0.31)		0.08 (0.28)		0.08 (0.28)	0.03 (0.74)	0.11 (0.21)
N	171	149	171	149	171	149	88	61
Pseudo-R^2	0.013	0.025	0.026	0.040	0.022	0.036	0.020	0.078
p (model)	0.012	0.012	0.002	0.002	0.001	0.001	0.044	0.004

Left-hand digit ratio

	(a)	(b)	(c)	(d)	(e)	(f)	(male)	(female)
$2D{:}4D-\widetilde{2D{:}4D}$	−10.55 (0.03)	−11.58 (0.03)	8.82 (0.54)	12.38 (0.41)				
$(2D{:}4D-\widetilde{2D{:}4D})^2$			−272.45 (0.17)	−338.02 (0.1)	−161.24 (0.02)	−182.25 (0.01)	−188.39 (0.01)	188.39 (0.01)
Female		−5.45 (0.25)		−7.02 (0.16)		−6.41 (0.20)		
Fem. *2D:4D		5.76 (0.24)		7.38 (0.15)		6.74 (0.19)		
Risk Aver.		0.04 (0.59)		0.04 (0.61)		0.04 (0.62)	0.15 (0.91)	0.15 (0.25)
N	170	148	170	148	170	148	87	61
Pseudo-R^2	0.010	0.017	0.014	0.023	0.014	0.021	0.043	0.031
p (model)	0.029	0.12	0.044	0.068	0.015	0.050	0.003	0.036

p-values in parentheses. Constants at 1% in all models except (top d) (p = 0.028) and (bottom female) (p = 0.25).

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Table 5: Dictator giving and the deviation from the population median of the 2D:4D censored regressions.

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CHAPTER 3

Heterogeneous Returns in Public Good Games[3]

ABSTRACT

In this article we investigate the group compositions in a public good game where subjects differ from each other by their marginal per capita return levels. We focus solely on returns from the public good without sanctioning possibility and compare diversely formed societies where dominant strategy is not to contribute (free-riding). First, we compare homogeneously formed groups, where each group member has the same marginal per capita return, with other homogeneously formed groups which have a different marginal per capita return. According to our aggregate results, marginal per capita return has a positive effect on contributions in homogeneous societies. This effect is stronger if the distance between two compared levels of return is larger. Then we compare the contributions of the players in heterogeneously formed groups, where group members do not have the same marginal per capita return. In this case we find that players with lower returns contribute less than the ones with high returns even the distance between two compared levels of marginal per capita returns are small. What is more, if we compare the heterogeneously formed groups with each other we do not find any aggregate contribution differences.

[3] This is a joint work made with Pablo Brañas-Garza, Elena Molis and Raul Peña Fernandez.

Introduction

Individuals, in many instances, may receive distinct benefits from public goods. While some prefer or need to consume more, another may be indifferent to it. Likewise, in some cases usage rights may be allocated unevenly. Although the experimental literature on public goods is highly abundant, there are relatively few papers studying heterogeneous benefits. This study experimentally investigates the heterogeneous returns from public goods and how related they are to different social environments.

We analyze the heterogeneity in two dimensions: In a macro environment (*global*) and in a microenvironment (*local*). A new underground station, for instance, would benefit the local residents more than those living in a closer district to the next station along. This type of aggregate heterogeneity, which corresponds to variance of benefits between districts in this very example, is the focus of our *global* analysis. In similar fashion, that new underground station would be more beneficial for the people who mostly use the public transport rather than their own cars, even though both live in the same district. This is the scope of our *local* analysis. We make between and within comparisons in both heterogeneously and homogeneously formed groups in our analysis. Homogeneously formed groups consist of 3 players with equal marginal per capita return (MPCR hereafter) rates and each heterogeneously formed group has a member with a different MPCR than the other two.

Experimental methodology has widely been used to study public good provision for more than three decades.[4] Linear public good games have focused on the motives behind contributing to public pool where various behavioral explanations behind contributing arose. Andreoni (1990) suggested that it is the “warm glow of giving”. Models of inequity aversion, (Fehr & Schmidt 1999), fairness (Rabin 1993) and conditional cooperation have also been reported to explain cooperative behavior in these environments. See Fischbacher et al (2001) and Chaudhuri (2011) for more detailed research on conditional cooperation.[5]

The effect of heterogeneity in endowments is unclear. While some papers show a positive effect on contributions (Chan et al. (1996), Buckley & Croson (2006) and Georgrantzis & Proestakis

[4] See Ledyard (1995) for a detailed survey on public good games and Zelmer (2003) for a meta study.
[5] Public goods provision is sensitive to group size (Isaac & Walker 1988, Isaac et al. 1994, Janssen & Ahn: 2006), sanctions (Fehr & Gächter 2000, Carpenter 2007, Nikiforakis 2008), repetitions (Andreoni 1988), framing (Willinger & Ziegelmeyer 1999)

(2011)) others find a negative effect (Cherry et al (2005) and van Dijk et al. (2002)) where some do not find any (Chan et al. (1999), Sadrieh & Verbon (2006), Hofmeyr et al (2007) and Reuben & Riedl (2013)).

Regarding the heterogeneity in MPCR, number of studies is more limited and they are mainly focused on the between group analysis, (comparison of groups A and B where $MPCR_A > MPCR_B$, but identical among members of each group), which find positive effect of MPCR on contributions (See Isaac & Walker (1988), the survey of Ledyard (1995) and the meta study of Zelmer (2003)). Also, if detailed instructions, explaining the function of MPCR is provided to the subjects, reducing MPCR levels of the players decreases the contribution (Laury et al. 1999).

The evidence on heterogeneity of MPCR within groups, on the other hand, point out a positive effect of MPCR on contributions (Tan (2009), Reuben & Riedl (2009, 2013), Fellner et al. 2011, Kölle (2012).) where Fischbacher et al. (2014) find a weak impact and Fisher et al. (1995) do not find any effect.[6] However these studies do not solely focus on MPCR heterogeneity but sanctions (Tan 2009, Reuben and Riedl 2009, 2013, Kölle 2012), contribution norms (Reuben and Riedl 2013), information heterogeneity (Fellner et al. 2011), uncertainty and conditional cooperation (Fischbacher et al 2013). Besides, there is also heterogeneity in dominant strategies in Reuben and Riedl (2009) and Kölle (2012). In aggregate terms heterogeneity decreases group contributions in Tan (2009) and Fischbacher et al. (2014). [7]

To the best to our knowledge, current study is the first to analyze the effects of four different levels of MPCR with a unique dominant strategy in both homogeneously and heterogeneously formed groups. With the absence of interest on sanctions, information heterogeneity, norms and belief elicitations we solely focus on the effect of MPCR in diversely formed societies. A relatively large subject pool is also one of the properties of this experiment.

In our design each group has three members, whose dominant strategy is to free ride (*MPCR < 1*). Heterogeneously formed groups have both low type players with an MPCR of *.5* and high

[6] Marwell and Ames (1979) studied on private return heterogeneity but their study can only be considered as initial steps towards MPCR research in Public Good Games.
[7] In Fisher et al (1995), Tan (2009) and Fischbacher et al. (2013) player types are allocated evenly in heterogeneous groups, meaning that the number of high type players is equal to the number of low type players. Instead of such a balanced heterogeneity our design comprises unbalanced heterogeneous groups.

type players with an MPCR of *.75*. Having three members in each group enables us to form various heterogeneous societies which may include a majority of high types or vice versa in the groups. Besides heterogeneously formed groups there also exist homogeneously formed groups to observe both *local* (within group) and *global* (between group) heterogeneity. In a homogeneously formed group all three members have an identical MPCR rate, which means all of them receive precisely the same payoff from the public good. There exist 4 different homogeneous groups. Two of them have MPCR levels of *.5* and *.75* and the other two have *.4* and *.9*. We compare the former two between each other and also with heterogeneous groups. The latter two *(.4* and *.9*) serve as supporting treatments which we compare merely with each other.

In our results, MPCR has a significant positive effect in homogeneous group contributions on the aggregate level, where low returns yield to smaller mean group contributions. Although there is no significant difference between homogeneous and heterogeneous societies in aggregate level, individual results show the positive impact of MPCR in heterogeneously formed groups. Yet, we do not find any effect of MPCR in homogeneous groups in the individual analysis.

Remainder of the paper is organized as follows. Design of the experiment is explained in the next section, and then we give the results in two subsections as global and local analysis, which is followed by discussion and conclusion sections.

