Intergenerational cooperation within the household: A Public Good game with three generations*

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Abstract

We analyze cooperation of individuals in a family context, using a Public Good game. In a lab experiment, 165 individuals from 55 three-generation families (youth, parent, and grandparent) play a repeated Public Good game in three different treatments: one in which three members of the same family play each other (family), a second with the youth and two non-family members, while preserving the previous generational structure (inter-generational), and a third in which three randomly-selected players play each other (random). We find that all the age groups cooperate more when playing with relatives, indicating that family ties may have a positive relationship to contributions to the Public Good. We also find that this trend is more evident for the youths and the parents than for the grandparents. Furthermore, young individuals tend to cooperate less than older generations, especially in non-family treatments. Our results serve as evidence of the relationship between family ties and inter-generational cooperative behaviors.

Keywords: Intergenerational cooperation, Public Good game, Evolutionary game theory, Kinship, Social networks
JEL Codes: D03, D64, D70

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*We are grateful to the IBERCIVIS Foundation for organizing volunteer recruitment. This paper has benefited from funding by the Spanish Ministry of Economics (Project ECO2012-34828), the EU FET Proactive Project Dolfins (Grant 640772) and FET Open Project IBSEN (Grant 662725). This paper was partially designed while Jose Alberto Molina was Visiting Fellow at the Department of Economics of Boston College (US), to which he would like to express his thanks for the hospitality and facilities provided.

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1. Introduction

We analyze the cooperative behavior of individuals in a Public Good game, with a focus on how the relationships among different generations of same-family members (e.g., family ties among youth, parent, and grandparent) are related to their cooperation. The cooperation of individuals has been widely analyzed in different fields. The analysis of cooperation by experimental science has a reference milestone in Nowak and May (1992), who developed the *Prisoner's Dilemma* (PD) to prove the survival of the cooperative agent in a network, and since then different versions of the PD have been used to analyze cooperative behaviors. Public Good games, in which individuals secretly choose how many of their private tokens to put into a public pot, have also been used to analyze the cooperative behavior of individuals, finding that individuals contribute more to the Public Good than expected, with observed cooperation declining over time (see, for a survey, Chaudhuri, 2011).

Among the mechanisms that may help to explain cooperation among individuals, Becker (1962, 1974) established the generosity criterion guiding cooperation or transfer of resources from donor to recipient, with this approach contrasting with alternative hypotheses (Cox, 1987), under which donors expect some sort of reciprocity from the receivers in a cooperative context. Furthermore, family relationships (or family ties) may also help to explain cooperation among individuals, so that those who share genes have a cooperative behavior motivated by generosity. This reasoning has been mathematically formalized through Hamilton's rule (Hamilton, 1964), according to which cooperation between two individuals will take place if the benefit obtained, corrected by the kinship relationship between these individuals, exceeds the cost of giving or helping. This concept has been tried and tested empirically in the literature (West et al. 2001; Oli, 2003; Peters et al., 2004; Waibel, Floreando and Keller, 2011).

Prior research has specifically analyzed how cooperative behavior changes with age and/or across generations; for example, experimental research has shown that younger children are less altruistic (Peters et al., 2004; Fehr, Bernhard and Rockenbach, 2008; Fehr, Rützler and Sutter, 2011). Charness and Villeval (2009) and Gutiérrez-Roig et al. (2014) have included subjects of different ages who were involved in the same experimental set-up, to test cooperativeness differences across generations, with their main findings being that the elderly are more cooperative. In both studies, individuals of different ages play within the same generation, and while the repeated PD has been used extensively in experiments with adults (Blake et al., 2015), PD experiments with children remain rare, with some few exceptions that include Blake et al. (2015) and Molina et al. (2013).

Prior research has also analyzed cooperation in families.[1]A trust game played by couples and strangers is shown in Görges (2015), finding that women are more likely to cooperate (e.g., give up their income autonomy and perform the unpaid task) when playing with a partner rather than with an unfamiliar man. Beblo and Beninger (2017) test in-couple income pooling in Germany, and find that income pooling, and thus cooperation, is more common among couples in which the spouses' socio-economic characteristics are more similar. Cochard, Couprie and Hopfensitz (2017) test for a willingness to cooperate and share income by men and women who are either in couple with each other or complete strangers, finding that lack of preferences for joint income maximization, having children, and being married lead to higher defection rates in the social dilemma. Dauphin, Fortin and Lacroix (2017) test the collective rationality (e.g., consumption efficiency) within households in Burkina Faso, using monogamous and polygamous households. They find that while the collective rationality within monogamous households is not rejected, it is rejected in polygamous households. Consumption efficiency is based on Pareto efficiency, where the individuals within the household cooperate, and thus this evidence serves as evidence that households are not as cooperative as previously hypothesized.

The issues of family, age/generation, and cooperation have all been studied by Peters et al. (2004), Reynolds (2005) and Porter and Adams (2016). Peters et al. (2004) place parents and children in a laboratory to participate in a Public Good game, where subjects are endowed with an initial income and must choose how to allocate that income between private and group accounts. The study finds that parents may behave more altruistically than do their children in a family setting, and that parents and children contribute more to a Public Goodwhen grouped with family members than when grouped with strangers. Reynolds (2015) applies two games to test for Pareto efficiency and bargaining in a sample of adolescent women who live with their mothers in Brazil, and the results confirm a cooperative relationship. Porter and Adams (2016) study the motivations behind transfers between two generations (adult children and their parents) in an experimental setting, with results indicating that a greater proclivity for

[1]Munro (2015) offers a review of the literature on this issue, along with certain methodological observations.

giving appears when parents, rather than strangers, are the recipients of transfers while playing a series of dictator games.

Against this background, we contribute to the literature on the factors affecting the cooperative behavior of individuals, by focusing on the relationship between family ties, age/generation, and cooperation. In particular, we focus on how family ties are related to cooperation, and also on whether older generations cooperate more than younger ones. To that end, in an experimental setting, three generations of individuals from the same family (youth, parent, and grandparent) play a repeated Public Good game in three different treatments: one in which three members of the same family play each other (family), a second with the youth and two non-family members, but preserving the previous generational structure (intergenerational), and a third in which three randomly-selected individuals play each other (random).

Several conclusions can be drawn from our experiment. We find that the level of cooperation of the youths is significantly lower than that of the parents and the grandparents, consistent with prior literature showing that young people are less cooperative (Peters et al., 2004; Charness and Villeval, 2009; Gutiérrez-Roig et al., 2014). Furthermore, in comparison with a setting where players are randomly assigned to a group, family ties have a positive relationship to the contributions to the Public Good, with this effect being greater for the youths than for the parents and the grandparents. Also, youths and parents contribute more to the Public Good when the group has a generational structure, while grandparents are not affected in this behavior. This evidence indicates that the behavior of parents and grandparents is not greatly affected by the treatment, while youths contribute significantly less when not playing with their own family members. Finally, the differences in the contribution by youths, on the one hand, and parents and grandparents, on the other, are larger when playing with randomly-assigned players.

The results shown are interesting, and represent an important contribution to the literature. Despite that we cannot know the mechanisms behind the differential behavior of youths in comparison to parents and grandparents, we can hypothesize several possible explanations: an age effect (i.e., older individuals may have more income, increasing their level of generosity), a cohort effect (i.e., individuals become less generous towards strangers) or a selection effect (i.e., those who become parents are more generous). Furthermore, family ties may have a positive effect on the cooperation of individuals, which may serve as a mechanism to stabilize cooperation in different settings. The evidence presented here opens interesting lines of research.

