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Personality Traits and Endogenous Group Formation

James Ahloy*
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Using a public goods game in which participants can select their groups, we investigate the role that personality plays in contribution behavior and group selection as the information available to participants about groups varies. We find that when participants only have access to information about the average personality profiles of groups, reliable relationships exist between personality traits and contribution behavior, and participants who are more agreeable than their group members on average are more likely to remain in their groups. However, when participants have access to historical contribution information about groups, both by itself and along with personality information, the relationship between personality traits and contribution behavior varies, and no reliable relationships between personality and movement exist.

TRAITS DE PERSONNALITÉ ET FORMATION ENDOGÈNE DES GROUPES

À l'aide d'un jeu de biens publics dans lequel les participants peuvent sélectionner leurs groupes, nous examinons le rôle que joue la personnalité dans le comportement de contributions et dans la sélection du groupe grâce à la variation des informations disponibles sur les groupes. Nous constatons que lorsque les participants ont uniquement accès aux informations sur les profils de personnalité moyens des membres du groupe, il existe une relation fiable entre traits de personnalité et comportement de contribution, et les participants qui sont plus agréables que la moyenne des membres de leur groupe ont plus de chances de rester dans leur groupe. Cependant, lorsque les participants ont accès aux informations sur l'historique des contributions des membres du groupe, à la fois en isolation ou en plus des informations sur la personnalité, le lien entre traits de personnalité et comportement de contribution varie et il n'existe plus de relation fiable entre la personnalité et la mobilité.

Mots clés: biens publics, formation des groupes, HEXACO

Keywords: public goods, group formation, HEXACO

JEL Codes: C92, H41.

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INTRODUCTION

As a social species, humans spend significant amounts of time collaborating with others in groups. Indeed, contributions to society are often framed as a foundation of ethical and moral behavior in the Kantian sense (Brekke, Kverndokk and Nyborg [2003]; March and Olsen [1995]). Once people recognize a need for collective action, what underlies the process by which social groups are formed? How do individuals decide with whom they would like to interact, and when they wish to move to a new group? Economists have typically addressed mobility in terms of how households respond to incentives such as employment opportunities (Blanchard and Katz [1992]). Economists have found that individuals will move between groups to avoid low social contributors (Ahn, Isaac and Salmon, [2008]; Ehrhart and Keser [1999]), and also move to groups with clearly-defined institutions that encourage public good provision (Gürek, Irlenbusch and Rockenbach [2006]).¹

Yet economic factors alone may sometimes be insufficient to induce people to move (Molloy, Smith and Wozniak [2011]; Wozniak [2010]). Recent research has shown that people sort into communities based on non-financial criteria such as shared socio-political views (Maxwell [2019]). More generally, psychologists have developed a rich literature showing that people prefer interacting with others with whom they have more in common (Byrne [1971]). This idea of similarity can be considered as either perceived or actual similarity, where actual similarity is especially predictive of preference if less additional information is known.²

We examine the effect that information about participants' personality traits has on contribution behavior and group formation in an endogenous public goods game.³ This examination is particularly important because while there is evidence that stronger moral and ethical views correspond to greater public good provision (Figuieres, Masclat and Willinger [2013]; Pickhardt [2010]), evidence from economics and psychology shows that circumstances may have a strong impact on behavior not predicted by stable personality traits (Dana, Weber and Kuang [2007]; Doris [2002]).

Numerous recent studies have shown that differences in personality traits can account for variation in behavior in an array of social settings.⁴ While public goods games are among those that have been explored, the literature has generally emphasized how personality traits influence contribution behavior within exogenously determined groups.⁵ Attention has yet to be given to any role traits

1. Sutter, Haigner and Kocher [2010] find that individuals respond more strongly to sanctioning and reward institutions when allowed to choose such institutions endogenously, compared to when they are imposed, though they do not address movement between such groups.

2. See Montoya, Horton and Kirchner [2008] for an overview and meta-analysis.

3. To measure participants' traits, we use the HEXACO model of personality (Ashton and Lee [2007]; Ashton et al. [2004]), which provides scores on the following six dimensions: honesty-humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience.

4. See Zhao and Smillie [2015] and Drouvelis and Georgantzis [2019] for an overview of the role of personality traits in social decision-making. In particular, agreeableness often appears as a significant trait.

5. For example, Volk, Thöni and Ruigrok [2011] find that agreeableness is positively correlated with cooperative behavior in a longitudinal study of public goods games.

might play in the formation of groups for solving collective action problems, though there are reasons why it might be important in this context.

First, when an individual is considering joining a group, it may be difficult to know what the exact contributions of members to the public good were in the past and what they are likely to be in the future. A sense of the members' personalities could be easier to develop, and insofar as personality predicts behavior, this may inform the individual's perception of the merits of joining the group. Second, people may generally have a preference for associating with others who have traits that are similar to theirs (Miller [2009]). If the formation of groups to solve collective action problems revolves around such a preference, it is important to understand the outcomes that arise as a consequence.

Participants in our experiment repeatedly interact in the nonlinear VCM environment from Ahn, Isaac and Salmon [2008], which simulates a pure public good with a group return that is increasing in the number of group members. Before making their contribution decisions in each round, participants observe information about either the contribution history of all groups, the average personality composition of all groups in the previous round, or both. They are then allowed to decide, at no cost, whether they would like to remain in their current group or join another group.