Experimental Design

The experiment was conducted in EGEO, the experimental lab of University of Granada in Spain and run with Z-tree software (Fischbacher 2007). The subjects were recruited with ORSEE (Greiner 2004). The total number of subjects is 183 (female=105), who were students of the School of Business and Economics.

In each session 18 subjects were randomly assigned to the computers (and groups). After they read the instructions, experimentalists read the instructions out loud once more. Following several control questions and two rounds of trial they were informed about their own MPCR and also the MPCR of the other two members in their groups. Then they began the experiment. After the subjects completed the experiment they were paid confidentially for a randomly selected round and left the lab. The duration of a session was about 1 hour. Subjects earned €12.62 in average (including €3 show up fee).

Each group consists of three players who are randomly matched. As a standard Public Good Game procedure, each subject makes a contribution decision from her endowment of 20 tokens ($c_i \in [0, 20]$ and exchange rate of a token is € .33). Players decide how much to keep for themselves and how much to contribute to the public pool. Any amount of money contributed to public pool is multiplied with a number (a multiplication factor) and divided equally across the members of the group. Dividing the multiplication factor by the number of members in the group gives MPCR. MPCR defines the personal benefit that the subjects receive from the public pool. Payoff function of each player is such

$$\pi_i = (w_i - c_i) + \alpha_i \cdot (\sum c_j + c_i)$$

Where w_i is the initial endowment of subject i, c_i is her contribution to the public pool and α_i is her MPCR, which is the division of multiplication factor by number of the players in the group. c_j stands for the contributions of the other players in the group.

The experiment is run for 10 periods. After each period, subjects are given full information about their own payoffs and also a vector showing contributions of each group member. After each period they record the contributions of each player and also their own payoff in the sheets we gave them in the beginning of the experiment. This sheet served them as a history table throughout the whole experiment.

We use four different MPCR in global analysis (*.4, .5, .75, .9*) and two different MPCR (*.5* and *.75*) in local analysis which define the types of players as low or high. The whole design comprises 4+2 treatments (See Table 1). Treatments T1 to T4 let us study local heterogeneity while T1-2 with respect to T5-6 (homogeneous treatments) let us study global heterogeneity.

Treatment 1 consists of only high type players with an MPCR of *.75* and Treatment 2 has only low type players whose MPCR is *.5*. Treatment 3 has a majority of high type players while low type players are the majority in 4th treatment. We made clear that all subjects in treatments T1 to T4 were informed about the existence of two different MPCR (*.5* and *.75*) in the game.

Final two treatments are supporting treatments, which enable us to perform a more detailed analysis on the homogeneous groups. All players in 5th treatment have an MPCR of *.9* and in 6th

MPCR of each subject is *.4*. They also were aware of two different MPCR levels (*.4 and .9*) in the experiment.

Recall that in treatments T5 and T6 there is a *.5* difference between high and low MPCR levels. The distance between two MPCR levels in T1 and T2, on the other hand, is half of T5 and T6 (*.25*). This difference in distances enables us to compare societies where the gap between the benefits from the public pool varies.

Table 1: Treatments

	Homogeneous Groups				Heterogeneous Groups		
T	MPCR	N	Formation	T	MPCR	N	Formation
1	*.75*	36	HHH	3	*.5 ; .75*	36	LHH
2	*.5*	39	LLL	4	*.5 ; .75*	36	LLH
5	*.9*	18	HHH				
6	*.4*	18	LLL				

Experimental Results

Statistical analysis of the experiment is run in two parts. In global results section we observe aggregate group behavior initially by focusing on homogeneous treatments and we also make a group comparison between treatments T1 to T4 to examine the effect of heterogeneous group formations in the aggregate level. Global analysis is followed by local analysis where we concentrate on types of players individually.

Global Analysis

Figure 1 shows the mean contributions of each treatment across treatments along 10 rounds. Average MPCR of each treatment is given in the parentheses on the X axis. Homogeneous groups with extreme MPCR levels are placed in both ends of the figure. LLL (*.4)* groups are the least contributors where HHH (*.9*) groups are the highest while the difference between the contributions of HHH (*.75*) MPCR and (*.5)* is relatively smaller. Heterogeneous groups on the other hand, contribute similarly with each other and also with HHH (*.75*) and LLL (*.5*).

Figure 1: Mean Contributions across Treatments

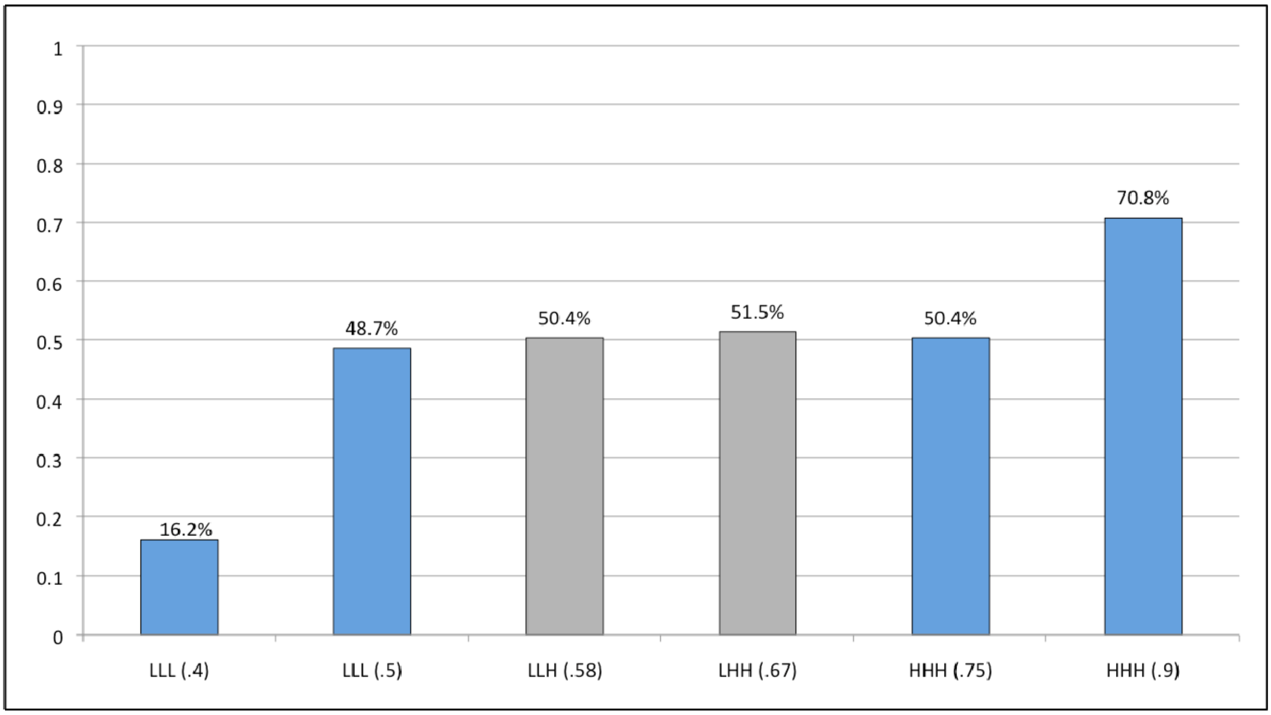


Table 2 shows the Mann-Whitney test (M-W hereafter) results of mean contributions between treatments. First 4 rows are devoted only to homogeneous treatments and the rest to comparisons between heterogeneous and homogeneous groups in treatments T1 to T4.

Table 2 Comparisons of Mean Contributions across Treatments

HOMOGENEOSLY FORMED GROUPS					
				z	*p*
(1)	LLL (.*4*)	vs	HHH (.*9*)	*-5.000*	*.000*
(2)	LLL (.*5*)	vs	HHH (.*75*)	*1.697*	*.089*

COMPARISON WITH HETEROGENEOSLY FORMED GROUPS					
				z	*p*
(3)	LLL *(.5)*	vs	LLH	-*.419*	*.675*
(4)	LLL *(.5)*	vs	LHH	-*.233*	*.815*
(5)	HHH (.*75*)	vs	LLH	*1.554*	*.120*
(6)	HHH (.*75*)	vs	LHH	*1.194*	*.232*
(7)	LLH	vs	LHH	-*.084*	*.932*
(8)	(HHH (.*75*) + LLL (.*5*))	vs	(LLH+LHH)	-*.707*	*.479*

Notes: Mann-Whitney tests comparing the mean contributions in each treatment. MPCR levels of homogeneous groups are shown in parentheses. (HHH (.*75*) + LLL (.*5*)) denotes homogeneous treatments T1 & T2 where (LLH + LHH) denotes heterogeneous treatments T3 & T4.