The rest of the paper is organized as follows. Section 2 describes the intergenerational Public Good game. Section 3 presents the lab-in-the-field results. Section 4 shows the empirical strategy and the estimation of results, and Section 5 sets out our main conclusions.

2. Experimental design and implementation

2.1. Design

Our design involves observing individuals participating in a repeated Public Good game, where each volunteer participates in three different 3-player games, corresponding to three different treatments: (a) one in which three members of the same family (youth, parent, and grandparent) play each other (family treatment, F); (b) a second with three non-related members (strangers) but preserving the generational structure with one youth, a parent, and a grandparent (intergenerational treatment, IG); and (c) a third in which three randomly-selected players are assigned and play each other (random treatment, R).[2] The number of rounds (decision periods) is set at 10 for each treatment, although this is not known a priori by the players. To account for the possibility of order effects, volunteers are assigned to 2 different groups, by arrival order, and the first group (n=34 families) play treatments in the order F-IG-R, while the second group (n=21 families) play treatments in the opposite order, R-IG-F. Arrival order is completely random, as all families are called at the same time.

As argued by Peters et al. (2004), to ensure that behaviors when playing with strangers and with their families are comparable, each participant's group in the strangers' treatment must have the same composition as the participant's family treatment, and thus the only difference between treatments F and IG is that members of the same group are not from the same family as in treatment IG. Furthermore, treatment

[2] In the IG treatment, we impose the restriction that none of the players are from the same family, which assures that individuals playing in the IG treatment are different from individuals playing in the F treatment. However, in the R treatment, we do not impose any restriction on the players, and it could be that players from the same families could be matched in the same group. The probability that in the R treatment all the players were from different families was very low (e^(-3)=5%), and thus in 10 groups two members of the same household were matched to play the game. No groups have all three members from the same household. Despite that there were several groups with players from the same households, we cannot hypothesize that family ties were influencing the behavior of players, as the game was completely anonymous and players did not know with whom they were playing.

R eliminates the effects related to matching so that it constitutes a null-model in which there are neither kinship nor (inter)generational influences. This allows us to compare non-random treatments F and IG, in which there can be family and intergenerational effects, with the null-model treatment R that provides a baseline. This comparison provides a method to evaluate respectively the influence of kinship and generation on cooperative behavior. Although there is no consensus on the merit of random treatments in Public Good game experiments (Andreoni and Croson, 2008), many experimental studies of cooperation show that non-random treatments exhibit a much higher level of cooperation than randomized treatments (see Duffi and Ochs, 2009).

In each round of each treatment (3 treatments x 10 rounds=30 rounds), participants are endowed with 10 monetary units (ECUs), and their decision problem is how to allocate this amount between a private account and a group account. For each round, the sum of the contributions made by all 3 players is calculated, and the total contribution is multiplied by a factor of 1.5 and then shared equally by the 3 players. The obtained payoff in each round is the sum of this share plus the ECUs held back, i.e. not invested in the common fund. In each round, players are informed about how many units the other two players in the same group have contributed to the Public Good in the previous round (except in the first round of each treatment).

2.2. Recruitment

Fifty-five families participated in the experiment, accounting for 165 volunteers: 55 volunteers aged between 17 and 19 years old, plus one of their parents and one of their grandparents. For the recruitment, different channels were used to advertise the experiment, including advertisements in the principal newspapers of the region (Heraldo de Aragón, El periódico de Aragón), ads in the city council, the University of Zaragoza, and regional government web pages, and posters sent to local high schools. The Ibercivis Foundation was in charge of the diffusion of the experiment, with the aim of recruiting individuals from the general population of the city of Zaragoza (Spain). The selection process consisted of attracting sets of three volunteers of different generations of the same family, by filling-in an on-line form. Applications were open to any set of three relatives meeting the above conditions, regardless of their social status or other demographic variables. Thus, the entire population of Zaragoza was open to participation in the experiment, not only young students (which is important in our framework, since students may have participated in economics experiments before, or have had some training in economics). Furthermore, the type of game was only known by the volunteers after arriving at the lab, and the aim of the experiment was never revealed to the volunteers. Unfortunately, we do not have information on whether or not the young volunteers were students, but we have reason to believe that the lower contribution rates among youths relative to parents and grandparents (as shown above) is not due to previous experience with Public Good games and/or their studies in economics.

One third (33%) of the players are male, and the average age is 48.09 years. By group of players, 35%, 38%, and 27% of youths, parents, and grandparents are male, with an average age of 17.44, 50.62, and 76.22, respectively. Furthermore, 38% of the players were assigned to the second session. As a fundamental ethics statement, the anonymity of all participants in the experiments reported was always preserved (in accordance with the Spanish Law on Personal Data Protection) by assigning them, randomly, a username that would identify them in the system. No association was ever made between their real names and the results. As is standard in socio-economic experiments, no ethical concerns are involved, other than preserving the anonymity of participants.

2.3. Implementation

We ran 3 treatments in each of the 2 sessions. All sessions were conducted using a local area network of the Institute for Biocomputation and Physics of Complex Systems at the University of Zaragoza, where a total of 102 computers were available for the experiment. The experiments were performed on a web-based platform, and results were gathered in a database for further analysis. Individuals could not interact during the experiment, and non-personal data only was collected. Before the first treatment of each session, detailed instructions were read aloud and shown on the screens, that participants had to read and accept before beginning the experiment. After reading the instructions, participants had one game to get acquainted with the computer program.[3] At the end of the experiment, each player received the sum of the payoffs corresponding

[3] In each round, each player had up to 20 seconds to choose how much to contribute to the pool. After 20 seconds, the system randomly chose for them, but then the players could continue to choose without problems in the following rounds. Up to 4,950 total contributions made during the experiment, and 141 (2.85%) contributions were done by the system, which represents a low percentage and does not bias our main results.

to all rounds of the three treatments in which he/she participated, converted into Euros with a factor set by the research team to adjust to the available budget (1,720€). Typical earnings ranged from 8 to 12 euros, including a 5-euro attendance fee per person.[4] The typical duration of a session was around 20 minutes.

3. Lab-in-the field results

Figure 1 shows, by round number and generation, the mean contribution when individuals play in the different treatments. We also show confidence intervals of the contributions at the 95% confidence level. Panel A shows results when individuals play in the F treatment. We do not observe between-group differences in contributions to the Public Good when individuals play in the F treatment, as confidence intervals intersect in most rounds. Panel B shows the average contributions when individuals play in the IG treatment. In this case, we do not find statistically significant differences (e.g., confidence intervals do intersect) in the contributions parents and grandparents make during this treatment, and the same applies when parents and grandparents play in the R treatment (Panel C). But youths make relatively lower contributions to the Public Good in comparison to parents/grandparents when they play in both the IG and F treatments. In the IG treatment, youths make lower contributions in comparison to grandparents in rounds 4, 6, 8 and 9, and in comparison to parents in rounds 4 and 5. Furthermore, in the R treatment, youths make lower contributions in comparison to grandparents and parents in rounds 4, 5, 6, 8, 9 and 10. Thus, while we do not find inter-generational differences in contributions during the F treatments, youths make lower contributions to the Public Good in both the IG and R treatment.[5]

(Figure 1 about here)

Figure 2 shows, for each generation and round number, the mean contribution of players according to the treatment. Panel A shows the average contribution of youths in

[4] The amount given to the volunteers may seem low in comparison to Peters et al. (2004), although it is not low in comparison with other experiments (Gutierrez-Roig et al., 2014; Poncela-Casasnovas et al., 2016). In fact, the payment/hour is quite high, as the sessions lasted around 20 minutes (10€ for 20 minutes= 30€ per hour). In any case, the amount of the attendance fee was not described during the process of recruitment, and volunteers knew the total amount assigned to them only at the end of the experiment. Furthermore, during the recruitment process it was announced that a tablet would be raffled among all the volunteers at the end of the experiment. Also, snacks were offered after (first session) and before (second session) each session.