Previous research on personality and public goods games using HEXACO and the Big Five have found positive associations between prosocial behavior and honesty-humility (Hilbig, Zettler and Heydasch [2012]), agreeableness (Perugini, Tan and Zizzo [2010]), and conscientiousness (Kebede et al. [2016]). While we examine the relationship between all of the HEXACO personality traits and contribution behavior in our game, we limit our attention to the three above-mentioned traits when addressing how subjects decide to switch groups. We do this in light of related exogenous group formation studies (Ahn, Isaac and Salmon [2008]; Ehrhart and Keser [1999]) that demonstrate a tendency for both high contributors to leave groups in which they are exploited and low contributors to follow high contributors around. If connections between prosocial behavior and the personality traits of honesty-humility, agreeableness, and conscientiousness exist in our experiment, we may find similar behavior, where subjects higher in those traits than their group's average are likely to leave their groups and those lower in those traits than their group's average are likely to remain.

We find that when participants have access to only personality information, two traits—agreeableness and emotionality—predict contribution behavior in a reliable way. However, when participants have information about the contribution history of other groups, no consistent relationship between contributions and personality traits exists. In deciding whether to switch groups, participants who are more agreeable than their group members on average are more likely to remain in their groups when only personality information is available. When contribution information is present, whether alone or in conjunction with personality information, no reliable relationship exists between the decision to leave a group and a participant's contribution relative to the average of their group.

Altogether, these results point to a situational dependency of the influence of personality on behavior, similar to psychology findings mentioned previously.⁶

6. This finding bears similarity to the classic "Person-situation" debate in personality psychology (Allport [1927]; Epstein and O'Brien [1985]; Mischel [2013]), in which researchers debated whether

Our findings that personality has situational effects also support the results of Fréchette, Schotter and Trevino [2017], who found that Big Five neuroticism, extraversion, and conscientiousness influenced behavior when individuals made choices over lotteries under uncertainty but not when they did so under risk.

The remainder of the paper proceeds as follows. The second section contains a review of the relevant literature. The third section details the experimental design and hypotheses. The fourth section provides the results of the experiment, and the fifth section concludes with discussion of our findings, limitations of the study and directions for future research.

RELATED LITERATURE

Our study fits closely with two strands of research. The first is research on group formation in public goods games. Early experimental work on groups in public goods games (Isaac and Walker [1988]; Isaac, Walker and Williams [1994]; Kim and Walker [1984]; Marwell and Ames [1979]) was concerned with how group size affected contributions to the public good. In these studies, the size of the group remained fixed for the duration of the experiment, but comparisons were made across exogenously determined groups of different sizes. The literature on group formation has since approached the formation process from a variety of angles.

The second is research incorporating personality psychology into the study of economic games. The recent studies that form the literature in this area have considered the role of personality in bargaining and social dilemma games, including both one-shot and repeated public goods games with randomly determined, fixed groups. Our study contributes to both strands of research by applying personality psychology to the study of group formation in a public goods game.

Endogenous Group Formation in Public Goods Games

The first paper to fully endogenize group formation was Ehrhart and Keser [1999], which considered a public goods game that allowed subjects to switch groups, at a fixed cost, after observing the sizes and average contributions of all groups. This setup gave rise to a pattern of cooperative individuals fleeing free riders.

Ahn, Isaac and Salmon [2008] (hereafter AIS) used a similar environment to test the impact of group entry and exit rules on behavior. Prior to making their contribution decisions in each round, subjects observed past group sizes and average contributions for all groups and decided whether to change groups while facing one of three rules: free entry and exit, restricted entry and free exit, or free

individuals have stable traits at all or if all behavior is situationally-driven. Here, as in the research cited, we take stable traits as given. In this way, we examine the impact of traits in the face of varied situations.

entry and restricted exit. The authors found that free association by itself had little positive effect on efficiency, and restricted exit had the effect of lowering contributions to the public good over time. Restricted entry was used to teach subjects to increase contributions to the public good, but led to smaller group sizes and lower overall efficiency as a result of the smaller groups.

In a follow-up study, Ahn, Isaac and Salmon [2009] modified the nonlinear VCM game to make the public good congestible. Considering the same formation rules as in their previous paper, they found that restricted entry led to higher average contributions and earnings than either of the other mechanisms. Similarly, Cinyabuguma, Page and Putterman [2005] found how contributions to a public good were increased significantly by the threat of expulsion from a group without the possibility of redemption. Charness and Young [2014] allowed subjects to exit a group, exclude members from their group, or merge with other groups, after beginning the experiment in groups of size three. The authors found that their mechanism improved contributions to the public good when compared to instances where groups were randomly formed and fixed.

Other experimental public goods studies have moved beyond fixed, randomly determined groups without completely endogenizing the formation process. Gunnthorsdottir, Houser and McCabe [2007] sorted subjects into groups of a fixed size based on past cooperative behavior, matching high contributors with other high contributors, and low contributors with other low contributors. Page, Putterman and Unel [2005] allowed subjects to state their preferences for group members based on public information about average contribution to the public good. Groups were then reconstructed based on the strength of individuals' mutual preferences. In Coricelli, Fehr and Fellner [2004], group size was fixed at two, but subjects were permitted to select group members according to unilateral or bilateral matching. Brosig, Margreiter and Weimann [2005] investigated partner selection three-person public goods game. Subjects were initially placed in groups of four and were then allowed to communicate in order to choose a member to exclude from the game.

Personality Traits and Decision Making

The earliest study to look at the role of personality in a public goods game was Kurzban and Houser [2001].⁷ The authors found that Big Five conscientiousness and neuroticism were weakly correlated with cooperative behavior, with the former trait being negatively correlated and the latter being positively correlated. Kebede et al. [2016] found that conscientiousness correlates with cooperative behavior when there is inequality in the show-up fees paid to subjects. Perugini, Tan and Zizzo [2010] found that agreeableness in males predicted contribution behavior in early rounds of a repeated public goods game, while personality measures had no predictive power for females. Hilbig, Zettler and Heydasch

7. Several studies have examined the relationship between personality measures and giving in allocation tasks, using both the Big Five measure (Ben-Ner and Kramer [2011]; Ben-Ner, Kramer and Levy [2008]), the HEXACO scale used here (Hilbig et al. [2013], [2015]), and both (Zhao, Ferguson and Smillie [2017]). Findings generally show predictive power for agreeableness (in the Big Five) and honesty-humility (HEXACO) in explaining giving decisions.