Row 1 shows that the contributions of LLL (.*4*) are lower than HHH (.*9*) (*z = -5.000, p=.000*). This difference between mean contributions of homogeneous groups is smaller when treatments T1 and T2 are compared (Row 2). LLL (.*5*) contribute less than HHH (.*75*) on (*z = 1.697, p = .089*).

RESULT 1 (Rows 1 and 2 in Table 2): Homogeneous groups with low MPCR contribute less than the homogeneous groups with high MPCR.

This result supports the survey of Ledyard (1995), which points out the positive effect of MPCR on contributions. It is meaningful to observe such of a relationship between the benefits and the contributions. Individuals, understandably, would support a certain public investment less if they receive a lower utility from it.

The very evidence in first two rows may also elucidate an additional point: Difference between benefit distributions matters. Recall that the MPCR distribution was common knowledge in whole treatments. Thus, the players in T5 and T6 know that there exist two MPCR levels (*.4* and *.9*) in the whole game, and that the MPCR difference is *.5* between the low and the high types of these treatments. Likewise, in the rest of the treatments players are aware of two MPCR levels (*.5* and *.75*) as well where the difference between these two is only *.25*. Apparently as the MPCR difference increases from .25 to *.5*, contribution difference also does from *1.7*% to *54.6*% ($p=.089$ and $p=.000$ respectively).

RESULT 1A: If the MPCR difference is greater between two homogeneous groups, the effect of it on contributions is also stronger.

Differences between the mean contributions of homogeneous and heterogeneous groups are insignificant (Rows 3 to 6). Two heterogeneous groups LLH and LHH also contribute similarly ($z = -.084, p = .932$) (Row 7). Finally row 8 compares T1+T2 and T3+T4 which points out the insignificance of heterogeneity ($z = -.707, p = .479$).

RESULT 2 (Rows 3 to 6 and Row 8 in Table 2): There is not any significant difference between heterogeneously formed societies and homogeneously formed societies in aggregate level.

This result is in contrast with Tan (2009) and Fischbacher et al. (2013) where they find a negative effect of heterogeneity in contributions.

Finally, average contributions of two heterogeneously formed groups are not significantly different neither ($z=-.084$, $p=.932$) (Row 7). The next section focuses on local heterogeneity to compare heterogeneously and homogeneously formed groups at individual level.

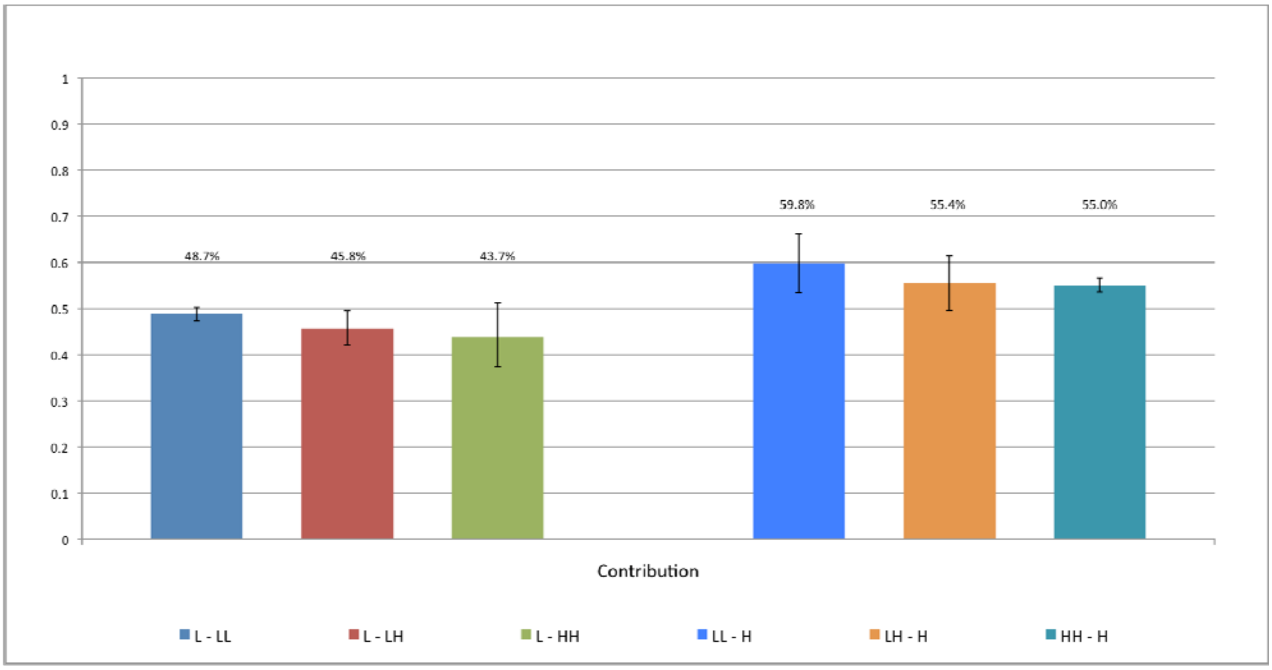
Local Heterogeneity

This section is devoted only to treatments T1 to T4. We compare homogeneously and heterogeneously formed groups at individual level where MPCRs are *.5* and *.75*.

Average contribution of each type of player is shown in Figure 3. Low type players of both homogeneous and heterogeneous treatments are on the left hand side of the figure, while high types are on the right.

It is apparent that there exists a positive relationship between types and contributions. As previous section on aggregate results has already proven, this difference is significant in homogeneous groups, LLL and HHH at $p = .089$ (M-W: $z = 1.697$). While low types in LHH are the least contributors high type players in LLH make the highest contributions. The individual results are investigated in detail throughout the regression analysis.

Figure 3: Average Contributions by types in Treatments 1-4



The regression analysis of individual behavior is shown in Table 3. Since the game is repeated, the contributions of each period are not independent than the previous. Thus, we use panel data in our analysis and employed GLS regressions. We also clustered our models over each group of three players.

Dependent variable is contribution of each subject as a percent of the endowment. Independent variables are: *homo=1* if the treatment is homogeneous, *low=1* if the player is a low type (*MPCR* = .5) and *period* is the time variable of 10 periods in the game. *LLH=1* if the treatment is T4

(LLH) and *LLH=0* if the treatment is T3 (LHH). We also controlled the models for gender effects.

Table 3: Regression Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All	Homo	Hetero	Hetero	Low	High	LHH	LLH
homo	.008	--	--	--	.035	-.035	--	--
	(.853)	--	--	--	(.570)	(.502)	--	--
low	-.096	-.063	.139	--	--	--	-.138	-.160
	(.012)	(.315)	(.001)	--	--	--	(.001)	(.028)
period	-.021	-.022	-.021	-.021	-.025	-.018	-.015	-.027
	(.000)	(.000)	(.000)	(.000)	(.000)	(.001)	(.044)	(.001)
LLH	--	--	--	-.017	--	--	--	--
	--	--	--	(.793)	--	--	--	--
cons	.712	.682	.763	.739	.581	.773	.711	.827
	(.000)	(.000)	(.000)	(.004)	(.000)	(.000)	(.000)	(.000)
N	1470	750	720	720	750	720	360	360

Note: GLS regressions clustered by group. Dependent variable: contribution as percentage of the endowment. *p-values* are indicated in parentheses. Model (1) contains treatments T1 to T4 together, (2) is devoted only to T1 and T2, (3) and (4) comprise T3 and T4. In model (5) all the low type players in T1 to T4 included where model (6) is for all high type players in T1 to T4. Model (7) and (8) contain T3 and T4 respectively. All regressions are clustered over groups of 3 (49 groups in (1), 25 groups in (2) , 24 groups in (3) and (4), 37 groups in (5) , 36 groups in (6) 12 groups in (7) and (8)). All models are controlled for gender effects.

Column 1 includes all players of both heterogeneous and homogeneous groups, while column 2 focuses on homogeneous treatments. Third and fourth column are devoted to heterogeneous treatments. Fifth model includes all low players in first four treatments independent of heterogeneity; same regression is run for the high type players in 6th column. Columns 7 and 8 analyse two heterogeneously formed groups separately. In column 7 only heterogeneous groups with a majority of high players (LHH) is analyzed and 8th model includes only the players in LLH treatments.