[5] Panel A of Table B1 in the Appendix shows the average contributions of players, by generation. The average contributions of youths, parents, and grandparents are 5.05, 6.21 and 5.95, with the differences in the average contributions across the 3 generations being statistically significant at the 99% confidence level.

the three treatments, Panel B the average contribution of parents in the three treatments, and Panel C the average contribution of grandparents in the three treatments. We also show confidence intervals of the contributions at the 95% confidence level. We observe that, for the three generations, the contribution made by the players in the F treatment is comparatively higher than the contribution made in the IG and R treatments, for all rounds. In the case of youths, the confidence intervals of the F treatment do not intersect with the confidence intervals of the IG and R treatments in rounds 2 to 5 and 7 to 10, in rounds 7 and 10 for parents, and in round 5 for grandparents. Thus, we can assume that the contributions to the Public Good made during the F treatment are higher than in the IG and R treatments, especially in the case of youths, where differences are larger, and in higher numbers of rounds.[6]

(Figure 2 about here)

Several conclusions can be drawn from this analysis. First, we observe that parents and grandparents contribute more to the group account (Figure 1), although differences across generations disappear when the individuals play in the F treatment (Figure 1). Youths tend to cooperate less than the other generations when they play in the IG and R treatments. We also observe that the level of cooperation is higher when individuals play in the F treatment for the three generations than when playing in the IG and R treatments, a difference that is especially large for the group of youths (Figure 2).[7] We interpret this result as evidence that family ties are positively related to cooperation. Third, from Figure 2, we observe that in the absence of family ties, inter-generational interactions do not change cooperative behavior, as the level of cooperation in the IG and R treatments is similar for the three generations.

When we analyze the intra-personal (within) variation in contributions by treatment, we observe that the variation in contributions is lower in the F treatment, in comparison with the IG and R treatments. For youths, parents, and grandparents, the variation in contributions during the F treatment is 2.14, 1.55 and 2.03, respectively. For the IG treatment, the variations are 2.32, 1.78 and 2.06, respectively, and for the R

[6] Panel B of Table B1 in the Appendix shows average contributions of players, by treatment. The average contributions in the F, IG and R treatments are 6.77, 5.27 and 5.17, with the differences in the average contributions across the 3 treatments being statistically significant at the 99% confidence level.

[7] The results do not differ significantly between the IG and R treatments, but this is not at all surprising. The second group includes the youth and two non-family members, and there is a 1 in 55 chance that a youth will have a parent and a 1 in 55 chance of having a grandparent within the same game (1/55*55 chance of having both of them in the same play). These probabilities are very low, which may explain why the average contributions in the two treatments are similar.

treatment the variations are 2.27, 1.69 and 2.06, respectively. Thus, this variation in contributions is lower in the F treatment, which may indicate that family ties serve as a mechanism to stabilize the cooperation of individuals. Parents and grandparents appear to react less to the game setting, as their intra-personal variation is lower in all the treatments. The intra-personal variations of youths, considering the three treatments together, is 2.75, much higher than the variations of parents (2.21) and grandparents (2.30), indicating that youths vary their behavior more, in comparison to parents and grandparents.

When we focus on the evolution of the contributions made by the players over rounds, prior research on voluntary contribution games has found that cooperation (contributions) decreases over time (Andreoni, 1988; Isaac and Walker, 1988; Palfrey and Prisbrey, 1996; Fischbacher, Gächter and Fehr, 2001;Andreoni and Croson, 2008; Muller et al., 2008; Fischbacher and Gätcher, 2010). One possible explanation for this behavior is that strategies depend on the history of play and therefore may cause players to change their actions over the course of the game. Another is that participants slowly begin to better understand the game and refine their strategies accordingly.

To determine whether cooperation decreases over time in our experiment, we first compute the correlation between contributions and the number of rounds, for each generation and treatment. For the group of youths, the correlation between the contribution and round number is -0.09 for the R treatment, while for the F and IG treatments the correlations are not statistically significant at the 95% confidence level. For the group of parents, the correlation between the contribution and round number is -0.10 for the IG treatment, while for the F and R treatments the correlations are not statistically significant at the 95% confidence level. For the group of grandparents, there are no statistically significant correlations at standard levels in any of the treatments. Thus, it seems that the level of cooperation remains relatively constant over time.

One specific mechanism that appears to explain the cooperation of individuals is that of conditional cooperation (Fischbacher, Gächter and Fehr, 2001; Fischbacher and Gächter, 2010). According to this mechanism, many individuals' propensity to cooperate is dependent on others' cooperative behavior, and is considered a consequence of certain fairness preferences, such as altruism, commitment, reciprocity (Croson, 2007) or warm-glow (Andreoni, 1990; Crumpler and Grossman, 2008). Thus, the (moody) "conditional cooperation" assumption implies that individual cooperation is a function of their own history of play and the average cooperation level of their neighbors (Gracia-Lázaro et al, 2012; Grujic et al., 2014). To test this hypothesis, we analyze whether players react to the contributions they observed in the previous round, by assuming that players have a one-step memory. In doing so, we examine the variation of contributions (i.e., the change in individual contributions) as a function of the difference between the own and partners' average past contributions.

Figure 3 plots the change in player's contributions (y-axis), as a function of the difference between the own contribution and other players' contributions in the previous round (x-axis).The change in contribution is measured as the difference between the player's contribution and the contribution in the previous round, with a positive value indicating an increase in the contribution in comparison to the previous round. The difference between own and other players' contributions in the previous round considers both the own and other players' average contributions, with negative values indicating that, on average, other players contributed more to the Public Good in the previous round than the player under consideration.[8] By generation and treatment, we average for all the cases with the same difference (e.g., -1) between own and other player's contributions, the change in the contribution.[9] We observe in all cases a very strong positive dependence of the contribution increment on the difference between own and partners' last action, for all the generations and treatments, as the linear fits have positive slopes. Thus, we observe that the contribution to the common good is strongly conditioned by both the player's previous action and the last observed contributions.

(Figure 3 about here)

4.Empirical strategy and results

We estimate models that take into account the unobserved heterogeneity of individuals, since there may be certain unobserved factors at the individual level that are correlated with the level of contribution, which would bias the results. For instance, past personal

[8]In order to measure within-group differences in the previous round, there is no obvious choice for a measure to compare individual contributions relative to the other players' contributions. Despite that we select the average contributions of the other players, this measure does not differentiate the situations when the other two members have behaved very differently. Alternative measures could be the maximum or minimum of the other players' contributions.