[2012] found that several traits can be positively correlated with contributions in the absence—but not presence—of punishment.

Two final studies of preference for personality traits warrant mention. Miller [2009] claims that individuals typically prefer to associate with others who have similar personalities, but may adjust their preferences for personality types depending on the task at hand. Motyl et al. [2014] advanced the “ideological migration hypothesis,” which supports the possibility that individuals generally have a preference for being around others who are like them. Using demographic data from online questionnaire responses, the authors looked at the relationship between an individual’s choice to migrate and their ideological fit with their community. Individuals appear to have a greater desire to migrate from their communities when they perceive a lack of ideological fit, and actual migration patterns suggest that individuals move from communities with low ideological fit to those with better fit. Given that select personality traits can systematically be linked to political ideology, this preference for ideological fit could have the effect of creating communities with low variability in those personality traits.⁸

EXPERIMENTAL DESIGN AND PROCEDURES

Participants interacted in the VCM environment introduced by AIS for a total of 20 periods.⁹ Participants belonged to a group of size $n \in [1, N]$ in every period, where N is the total number of participants in a session, and allocated 15 tokens between an individual account and a group account. In the first period, participants made solo investment decisions—that is, without any group members. Groups were then endogenously determined before the investment decision in each subsequent period through the group-formation mechanism employed by AIS in their Free Entry/Free Exit condition. Under this mechanism, participants can costlessly enter and exit any group they desire. In accordance with AIS, decisions were framed as investment decisions for participants but are sometimes referred to as contribution decisions in the following discussion.

Let x_i denote the number of tokens that individual i contributes to the group account, and let G_i represent the set of other members in i ’s group, not including i . The monetary payoff to individual i is

$$\pi_i = 0.5(15 - x_i) + 1.5\left(x_i + \sum_{j \in G_i} x_j\right) - \frac{1}{27}x_i^3. \quad (1)$$

Each token invested to the individual account yields 0.5 Experimental Currency Units (ECU) for a participant, while each token invested to the group account generates 1.5 ECU for the participant and 1.5 ECU for each of the participant’s group members. A participant also receives 1.5 ECU for each token invested by their group members to the group account. Investment into the individual account is costless, but investment into the group account is not: investing x tokens

8. See Gerber et al. [2011] for a summary of the relationship between personality and the political arena. Almlund et al. [2011] provides a further survey of the relationship between personality traits and academic ability, economic success, and additional life outcomes.

9 See Online Appendix I, DOI : 10.3917/reco.706.0999 for instructions and Online Appendix II for screenshots of the program.

into the group account costs a participant $\frac{1}{27}x_i^3$ ECU.¹⁰ The payoff function creates an environment with a pure public good whose marginal cost of individual contributions is increasing.

There are two key features of this environment. First, there is a dominant strategy for contributions, but unlike a traditional linear VCM, it is strictly positive. In the one-shot version of this public goods game, the dominant strategy choice for each subject is to contribute 3 tokens to the group account and 12 tokens to the individual account, independent of group size. Though the stage-game dominant strategy choice does not vary with group size, the external effect of group-account contributions results in a group-optimal contribution level that is greater than 3 tokens and that varies with group size, as shown in Table 1. For instance, if a session has 12 subjects and all subjects belong to the same group, then each subject earns 59 ECUs in a period if all subjects contribute to the group account at the stage-game dominant level of 3 tokens. However, group earnings are maximized when each subject contributes 13 tokens to the group account and experience an individual payoff of 153.6 ECUs per period.

Table 1. *Optimal investment into group account according to size*

Group Size	1	2	3	4	5	6	7	8	9	10	11	12
Individual Optimum	3	3	3	3	3	3	3	3	3	3	3	3
Group Optimum	3	5	6	7	8	9	9	10	11	11	12	13

The second key feature of this environment is that there is no cost of having additional group members, even if those members do not contribute to the group account. Consequently, a subject's payoff is non-decreasing in the size of the group under any contribution profile. This, together with the external effect of group-account contributions, ensures that subjects face clear financial incentives to form the largest possible group in each session, whether subjects are purely self-interested or have prosocial tendencies.

This environment permits a simple strategy of participants forming the largest group possible, irrespective of how others are contributing. Knowledge of the personality profiles of other participants should also be irrelevant when forming groups, so the environment allows us to manipulate the information provided to participants to see whether that is actually the case.

In our environment, participants can choose unilaterally to join any group they like. Were rejection possible, participants could refrain from attempting to join their most preferred group because of the possibility of rejection and instead only attempt to join groups they believe they could enter. This would increase the complexity of any ensuing analysis, since participants' beliefs would have to be taken into account. While our interest in the effect of personality information on

10. It is possible for participants to lose money in the experiment if they make high contributions to the group account and others do not contribute enough to offset the cost. To account for this, we followed the same bankruptcy rule used in AIS that provides an artificial buffer with a restart for the first bankruptcy. Across all sessions, we had 3 participants go bankrupt one time, each within the first 5 periods.

the group formation process could motivate an environment with restrictions on group entry, an absence of restrictions allows for a more straightforward determination of any preferences over personality types that might exist. As a first look at endogenous group formation in a personality context, we decided that a simpler environment without group entry restrictions would be more constructive.

Similarly, we did not impose a cost on individuals wishing to move groups, even though such moves commonly carry a cost outside the lab. Our primary interest here is to examine whether these information dimensions can affect movement at all. Imposing a cost would likely reduce movement across all treatments, making treatment differences more difficult to identify. Additionally, a cost would interfere with our ability to extract preferences for group member characteristics based on participant choices.