Our analysis in first column, including both heterogeneous and homogeneous treatments together, points out a strong negative effect of *low* on contributions (*p=.012*) where *homo* does not have a role in contributions (*p=.853*). If only homogeneous treatments considered as in model 2, the significance of *low* disappears (*p=.315*). Model 3 shows that *low* is strongly correlated with the contributions of the players in heterogeneous treatments (*p=.001*). This proves that the positive effect of *low* in regression (1) is due to significance in heterogeneous treatments. There is not any significant contribution differences between LHH and LHH in model 4 (*p=.793*)

Type-wise comparisons in model 5 and 6 confirm that same type of players behave similarly independent from homogeneity. Contributions of low type players of both heterogeneous and homogeneous groups are indistinguishable in model 5 (*p=.570*). Likewise, high type players in homogeneous groups contribute similar amounts with high type players of heterogeneous groups (*p=.502*) in column 6. In both heterogeneously formed groups, LHH and LLH, there is a significant effect of *high* (*p=.001 and p=.028 in* columns 7 and 8 respectively). According to these results we can conclude that:

RESULT 3: MPCR has a positive significant effect on individual contributions in heterogeneously formed groups, meaning that the subjects who receive lower returns from the public good contribute less.

In line with previous public goods game experiments, contributions decay over time significantly in all of our models ($p \leq .05$). Decay is also statistically significant in homogeneous treatment with MPCR of *.4* (T6) at *p=.003* but not in the homogeneous groups with where MPCR is *.9* (T5) *(p=.939).* [8]

Discussion and Conclusions:

In this article we studied the effects of varying benefits and the group formations in a Public Good Game. Our results confirm the previous findings in the literature concerning the positive effect of MPCR: Individuals contribute more to the public good if they are to receive more benefits from it. However, the relationship between heterogeneous benefits and various group formations is in the focal point of this study. We do this analysis in two levels: global and local. The global analysis makes comparisons focusing on aggregate contributions throughout the

[8] This analysis is based on Panel Data, GLS regressions run for T5 and T6 where coefficients are -*.0191* and -*.1346* respectively.

whole game. The local analysis, on the other hand, studies the type-wise differences in homogeneously and heterogeneously formed groups. In homogeneously formed groups all the group members benefit from the public good in the same proportions and in a heterogeneously formed group one of the group members has a different MPCR than the other two.

Global results point out a significant effect of MPCR in between comparison of homogeneous groups (Result 1), which complies with the previous findings in the literature (Ledyard 1995, Zelmer 2003). This significance is much stronger if the difference between MPCR levels of two compared groups is larger (Result 1A). In particular, a comparison between the mean contributions of T1 and T2 (*.75* & *.5*) yields a smaller difference than the comparison of T5 and T6 (*.4* & *.9*). We do not find any aggregate effect of heterogeneous group formations as Tan (2009) and Fischbacher et al (2013) do (Result 2). In their results contributions are lower in heterogeneously formed societies.

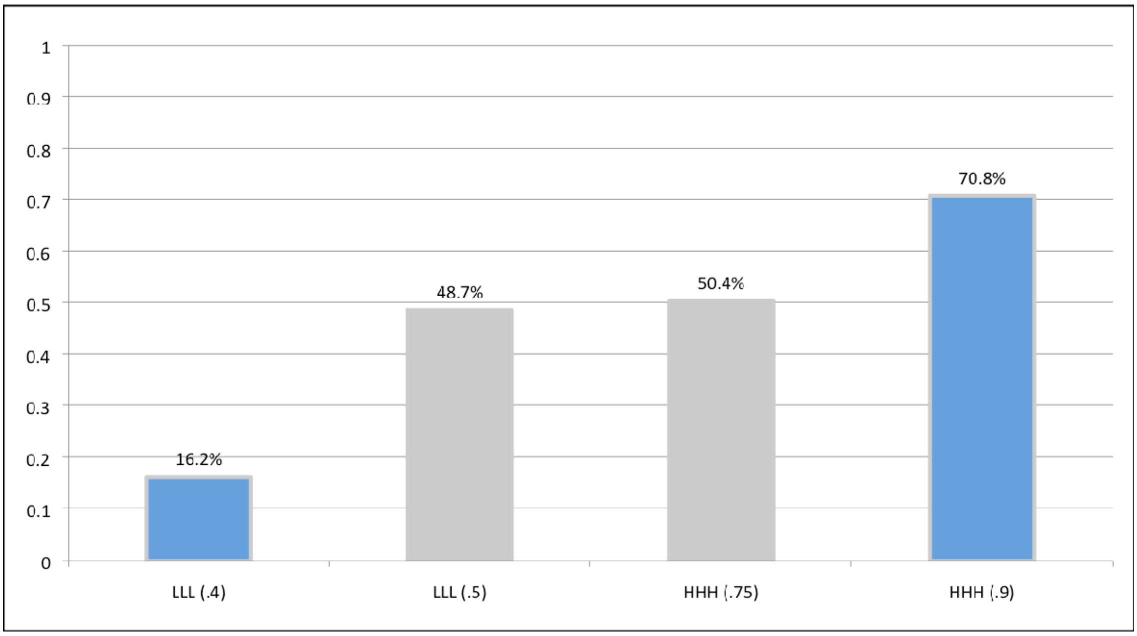
Our local analysis shows that in heterogeneous treatments the effect of MPCR on contributions increases (Result 3). This is to say that in heterogeneous treatments low types (MPCR=*.5*) contribute significantly lower than the high types (MPCR=*.75*). However in the local analysis MPCR does not have a significant impact on contributions in homogeneous groups. Finally, the contributions decay throughout the game in all treatments but continue in a fix trend in HHH (.9).

On top of these results there are also two observations deserve to be mentioned. First one is on the effect of the MPCR distance on contribution behavior:

Recall that: MPCR difference is *.25* between LLL (*.5*) and HHH (*.75*), while it is *.1* between two LLL groups (with MPCR of *.4* and *.5*) and *.15* between HHH groups (*.75* and *.9*). However average contributions do not follow such an order (See Figure 4). While the contribution difference is only 1.7% between LLL (.5) and HHH (.75) it is 32.5% between LLL (.4) and LLL (.5) and 20.4% between HHH (75) and HHH (.9).

A possible explanation of this result can be the knowledge of the players about the MPCR distribution in the overall society. In the instructions group members of LLL (*.5*) and HHH (*.75*) are told that they *may* either have a MPCR of *.5* or *.75*. After the instructions and trial periods they learned their own MPCR and their group formation in the screen. Likewise the members of LLL (*.4*) and HHH (*.75*) were given the same instructions and they knew the fact that there were two MPCRs: *.4* and *.9* in that global environment. Such basic information created a switch in the players' reference points to compare themselves with. Subjects with a MPCR of .4 feel less responsible for the provision of the public good than the players in HHH (*.9*). However for the members in groups LLL (*.5*) and HHH (*.75*) this difference in returns is smaller, thus the contribution difference also is.

Figure 4: Contributions in Homogeneous Treatments



The second observation is calling for the attention of policy makers which is concerning the efficiency of the public good provision. Our global analysis showed that the difference between two MPCR levels matters and forming groups heterogeneously does not have any effect on contributions in aggregate level. Beside these findings a comparison between the mean contributions of LLL (.4) + HHH (.9) together and the mean contributions in LLL (*.5*) + HHH (*.75*) together shows that the latter is higher than the former at $p=.085$ (M-W, $z=1.720$). Then we can conclude that: If the benefit difference is smaller individuals contribute to public good more. Such an example may explain this observation:

The government is creating a fund which will given to women entrepreneurs (MPCR=*.9*). Then male entrepreneurs would not support this as much as the women do (MPCR=*.4*). If the government gives the fund to "entrepreneurs" regardless of gender, then the efficiency gets higher in the provision of the public good. No matter if there are both females and males in the market (insignificance of heterogeneous group formations in aggregate level).

In conclusion, we show that heterogeneity in benefits creates a polarization effect in Public Good Provision. At global level as the distance between benefit levels increases also the difference between contributions grows. The same effect applies for the heterogeneously formed groups in our local analysis where a significant contribution difference appears between the low and the high type players. It is also interesting to see that the low type players in LHH are the least contributors where high types in LLH are the highest in the local analysis.