[9] We include proportional weights such that the size of the dot in the figure reflects the proportion of contributions included in it. We have added a linear fit to determine the extent to which scatters are distributed following a linear relationship.

experience, the mood on the day of the experiment, or personal attitudes towards justice, equity, and confidence, all may condition the decisions of individuals in our experiment. Thus, we estimate a random-effects (RE) linear model to control for the unobserved heterogeneity of individuals, using the following equation:[10]

$$C_{ij} = \alpha_i + \beta_1 F_i + \beta_2 IG_i + \beta_3 Parent_i + \beta_4 Grandparent_i + \delta X_i + \varepsilon_{ij} \quad (1)$$

where C_{ij} represents the decision (contribution) by individual "i" in round "j", and α_i represents the individual effect. The dependent variable is a variable that measures the amount given by individual "i" in round "j" to the common fund. We include two dummy variables to indicate whether player "i" is playing in the F treatment or the IG treatment, and thus the reference group is players in the R treatment. According to our hypothesis (that family ties are positively related to the level of contributions), we should obtain that $\beta_1 > 0$. We include two dummy variables to indicate whether the player belongs to the group of grandparents or parents (ref.: youths). The vector X_i includes the gender (1= male, 0=female) of participant "i".[11] We also control for the number of the round to account for possible learning effects, and we include a dummy variable to control for whether the player belongs to the second group (1) or not (0).[12] ε_{ij} is a random variable (standard error) that represents unmeasured factors, capturing all the factors for which we do not have information, and that may affect those participant

[10] The time variation needed to estimate a panel data model is given by the fact that respondents play more than one round during each phase. The use of Random Effects estimators leads to the assumption that individual heterogeneity plays the same role across all treatments, as if some individuals have a kind of "natural propensity to cooperate", depending on observed (gender, cooperation) and unobserved characteristics. The data set does not allow us to test for this assumption (and it may not be the case), and we leave this issue for future research. However, our results are consistent to the estimation of models where the unobserved heterogeneity of individuals is not considered, such as OLS models, and thus we expect that our conclusions do not change when issues of unobserved heterogeneity are taken into account. Furthermore, our results are consistent to the use of Fixed Effects models (available upon request).

[11] Prior research on cooperation, using experiments, has found mixed results from a gender perspective, although recent evidence appears to point toward women being more cooperative than men, from a social dilemma perspective (Molina et al. 2013). In the framework of the work-division within couples, research has found that there are gender differences in the contribution to the household Public Good (Thomas, 1990; Hoddinott and Haddad, 1995; Lundberg, Pollak and Wales, 1997; Cochard, Couprie and Hopfensitz, 2017), with a possible explanation being a greater sensitivity to social context by women (Ledyard 1995; Eckel and Grossman 2008; Croson and Gneezy 2009; Balliet et al., 2011).

12Given that the order of treatments is reversed in the second group, compared to the first group, this may affect the results. To disentangle this possible effect, we have analyzed the average contribution to the Public Good game, by group, treatment, and session. The average contributions in the F, IG, and R treatments in the first group are 6.01, 4.89, and 4.91, respectively, while the average contributions in the F, IG, and R treatments in the second group are 7.99, 5.88, and 5.60 (results are available upon request). Thus, the differences in the average contribution between the two groups are 1.98, 0.99, and 0.69 for the F, IG and R treatments, respectively, with such differences being statistically significant at standard levels.

decisions, and we assume that the error term follows a normal distribution, $\varepsilon_{ij} \sim N(0, \sigma^2)$.

Figure 2 shows that the increase in cooperation when playing in the F treatment, in comparison with playing in the R treatment, is greater for youths than for parents and grandparents. Thus, it could be that there are inter-generational differences in how treatments affect individuals. Thus, we need to reveal whether different treatments affect the generations differently, and to that end we estimate Equation (2)as follows:

$$C_{ij} = \alpha_i + \beta_1 F_{ij} + \beta_2 F_{ij} * Grandparent_i + \beta_3 F_{ij} * Parent_i + \beta_4 IG_{ij} + \beta_5 IG_{ij} * Grandparent_i + \beta_6 IG_{ij} * Grandparent_i + \beta_7 Parent_i + \beta_8 Grandparent_i + \delta X_i + \varepsilon_{ij} \quad (2)$$

where C_{ij} represents the decision (contribution) by individual "i" in round "j", and α_i represents the individual effect. We include two dummy variables to indicate whether player "i" is playing in the F treatment or the IG treatment, and we include their interactions with two dummy variables to indicate whether the player belongs to the group of grandparents or parents (ref.: youths). We also include the variables to indicate whether the player belongs to the group of grandparents or parents (ref.: youths).Thus, the reference group is youths in the R treatment. The vector X_i represents the rest of the factors included in Equation (1), and ε_{ij} represents the error term in the equation.

Column (1) of Table 1 shows the results of estimating Equation (1) for the sample of players. We observe a positive and statistically significant coefficient for the variable representing the F treatment. Playing in the F treatment is related to an increase of the average contribution by 1.72 monetary units, in comparison with the R treatment. When we focus on the IG treatment, in comparison with the R treatment, we observe that the coefficient of the dummy variable is not statistically significant. Thus, we find that, in comparison with the R and IG treatment, playing with family members increases the contribution of players to the Public Good, indicating that family ties are positively related to the contribution of the players. Furthermore, the coefficients for the dummy variables controlling for whether the player belongs to the group of grandparents or parents are positive and statistically significant at the 99% level. Given that the reference group are youths in the R treatment, we observe that grandparents contribute, on average, 1.15 more monetary units, and parents 0.90 more monetary units, when they play in the R treatment, in comparison to the contributions of youths to the Public Good in the same treatment. This is consistent with Figure 1, as it shows that youths contribute less to the Public Good in comparison with parents and grandparents, especially in the IG and R treatments.

(Table 1 about here)

Although prior evidence has shown that the cooperative behavior of males and females is different (Thomas, 1990; Lundberg, Pollak and Wales, 1997; Molina et al., 2013; Cochard, Couprie and Hopfensitz, 2017), the coefficient for males is not statistically significant in our sample.[13] Furthermore, we find that the coefficient controlling for whether individuals were assigned to the second group (i.e., Second group in experiment) is positive and statistically significant at the 99% level, indicating that the contributions of the second group are comparatively higher than in the first group, independent of the treatment, and such differences cannot be attributed to the difference in the order of treatments. This difference may be due to a session effect, since, perhaps, individuals could create ties before the experiment, given their higher waiting time, or it is possible that the students knew each other before participating in this specific session. However, the positive relationship between family ties and cooperation is present after controlling for this session (i.e., order of treatments) effect, which indicates that this result holds net of this session effect.

Column (2) of Table 1 shows the results of estimating Equation (2) on the contribution to the Public Good. Considering that the reference group is youths in the R treatment, our results show that playing in the F treatment is related to an increase in the contribution to the Public Good of 2.53 monetary units by youths, 1.68 (2.53-0.85) monetary units by grandparents, and 0.95 (2.53-1.58) monetary units by parents.[14] Thus, consistent with previous results, we observe that, in comparison with the R treatment, playing with family members increases the contribution to the Public Good. Furthermore, there are differential effects of the F treatment by generation, as the

[13]In order to analyze whether there are gender differences in cooperation in, for example, the round number or the treatment, we have interacted all our controls of Equation (1) with the gender dummy. We find no differences according to the gender of individuals, and results are consistent with the positive relationship between family ties and cooperative behavior (results available upon request).