Our sessions began with the measurement of participants' personality traits using the 60-item HEXACO Personality Inventory (Ashton and Lee [2009]) (see the Online Appendix III for inventory items). Several possible frameworks exist for the measurement of personality traits, but there are two that are commonly applied to the study of economic games: the Five-Factor/Big Five model (Costa and MacCrae [1992]; Digman [1990]; Goldberg [1981], [1993]) and the HEXACO model.¹¹ While there is significant overlap between the two models, HEXACO easily allows for the measurement of two different types of cooperation: active cooperation (or fairness) as captured by the honesty-humility dimension, and reactive cooperation (or forgiveness) as captured by the agreeableness dimension.¹² Anglim and O'Connor [2019] suggests that the HEXACO survey is more appropriate when studying morally-relevant or prosocial behavior. These features of HEXACO arguably make it the more pertinent model for the study of cooperative behavior in a public goods environment.

Participants received a fixed payment of 150 ECUs for completing the HEXACO inventory. Though participants were not informed of the purpose of the inventory prior to taking it, they were asked to answer each question honestly. Following completion of the inventory, participants repeatedly made the investment decision, as described above.

We conducted three conditions that differ from one another in terms of the information presented to participants when it was time for them to select their groups: *Contribution Info*, *Personality Info*, and *Contribution and Personality Info*.

For *Contribution Info*, which serves as the baseline, we provided participants with the same information that AIS provided in each of their conditions. When participants were deciding whether they would like to switch groups, they were presented with a table that summarized the size and average contribution to the group account for each group for the previous five periods.

In the *Personality Info* condition, participants were provided with information about the measured personality traits instead of contribution information. Prior to making their group-change decisions, participants observed the average HEXACO scores for each group in the previous period, formatted for readability.¹³

11. The Five-Factor model includes as dimensions: extraversion, agreeableness, conscientiousness, openness to experience, and neuroticism.

12. See Ashton and Lee [2007] for a comparison of the Big Five model and HEXACO.

13. Specifically, scores that were within one point of theirs were highlighted in green. Given the abundance of information being presented to participants (12 groups, 6 traits per group) we felt

Participants were also provided with descriptions of the personality traits in the instructions for stage 2, which were taken directly from the HEXACO website. Given that participants made their investment decisions by themselves in period 1, the personality information presented in period 2 was equivalent to the individual personality profile of each participant. However, no identifying information was provided, so participants could not map personality profiles to any particular individual.

In the *Contribution and Personality Info* condition, participants were provided with a combination of the information types from the other conditions. When deciding whether they would like to change groups, participants saw the size and average contribution to the group account for each group for the previous five periods, along with the average HEXACO scores for each group in the previous period. To the extent that behavior differs between the first and second conditions due to the information provided, this condition was intended to see if information would be used additively or if one information type would dominate the other when both were present.

Across all conditions, participants received feedback at the end of each period that summarized the total contribution to the group account for their group and their earnings according to account type. Participants in the *Personality Info* condition were thus able to determine the average contribution within their groups, but they would have had no knowledge of the average contributions in other groups. At the end of each session in the *Personality Info*, and *Contribution and Personality Info* conditions, participants completed a short questionnaire that asked them about their group change decisions and how the provided information factored into the decision, if at all. The full questionnaires can be found in the Online Appendix IV.

Four sessions were run for each condition, with 10-12 participants per session, for a total of 139 participants across the twelve sessions. The sessions were conducted at the XS/FS laboratory at Florida State University and the experiment was programmed using z-Tree (Fischbacher [2007]). Participants were recruited from a pool of pre-registered students using the online system ORSEE (Greiner [2015]). Participants were paid a show-up fee of \$7 plus any additional earnings from the experiment, with ECU exchanged at a rate of 150 ECUs to \$1.¹⁴ On average, participants earned \$15.59 per session. Instructions were distributed for each stage prior to the start of the stage and read aloud to participants. Each session lasted between 60 and 90 minutes.

BEHAVIORAL HYPOTHESES

Our hypotheses rely both on the results of AIS and on previous findings in the literature on personality and social decision-making.

In their Free Entry / Free Exit condition, AIS found that participants formed the largest possible group early in a session and generally remained in that group

it was necessary to present the information in some way without actively filtering anything out.

14. ECU were exchanged at a rate of 100 ECUs to \$1 in session 1, and the show-up fee was \$10 in sessions 1-4. The change to the show-up fee was approved by FSU's IRB.

until the end. Contributions were higher than the stage-game dominant choice of 3 tokens but only moderately so. Since our environment is modeled after their Free Entry / Free Exit condition, we expect to see similar behavior across conditions.

HYPOTHESIS 1. Participants quickly form and maintain the largest possible group for a session and contribute at or near to the stage-game dominant choice of 3 tokens.

Turning to personality traits, honesty-humility and agreeableness are both intended to capture prosocial tendencies: the former is a measure of active cooperation (fairness when dealing with others despite opportunities for exploitation), while the latter is a measure of reactive cooperation (forgiveness and tolerance of others' uncooperative behavior) (Ashton and Lee [2007]). Given that a positive association between honesty-humility and cooperation in a one-shot public goods game has been found by Hilbig, Zettler and Heydasch [2012], and a positive association between agreeableness and cooperation in a repeated public goods game has been found by Perugini et al. [2010], it stands to reason that we should also find a positive relationship between cooperation and these traits in our experiment.

Connections between conscientiousness and cooperative behavior have also been found in several studies cited earlier, so a positive relationship between cooperation and conscientiousness may also be found in our experiment. One way in which this may manifest is that participants who are high in conscientiousness could have a better understanding of the payoff function and the value in contributing beyond the stage-game dominant amount.

HYPOTHESIS 2. Positive associations exist between contributions to the group account and one or more of the following personality traits: honesty-humility, agreeableness, and conscientiousness.