Dissimilar preferences, needs and also the unequal usage rights create benefit heterogeneity in the utilization of the public goods. Our results call for the attention of policy makers and governments to consider this benefit heterogeneity which may lead public policies to operate more efficiently. Successful provisions of public goods may also be more feasible.

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CHAPTER 4

Heterogeneous Motives in Trust Game[9]

ABSTRACT

This paper experimentally tests whether there are heterogeneous motives behind observed trust behavior. We use a binary Trust Game to differentiate the motives behind Trust Game decisions and study the behavioral and socio-demographical underpinnings of those decisions. For this purpose our study also includes a dictator game, an ultimatum game, risk and time preferences elicitation, cognitive ability questions and survey items on socio-demographics. The results suggest that there are two groups of players who have different motives. In the first group, players choose both to send and to return a positive amount. We refer to this group as pro-social. Subjects in the second group transfer a part of their endowment to the second player but they choose to keep the money when they play as the second player. Therefore, their motive behind sending a positive amount as the first player may be due to oppurtunistic reasons. This finding is also supported by the results of Dictator and Ultimatum Games. Prosocial players, indeed send more in Dictator Game and they are easier to come to an agreement with in the Ultimatum Game. Besides, risk attitudes and cognitive abilities are also related to players' decisions in the Trust Game. These results call for caution of the experimenters using Trust Game in their studies to take this duality of motivation in to account.

[9] This is a joint work made with Filippos Exadaktylos

Introduction

Interpersonal trust is one of the major concepts that enable social systems to operate smoothly. It is a *lubricant of a social system* (Arrow 1974) and also a key concept of Social Capital (SC hereafter), together with reciprocity and social connectedness (Putnam 1995). More than its social function, its economic significance has attracted the attention of governments and political institutions, which now invest considerable funds and effort for its development (World Bank Group 2011). Indeed, trust and SC have been found to be correlated with a country's rate of growth (Knack and Keefer 1996), quality of institutions (Putnam 1993), decreased transaction costs (Williamson 1975), successful negotiations (Deutsch 1958), firms' operational efficiency (La Porta et al. 1997), and also to allow informal transactions (Karlan et al. 2009).

The economic externalities of trust drew interest of the economists with an estimated 7,000 academic articles in the last fifteen years analyzing its effects (Sapienza et al. 2013). A large part of these studies have employed attitudinal survey questions of the type developed for the General Social Survey, which typically ask: "*Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?".* While data of this type are useful, they also possess several drawbacks such as lacking of *incentive compatibility, hypothetical and idealized persona biases*.[10] Experiments on the other hand, can overcome those problems by allowing researchers to observe subjects' behavior in controlled situations, at which behaviors are connected with final monetary payoffs thus, providing incentive compatibility.[11]

Experimentalists use, in particular, Trust (or Investment) Game (Berg et al. 1995) to study trust and reciprocal behavior. Trust Game (TG hereafter) involves two players. The first is given a monetary endowment and asked whether she wants to transfer any part of it to the second player.

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[10] Carpenter (2002) defines these major three issues in experiments. Respondents might not be revealing their true attitudes, since their answers are not performance-based and possibly due to lack of enthusiasm about spending time and effort on the survey. The reason is lacking of *Incentive Compatibility*. Another matter is that responders, in general, are expected to imagine themselves in situations and indicate a behavior pattern, which however is not always easy to do and thus create doubts as to whether they would actually behave as indicated (*hypothetical bias*). Survey respondents can also misrepresent their real opinions by responding the questionnaire as the character they or the researcher would want them to be (*idealized persona bias)*.

[11] Experiments however are not without problems. Levitt and List (2007) categorize problems as moral concerns, scrutiny by others, the context dependency, self selection and the stakes of the game.

Experimenter triples the amount that Player 1 sends, say *X*, before delivering it to Player 2. Then the second player is given an option to send some part of *3X*, that she received, back to Player 1. "*X*", in this design, is a measure of trustful behavior. Player 1 cannot be sure whether Player 2 will send some part of *3X* back or not; therefore, Player 1's transfer is a risky choice that is reliant on the trustworthiness of Player 2. In other words, Player 1 has to *trust that Player 2 will be trustworthy* and transfer back the money. On the other hand, the money that Player 2 sends back to Player 1 is considered to be a measure of trustworthiness.

Yet, many discussions arose since then regarding what Player 1's decision actually measures. A positive amount sent by the first player, apart from the belief in Player 2's trustworthiness may as well be motivated by altruism (Ashraf et al 2006), reciprocity (Cox 2004) or even risk attitudes (Eckel and Wilson 2004) and aversion to feel like a fool (Bohnet and Zeckhauser 2004). The way researchers tried to tackle the issue normally involved eliciting Player 1's expectations regarding Player 2's trustworthiness (see for example Pillutla et al 2003 and Sapienza et al. 2013). However, this method might be confounded by the fact of an ex-post justification of ones' actions.

In the current study, we test whether there exists heterogeneity across subjects' motives behind the transfers of TG. For the purposes of the study we recruited a representative sample of a city's population, which enables us to have a more general subject pool that does not only involve only college students. It includes subjects from diverse socio-demographic backgrounds with different education and income levels. Its age distribution is also highly similar to the official recordings of the city.

Each subject that participated in the survey-experiment made not only a TG- first player decision but also four others: as a TG second player, as a dictator in a Dictator Game (DG hereafter), as a proposer in a Ultimatum Game (UG hereafter) and as a responder in the same game. Decisions were also randomized in order to avoid any order effects. In addition, for every subject we have measured the risk and time preferences, cognitive abilities and large set of questions regarding socio-demographic information, including age, income, and education level.

Our results confirm a duality in first player's motives in TG. A large majority of subjects choose both to trust and to reciprocate the trust in the game, signaling a pro-sociality in their behavior. There also exists another group of individuals who instead choose to trust but not reciprocate, which implies a strategic behavior. The first group of individuals (pro-social players) demonstrates higher levels of generosity and a greater ability facilitate the agreements than the latter[12].

The paper is organized as follows: the next section describes the methodology, procedures and the main variables of our analysis. Section three present the results and section four discusses the implications and concludes.

2. Design and Procedures

The survey-experiment took place in Granada (Spain) from November to December 2010. A representative sample of the city was recruited resulting in a total of 835 individuals who are older than 16 years old (450 female, mean age 38.5 ±17.5 (SD)). 108 pairs of interviewers contacted individuals at their households. One in every 10 winning subjects was randomly selected to get paid. Average earnings among winners were €9.60.

In order to achieve highest socio-demographic representativeness in sampling we ran the experiment in the whole city, making sure that we create our sample evenly from all districts of the city. The age and gender distribution of the sample is also similar to the official statistics of the actual population in the city (See Figure A1 for age distribution of the sample).

Current study utilizes three sections of a larger experimental protocol (See Table A1). While the first focuses on socio-demographics, the seventh section includes risk and time preferences elicitation in addition to a test regarding cognitive abilities. The eighth comprises the experimental decisions for three experimental games, namely the Trust Game (playing both roles), the Dictator Game (as dictators) and the Ultimatum Game (playing both roles).[13] As noted before, in order to avoid any possible order effect we randomized the order of the questions and decisions.

In order to measure trust behavior, a binary version of the TG developed by Ermisch and Gambetta (2006) was employed. In this version, of the game the first player is endowed with 10

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[12] We use the variable called *Agree* to measure the ability to agree. It is the difference between Ultimatum Game offer and Minimum Acceptable Offer of the players.

[13] See Exadaktylos et al. (2013) for the whole survey protocol and details about the experimental decisions.

Euros and has to decide between keeping the whole amount for herself (i.e. not transferring anything to the second player; in which case the game ends and the second player gets nothing) and transferring the whole amount of money to the second player. In this case, the money is being quadrupled, and consequently the second player receives 40 Euros. The second player can keep all 40 Euros for himself, leaving Player 1 with zero payoff or giving back 22 to player one and keeping 18 for himself.

This game is designed in such a way that facilitates its application in survey-experimental settings (for an application see Ermisch et al. 2008). More importantly, it allows indentifying trust behavior in a rigorous way. While we use *TGoffer* as the binary trust decision in our analysis, *TGreturn* stands for the TG responder decision.

Our experimental protocol also includes a DG to measure unconditional generosity and an UG to measure one's ability to shake hands. Participants play for both roles in UG as well.[14] In their first decision they indicate a maximum amount that they can offer in UG as the first player and in the second a minimum acceptable offer (MAO hereafter) as the second player.