[14]We test whether the linear combinations obtained for parents (e.g., 2.53-0.85) and grandparents (e.g., 2.53-1.58) are statistically significant or not. To that end, we use a Wald-type test to test whether the linear combination can be considered to be zero (Ho, null hypothesis) or different from zero (Ha, Alternative hypothesis). We obtain that the linear combinations are statistically significant, which indicates that the contributions of parents and grandparents are higher in the F treatment than in the R treatment.

greater increase is present in the group of youths, while lower increases are present in the group of parents and grandparents.[15] Thus, playing with family members increases the contribution of players more in the case of youths.

Moreover, playing in the IG treatment is, in comparison with playing in the R treatment, related to a statistically significant increase in the contribution to the Public Good of 0.34 monetary units by youths and parents, and with a non-statistically significant decrease of 0.08 (0.34-0.42) monetary units by grandparents. These results indicate that the relationship between the contribution to the Public Good and the IG treatment is mixed, as it depends on the generation under analysis. Finally, when playing in the R treatment, grandparents and parents contribute 1.58 and 1.47 more monetary units to the Public Good, which is consistent with Figure 1.

5. Conclusions

Prior research has analyzed cooperation within families (Reynolds, 2015; Görges, 2015; Beblo and Beninger, 2017), but these studies focus on same-generation or two-generation cooperation, with little or no experimental evidence provided on the level of cooperation among three generations. To bridge this gap, we report a repeated Public Good game with three generations (youths, parents, and grandparents) with the participation of 165 volunteers (55 individuals aged between 17 and 19, one of their parents, and one of their grandparents).

All the age groups cooperate more when playing with relatives, with this trend being more evident for the youths and the parents than for the grandparents. Thus, family ties appear to have a positive relationship to contributions to the Public Good. We find that the level of cooperation of the youths is significantly lower than that of the parents and the grandparents, consistent with the prior literature showing that young people are less cooperative (Peters et al., 2004; Charness and Villeval, 2009; Gutiérrez-Roig et al., 2014).

One limitation of the paper is that, in the current context, it is not clear whether the findings for the youths reported here imply a behavior driven by altruistic motives, or driven by the fear of criticism by parents and grandparents later on. We simply do not

[15]We also test if the effect of the F treatment is different by generation. To that end, we apply Wald-type tests on the difference between the coefficients for youths (2.533), parents (2.53-0.85) and grandparents (2.53-1.58). We observe that the differences are statistically significant at standard levels, which indicates that playing with family members increases the contribution of players differently for each generation."

know whether the youths contribute more within the family because they recognize that the pooling of resources benefits them (the selfish motive), or they fear being shamed by their parents after the fact (psychic costs), or they act purely from generosity due to kinship. The absence of anonymity in the family treatment may be conditioning our results, which does not allow us to extract any causal claim. The experiment did not allow us to disentangle the motives behind this specific behavior, and a promising line of research remains open.

Our results indicate that the level of cooperation of the youths is significantly lower than that of the parents and the grandparents. This may well be driven by an income effect (Chowdhury and Jeon, 2014), but the absence of income information in the experiment does not allow us to disentangle the motives behind this specific behavior, despite prior evidence showing the differential behavior of older generations in terms of cooperation (Gutierrez-Roig et al., 2014). Other channels that could explain our results are a cohort effect (i.e., individuals become less generous towards strangers) or a selection effect (i.e., individuals who become parents are more generous). We leave this issue also for future research, where experiments similar to the one presented in this paper, and that collect information on personal or household income, will be crucial in discerning the reasons behind generational differences in cooperation.