Motyl et al. [2014] and Gerber et al. [2011] combine to suggest that individuals have preferences for being around others who are similar to them. Ehrhart and Keser [1999] found that high contributors to the public good in their game would leave groups and be followed around by low contributors, while Drouvelis and Georgantzis [2019] showed that agreeable individuals were prosocial in a public goods game when matched with other agreeable individuals but not when matched with disagreeable individuals. While we ultimately expect participants to form the largest possible group in a session because of the financial incentives to do so, we do not expect group size to be the only factor associated with movement.

HYPOTHESIS 3a. Higher-than-average contributors are more likely to leave their groups when contribution information is available, while lower-than-average ones are more likely to remain in theirs and free-ride.

HYPOTHESIS 3b. When only personality information is available, and insofar as honesty-humility, agreeableness, and conscientiousness predict prosocial behavior, participants who are higher-than-average in these traits may be more likely to leave their group to avoid being taken advantage of, while lower-than-average participants are more likely to remain in theirs and free-ride.

Participants are presented with two sets of information in *Contribution and Personality Info* that they may use to inform their group-change decisions. It is

possible that subjects ignore one type of information in favor of the other, or use both types of information in some way.

HYPOTHESIS 4. If participants in Contribution and Personality Info use only contribution information, there should be no relationship between the personality information and the decision to leave a group. Similarly, if participants use only personality information, there should be no relationship between the contribution information and the decision to leave a group.

RESULTS

In the results that follow, we begin by examining the distribution of contributions to the group account and trends in the averages of key variables. We then investigate the connection between contribution behavior and personality, and conclude with a closer look at movement across groups.

Distributions and Trends

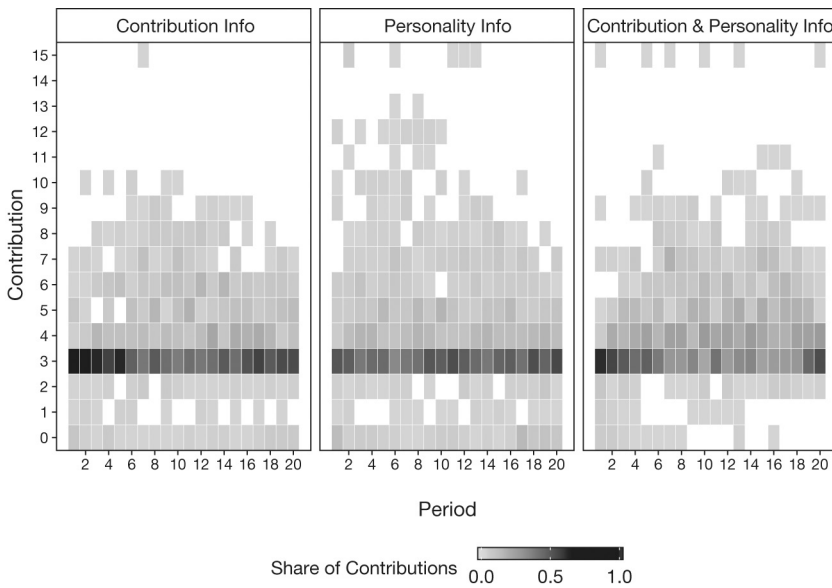
Figure 1 presents heatmaps of contributions to the group account for each treatment. Some participants made choices in the 12-15 tokens range during the first period, and while a misunderstanding of the payoff function or contribution mechanism cannot be ruled out, it is possible that participants begin with a strong signal of prosocial behavior. From the heatmaps, it can be readily seen that participants deviated little from the stage-game dominant contribution over time, irrespective of condition.

To get a sense of how several key variables changed throughout a session, Figure 2 shows line graphs for the average contribution to the group account, the average of each participant's group size as a proportion of the session size, the average of each contribution to the group account as a proportion of the optimal contribution for the group, and average earnings.¹⁵ The chart for average contributions shows that, in each condition, contributions appear to increase by around 1 token within the first half of a session and then decrease for the remainder until they are near to their initial levels. Contribution behavior in the baseline was similar to that in the free entry/exit condition of AIS—where the overall average contribution in the baseline was 3.90 tokens, the overall average in AIS was 4.34.

Most of the movement between groups occurs during the first half of a session. Participants form the largest group possible within the first 10 periods and then remain in that group for the remainder of a session. This behavior appears consistent with Hypothesis 1. The overall averages were 0.85 in the baseline, 0.74 in *Personality Info*, and 0.85 for *Contribution and Personality Info*. Rank-sum tests using each session as the unit of observation show no significant differences between treatments.

15. We present the average of group size as a proportion of the session size because the session sizes were not all identical.

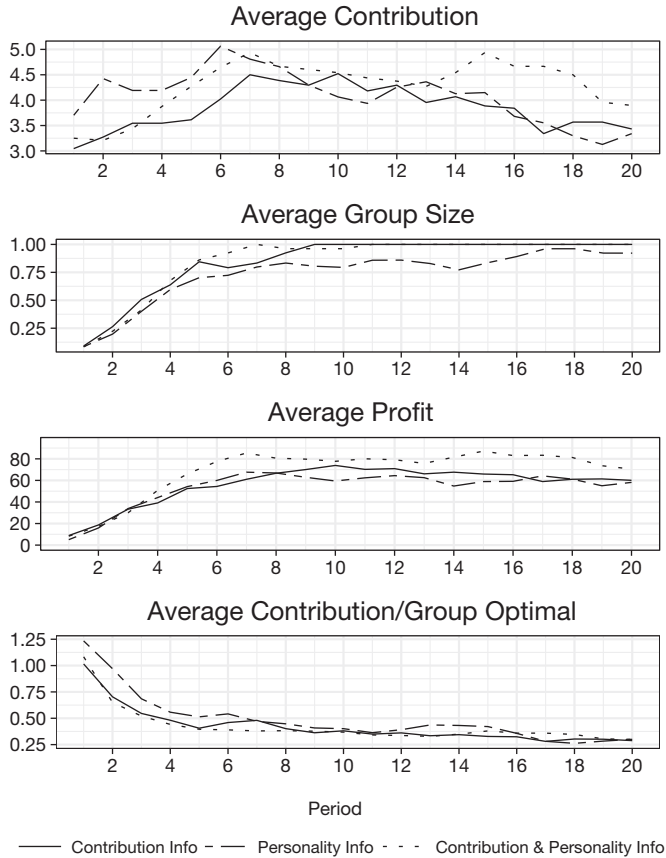
Figure 1. Heatmaps of contributions to the group account