Agree, a generated index from UG decisions, is utilized to observe the individual ability to shake hands or to come to an agreement. It is the difference between the offered amount and minimum acceptable offer in UG. A large difference between those two, i.e. offering large amounts and accepting requesting very few refer a high ability to agree with other individuals.

$$\textbf{\textit{Agree}} = \textbf{\textit{UG}}_{\textbf{\textit{Offer}}} - \textbf{\textit{UG}}_{\textbf{\textit{MAO}}}$$

Beside experimental games, risk and time preferences elicitation, a cognitive ability test and survey questions on socio-demographics are also included in the protocol (See Appendix for the complete survey). Results are explored in the next section.

[14] See Camerer (2003, pp 43--117) for a review of DG, UG and TG.

3. Results

Starting from TG first we report the general results of each experiment. Then with regression analysis the relationship between TG decisions and the other variables will be investigated.

Allocation of TG decisions is given in Table 2. A large majority of the players (70.7%) choose to transfer the money in TG; where 71.2% reciprocated in return. However only 56.72% of the sample both send and return in the same time. 13.95% of the sample does not reciprocate but only cooperates as the first player. Likewise such a difference exists in second players' decisions. 14.47% of those who reciprocated do not send any amount as the first player. Another 14.86% of the sample has chosen "not send" when playing both first and second player.

Table 2: Allocation of TG Decisions

		TG Return		
		YES	**NO**	**TOTAL**
TG Offer	**YES**	439 (56.72%)	108 (13.95%)	558 (70.7%)
	NO	112 (14.47%)	115 (14.86%)	237 (29.3%)
	TOTAL	566 (71.2%)	229 (28.8%)	774 (100%)

Note: Values indicate the number of players; percentages of decisions in the whole sample are given in the parentheses

This duality in TG Offer confirms the existence of two different motives behind the first players' sending decisions. Group of players who both send and return in TG are pro-social while the players that send but not return are more likely to interpret the TG as an investment game. Behavioral underpinning of this divergence may be related with high generosity and higher ability to agree of pro-social players:

- Those, who send in TG but not reciprocate, are expected to be less generous, less prone to come in to an agreement easily. Also risk-taking may be related to first players' behavior.
- A similar interpretation may be valid for TG Return decisions. Since reciprocation is accepted as a norm[15] it would make sense to expect high level of generosity and ability to shake hands from reciprocators. Our analysis will be based on these hypotheses.

[15] See Gouldner (1960) for a sociological discussion on the norm of reciprocity

On average participants send *39.28%* (*S.D.= .216*) of their endowment in DG, where 128 participants keep all the endowment to themselves and 449 of them choose to share the pie evenly. Females send the *40.04%* (*S.D.= .206*) where men send *38.39%* (*S.D.=.226*) of their endowments. This difference is not significant test (Mann-Whitney Test, *z = 1.605, p=.108*).

Ultimatum game offers on average are *46.5%* (*S.D.= .150*) of the endowment. Participants return *70%* (*S.D.= .357*) of the amount as UG receivers. There is no gender effect observed neither in UG offers (*z=.216, p= .892*), nor in UG MAO (*z=.657 p=.511*).

Figure 2 shows the DG offers as a percentage of the endowment across four TG decisions. Wilcoxon Ranksum test confirms the difference between the DG offers of the players who both send and return in TG and of those who send but not return (*z= 6.927; p=.000*). It is also interesting to see that reciprocators who do not send as the first player transfer bigger amounts in DG than the players who send as first players but do not reciprocate. In other words, a comparison between the players who either only cooperate as first or the second player shows that, reciprocation is in a stronger relationship with unconditional generosity (*z=3.560; p=.001*).

A similar comparison is given in Figure 3 for *Agree*. Results are almost identical; players who cooperate in both roles have significantly higher *Agree* than those who only send as in the first role but do not return (*z=3.375; p= .001*). Players who just reciprocate but do not send as first player have a higher Agree than those who only send but not return (*z=2.313; p=.020*)

Figure 2: DG (%) across TG Decisions

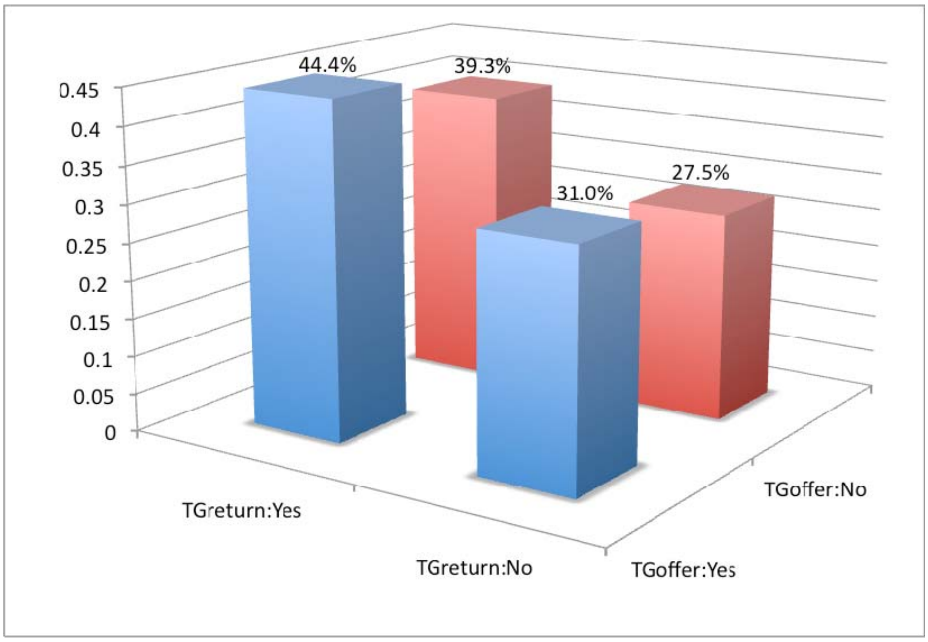
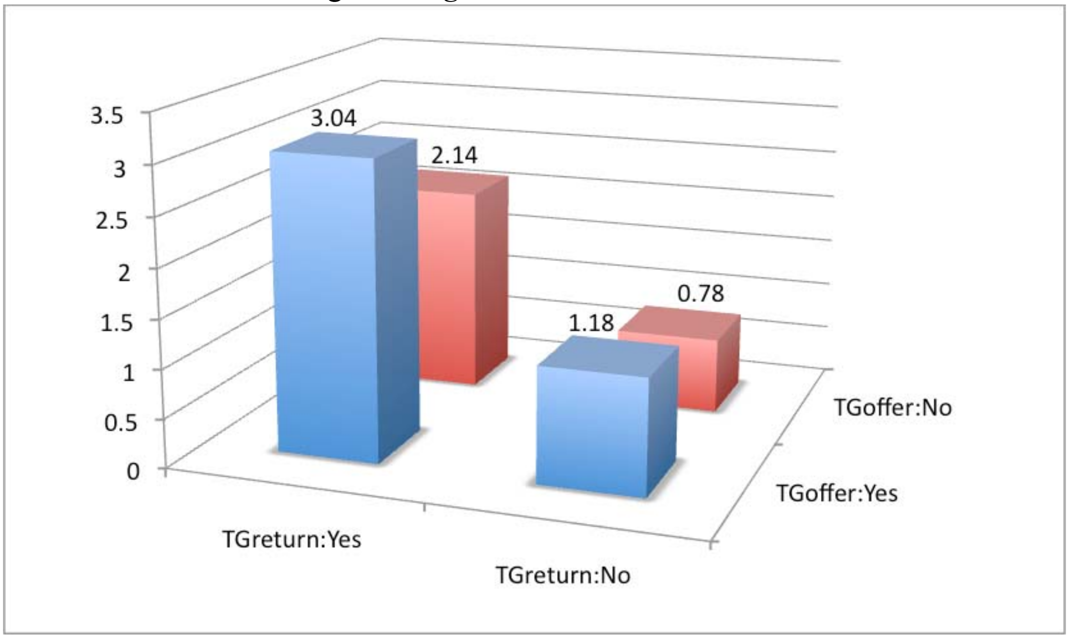


Figure 3: *Agree* across TG decisions



Regression analysis is shown at Table 3. Dependent variable is previously explained *TGoffer* (First player's decision in TG) in first three models and *TGreturn* (Second player's decision in TG) in models (3) to (6). Final dependent variable Tsocial=1 if the subject sends a positive amount in both roles and Tsocial=0 if the player sends only as the first player but does not reciprocate. Recall that both TGoffer and TGreturn are binary variables as well, which are *1* if the decision is to transfer a positive amount or *0* in the case that the player keeps the money. All of them are Probit Models where independent variables are *DG* as a percentage of the whole endowment, *Agree* (see above for the explanation), *risk* for the risk loving and *time* is the time preferences variable, which can be interpreted as the patience level of the player. *cognitive* stands for "cognitive ability" which is the total score of 5 basic cognitive ability questions, which can be found in the Appendix with all control variables. We control each regression for the effects of age, age^2, gender, being a student, education level and income.