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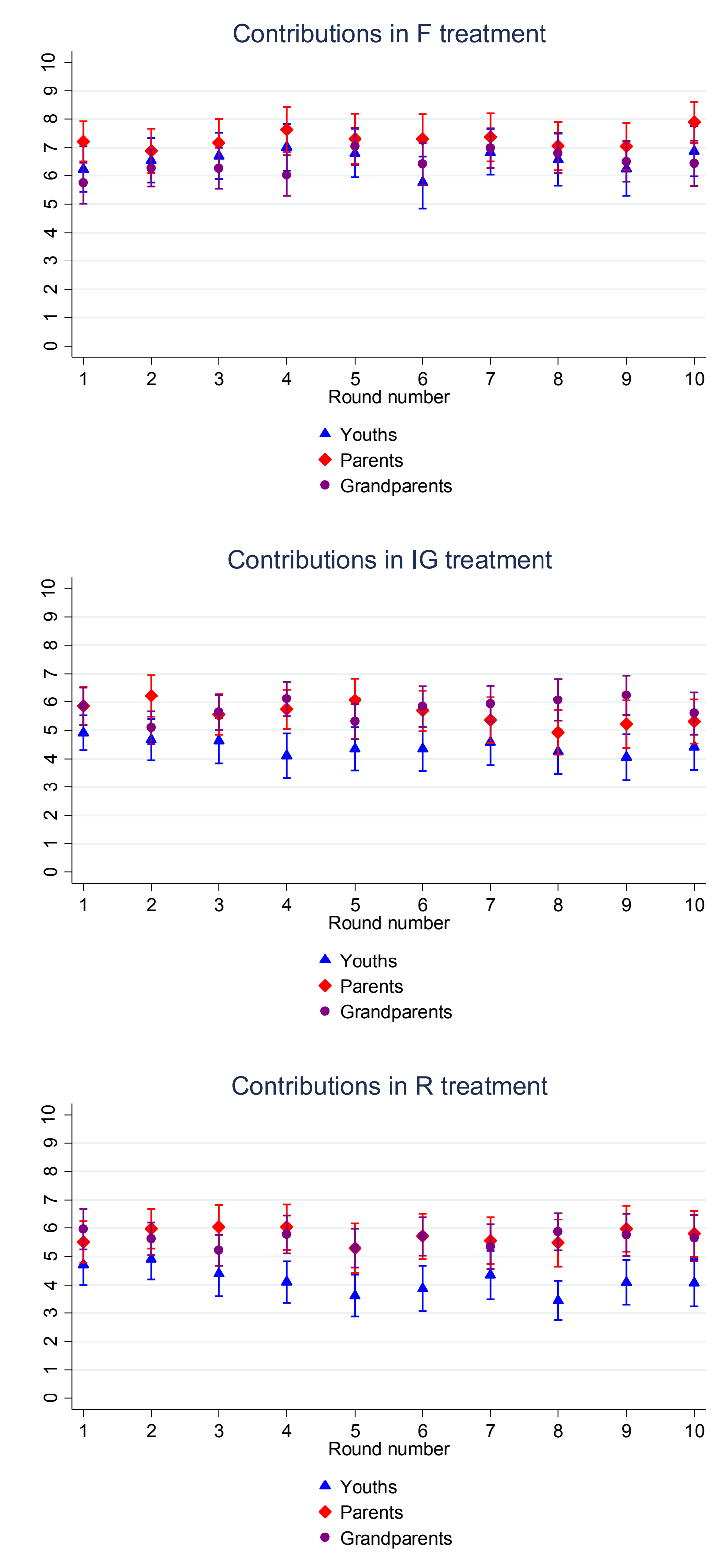
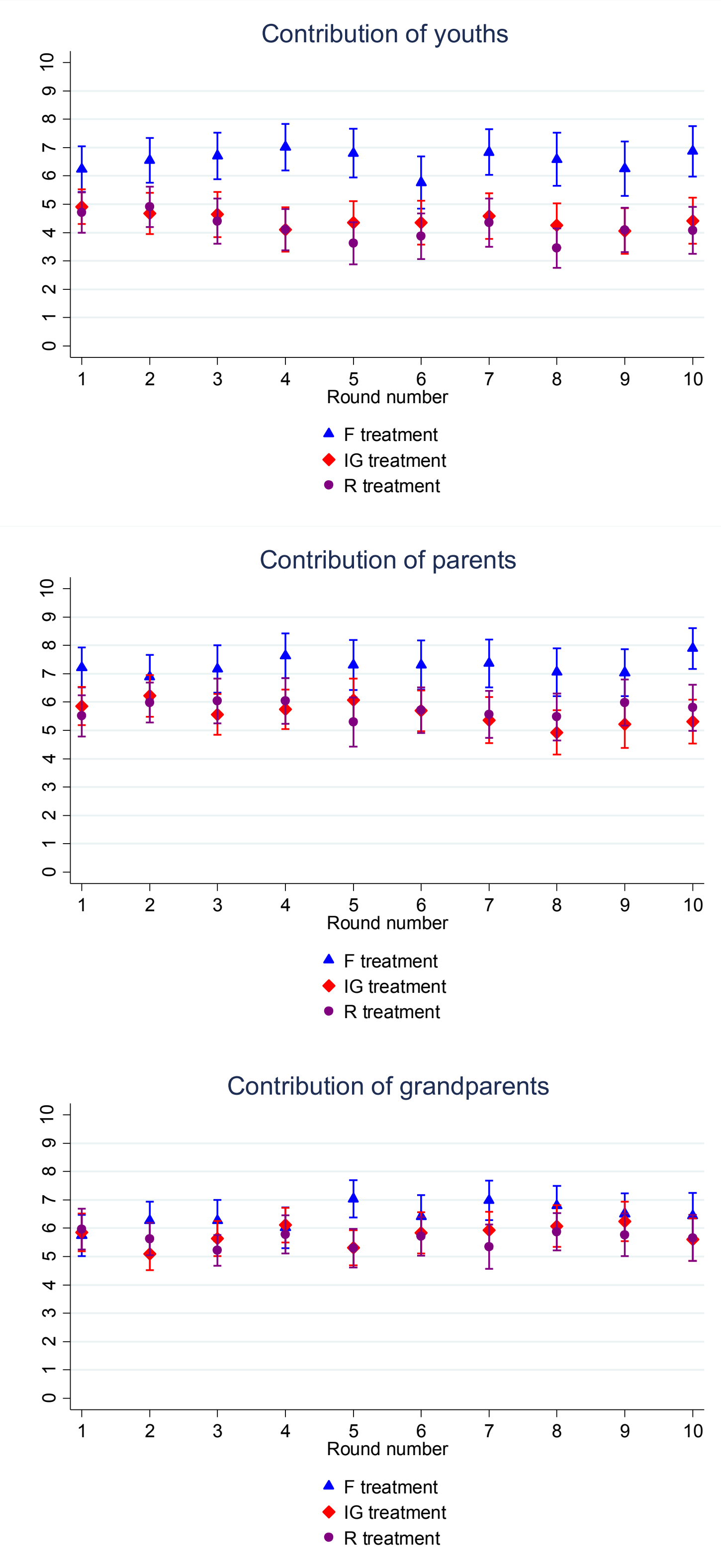
Figure 1. Contributions to the Public Good, by treatment



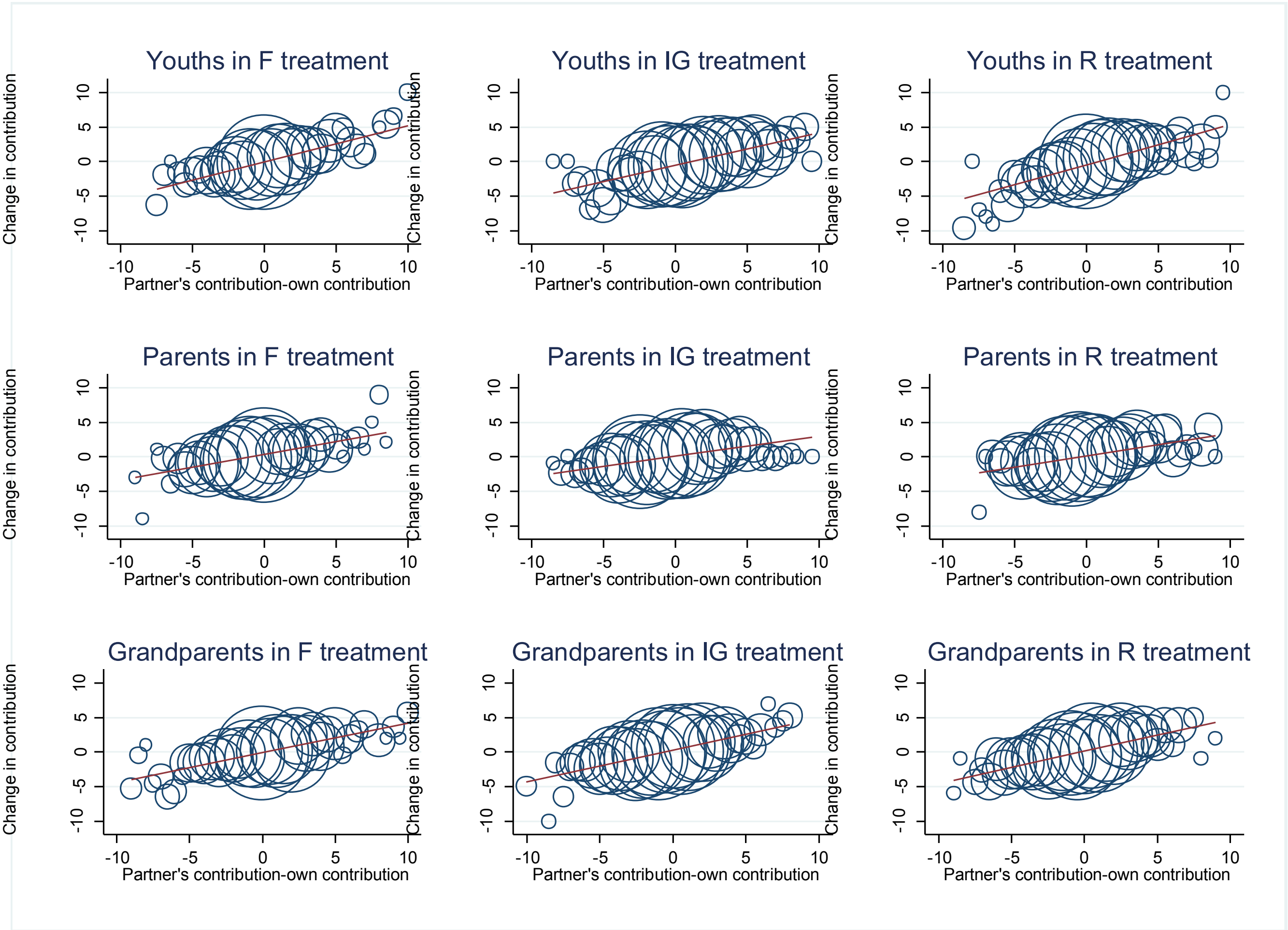
Notes: Data come from the experiment "Colabora con la ciencia en Familia" (http://www.ibercivis.es/projects/colabora-con-la-ciencia-en-familia/). "Contribution in monetary units" are calculated per round, averaged over all the participants for the same generation. Confidence intervals calculated as $\overline{X} \pm 1.96 * SE$, where $\overline{X}$ represents the mean value and SE represents the standard error.