The average contribution to the group account as a proportion of the optimal contribution for the group decreases between periods 1 and 10, and then is relatively flat until period 20. Given that participants begin each session in groups of size one and typically contribute at or above the stage-game dominant choice, the average proportion of the group optimal contributed to the group account begins at or above 1. The average proportion then decreases as the average contribution to the group account changes little over time and participants form increasingly larger groups (with larger group optimal contributions) until around period 10. Once the largest group forms around period 10 and stabilizes for the remaining periods, the average contribution to the group account as a proportion of the optimal contribution for the group also stabilizes. Overall, the average of each contribution to the group account as a proportion of the optimal contribution for the group was 0.43 in the baseline, 0.49 in *Personality Info*, and 0.42 in *Contribution and Personality Info* (all n.s.).

Finally, average earnings across conditions show a pattern similar to that for group size. As discussed in the design section, even if participants are contributing at the stage-game dominant level, larger groups will yield larger earnings, so the trends for the two should be similar. The apparent flattening out of the earnings curves supports that there was little variation in the average contributions to the group account across conditions once participants had formed the largest possible group. Overall average earnings were 56.67 ECUs in the baseline, 53.44 ECUs in *Personality Info*, and 68.44 ECUs in *Contribution and Personality Info*. According to rank-sum tests using sessions as the units of observation, significant differences exist between the baseline and *Contribution and Personality Info* ($p < 0.05$), and between *Personality Info* and *Contribution and Personality Info* ($p < 0.05$). However, no significant differences exist between the baseline and *Personality Info*.

Figure 2. Time trends for key variables



Personality and Contributions

Descriptive statistics for the personality trait measurements are presented in Table 2. Rank-sum tests yield no significant differences between conditions for any of the six traits. This suggests that systematic differences in responses to the personality inventory across conditions cannot be used to explain any differential behavior that is observed.

While the distribution and trend results provide some general insight into participants' behavior, this section presents regression results that are intended to better understand the relationship between personality and contributions. We implement a Bayesian multilevel model to analyze the relationship between a subject's personality traits and their contribution to the public good.¹⁶ Because we have multiple contribution decisions for each

16. A Bayesian approach permits estimation of the joint posterior distribution of all unknown parameters of interest simultaneously. The marginal distributions of the parameters can then be recovered to provide uncertainty intervals for the parameters. Estimation in a Bayesian framework

Table 2. Means and standard deviations of personality traits

Trait	Contribution Info	Personality Info	Contribution & Personality Info	All conditions
Honesty-Humility	3.18 (0.56)	3.09 (0.72)	3.31 (0.65)	3.19 (0.65)
Emotionality	3.34 (0.61)	3.22 (0.77)	3.34 (0.74)	3.30 (0.71)
Extraversion	3.34 (0.66)	3.48 (0.82)	3.32 (0.79)	3.38 (0.76)
Agreeableness	3.29 (0.49)	3.18 (0.77)	3.28 (0.68)	3.25 (0.66)
Conscientiousness	3.78 (0.59)	3.71 (0.66)	3.82 (0.62)	3.77 (0.78)
Openness to Experience	3.46 (0.73)	3.32 (0.78)	3.56 (0.78)	3.45 (0.77)
N	44	47	48	139

subject, and the subjects are clustered within sessions, we use subjects and sessions as our group levels.

We model a subject’s contribution decision as a series of 15 independent Bernoulli trials with a fixed probability of success. Because subjects were constrained to integer contributions between 0 and 15, this ensures that both fitted and predicted values of the contribution amount lie within the constraint (Wooldridge [2010]). The fixed probability of success is linked via the Logit function to the following predictors: a subject’s normalized personality trait scores, the number of periods a subject has spent in their current group, the size of a subject’s current group, a variable for period, an indicator variable for whether it is the endgame (period 18 or later), and interactions between each of the aforementioned variables and a categorical variable for condition. Varying intercepts for the subject and session are also included.

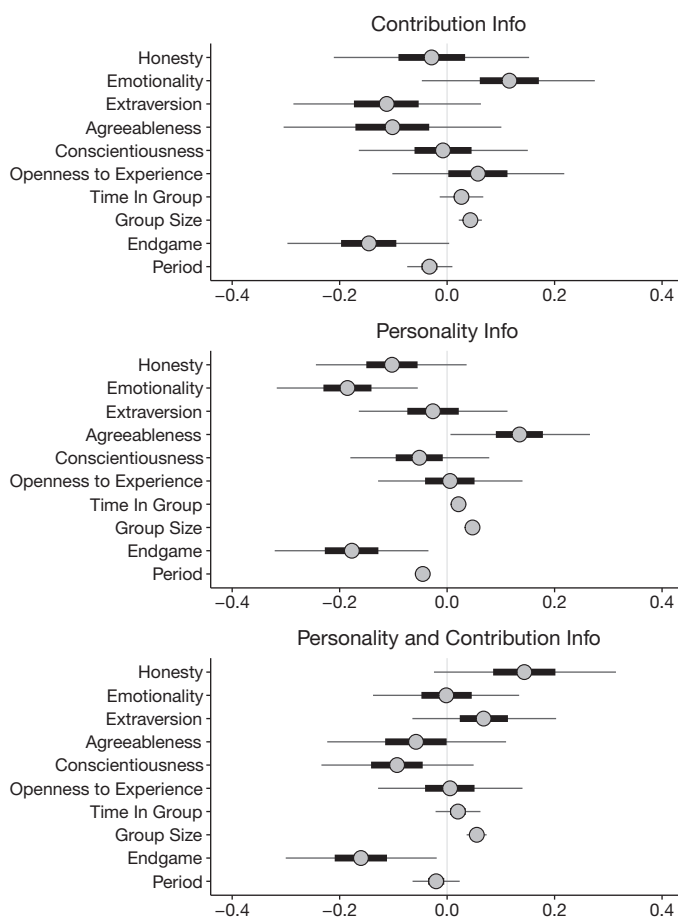
Figure 3 shows credible intervals for the marginal posterior distributions of the parameters according to condition.¹⁷

