Essays on social preferences, competition and cooperation : an experimental approach

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**NANYANG
TECHNOLOGICAL
UNIVERSITY**

SINGAPORE

**ESSAYS ON SOCIAL PREFERENCES,
COMPETITION AND COOPERATION:
AN EXPERIMENTAL APPROACH**

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SCHOOL OF SOCIAL SCIENCES

2018

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ABSTRACT

"Man is a social animal and his choices are not rigidly bound to his own preferences only. An act of choice for this social animal is, in a fundamental sense, always a social act."

- Sen, Amartya (1973, pp.252-3)

Assuming that humans are only motivated by self-interests seems at odds with the fact that humans are not solitary beings. They interact with others, and in their social interactions they would often show concerns for others and (or) receive kindness from others. A variety of models that depart from the pursuit of self-interests assumption have been developed over the last few decades to incorporate individuals' concerns towards others. Examples of those models are social preferences models based on inequality aversion (Fehr and Schmidt 1999, Bolton and Ockenfels 2000), spitefulness and altruism (Levine 1998), and affinity towards others belonging to the same identity group (Akerlof and Kranton 2005, Chen and Li 2009, Bénabou and Tirole 2011). This thesis focuses on the evaluation of the impacts of group identity in competitive and cooperative setting (the first two chapters) and also on the mechanism to promote cooperation in a social context (the third chapter).

Specifically, in the following two chapters, we embed social identities into a variety of individual and group decision making environments. We apply the Minimal Group Paradigm (MGP), which is the standard identity inducement method used in a laboratory setting, in our analysis (see Tajfel and Turner (1979) and Chen and Li (2009) for further details on the MGP procedure). In particular, the first chapter establishes a framework with two-dimensional induced identities and focuses on how people allocate resources to others with multiple identity attributes. The second chapter adopts group Tullock rent-seeking contests with two prize sharing rules, namely the equal and the proportional sharing rules. The former refers to the case where the winning prize is divided equally among members of the winning group, while the latter refers to the case where it is divided proportionally to members' effort level. An equal sharing rule would encourage contestants to cooperate with other

group members, whereas a proportional sharing rule would heighten the competitive feeling among members. The second chapter investigates how the interplay between the identity compositions of contest groups and the sharing rules influences cooperation and competition among contestants.

The Tullock rent-seeking group contest under the equal sharing rule has a similar incentive structure akin to the one found in the public goods games. Public good games capture a classic social dilemma in which there is a conflict between self and collective interests (see Ledyard (1995) for a literature survey on public goods games). In such a game, theoretically it is better if everyone cooperates by making full contribution, but it is not achievable because individuals would face strong temptation to free-ride on others (Fischbacher, Gächter et al. 2001).

Literature has focused on various mechanisms that can be employed to boost individual contribution. They are, for examples a peer-to-peer (second party) punishment (Ostrom, Walker et al. 1992, Fehr and Gächter 2000, Fehr and Gächter 2002, Cason and Gangadharan 2015), third-party punishment (Fehr and Fischbacher 2004, Carpenter and Matthews 2012), and a centralized punishment system (Andreoni and Gee 2012). The centralized punishment system is widely found in the modern society as some delegated or appointed parties to monitor people's behaviors, such as government officials, boards of directors, and church elders, but there are only few research studies which focus on that (Putterman, Tyran et al. 2011, Kamei, Putterman et al. 2015, DeAngelo and Gee. 2017). The third chapter intends to delve further into the role of centralized punishment in increasing contribution in a public goods setting.

The detailed abstracts of each chapter are presented below.

The first chapter reports findings from a laboratory experiment eliciting two-dimensional social identities: a horizontal identity determined either randomly or by preferences and a vertical identity defined by income status and determined either by luck or performance. We also vary income gaps between vertical identity groups. Participants make allocation decisions between two others differing in identity attributes. We find robust evidence of in-group favoritism and that both the identity

distance between the allocator and the in-group recipient and income gaps influence the degree of in-group favoritism.

The second chapter aims to delve further into the role of within- and between-group identity diversity in influencing individual behaviors in a team competition. We model the team competition as a Tullock rent-seeking group-contest. We apply the Minimal Group Paradigm (MGP) to induce group identity in a lab setting. We are interested in evaluating: 1) how a within-team identity diversity influences individuals' effort decisions, 2) how the identity composition of an opponent team influences individuals' effort decisions, and 3) how the identity effect interacts with the prize-sharing rule employed in the competition. We find that a homogenous team yields intra-team cooperation, while the within-team identity diversity escalates competitiveness among the team members. Additionally, for those competing teams sharing a common identity, a sense of rivalry between the competing teams is largely eroded.

The third chapter evaluates the role of centralized punishment in promoting collective cooperation to provide public goods. To avoid the race to the bottom in the provision of public goods, this centralized punishment mechanism relies on the use of the unilateral and tie punishment imposed on the lowest contributor(s). In this paper, we aim to examine how severe this unilateral and tie punishment should be to achieve the full-contribution equilibrium. Specifically, we are interested in investigating the size of the punishments that should be meted on the lowest contributor(s). We theoretically derive a range of punishment mechanisms which would lead to full contribution and put them into experimental test. Our results generally substantiate the theoretical predictions except for the more lenient punishment parameters. This discrepancy is successfully explained by individual evolutionary learning.

Chapter 1 Multidimensional Group Identity: An

Experimental Study

1.1 Introduction

Social identity is a person's sense of self in her social surrounding derived from her association with groups, e.g. family, clan, social class, sport club, gender, race group and many others (Tajfel and Turner 1979). Social identity makes a person sees herself differently from others belonging to different social groups. It induces her to view the world dichotomously from the perspective of in-group and out-group. Social identity can either have desirable or undesirable impacts. For example, in a workplace setting, working together with people of the same identity can boost morale and induce higher collective effort, making it less necessary for the principal to provide high wages to elicit high effort (Akerlof and Kranton 2000, Akerlof and Kranton 2005). However, when viewed from the perspective of an identity diverse organization, the presence of strong identity attachment among heterogeneous groups may also reduce the efficiency of the organization, especially when the inter-group conflict arises within the organization (Heap and Zizzo 2009).

Akerlof and Kranton (2000, 2005) were the first to explore the role of social identity in influencing economic outcomes through the lens of economic analysis. Their seminal work sparked interests among experimental economists to explore the role of social identity in influencing a host of behaviors in various economic settings. The most common method to induce and manipulate social identity in a controlled laboratory experimental setting is the Minimal Group Paradigm (MGP), a standard method borrowed from the field of social psychology (Tajfel and Turner 1979). Under this method, experimental subjects were allocated into two groups based on their preferences over seemingly identical abstract paintings by renowned abstract painters, Paul Klee and Wassily Kandinsky. In order to control for the influence of people's normative view on their in-group members and out-group members based on natural

identities developed throughout their social life, any meaningful social distinctions between subjects, such as social ties, gender, race, and other social traits, were removed from the experiment. The only remaining factor that distinguishes people is their group membership. Chen and Li (2009) followed closely this MGP procedure and evaluated the effect of minimal group categorization on subjects' social preferences through investigating the subjects' allocation of resources. They showed that individuals tend to be more generous towards an in-group member than an out-group member. This demonstrates that the presence of minimal and somewhat meaningless group classification was sufficient to generate in-group favoritism.