Figure 2. Contributions to the Public Good, by generations



Notes: Data come from the experiment "Colabora con la ciencia en Familia" (http://www.ibercivis.es/projects/colabora-con-la-ciencia-en-familia/). "Contribution in monetary units" are calculated per round, averaged over all the participants for the same generation. Confidence intervals calculated as $\overline{X} \pm 1.96 * SE$, where $\overline{X}$ represents the mean value and SE represents the standard error.

Figure 3. Change in contribution in relation to other player's previous contribution



Notes: Data come from the experiment "Colabora con la ciencia en Familia" (http://www.ibercivis.es/projects/colabora-con-la-ciencia-en-familia/).Contributions depend on own and partners' last action. Own contribution increment (y-axis) as a function of the difference between averaged partners' contribution and own contribution in the last round.

Table 1. RE results for contributions

Contributions to the Public Good	(1)	(2)
Family treatment	1.723***	2.533***
	(0.084)	(0.142)
Family treatment*Grandparents	-	-0.855***
	-	(0.199)
Family treatment*Parents	-	-1.576***
	-	(0.199)
Generational treatment	0.157*	0.339**
	(0.082)	(0.141)
Generational treatment*Grandparents	-	-0.416**
	-	(0.199)
Generational treatment*Parents	-	-0.129
	-	(0.199)
Grandparents	1.153***	1.576***
	(0.313)	(0.333)
Parents	0.902***	1.471***
	(0.314)	(0.334)
Second group in experiment	1.210***	1.210***
	(0.264)	(0.264)
Round number	0.027***	0.027***
	(0.004)	(0.004)
Male (ref.: female)	0.098	0.098
	(0.273)	(0.273)
Constant	3.504***	3.174***
	(0.272)	(0.279)
Observations	4,950	4,950
R-squared	0.130	0.139
Number of users	165	165

Notes: Robust standard errors clustered at the individual level (i.e., users) in parenthesis. Data come from the experiment “Colabora con la ciencia en Familia” (http://www.ibercivis.es/projects/colabora-con-la-ciencia-en-familia/). Contribution measures the contribution in each round to the Public Good, on a scale from 0 to 10. Youths includes youths between 17 and 19 years old. Parents includes parents of youths participating in the experiment. Grandparent includes grandparents of youths participating in the experiment. Second group indicates that the observation corresponds to the individuals participating in the second session of the experiment (there were 2 sessions). The reference group are contributions made in the random treatment during the first session, by female youths. *Significant at the 90% level **Significant at the 95% level ***Significant at the 99%.

Appendix A: The experiment

[First page before going to the login page]
This time from the start of the experiment. Please, stay silent throughout the experiment, turn off your mobile and remember that any element foreign to experiment is not allowed.
Click here to continue.

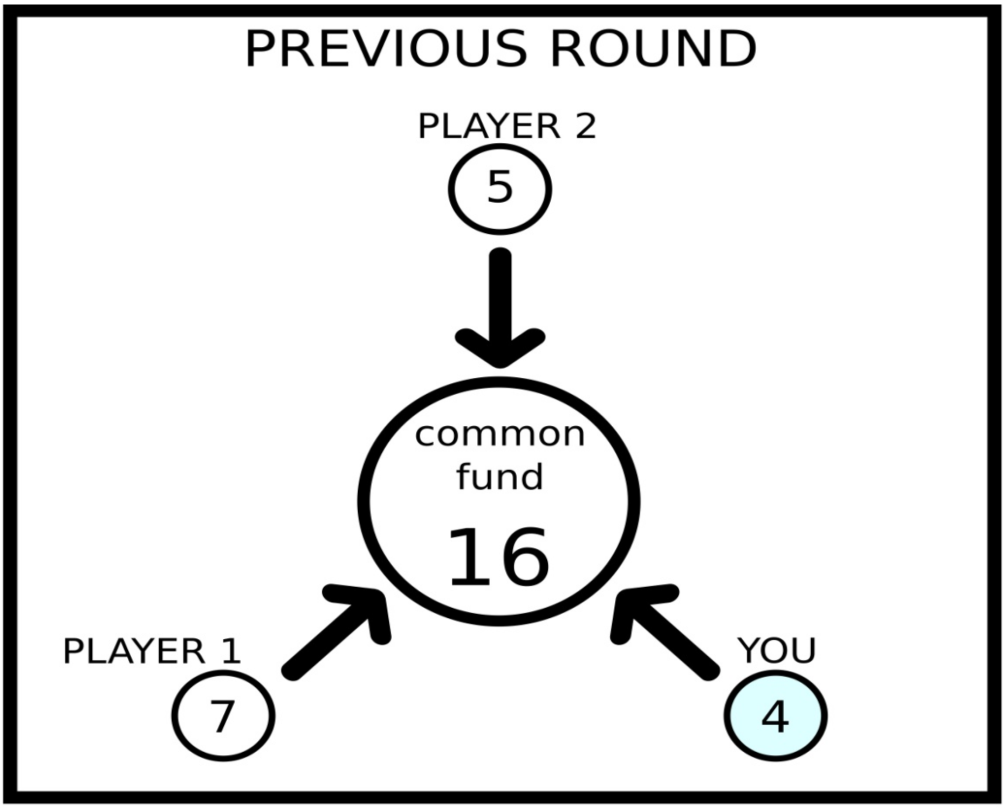
[Log in page]
Please enter your user name and password on the envelope that we have given.
Username:
Password:

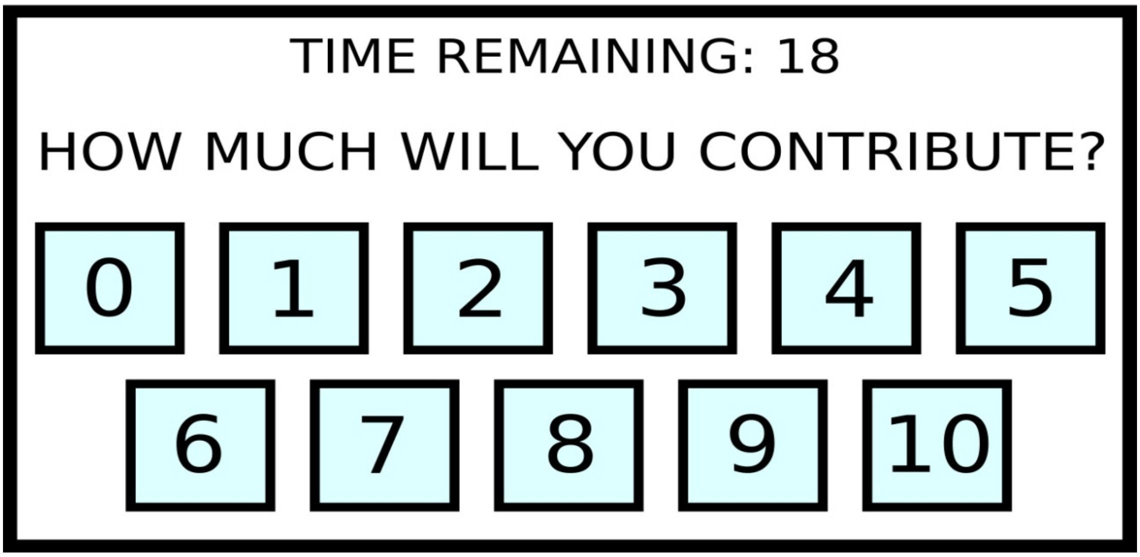
[By clicking OK, go to the next page]
This is an experiment to study how individuals make decisions. Do not think that we expect any particular behavior. What you do will affect the amount of money you can win. Please, do not talk during the experiment. If you need help, raise your hand and wait to be seen.
Click here to continue.