The models on *TGoffer* confirm the significant positive effect of DG and *Agree* at $p \leq .01$ in the models (1) and (2). The effect of DG is stronger ($p=.000$) than *Agree* ($p=.085$) when both variables are included in the same model (Column 3). Risk-loving is also a determinant of sending in TG. Risk takers send positive amounts in TG (p=.077 in model (1), p=.30 in (2) and $p=.071$ in (3)).

DG and Agree have even stronger positive effects on *TGreturn* though. In all models they are highly significant ($p \leq .01$), even when they are regressed together. Risk variable is not significant in none of the models. An interesting finding is the strong positive effect of *cognitive* variable in all models concerning *TGreturn* ($p \leq .01$ in all cases).

The results concerning *DG* and *Agree* are still alike in the last three models. Individuals who send positive amounts in both roles also send more in *DG* and they have higher *Agree* rates ($p \leq .01$ in all three models). Variables of *risk* and *cognitive* lose their significance but only in 9th model *cognitive* is significant at $p=.094$.

Table 3: Regression Table of TG behavior

	TGoffer			TGreturn			Tsocial		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DG	1.069 (.000)		.939 (.000)	1.712 (.000)		1.503 (.000)	1.93 (.000)		1.75 (.000)
Agree		.033 (.011)	.022 (.085)		.056 (.000)	.039 (.001)		.062 (.001)	.047 (.013)
risk	.137 (.077)	.169 (.030)	.144 (.071)	-.114 (.120)	-.054 (.441)	-.102 (.162)	-.137 (.168)	-.083 (.366)	-.129 (.190)
time	-.001 (.992)	.001 (.953)	.002 (.894)	.011 (.571)	.015 (.432)	.016 (.408)	-.012 (.605)	.003 (.890)	-.004 (.843)
cog	.017 (.686)	.024 (.548)	.015 (.702)	.105 (.017)	.114 (.006)	.114 (.009)	.099 (.122)	.100 (.102)	.106 (.094)
cons	-.567 (.175)	.058 (.899)	-.612 (.139)	-.854 (.078)	-.484 (.411)	-.933 (.057)	-.072 (.915)	.299 (.654)	-.084 (.906)
R^2	.043	.031	.048	.124	.097	.136	.153	.120	.166
N	774	774	774	774	774	774	547	547	547

Note: All are Probit models. Dependent variables are *TGoffer* for the models (1), (2) and (3); *TGreturn* for the models (4), (5) and (6) and Tsocial for the models (7), (8) and (9). Independent variables are *DG* as percentage of the endowment, *Agree*, risk loving, time preferences and cognitive ability. Control variables are gender, age, age squared, income, being a student and education level. All models are controlled for order effects and clustered by interviewers (108 groups for models (1) to (6) and 107 groups for models (7), (8) and (9)). *p-values* are given in the brackets.

4. Conclusion

The reason behind transferring a positive amount as the first player in TG is still vague and it has still been discussed for almost two decades. It may be due to an expectation from the other party as Gneezy et al (2000) suggest, or it may be an act of altruism (Ashraf et al 2006). In this paper we disentangle two motives behind first players' decisions as pro-social and opportunistic. Allowing subjects to play both roles in a binary Trust Game, and focusing on those who *do* chose to trust, we identify two different groups: those who both trust and reciprocate and those who trust but do not reciprocate. We suggest that the first group is motivated by pro-social concerns, displaying higher levels of unconditional generosity and ability to shake hands than the second group, which we claim are motivated in contrast by opportunistic concerns.

Our results confirm such reasoning. The people who send a positive amount both as the first and the second player in TG have sent more in DG and also have higher levels of *Agree* than the ones who only send as the first player. This may be an indicator of interpreting TG as an Investment Game and therefore making offers in such a way to maximize the earnings from the game.

In the case of the second players, results verify the fact that reciprocity has a closer relationship with norm obedience (Bicchieri et al. 2011) than trust. Players who reciprocate also send higher amounts in DG and show higher levels of *Agree* than those who do not reciprocate. An interesting result that is open for discussion is the one on cognitive abilities. It has a strong positive correlation with reciprocation.

Interpersonal trust may be due to pro-social behavior or pro-selfish behavior. In either case we do *not* claim that one of those motives should hold a more central place in explaining trust *behavior*. It should, however, be noted that mixing the two motives can lead to false conclusions about the true effect of trust and also its role on the SC literature. It is crucial for experimentalists who use TG to consider this heterogeneity in their research on trust and SC. This awareness may lead to better interpretations of results in TG experiments, which consequently would create a higher and more reliable knowledge on the underpinnings of economic and pro-social behavior of individuals.

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Resumenes de los Trabajos en Castellano

Capitulo 1

Second-to-Fourth Digit Ratio Has a Non-Monotonic Impact on Altruism

La teoría de “gene-culture co-evolution” destaca el papel conjunto de la cultura y los genes en la aparición de comportamientos altruistas y cooperativos, y la genética del comportamiento proporciona estimaciones de su importancia relativa. Estos teorías, sin embargo, no pueden determinar qué características biológicas determinan el altruismo o cómo lo hacen. Nosotros analizamos la relación que existe entre el altruismo en adultos y la exposición prenatal a las hormonas sexuales, utilizando el ratio digital (entre el dedo índice y el anular). Encontramos una relación en forma de U invertida para las manos izquierda y derecha, que es muy consistente para los hombres y menos sistemática para las mujeres. Los sujetos con ratios digitales tanto altos como bajos son menos generosos que los individuos con ratios digitales intermedios. Repetimos el ejercicio con los mismos sujetos siete meses más tarde y encontramos una relación similar, a pesar de que su comportamiento difiere con respecto a la primera vez que estos sujetos jugaron el juego. A continuación, construimos proxies del ratio digital mediano de la población (utilizando más de 1.000 sujetos diferentes) y mostramos que el altruismo de los sujetos disminuye con la distancia del ratio con estos proxies. Estos resultados proporcionan evidencia directa de que los acontecimientos prenatales contribuyen a la variación de comportamiento altruista y que la exposición a las hormonas fetales es un factor biológico relevante. Además, los resultados sugieren que podría existir un nivel óptimo de exposición a estas hormonas desde el punto de vista social.

Capitulo 2

Heterogeneous Returns in Public Good Games

En este artículo investigamos como afecta la composición del grupo en un juego de bienes públicos donde los niveles de rendimientos marginales per capita de los jugadores difieren. Nos centramos únicamente en los rendimientos sin que haya posibilidad de sanción y comparamos grupos formados de maneras diversas donde la estrategia dominante de todos los agentes es no contribuir (free-riding). Primero, comparamos grupos homogéneos, es decir, grupos formados por individuos con el mismo rendimiento marginal per cápita, con otros grupos homogéneos que tienen un rendimiento diferente. Nuestros resultados sugieren que existe un efecto positivo del nivel de rendimiento marginal per cápita del grupo sobre las contribuciones en estos grupos. Este efecto es más fuerte cuanto mayor es la la diferencia entre los niveles de rendimiento marginal. A continuación, analizamos las contribuciones de los individuos dentro de un mismo grupo cuando éste es heterogéneo, es decir, cuando está formado por agentes con distinto rendimiento marginal per cápita. En este caso observamos que los jugadores con un nivel alto de rendimiento contribuyen más que los jugadores con rendimiento bajo, incluso si la diferencia entre los dos niveles de rendimiento comparados es pequeña. También observamos cuando comparamos grupos heterogéneos entre si que, a diferencia de lo que ocurría al comparar grupos homogéneos, no hay diferencia en las contribuciones totales del grupo.