Other notable works that investigate the role of social identity in various social interaction settings ranging from competition, coalition formation, to cooperation in social dilemma settings include Charness, Rigotti et al. (2007), Akerlof and Kranton (2008), Benjamin, Choi et al. (2010), Tremewan (2010), Guala, Mittone et al. (2013), and Charness, Cobo-Reyes et al. (2014). These papers generally established that social identity promotes cooperation within in-group and intensifies inter-group competition. More recently, Chen and Chen (2011) and Chen, Li et al. (2014) showed the important role of social identity as a focal coordination device for players to synchronize their action towards a particular equilibrium in a strategic setting involving multiple equilibria. They showed that similarity in group-identity helps people coordinate on Pareto dominant outcomes.

It should be noted, however, studies on the link between group identity and social preferences typically only consider a single dimension of group identity. That is, in the context of the MGP experiment, the dimension that distinguishes people is the group membership based on painting preferences. In reality, however, people differ from each other by more than one identity attribute. For example, two individuals who are members of the same hobby club may come from different racial backgrounds or social classes. Our paper departs from one dimensional group-identity setting to a multi-dimensional group identity setting. It seeks to shed some lights on the interplay between the multi-dimensional group-identity and social preferences.

Specifically, in this paper, we focus our attention on two group-identity attributes that we coin as, respectively, the *horizontal* and *vertical* identity. We define the former as the group identity that does not carry any hierarchical social distinction. Examples of this in real life include ethnic identity and the membership to a political party. To elicit the horizontal identity attribute, we group subjects using Klee's and Kandinsky's paintings in line with the standard MGP procedure. We argue that the MGP procedure is useful to induce group identity that does not carry any social stratification.

The vertical identity, on the other hand, embodies an explicit social stratification. Although examples of social stratification abound including the caste system in India and the old apartheid system in South Africa, the income-based social status is the vertical identity we focus in this paper. To induce the vertical group identity, we group subjects into the *high* and *low* income group. The presence of the vertical group identity, essentially, embeds hierarchical social distinction into otherwise identical subjects sharing the same horizontal identity attribute. It also allows us to evaluate how social structure interacts with the in-group favoritism that is typically shown to exist in studies using the MGP procedure. To sum-up, we have a setting where social class structure exists even among people who are members of the same group. A real life example that depicts this setting would be people who come from the same ethnic group or the same political affiliation but differ in their economic status.

Several interesting points emerge when we depart from the single-dimensional group-identity setting to the two-dimensional group-identity setting like the one we focus in this paper. *First*, the definition of in-group becomes more nuanced. In the former, an in-group member is defined as someone who belongs to the same group affiliation. In contrast, in the latter, the definition of an in-group member is based on the relative similarity. We define a person's in-group member as someone who has relatively closer identity attributes to him (her) than someone else. The definition thus embodies the notion of '*identity distance*', and gives rise to an interesting question as to how the degree of in-group favoritism would vary with the identity distance.

Second, because in our setup we have two dimensions of identity, e.g. the horizontal and vertical dimensions, the strength of in-group favoritism when the in-group notion is based on the horizontal dimension (meaning that a person's in-group member shares the same horizontal identity with her) may be different from the strength of in-group favoritism when the in-group notion is based on the vertical dimension. The horizontal dimension, which is elicited using the MGP procedure, represents the standard in-group favoritism found in the literature. The vertical dimension, on the other hand, represents the social-stratification based in-group favoritism. Thus, in our two-dimensional identity setup, the robustness of the in-group favoritism result obtained in the existing studies employing the MGP procedure can be further evaluated.

Third, our setup also allows us to evaluate the manner with which identity is acquired. In reality, social identity can either emerge naturally or through conscious effort or deliberate choice. The horizontal identity can be obtained either through *nature* or through *choice*. Ethnic background is an example of the horizontal identity obtained through nature beyond one's control, while membership to a hobby club is an example of the horizontal identity obtained through choice. The vertical identity can be obtained either through *luck* or through *effort*. That is, someone can become rich either because of inheritance or hard work. The way income (social) status is determined, that is either by luck or through effort, has been shown to influence individuals's demand for and supply of redistribution (Piketty 1995, Fong 2001, Alesina and La Ferrara 2005, Denant-Boemont, Masclet et al. 2007).

In a nutshell our experimental design and procedure can be explained as follows. The horizontal identity that is acquired by choice was elicited using the standard MGP procedure whereby subjects must indicate their painting preferences. The one that is acquired by nature was randomly assigned to participants in the following manner. These participants were also shown the abstract paintings by Klee and Kandinsky; however instead of being asked to express their choice over those paintings, they were simply randomly assigned to either Klee or Kandinsky group. The vertical identity that is acquired by performance was elicited through a real effort

task involving summing a series of single digit numbers. Subjects were grouped into the high and low income groups based on their performance on the task. The vertical identity that is acquired by chance was simply generated by a random allocation of subjects into the high and low income groups. We also varied the level of income gap between the rich and the poor, and by doing so we would be able to investigate the *fourth* point on how the degree of in-group favoritism varies with the income inequality between the rich and poor groups.

After the above identity elicitation procedure is completed, each subject will be endowed with a two-dimensional identity. To make the horizontal identity more salient, in some treatments, after the identity elicitation procedure was completed, we required participants who had already been grouped into either the Klee or the Kandinsky group to engage in a group task requiring the group to solve a series of spot-the-differences puzzles. This was done to enhance their sense of horizontal identity. In other treatments, we enhance the vertical identity in a similar fashion.

Subsequently, we moved on to the main part of the experiment where we asked subjects to engage in a series of allocation decisions to two other individuals from, respectively, their in-group and out-group. In each of the allocation decisions, the two beneficiaries always differ in one dimension of identity, and the in-group beneficiary is the one closer to the allocator than the other one, in terms of identity attributes. Due to the two-dimensional identity framework, the in-group beneficiaries are categorized into two types according to whether their in-group association to the allocators are defined over absolute or relative identity similarity. The first type is an absolute in-group beneficiary who share exactly the same set of identity attributes as the allocator, while the second one is a relative in-group beneficiary who only shares one identity attribute with the allocator. Because the allocation decisions made were never between oneself and another person, we removed the self-interest consideration and this allowed us to focus on the in-group favoritism. (Deffains, Espinosa et al. 2016) define the supply of redistribution as individuals' preferences for redistribution when their well-being is not directly influenced by the redistribution. According to this definition, in our experiment, the allocation decisions the subjects made reflect their

preference over the supply of redistribution. In reality, government officials decide on transfer payments made to people from various social groups. One natural question to emerge is whether or not government officials would make impartial transfer decisions regardless of the social background of the beneficiaries. Our experiment's framework can be interpreted as a setting whereby subjects assume the role of a social planner who has to make a redistributive transfer to two groups with differing identity attributes.¹