This experiment consists of three parts. Each part consists, in turn, of an undetermined number of rounds. Each part will take about 5 minutes, but may end earlier. The total duration of the experiment will be about 20 minutes.
You may be gaining different amounts depending on the decisions made in each round by you and the other participants. The gain of each round is expressed in its own currency: the ECU. At the same time, at the end of the experiment, an exchange rate will be set at ECU-euros, depending on the number of participants.
The total gain that you can get in this experiment is the sum of the profits earned in all rounds, and converted to euros, plus a fixed amount of 5 euros for your participation. This money will be given in cash at the end of the experiment.
Click here to continue.

"Decision to be taken in every round"
In this part of the experiment, players are assigned completely at random, peers may be any of the remaining players. They may belong to any generation or may not be related to you (in fact, almost certainly, they are not your family).
In each round, you will have a fixed amount of 10 ECU. Of those 10 ECUs, you can donate the desired amount into a common fund. The amount you choose not to provide becomes your property, and your benefits accumulate. The other two participants also have 10 ECUs each and, like you, can also contribute to the common fund any amount they wish.
In each round, you have up to 20 seconds to choose how much to contribute to the pool. After 20 seconds, the system will choose for you, but then you can continue to choose without problems in the following rounds. (Do not worry, 20 seconds to choose should suffice).
Once the three participants have chosen, the round ends. At that time, the sum of the amounts that the three participants have contributed to the common fund is multiplied by 1.5 (that is, the program increases the pool 50%), and the result is divided equally among the three participants, regardless of how much has been invested by each.

This is the screen you see during the experiment:





The large central circle represents the common fund. The number inside indicates the total amount the three players contributed to the fund during the previous round. Regarding the three small circles, the blue circle is you and the other two correspond to your companions. The number in each circle indicates how much each contributed to the pool in the previous round. At the bottom of the screen are 11 buttons, from 0 to 10. Simply click on the corresponding amount to invest in the pool.
Click here to continue.

"Earnings"
Once all participants have made their choice, for that round your total gain is equal to the sum of what you did not contribute plus your share of the common fund, multiplied by 1.5. That amount is accumulated in each round. At the end of the game, your gain is equal to the sum of the profits earned in all rounds.

“Repeated round”
Remember that each part will be an undetermined number of rounds. In each round, you have up to 20 seconds to choose what amount to deposit in the common fund. After 20 seconds, the system will choose for you, but then you can continue to choose without problems in the following rounds. (Do not worry, 20 seconds to choose should suffice). The round is not over until all participants have chosen.

[New page]
Click here to start Part I of the experiment.

[Part I Begins]
[Game]
[Part I ends]
Part I of the experiment is over. Please, keep silent. Begin Part II.
Click here to continue.

[Brief tutorial part ii, page 1]
In this part, players are assigned randomly, and are not necessarily members of your family. You do not know who plays, nor do they know who you are. A difference in the game now is a student, a parent of a different student, and a grandfather of another student are the participants. That is, the three players belong to different generations: student, father and grandfather, designated on the screen with more words for grandfather / a, lower for the grandson / ae intermediate for the father / mother. However, players are not necessarily members of the same family (in fact, almost certainly, they are not related to each other or to you). Moreover, the experiment is exactly the same as above, any rule changes.
Click here to begin Part II of the experiment.

[Part II Begins]
[Game]
[Part II ends]
Part II of the experiment is over. Please, keep silent. Begin Part III.
Click here to continue.

[Brief tutorial part iii, page 1]
In this part, you will play with two members of your family: his [choose] {father / mother and grandfather / a} {child and his / her father / mother} {child and his / her grandson / a} [end choose]. The game rules are the same for all participants. Moreover, the experiment is exactly the same as above, with no rule changes.
Click here to start Part III of the experiment.

[Part III Begins]
[Game]
[Part III ends]
Experiment rounds are over. Please, keep silent. Experiment has not finished yet. You must answer the following questions:
Click here to continue.

[Questions]
Did you follow a strategy to decide? BUT
Did you have in mind what the other players contributed to the fund in Part I? BUT
Did you have in mind what the other players contributed to the fund in Part II? BUT
Did you have in mind what their family background contributed to in part III? BUT
[Last page after questions]

Experiment is over.
Change ECU Euro voucher:
1ECU =[($ Budget - $ n * $ Fixed Bonus = 5) / $ Total Accumulated PayOff] Euros

YOU HAVE WON: [Payoff $ (i)] euros in rounds, plus a bonus of 5 euros for participating:
$ Payoff (i) + $ Fixed Bonus = [$ Payoff (i) + $ Fixed Bonus] euros.

Thanks for your cooperation!!

APPENDIX B: ADDITIONAL RESULTS

Table B1: Average contributions, by generation or treatment

	(1) All	(2) Youths	(3) Parents	(4) Grandparents
	Panel A: by generation			
Contribution	5.73	5.05	6.21	5.95
	(3.02)	(3.21)	(3.07)	(2.63)
Diff Youths-Parents		-1.16		
P-value diff		(<0.01)		
Diff Youths-Grandparents		-0.9		
P-value diff		(<0.01)		
Diff Parents-Grandparents		0.26		
P-value diff		(<0.01)		
	Panel B: by treatment			
		F	**IG**	**R**
Contribution		6.77	5.27	5.17
		(3.04)	(2.82)	(2.94)
Diff family-generations		1.5		
P-value diff		(<0.01)		
Diff family-random		1.59		
P-value diff		(<0.01)		
Diff generations-random		0.09		
P-value diff		(0.45)		

Notes: Standard deviations in parenthesis. Data come from the experiment “Colabora con la ciencia en Familia” (http://www.ibercivis.es/projects/colabora-con-la-ciencia-en-familia/). Contribution measures the contribution in each round to the Public Good, on a scale from 0 to 10. Youths includes youths between 17 and 19 years old. Parents includes parents of youths participating in the experiment. Grandparent includes grandparents of youths participating in the experiment. Second group indicates that the observation corresponds to the individuals participating in the second session of the experiment (there were 2 sessions). “F” refers to family treatment, “IG” refers to intergenerational treatment, and “R” refers to random treatment.*P-Value diff* refers to the p-value of the non-parametric test of Mann-Whitney, where the null hypothesis sets that means of the two samples are equal.