The marginal posterior distributions suggest differences in the relationship between a subject’s personality traits and expected contribution amount across conditions. In the conditions with contribution information available to subjects, zero is a plausible parameter value for all of the personality traits. Only when

requires specification of prior distributions for the parameters and a likelihood for the observed data, and is typically conducted via Markov Chain Monte Carlo simulation. We use a subset of Markov Chain Monte Carlo methods known as Hamiltonian Monte Carlo (HMC), which is well-suited to estimating multilevel models (Betancourt and Girolami [2015]), and implement it automatically using Stan (Stan Development Team, 2018) by way of the brms package (Bürkner [2017], [2018]) in R.

17. For all estimations, coefficients are given normal priors with mean 0 and standard deviation of 2, and the varying intercepts are given hierarchical normal priors with mean 0 and standard deviations estimated from the data. Parameter estimates are the result of 12,000 post-warm-up iterations of HMC across 4 chains. Chains were checked for convergence using \hat{R} , the ratio of the within-variance of the chains to the between-variance. If all of the chains have converged, \hat{R} should be close to 1; we accept $\hat{R} < 1.1$.

Figure 3. Posterior distributions for parameter estimates by condition



Note: The thinner lines represent 95% credible intervals, while the thicker lines represent 50% credible intervals. Circles represent posterior means.

personality information alone is available to subjects does 95% of the posterior probability mass lie to the left or right of zero for any of the personality traits. In particular, agreeableness has a reliably positive association, and emotionality a reliably negative one, with a subject's expected contribution. This finding is in line with Hypothesis 2, though we did not expect the information provided to a subject to have an effect on the relationship between their personality traits and contribution decision.

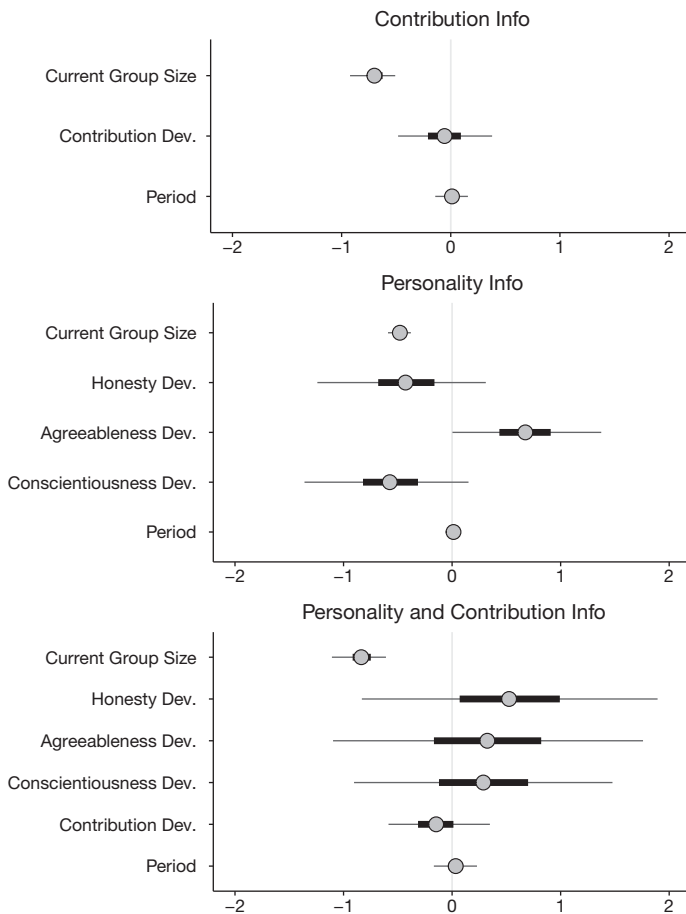
Across all conditions, the marginal posterior distributions are similar for group size, time in group, period, and the endgame indicator variable. The negative relationships between expected contribution and the period and endgame variables are consistent with the results of other public goods games in which contributions to the public good decrease over time and exhibit negative endgame effects. A positive relationship between group size and expected contribution may indicate that subjects recognize the potential value in increasing

contributions to the public good as group size increases, even if they do not quite approach optimal contributions for their group's size.

Group-change Decisions

Below we model a subject's decision to leave their current group, since in all but the final period, subjects can move to a new group if they so choose. To address the behavioral hypotheses mentioned earlier, we examine subjects' deviations from their group's average for previous-period contributions, honesty-humility, agreeableness, and conscientiousness where applicable. In all instances, the deviation is the group's average along a dimension minus the subject's value along the same dimension.

Figure 4. Posterior distributions for parameter estimates by condition



Note: The thinner lines represent 95% credible intervals, while the thicker lines represent 50% credible intervals. Circles represent posterior means.