Several interesting results emerge from our analysis. *First*, in general the evidence of favoritism shown by subjects to their in group fellows existed regardless whether the in-group association is defined over exact/ absolute or relative identity similarity with the allocator, and regardless of whether the two recipients differ in the horizontal or vertical identity dimension. This result shows the robustness of the standard in-group favoritism result in one dimensional identity setting to our more realistic multi-dimensional identity setting. *Second*, we found that the degree of in-group favoritism shown by subjects when the in-group categorization was defined on the basis of the absolute similarity in both identity attributes was stronger than that when the in-group categorization was defined on the basis of relative similarity in identity attributes. Thus, the degree of in-group favoritism was negatively correlated to the identity distance. *Third*, the degree of in-group favoritism seems to be stable and robust to the way the group differences, including the income inequality, were generated. *Fourth*, despite being favorable towards the in-groups, the allocators exhibit certain degree of fairness concern when making allocation decisions between two recipients with distinct income levels. Moreover, the poor allocators responded to the worsening income gap by giving more to their poor in-groups while the rich allocators are unresponsive to it. *Finally*, the inequalities along the vertical dimension have a spill-over effect on the horizontal identity. In particular, the in-group bonds seem to be stronger within the horizontal groups when income gaps between the vertical groups are worsening.

¹ It is perhaps worth noting that Deffains, Espinosa and Thoni (2016) only investigates the supply of redistribution to two beneficiaries with differing income status; a wealthy individual and a poor. Unlike our paper, they do not investigate the role of social identities and in-group favoritism.

A couple of recent papers investigate multi-dimensional identity too. Chen, Li et al. (2014) shed light on the effects of a common (school) identity versus a fragmenting (ethnic) identity on behaviors in variants of Prisoners' Dilemma games and minimum-effort games with strategy method and different incentive structures. In particular, they find that priming a common identity leads to a choice of maximizing total welfare in the sequential Prisoners' Dilemma games, while priming a fragmenting identity reduces efficient coordination in the sequential minimum-effort games. Kranton, Pease et al. (2016) (also conducted experiments with two types of identities, i.e. political group identities and the artificial group identities based on preferences on paintings. They find social-welfare destructing behavior toward the out-group subjects, especially for Democrats and Republicans compared to Independents. Both papers prime existing social identities that are associated with idiosyncratic norms or cultures. Moreover, none of the multi-dimensional identities studied in Chen, Li et al. (2014) and Kranton, Pease et al. (2016) entails hierarchical meanings, while we consider both horizontal group identities as well as vertical group identities in our experiment. Relatedly, Klor and Shayo (2010) combine existing social identities with differentiated income levels generated in the laboratory and study redistributive preferences. They find that a significant subset of the subjects choose the tax rates that benefit their in-group members. While in their study the subject's choice on redistributive policies affects own income, we focus on other-other allocations to single out other regarding preferences and in-group favoritism from self-interested concerns. They do not investigate alternative ways of generating group differences either.

The paper is organized as follows. Section 1.2 outlines our experimental design and procedures. Section 1.3 presents the experimental results. Section 1.4 concludes the paper.

1.2 Experimental Design and Procedure

Our experiment consists of 3 stages: 1) *Identity Inducement*, 2) *Identity Enhancement* and 3) *Token Allocation*, respectively. In the first stage, we induce horizontal and vertical identity attributes for each subject. The horizontal identity attribute is determined either by subjects' preferences over abstract paintings in line with the procedure adopted by Chen and Li (2009) or by chance. The vertical identity attribute is either determined by Chen and Li (2009) by subjects' performance in a simple real-effort task or assigned randomly. There are two vertical identity attributes associated with high and low endowment tokens respectively. In the second stage, subjects sharing either the same horizontal identity attribute or the same vertical identity attribute play a team task. This task is intended to enhance the bond among members of the same team. We do not provide any monetary incentives in this group task in order not to invoke any reciprocal motive that could influence giving behavior in the subsequent token allocation stage. We will explain later why it is important for us to turn off reciprocal incentive in the token allocation stage. Only one dimension of identity (either the horizontal or the vertical identity) is enhanced under this team-building mechanism. In the last stage, which is the main stage of our experiment, each subject makes allocations to two other subjects.

We have 6 treatments, which differ from each other in the first two stages; 1) Random_Random_KK, 2) Random_Random_XY, 3) Choice_Random_KK, 4) Choice_Random_XY, 5) Random_Performance_KK, and 6) Random_Performance_XY. The first word ("Random" or "Choice") of the treatment-name string indicates whether the horizontal identity attribute is determined by *chance* or by the subject's *choice* of preferred paintings; the second word ("Random" or "Performance") in the treatment-name string indicates whether the vertical identity attribute is determined by *luck* or by *performance* in the real-effort task; "KK" or "XY" in the end indicates whether the horizontal or vertical group identity is enhanced in the second stage. In the next sub-sections we explain the details of the three stages. In the meantime, the first two stages for each of the six treatments are

summarized in the following table. A sample of experimental instructions (for Treatment Random_Performance_KK) is presented in the appendix.

Table 1.1. Summary of Treatments

Treatment	Identity Assignment		
	Horizontal Identity	Vertical Identity	Identity Enhanced
Random_Random_KK	Randomly	Randomly	Horizontal
Random_Random_XY	Randomly	Randomly	Vertical
Choice_Random_KK	By Choice	Randomly	Horizontal
Choice_Random_XY	By Choice	Randomly	Vertical
Random_Performance_KK	Randomly	By Performance	Horizontal
Random_Performance_XY	Randomly	By Performance	Vertical

1.2.1 Stage 1: Identity Inducement

There are two steps in this stage, through which we elicit subjects' horizontal and vertical group identity attributes respectively.

Inducement of Horizontal Identity Attributes

In the first step, we elicited subjects' horizontal identity attributes in line with the MGP procedure done in Chen and Li (2009). Subjects reviewed seven pairs of abstract paintings successively, with one painted by Paul Klee and the other by Wassily Kandinsky in each pair. The first two pairs were shown with the information about the artists, years of completion and names of the paintings. For the last five pairs, without being told the above mentioned information, each subject in treatments Choice_Random_KK and Choice_Random_XY was asked to choose which painting in each pair she preferred. After the subjects made their choices, half of the subjects who preferred relatively more paintings of Paul Klee were grouped to "Team Klee" and the rest who preferred relatively more paintings of Wassily Kandinsky were

grouped to “Team Kandinsky”.² In case of a tie, the team membership was determined randomly to ensure that each team had the same number of members.³

In the other 4 treatments, the team membership was determined randomly. Specifically, in these treatments, subjects reviewed the same seven pairs of paintings as in treatments Choice_Random_KK and Choice_Random_XY, with the relevant information on the artists etc. provided in the first two pairs but not in the other pairs. The only difference is that subjects were not asked to indicate their preferences and after all the pairs of paintings were shown to them, half of the subjects were randomly assigned to Team Klee and the others to Team Kandinsky.