Capitulo 3

Heterogeneous Motives in Trust Game

En este trabajo analizamos experimentalmente si existe una motivación heterogénea detrás del comportamiento de confianza observado. Utilizamos un Juego de Confianza binario para diferenciar los motivos que hay detrás de las decisiones del Juego de Confianza e investigamos los fundamentos conductuales y socio-demográficos de estas decisiones. Para este propósito nuestro estudio también incluye un Juego del Dictador, un Juego del Ultimátum, la obtención de preferencias sobre el riesgo y el tiempo y preguntas de habilidad cognitiva además de una escuesta sobre cuestiones socio-demográficas. Los resultados sugieren que hay dos grupos de jugadores que difieren en sus motivaciones. En el primer grupo, los agentes eligen tanto enviar como devolver una cantidad positiva. Nos referimos a este grupo como pro-social. Los sujetos en el segundo grupo transfieren una parte de su dotación al segundo jugador pero eligen quedarse el dinero cuando juegan como segundo jugador. Por lo tanto, su motivación dentrás de enviar una cantidad positive podría deberse a razones oportunistas. Estas observaciones son también reforzadas por los resultados obtenidos en el Juego del Dictador y del Ultimatum. Los jugadores por-sociales envían más en el Juego del Dictador y llegan a un acuerdo de manera más fácil en el Juego del Ultimatum. Además, las actitudes ante el riesgo y las capacidades cognitivas también están conectadas con las decisiones de los jugadores en el juego. Estos resultados llaman a la prudencia de los experimentadores que utilizan el Juego de Confianza en sus estudios para tener en cuenta esta dualidad en la motivación de las decisiones de los sujetos.

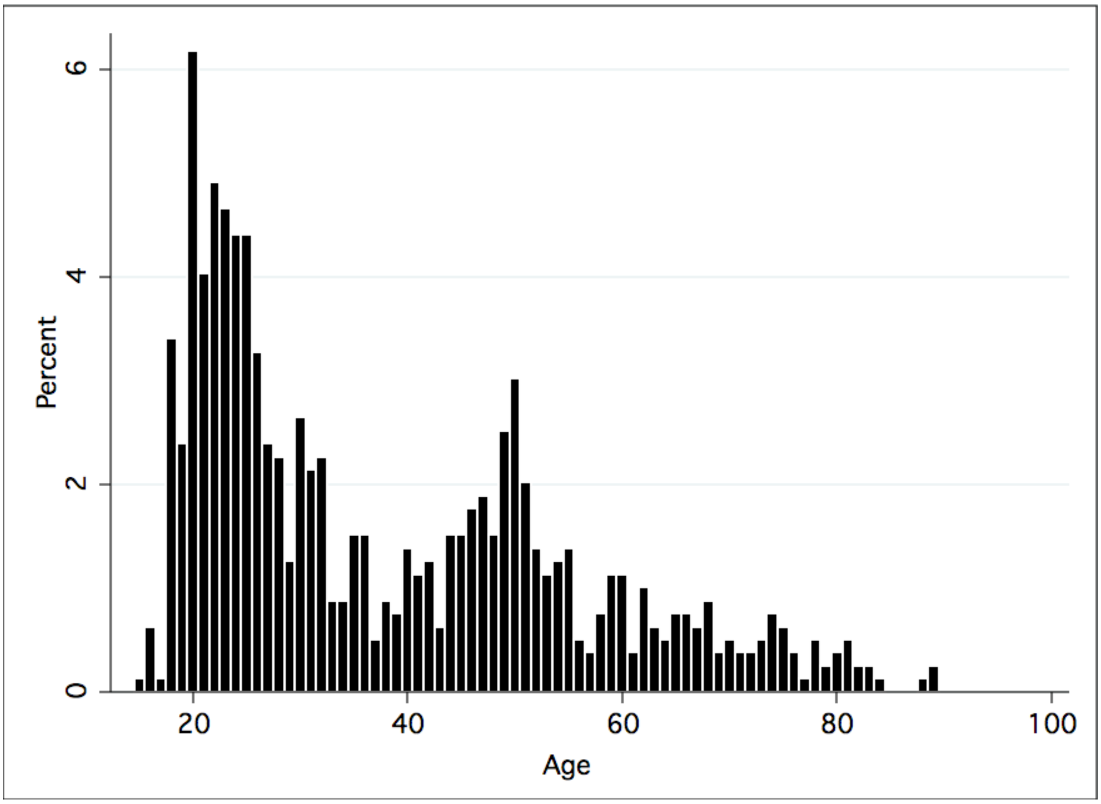
APPENDICES

Appendix of Chapter 4

Table A1: Information gathered in each section of the experiment.

Part	*Information gathered*	*Number of items*
1	Age, gender, religion, education, marital and labor status, income	30
2	Reciprocity, generosity, distributional preferences, social capital (I), self-esteem, trustworthiness	30
3	General and relative life satisfaction	2
4	Competitive and sanctioning behavior, social capital (II), crime victimization, Personal strengths and weaknesses	13
5	Trust in known and unknown others, trust in social and public institutions	13
6	General trust, social capital (III)	4
7	Cognitive abilities, risk and time preferences (hypothetical)	21
8	Experimental games (DG, UG p/r & TG s/r)	5
9	Height, weight, digit ratio, phone number, participation in future studies	9

Figure A1: Age Distribution of the Sample



Control variables

AGE Є [16, 91]: continuous variable

GENDER: binary variable, 1=male

EDUCATION Є [0, 17]: years of schooling. Categories: no studies (0), incomplete primary school (3), complete primary school (6), incomplete secondary school (8), complete secondary school (10), incomplete university diploma or technical degree (14), complete university diploma or technical degree (15), incomplete bachelor or postgraduate degree (15), complete bachelor or postgraduate degree (17).

HOUSEHOLD INCOME ∈ [0, 4500]: average household monthly income in the last year (in Euros). Categories: €0 (0), €500 (1), €1.000 (2), €1.500 (3), €2.000 (4), €2.500 (5), €3.000 (6), €3.500 (7), €4.000 (8), more than €4.000 (9).

RISK PREFERENCES ∈ [0, 3]: sum of "risk-loving" answers on the three following questions (b, a, Y on questions 1, 2 and 3 respectively):

1. We flip a coin. Choose one of the following options:
a. Take 1.000 Euros no matter if it is heads or tails.
b. Take 2.000 Euros if it is heads and nothing if it is tails.

2. Choose one of the following options:
a. Take a lottery ticket with 80% chance of winning 45 Euros and 20% chance of winning nothing
b. Take 30 Euros

3. Would you accept the following deal? We flip a coin. If it is heads you win 1,500 Euros and if it is tails you lose 1,000 Euros:
Yes (Y),
No (N)

TIME PREFERENCES ∈ [0, 11]: proxy for time discounting, given by the total number of impatient choices in the discounting tasks for the short-term and for the long-term with front-end delay. Each task is described below:

Part 1 "Short-term": Choose one of the two options in each line,
1. Receive €5 today or receive €5 tomorrow (Td or T)
2. Receive €5 today or receive €6 tomorrow (Td or T)
3. Receive €5 today or receive €7 tomorrow (Td or T)
4. Receive €5 today or receive €8 tomorrow (Td or T)
5. Receive €5 today or receive €9 tomorrow (Td or T)
6. Receive €5 today or receive €10 tomorrow (Td or T)

Part 2 “Long-term”: Choose one of the two options in each line,

1. Receive €150 in a month or receive €150 in 7 m. (1 or 7)
2. Receive €150 in a month or receive €170 in 7 m. (1 or 7)
3. Receive €150 in a month or receive €190 in 7 m. (1 or 7)
4. Receive €150 in a month or receive €210 in 7 m. (1 or 7)
5. Receive €150 in a month or receive €230 in 7 m. (1 or 7)
6. Receive €150 in a month or receive €250 in 7 m. (1 or 7)

COGNITIVE ABILITIES € [0, 5]: number of correct answers to the following five questions:

1. If the probability of being infected by an illness is 10%, how many persons of a group of 1000 would be infected by that kind of illness?
(N if s/he cannot /do not want to answer).

2. If there are 5 persons that own the winning lottery ticket and the prize to be shared is two million Euros, how much money would each person receive?

3. Suppose that you have €100 in a savings account and the rate of interest that you earn from the savings is 2% per year. If you keep the money in the account for 5 years, how much money would you have at the end of these 5 years?:

a. More than €102
b. €102 exactly
c. Less than €102
d. S/he cannot/do not want to answer

4. Suppose that you have €100 in a savings account. The account accumulates a 10% rate of interest per year. How much money would you have in your account after two years?

5. The total cost of a bat and a ball is 1.10 Euros. The bat costs 1 Euro more than the ball. How many cents does the ball cost?