Figure 4 shows the results of Bayesian multilevel logistic regressions for the decision to leave the current group for each condition. Predictors include group size and deviations along the aforementioned dimensions.

The credible intervals for the marginal posterior distributions of parameters indicate that, in the baseline, there is a reliably negative relationship between group size and choosing to move to a new group—that is, as the current group size increases, a subject is less likely to move to a new group. A reliably negative relationship between group size and choosing to switch groups also exists in the *Personality Info* and *Personality and Contribution Info* conditions.

Perhaps surprisingly, no reliable relationship exists between deviations from the previous-period average contribution and the decision to leave a group in any of the conditions where contribution information is present. This suggests that subjects who contribute above the group's average are not consistently more likely to move to a different group, nor are those who contribute below the group's average more likely to remain. This finding is inconsistent with Hypothesis 3a.

When only average personality information about a group is present, deviation from the group's average agreeableness score is reliably positively associated with the decision to move. So, subjects are more likely to leave their group the lower their agreeableness score is relative to the group's average. Likewise, subjects who are more agreeable than their groups on average are less likely to leave. This runs counter to Hypotheses 3b. Deviations from the average for the remaining personality traits do not appear to be reliably predictive in one direction or another.

When average personality information is present along with average contribution information, no reliable relationship exists between any of personality traits and the decision to leave a group. While this resembles the baseline, it is not in the manner we expected, since information about their contribution relative to the rest of their group does not appear to consistently sway subjects' decision in the direction predicted for the baseline.

DISCUSSION

Personality psychology has increasingly been applied to the study of economic games as a means of explaining differences in behavior. For group decision-making, agreeableness, conscientiousness, and honesty-humility have been found to correlate with behavior in various contexts. In this vein, we investigate the role of such traits in the formation of groups by conducting a public goods game in which participants can freely move between groups. We find that the relationship between personality traits and contributions to a public good depends critically on the information available to participants. Broadly, we find that economic information crowds out any effect of personality information.

When contribution information is absent and participants are informed of average personality profiles of all groups, the relationship between agreeableness and contributions is reliably positive, while that between emotionality and contributions is reliably negative. Under these circumstances, group size and deviation from the group's average agreeableness score appear to be factors in

the decision to leave a group, with the likelihood of leaving a group decreasing as group size increases, and increasing the farther below average the agreeableness score is. This latter relationship is consistent with the interpretation of agreeableness as reactive cooperation: given the positive association between agreeableness and contributions to the group account, the increased likelihood of remaining in a group for higher-than-average agreeable individuals may stem from a willingness to forgive less prosocial behavior.

In contrast, when contribution information is present, whether alone or alongside personality information, the marginal posterior distributions for all personality traits show that no relationship between traits and contributions is plausible, though the credibility assigned to positive and negative relationships varies between conditions for the traits. Participants are more likely to remain in a group as its size grows and no reliable association between deviations from the group's average contribution and the decision to leave the group exists.

One possible cause for the differential effect of information on personality's role in contribution to the group account and forming groups is that its influence may be strongest in environments that lack situational strength, in line with findings from psychology (Byrne [1971]; Montoya, Horton and Kirchner [2008]). Contribution information may provide salient cues that can guide behavior. For instance, the average contributions of other groups could give participants feedback about typical contributions to the group account and permit them to align their behavior with that of others, irrespective of their own personality traits. This may be why agreeableness is predictive of contributions in the *Personality Info* condition but not in any of the others: once agreeable individuals are informed of the average behavior of others and see that it differs little from the stage-game dominant choice, their tendency towards cooperation may be muted.

The research presented here joins other recent work in an initial attempt at incorporating measures from social psychology into the study of group formation in a public goods setting. As such, it is not without its limitations, two of which merit acknowledgement. First, it is natural to wonder how people would migrate between groups if no information were provided. Specifically, is it the type of information, or the mere presence of information, that is most impactful in group selection? While this would be an informative baseline comparison to our results, it was omitted here due to not quite fitting in with our interest in preferences for characteristics of group members. Additionally, it is a bit unnatural to think of moving groups without any knowledge about the new members, and our selected treatments reflect this by always providing information along some dimension. Even if information about the new members were provided, but less than what we provided in our baseline, we would be restricted to either including only indicators for which groups had members or including only group size information for each of the groups. The former is also unnatural and the latter has the potential to be leading. Nonetheless, it would be valuable to consider these scenarios in future research on group migration.

A second limitation may stem from our use of the AIS framework, in which forming the largest possible group is a dominant strategy. This strong incentive is likely to have diluted the impact of personality information, as practically all group movement stopped after period 10, by which time participants had formed the largest groups. Without this incentive, we may get a closer look

at how personality traits drive group formation by reducing the salience of the environment. Although we considered alternative environments, we like that the AIS design did not pose exogenous limits on group size. That we do still see some impact of agreeableness and emotionality is promising but warrants further study.

Placing restrictions on group entry may be the most fruitful next step. While this increases the complexity of the environment, as discussed earlier, the ability to limit entry to groups would allow participants greater control over their group members. Participants would still face financial incentives to form the largest group possible, but unlike in AIS, if participants only have access to personality information about incoming group members, they would not be able to use the entry mechanism to teach prospective members to increase their contributions. Insofar as participants desire to admit cooperative individuals to their groups, they would have to make inferences about cooperativeness based on personality traits alone.

Restricting entry to the group could then be built upon by changing the nature of the public good. Instead of a pure public good, participants could be made to contribute to one that is congestible. With a congestible public good, the return to members of a group could potentially decrease with each additional member unless contributions are sufficient to overcome the costs of congestion. Depending on the structure of the payoffs, achieving the optimal group outcome could require substantial contributions to the public good by its members. This would place even greater pressure on existing members to admit the most cooperative individuals, necessitating accurate inferences about which personality types are likely to be high contributors.

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