Inducement of Vertical Identity Attributes

In the second step of Stage 1, subjects in treatments Random_Performance_KK and Random_Performance_XY were asked to participate in a real effort task individually. This contains questions requiring subjects to sum up a sequence of numbers, such as “4 + 3 + 5 + 7 + 7”. The subject could not proceed to the next question until she answered the current question correctly. Each subject was given 90 seconds to complete as many questions as she can.⁴ After the allotted time ended, one half of subjects with better performances were grouped into Group X and the other half into Group Y. In case of a tie, the group membership was assigned randomly in such a way that the two groups always had the same size. In the other 4 treatments, one half of subjects were randomly assigned to Group X while the other half to Group Y.

² For the grouping based on the horizontal dimension we use “team” rather than “group” to label different horizontal identity attributes. We will use “group” rather than “team” in labeling vertical identity attributes to avoid confusion.

³ Note that the grouping is based on relative preferences. A member in Team Klee might prefer more paintings from Kandinsky than from Klee. She is assigned to Team Klee because she prefers relatively more Klee’s paintings than those in the Team Kandinsky. Kandinsky. However, subjects were not told how many Klee’s or Kandinsky’s paintings they had chosen. They were only informed of their own team membership after the choice of paintings.

⁴ On average a subject completed 13.55 questions within the 90 seconds. The best subject completed 23 questions correctly.

The membership in Group X or Y indicates the vertical identity attribute with higher or lower income status respectively. As shown in Table 1.2, we vary the income gaps ($X - Y$) into 4 possible scenarios, each occurring with equal probability. The first row shows in each scenario the income of a Group X member while the second row indicates the income of a Group Y member.⁵ Group X members (“the rich”) always have higher income than Group Y members (“the poor”), no matter which scenario of income gap they are in. While the average income is always equal to 150 tokens across the four scenarios, as we move from the first scenario to the latter, the inequality increases. Thus, we preserve the mean income but let the standard deviation of income varies. One of these scenarios will be randomly selected as the binding scenario to determine subjects’ earning from the experiment at the end of the experiment.

Table 1.2. Four Possible Income Gap Scenarios

Group	Scenario 1	Scenario 2	Scenario 3	Scenario 4
X	175	200	225	250
Y	125	100	75	50

At the end of Stage 1, subjects were informed of their own pair of the horizontal team identity and vertical group identity individually, without knowing others’ group identity attributes or preferences over the paintings or performances in the real-effort task. Because there are 2 identity attributes (horizontal and vertical), each of the subjects thus belongs to one of the following 4 identity combinations:

1. Team Klee & Group X
2. Team Klee & Group Y
3. Team Kandinsky & Group X

⁵ Throughout our experiment, income is expressed in terms of experimental tokens. At the conclusion of the experiment, the total experimental tokens earned are converted into the Singapore Dollars equivalent based on our conversion rate.

4. Team Kandinsky & Group Y.

For each subject, the identity attributes remained the same throughout this experiment. Overall, for the identity inducement stage, we employ a combination of within-subject and between-subject design. The within-subject design is done through exposing all the four possible income gap scenarios to the subjects under each of which they will be asked to make allocation decisions. The between-subject design is done through the assignments of the horizontal and vertical identity attributes. Treatments with names starting with “Random_Random” are baseline treatments where both identity attributes are elicited in a random way.

By comparing treatments with names starting with “Choice_Random” with “Random_Random” , we would be able to examine, holding all else equal, whether the horizontal identity assignment method influences the subjects’ decisions in the allocation stage. Likewise, by comparing treatments with names starting with “Random_Performance” with “ Random_Random” , we would be able to examine, holding all else equal, whether the vertical identity assignment method influences the subjects’ decisions.

1.2.2 Stage 2: Identity Enhancement

Eckel and Grossman (2005) and Chen and Li (2009) argue for the importance of team building in identity experimental design. They recommended to adopt a group task of achieving a common goal among group members, to enhance group identifications. In view of this argument, we incorporated a stage of identity enhancement in which subjects played a team-building group task, after the identity inducement stage. To investigate the potential effect of identity enhancement, we vary the dimension of identity attributes to be enhanced. In stage 2 of our experiment, in treatments with names ending with “KK” (i.e. Random_Random_KK, Choice_Random_KK, and Random_Performance_KK), subjects sharing the same horizontal identity attribute worked together on a task; that is, members in Team Klee worked together on this group task, with members in Team Kandinsky also working on the same task within their Team Kandinsky. Similarly, in the other 3 treatments with names ending with

“XY” , subjects worked with their group (either Group *X* or *Y*) members on the task. We thus have the 3×2 between-subject design as shown in Table 1.1.

Figure 1.1. Screenshot of a "Spot-the-Difference" Puzzle

Specifically, in the group task, subjects belonging to the same team (group) must work collectively to solve a sequence of four spot-the-differences puzzles. For each of these puzzles, teams (groups) were given two very similar pictures and asked to spot the differences between the two pictures within a time limit. Subjects were also allowed to chat with their team (group) mates via an online chat box. The chats were only visible to their own team (group) members. A screenshot of such a puzzle is shown in Figure 1.1. For each of these puzzles, a team (group) member was randomly selected as the team (group) representative to submit the team’s (group’s) answer on behalf of the entire team (group). After completing each puzzle, subjects would be able to verify whether their team’s (group’s) answer was correct.

We opted not to incentivize this identity enhancement stage in order to eliminate any reciprocity motive from the allocation decisions that subjects would make in the subsequent stage. If we would have given them a group incentive so that team (group) members worked together and helped each other to earn money in solving the puzzles, the subjects might reciprocate their (team) group members in the subsequent allocation stage therefore biasing our results. The reciprocity motive could

potentially be a confounding factor that would prevent us from having a clean investigation on how token allocations would be affected by group identities.

1.2.3 Stage 3: Allocation of Tokens

The third stage, which is common in all treatments, is the main stage of our experiment. In this stage, we seek to identify the effects of group identity attributes on subjects' other-regarding preferences. We employ the strategy method to elicit subjects' preferences under those four scenarios of income gaps summarized in Table 1.2. Under each scenario, subjects were asked to make four allocation decisions to two other (anonymous) subjects with various identity configurations. For each allocation decision, the subjects were asked to allocate 100 extra tokens, on top of their tokens determined by their vertical identity attribute, between the two beneficiaries. This allocation decision, thus, would not have any affect on the allocator's earnings. The allocation should be made in integer numbers. We focus on the subjects' allocation decisions to two other subjects with the followings identity configurations (see Table 1.3).

Table 1.3. The Beneficiaries of the Allocation Decisions		
The Beneficiaries of the Allocation Decisions		
Decision No.	Beneficiary 1	Beneficiary 2
1	(Klee & Group X)	(Klee & Group Y)
2	(Klee & Group X)	(Kandinsky & Group X)
3	(Klee & Group Y)	(Kandinsky & Group Y)
4	(Kandinsky & Group X)	(Kandinsky & Group Y)

Some explanations are in order. In each of the four allocation decisions, the two beneficiaries differ only in one identity attribute (either the horizontal or the vertical one). The summary presented in Table 3 shows that decisions number 1 and 4 involve two beneficiaries differing only in the vertical identity (one is *X* and the other one is *Y*), and decisions number 2 and 3 involve two beneficiaries differing only in the horizontal identity (one is Klee and the other one is Kandinsky). Given any particular identity combination of the allocator, one of the two beneficiaries will thus be always closer to the allocator in terms of identity combination than the other. For instance,

suppose that the allocator’s identity combination is (Klee & Group X). In this case, Beneficiary 1 is always closer to the allocator than Beneficiary 2. That is, in allocation decision 1, Beneficiary 1 has exactly the same set of identities as the allocator, while Beneficiary 2 differs from the allocator in the vertical identity. In allocation decision 4, Beneficiary 1 differs from the allocator in the horizontal identity, while Beneficiary 2 differs from the allocator in both identity attributes. We coin the extent of identity similarity between the allocator and beneficiary 1 as the degree of *identity distance*.⁶ Further explanation on our notion of identity distance can be found later in our subsequent section. All in all, subjects must therefore make 16 allocation decisions, because there are 4 allocation decisions that they must make under each of the 4 income-gap ($X - Y$) scenarios depicted in Table 1.2.

After all allocation decisions were made, one of the four income-gap scenarios was randomly selected to be the binding income-gap scenario to determine subjects’ earning from the experiment. In particular, a subject’s earning was set equal to the sum of her income, which was equal to the value of the endowment, that is either X or Y in the binding scenario, and the average amount of tokens allocated by other subjects in the relevant allocation decisions.

To illustrate the meaning of the relevant allocation decisions, consider the following example of a subject with (Klee & Group X) identity configuration. The relevant allocation decisions for this subject would be the allocation decisions made by all of the other subjects to someone with (Klee & Group X) identity configuration. If we examine Table 1.3, the relevant decisions for this subject would be allocation decisions 1 and 2, i.e. two out of the four available allocation decisions. We have N subjects, and all of them would have to make allocation decisions 1 and 2 for the binding income-gap scenario.

⁶ Note that the comparisons can also be made for settings where the two beneficiaries differ in both identity attributes rather than only one like the one in our setup. There are four of such settings. Incorporating these settings would require us to run many more experimental sessions without any guarantee of new insights beyond those presented in this paper. We therefore opted to exclude such comparisons in this paper.

Formally, the final income of subject i who has (W, Z) identity configuration, with $W \in \{\text{Klee, Kandinsky}\}$ and $Z \in \{X, Y\}$, can be expressed as

$$\Pi_i(W, Z) = Z_i + \frac{\sum_{j \neq i} \text{Both Allocation to } (W \& Z)}{2(N-1)}, \quad (1)$$

where $\sum_{j \neq i} \text{Both Allocation to } (W \& Z)$ is the sum of other subjects' allocation to a person with the same $(W \& Z)$ identity configuration as subject i in the two relevant decisions under the binding income gap scenario. Subjects were informed about the payment scheme before making their allocation decisions.

1.2.4 Experimental Procedure

The experiment was conducted at Nanyang Technological University in September 2014. Subjects were undergraduate students with Economics and Business, Engineering, Science, Social Science, and Humanities majors. Overall we had 128 subjects randomly assigned to 6 experimental sessions; one session for each treatment. Table 1.4 below presents the breakdown of subjects across all treatments.⁷ Each subject was only allowed to participate once. The experiment lasted for about one hour. Each subject made 16 allocation decisions, involving 4 allocation decisions (see Table 3) for each of the 4 income-gap scenarios (see Table 1.2). Thus, we had $128 \times 16 = 2048$ observations of allocation decisions. The experiment was programmed and conducted using z-Tree (Fischbacher 2007).

Once subjects were seated in the lab, they were given experimental materials that include experimental instructions, a participant information sheet and a consent form. We then read the instructions aloud. Before the experiment began, we gave the

⁷ In most of the treatments, the ratio of male subjects is close or equal to $\frac{1}{2}$. One exception is Treatment Choice_Random_XY, where we have more female subjects (17) than male (7). However, our estimation of any treatment variable will not depend on any single treatment. For instance, to investigate the effect of identity enhancement at the horizontal dimension versus that done at the vertical dimension, we can compare Treatment Choice_Random_KK with Choice_Random_XY, Treatment Random_Performance_KK with Random_Performance_XY, or Treatment Random_Random_KK with Treatment Random_Random_XY. Thus, the high ratio of female subjects in Treatment Choice_Random_XY is unlikely to confound our estimation of treatment effects.

participants an opportunity to ask questions if there were parts of the instructions that were not clear to them. We attended to these questions in private.

The tokens the subjects earned were converted to Singapore Dollars with the conversion rate of 12 tokens = S\$1. In addition to the earning they obtained from the experiment, subjects also received S\$3 show-up fee. On average, subjects earned S\$19.46, which was roughly equivalent to US\$ 14.20 at the time of the experiment. They were paid in private at the end of the experiment.

Table 1.4. Distribution of Subjects across Treatments

	Treatment	N	%Female
1	Random_Random_KK	24	41.6%
2	Random_Random_XY	24	70.8%
3	Choice_Random_KK	18	50.0%
4	Choice_Random_XY	20	40.0%
5	Random_Performance_KK	22	45.5%
6	Random_Performance_XY	20	50.0%
	Overall	128	50.0%

1.3 Experimental Results

In this section, we focus our analysis on how allocators allocated the 100 extra tokens to two recipients (Beneficiary 1 and Beneficiary 2).

1.3.1 The Definition of In-Group and Out-Group Member

Recall that in any allocation decision, one of the two recipients would be closer in terms of identity similarity to the allocator than the other. We thus call the recipient with identity attributes closer to the allocator an *in-group member* of the allocator, and the other recipient an *out-group member*, throughout this paper.

The following example clarifies our definition. Suppose that the allocator is a rich (X) member of Team Klee, i.e. (Klee & Group X), and the allocation decision made is allocation Decision 1 shown in Table 1.3. The two recipients (Beneficiary 1 and Beneficiary 2) are, respectively, a rich (X) member of Team Klee (Klee & Group

X) and a poor (Y) member of Team Klee (Klee & Group Y). By our definition, Beneficiary 1 is classified as an (absolute) in-group member of the allocator, while Beneficiary 2 is classified as an out-group member of the allocator, even though she has the same horizontal identity (Team Klee) as the allocator. We thus say the allocation decision is made over the vertical dimension between a rich and a poor individual who are both members of Team Klee. Next, in allocation Decision 3 shown in Table 3, the two recipients (Beneficiary 1 and Beneficiary 2) are, respectively, a poor member of Team Klee (Klee & Group Y) and a poor member of Team Kandinsky (Kandinsky & Group Y). By our definition, Beneficiary 1 is classified as the allocator's (relative) in-group member. She shares the same horizontal identity (Team Klee) with the allocator. Beneficiary 2 is classified as the allocator's out-group member as she bears no identity resemblance to the allocator. We thus say the allocation decision is made over the horizontal dimension between a member of Team Klee and a member of Team Kandinsky who are both poor.

1.3.2 The In-Group Favoritism in General

It should be noted that more tokens allocated to an in-group implies less tokens available for an out-group because the sum of tokens is always equal to 100 points. The tokens received by the in-group thus measure the allocator's *degree of in-group favoritism*. In a setting with one dimensional identity attribute elicited using the MGP procedure, Chen and Li (2009) demonstrated that there exists an in-group favoritism, by which subjects make more favorable decisions towards those sharing the same identity attribute as themselves. In our setting, we have two identity attributes, the horizontal and vertical identity, and we have defined in-group members in the above manner. According to this definition, an in-group recipient may not have exactly the same identity attributes as the allocator, but is closer to the allocator than the other recipient in one dimension of the identity attributes. This raises a question as to whether or not the in-group favoritism as shown in Chen and Li (2009) is robust to our definition of in-group members and the dimension of the identity attribute used to define in-group, in our multi-dimensional identity setting.

To answer this question, we first looked at the aggregated data on allocation of tokens to an in-group member. We found that around 70.36% of all allocation decisions favored the in-group recipients by giving the in-group more tokens than the out-group. Around 9.28% of all allocation decisions involve giving the entire 100 tokens to in-group recipients. Overall, about 65% of the tokens were allocated to the in-group recipients while only around 35% of the available tokens went to out-group recipients. We then conducted the following non-parametric test. We calculated the average allocated tokens to the in-group for each subject, and then ran the two-sided Wilcoxon signed-rank test on the subject-averaged allocation for each session. Throughout our analysis, other non-parametric tests will be conducted in a similar way. We found that in all treatments, in-group allocations are significantly higher than 50, the fair allocation of the 100 tokens (p -value < 0.1 for Treatment Random_Random_XY; p -values < 0.01 for all the other treatments).

1.3.3 The Allocation Decisions over the Vertical and the Horizontal Identity

Next, we looked into allocations over the vertical identity and allocations over the horizontal identity respectively. The first type of allocations prevails when the two recipients share the same horizontal identity (Klee or Kandinsky) but differ only in their vertical dimension. The second type prevails when the two recipients share the same vertical identity (either rich or poor) but differ only in their horizontal dimension. The left bar in Figure 1.2 shows that allocators gave on average 64.9 tokens to in-group recipients when the allocation is over the horizontal identity, while the right bar shows that when the allocation is done over the vertical identity instead, allocators gave on average 65.9 tokens to in-group recipients. The two-sided Wilcoxon signed-rank test shows that the individual-averaged in-group allocations over the horizontal identity are significantly higher than 50 in all the treatments (p -values < 0.01) except Treatment Random_Random_XY, where the individual-averaged in-group allocations over the horizontal identity are insignificantly higher than 50 (p -value = 0.19). Meanwhile, in all of the six treatments, the individual-averaged in-group allocations over the vertical identity are significantly higher than 50 (p -values < 0.01). All in all,

these results suggest the existence of in-group favoritism under the multi-dimensional identity setting with our in-group definition. Interestingly, the strength of in-group favoritism was remarkably similar in the two dimensions. The Wilcoxon Signed-Rank test indicates that for all the treatments, there is no statistically significant difference between the individual-averaged tokens allocated to in-group recipients over the horizontal identity and those made over the vertical identity (p -values > 0.1).

The following result summarizes the findings.

Result 1 (In-group Favoritism) *In all of the treatments, individual-averaged in-group allocations are significantly higher than 50, the fair allocation of the 100 tokens. In all the treatments except Treatment Random_Random_XY, in-group allocations over the horizontal identity are significantly higher than the fair allocation of the 100 tokens. In all of the treatments, in-group allocations over the vertical identity are significantly higher than the fair allocation of the 100 tokens. For all the treatments, there is no significant difference between in-group allocations made over the horizontal dimension and those made over the vertical dimension.*

Figure 1.2. Allocation of Tokens to In-group Members.

The figure illustrates the average number of tokens allocated to an in-group member, when the in-group and out-group beneficiaries differ in, respectively, the horizontal dimension (the left

bar) and the vertical dimension (the right bar). For each bar, allocations corresponding to the 95% confidence intervals are also indicated.

This result confirms the existence of in-group favoritism in our setting with multiple dimensions of identity, and suggests that in general the degree of in-group favoritism is robust to the variation of whether the group identity involves a hierarchical meaning.

1.3.4 The Degree of Identity Distance

Recall that our definition of in-group is based on the relative identity distance between the two recipients and the allocator. The two recipients always differ in one identity attribute from each other, which could either be the horizontal or the vertical identity. An in-group member is a recipient who is relatively closer to the allocator and there are two types of in-group recipients. The first one is an *absolute in-group* recipient who has exactly the same set of identity attributes as the allocator, and the second one is a *relative in-group* recipient who only shares one identity attribute with the allocator.

In Figure 1.3, we break down Figure 1.2 according to whether or not the in-group recipient's identity attributes are exactly the same as the allocator. The left panel is for the token allocation over the horizontal dimension, while the right panel is for the token allocation over the vertical dimension. Within the same panel, the left and right bar show, respectively, the token allocation to an absolute in-group recipient and to a relative in-group recipient. The figure shows that the average number of tokens transferred to an absolute in-group recipient in the allocation over the horizontal and the vertical dimension are, respectively, 70.3 tokens and 70.1 tokens. The average number of tokens given to a relative in-group member in the allocation over the horizontal and the vertical dimension are, respectively, 59.5 and 61.6 tokens.

The two-sided Wilcoxon signed rank test reveals that for all the treatments, the individual-averaged allocations made to an absolute in-group recipient are significantly higher than 50, the fair allocation (p -value < 0.1 for Treatment Random_Random_XY; p -values < 0.01 for all the other treatments), and that for all the treatments except Treatment Random_Random_XY, the individual-averaged

allocations made to a relative in-group recipient are significantly higher than 50 (p -values < 0.1). We also found that on average an absolute in-group recipient would attract 10 to 11 tokens more than a relative in-group recipient, and the differences in individual-averaged allocations are statistically significant by the Wilcoxon signed-rank tests, for all the treatments (p -values < 0.1).

Figure 1.3. Identity Distance and In-group Allocations.

This figure is obtained by breaking down Figure 1.2 by the type of in-group beneficiary. It illustrates the average number of tokens allocated to an in-group member when, respectively, the in-group beneficiary and the allocator only share one identity attribute (relative in-group) and the in-group beneficiary and the allocator are absolutely similar in their identity attributes (absolute in-group). The left panel is for the case where the in-group and out-group beneficiaries differ in the horizontal dimension, and the right panel is for the case where they differ in the vertical dimension. For each bar, allocations corresponding to the 95% confidence intervals are also indicated.

The results are summarized as follows.

Result 2 (Identity Distance) *In all of the treatments, individual-averaged in-group allocations to absolute in-group recipients are significantly higher than the fair allocation of the 100 tokens. In all the treatments except Treatment Random_Random_XY, individual-averaged in-group allocations to relative in-group recipients are significantly higher than the fair allocation of the 100 tokens. In all of the treatments, the individual-averaged allocations to absolute in-group recipients are significantly higher than those made to relative in-group recipients.*

Result 2 confirms the existence of in-group favoritism for both absolute and relative in-group recipients. In-group favoritism is present regardless of the identity distance between the allocator and the in-group recipient. This result implies that in reality where identity is naturally multidimensional, people tend to favor those having similar identity attributes, who do not necessarily share exactly the same identity attributes with themselves. Result 2 also shows that, however, being closer in terms of the identity distance to the allocator would attract higher amount of tokens from the allocator. The existing studies on in-group favoritism is generally based on a setting where the allocator and the recipients only differ in one identity attribute. By extending this standard setting into a setting where each subject's identity can be defined on the basis of the horizontal identity attribute and the vertical identity attribute, we were able to show that the degree of favoritism towards an in group recipient is increasing in the identity closeness between the allocator and the in-group recipient. Finally, Figure 3 shows that conditional on the degree of identity distance, the average amount of tokens allocated to the in-group over the horizontal and the vertical dimension appears to be very close.

1.3.5 Do the Method of Acquiring Identity Attributes and the Identity Enhancement Matter?

Recall that in the identity inducement stage, we varied the ways subjects acquired their identity attributes (see Table 1.1). The horizontal identity was determined either by choice or randomly, while the vertical identity was acquired either by performance or randomly. In this subsection we first investigate whether or not the method of acquiring identity attributes influences the degree of in-group favoritism.

Figure 1.4 breaks down Figure 1.2 based on the identity acquisition methods. The left and the right panel depict the in-group token allocation over, respectively, the horizontal dimension and the vertical dimension. In the left (right) panel, the two bars show, respectively, the token allocations to the in-group recipient when the horizontal (vertical) identity is determined randomly and by choice (performance). We find that when the allocation is made over the horizontal dimension, the average amount of tokens allocated to the in-group is slightly higher (by 1.6 tokens) if the horizontal

identity is determined by choice than randomly; when allocation is made over the vertical dimension, the average amount of tokens allocated to the in-group is higher (by 3.9 tokens) if the vertical identity is determined by performance than randomly. Our experimental design allows us to run non-parametric tests on these comparisons. Nevertheless, the two-sided Wilcoxon-Mann-Whitney test shows that there is no statistically significant difference in the individual-averaged in-group allocations over the horizontal identity between Treatment Choice_Random_KK and Random_Random_KK, or between Treatment Choice_Random_XY and Random_Random_XY (p -values > 0.1); moreover, there is no statistically significant difference in the individual-averaged in-group allocations over the vertical identity between Treatment Random_Performance_KK and Random_Random_KK (p -value > 0.1), while the individual-averaged in-group allocations over the vertical identity in Treatment Random_Performance_XY are marginally significantly higher than those under Treatment Random_Random_XY (p -value = 0.072).

We next examine the effect of identity enhancement in the second stage of the experiment. Overall, the average in-group allocation is 66.4 tokens when the identity dimension over which the allocation is made is enhanced and 64.4 tokens when not. In Figure 1.5, the left panel shows the average in-group allocations over the horizontal dimension when the horizontal identity is enhanced and when it is not, while the right panel shows the average in-group allocations over the vertical dimension when the vertical identity is enhanced and when it is not. We find that if allocation is made over the horizontal (vertical) dimension, on average subjects allocate slightly more tokens to their in-groups when the corresponding identity dimension is enhanced than not. However, the differences are not statistically significant. The two-sided Wilcoxon-Mann-Whitney test shows that there is no significant difference in terms of individual-averaged in-group allocations over the horizontal or vertical identity between Treatment Choice_Random_KK and Choice_Random_XY, or between Treatment

Random_Performance_KK and Random_Performance_XY, or between Treatment Random_Random_KK and Random_Random_XY (p -values >0.1).⁸

The following result summarizes our findings about the effects of the methods of identity acquisition and identity enhancement.

Result 3 (Identity Acquisition Method and Identity Enhancement) *In general, the way by which the identity attributes are acquired does not have significant effects on subjects' allocation decisions, while there is weak evidence showing that when the vertical identity is determined by performance rather than randomly, subjects' in-group allocations over the vertical dimension tend to be higher. There is no significant effect of the second stage identity enhancement on subjects' allocations.*

Figure 1.4. Identity Acquisition Method and In-group Allocations.

This figure is obtained by breaking down Figure 1.2 by the manner in which the identity attributes are acquired. The left panel is for the case where the in-group and out-group beneficiaries differ in the horizontal dimension, and the right panel is for the case where they differ in the vertical dimension. The left bar in the left panel is for the case where the horizontal identity is determined randomly, and the right bar is for the case where it is determined by choice of participants. The left bar in the right panel is for the case where the vertical identity is determined randomly (by luck) and the right bar is for the case where it is determined by the performance in a real effort task. For each bar, allocations corresponding to the 95% confidence intervals are also indicated.

⁸ When we look at the individual-averaged allocations made to absolute in-group recipients and those made to relative in-group recipients separately, the enhancement effects are still statistically insignificant (p -values >0.3 , two-sided Wilcoxon-Mann-Whitney test).

Therefore, the effects of the identity acquisition methods and the team-building group task on in-group favoritism, if any, are weak. This is consistent with Gioia (2017) finding that while group identity influences the magnitudes of peer effects, introducing a group task has no significant effect on behavior, possibly because interaction does not always contribute to enhancing group identity. Our result is also in line with Chen and Li's (2009) finding that a random assignment could be as effective as categorization based on painting preferences for identity inducement. The findings in Result 1 show that even for treatments with random assignment of horizontal (vertical) identity attributes, the in-group allocations over the horizontal (vertical) identity are higher than 50, the fair allocation of the 100 tokens. The Wilcoxon signed rank tests further show that for all the treatments, the individual-averaged in-group allocations over the dimension that was not enhanced in the second stage of the experiment are significantly higher than 50, the fair allocation of the 100 tokens (p -values <0.01). Altogether these results suggest, in a methodological sense, that in an experimental setting, in-group favoritism could emerge even with random assignment of identity attributes and without team building tasks among group members.

Eckel and Grossman (2005) argue that an identity enhancement stage is essential for a salient group effect, while our experimental findings suggest otherwise. One reason that may account for this difference is that Eckel and Grossman (2005) conduct a public goods experiment in which the subjects' decision-making affects his self-interest, while in the decision task of our study, subjects make other-other allocations, where there is no link between the allocation decisions and the allocator's self-interest, so that enhancement is not necessary for the emergence of a group effect. Appendix A further shows that the performance in the group task in Stage 2 does not seem to affect in-group allocations either.

Figure.1.5. Identity Enhancement and In-group Allocations.

This figure is obtained by breaking down Figure 1.2 by whether or not the identity attributes are enhanced. The left panel is for the case where the in-group and out-group beneficiaries differ in the horizontal dimension, and the right panel is for the case where they differ in the vertical dimension. The left bar in the left (right) panel depicts the average in-group allocation over the horizontal (vertical) dimension when the horizontal (vertical) identity is not enhanced. The right bar, in contrast, depicts the same case when the horizontal (vertical) identity is enhanced. For each bar, allocations corresponding to the 95% confidence intervals are also indicated.

1.3.6 Income Gaps

We now look at how in-group allocations vary with the income gap between Group X and Group Y . Recall that we have four (4) possible scenarios of income gap, $X - Y$, which are 50, 100, 150, and 200 respectively as in Table 1.2. Figure 1.6 shows the average allocations to the in-group under the four income-gap scenarios, suggesting an increasing trend of in-group allocations as the income gap worsens. The Kendall rank correlation test shows that individual-averaged in-group allocations are significantly correlated with the income gap ($p\text{-value} < 0.01$). Given the exogeneity of the income gap, this test result suggests a causal effect from the income gap to in-group allocations.

Figure 1.6. Income Gaps and In-group Allocations.

This figure illustrates the average number of tokens allocated to an in-group beneficiary categorized by the extent of the income gap between the rich and the poor groups. The income gap increases as we move from the most left bar to the most right bar. For each bar, allocations corresponding to the 95% confidence intervals are also indicated.

Next, we take a deeper look into the effect of income gaps on the in-group allocations over both identity attributes. In Figure 1.7, the left and the right graphs show the average in-group allocations based on the horizontal and vertical dimension respectively. The left graph shows that when allocation is made over the horizontal dimension, the magnitude of in-group allocations increases when the income gap worsens. We ran the Kendall rank correlation test and found that the increase in the individual-averaged in-group allocations over the horizontal dimension across scenarios is statistically significant ($p\text{-value} < 0.01$). This result suggests that when the two recipients have the same income status and only differ in the horizontal identity attribute, a larger income gap between the rich group and the poor group would induce the allocator to increase in-group allocation.

Figure 1.7. Tokens Allocated to In-group Members across Income Gaps.

The figure illustrates the average number of tokens allocated to an in-group member under different income gaps, when the in-group and out-group beneficiaries differ in, respectively, the horizontal dimension (the left panel) and the vertical dimension (the right panel). In the right panel, the red and the green curves break down the average in-group allocations (the blue curve in the middle) to poor and rich allocators in-group allocations respectively.

This finding suggests that there seems to be a causal relationship between the increase in income inequality and the in-group bias. The more unequal “the society” is, the more in-group favoritism will be bred. If we think that the in-group bias can potentially lead to inter-group conflict, our result, thus, points to the role of income inequality as a cause of inter-group conflict. This is consistent with the argument put forward by Collier (2000) and Cramer (2003) who argued that income inequality is not an outcome of inter-group conflict, but rather a potential cause of it. In the empirical literature, using cross-country data, some studies, such as Alesina and Perotti (1996) and Nafziger and Auvinen (2002), demonstrated that income inequality correlates with inter-group (social) conflict. However, these studies only established correlation but not causality. In fact, there seems to be no consensus in the literature on the direction of causality between income inequality and inter-group (social) conflict (see Cramer (2003), Cramer (2005)). Our laboratory experimental study, which varies the income gap exogenously, can be seen as an attempt to establish the causal relationship from income inequality to biased attitude towards in-group members. We conjecture that a larger income inequality provides some “justification” for in-group favoritism.

The right panel of Figure 1.7 depicts in-group allocations along the vertical identity. The curve in the middle depicts the average in-group allocation for all the allocators, while the upper and lower curves decompose the middle curve for poor and rich allocators respectively. We find a couple of interesting results. *First*, there is a gap between the poor's and the rich's in-group allocation: The rich make much lower in-group allocations over the vertical identity than the poor. On average the rich give 57.6 tokens while the poor give 73.9 tokens to the in-group along the vertical dimension, and the two-sided Wilcoxon-Mann-Whitney test shows that the differences between the rich and the poor in the individual-averaged in-group allocations over the vertical identity are statistically significant ($p\text{-values} \leq 0.07$) in 4 out of the 6 treatments (Random_Random_KK, Random_Random_XY, Choice_Random_KK, and Random_Performance_KK). By contrast, the differences in the individual-averaged in-group allocations over the horizontal identity between the rich and the poor allocators are statistically insignificant in 5 treatments and in only one treatment (Choice_Random_XY) the difference is marginally statistically significant at the 10% significance level, where the rich appeared to give slightly more than the poor.

The finding that the rich give similar amount of tokens to the in-group as the poor over the horizontal identity, but give less to the in-group over the vertical dimension than the poor could be potentially explained by the *aversion to inequality* between the two recipients and also the in-group favoritism. Note that when allocation is made over the horizontal identity, the two recipients have the same income status; however, over the vertical identity, the rich's in-group are also rich while the poor's in-group are also poor. If the allocators are concerned about the fairness between the two recipients to some extent, when making allocations over the vertical identity, the inequality aversion may induce the rich to give less to the in-group, and induce the poor to give more to their in-group. It is worth mentioning that our allocation setup is similar to Engelmann and Strobel (2004). In their setup, participants were also asked to make an allocation decision towards two recipients; one of them is a rich individual and the other one is a poor individual. They found that there is a tendency for allocators to choose a relatively fair allocation because of the desire to improve the

minimal payoffs and to reduce the income gap between the two recipients. Our finding here implies that although allocators exhibited in-group favoritism when making other-other allocations, their allocation decisions also exhibited some degree of fairness concern such that the allocation is not too much biased toward their in-group. In order to disentangle the role of inequality aversion and in-group favoritism, we present a reduced form regression analysis in the later part of this paper.

A second interesting finding of the right panel of Figure 1.7 is that when allocation is made over the vertical dimension, poor allocators tend to increase allocations to the in-group poor as the income gap worsens. When the income gap is at the highest level (200 points), the poor allocator would on average allocate around 80% of the extra tokens to the in-group recipient. The increase in allocation is statistically significant (the p -value of the Kendall rank correlation test is less than 1%). In contrast, the rich allocator's allocation to the rich in-group recipient is more or less constant, hovering around 55 – 60 tokens when the income gap gets bigger; the p -value of the Kendall rank correlation test was 0.69 indicating that the allocation is invariant to the degree of the income gap.

Overall, the right panel of Figure 1.7 implies that the allocators exhibit certain fairness concern by allocating more to poor in-group recipients and less to rich in-group recipients when there is income inequality between the two recipients; moreover, this tendency is strengthened for the poor allocators as income inequality worsens, while the rich do not seem to be responsive to the enlarged income gap. The following result summarizes our findings regarding income gaps.

Result 4 (Income Gaps) *The degree of in-group favoritism over the horizontal identity increases as income inequality worsens. Over the vertical identity, the poor tend to make more in-group allocations than the rich; moreover, the poor increase in-group allocations as income inequality worsens while the rich's in-group allocations are insensitive to the enlarged income gap. Two factors are potentially at work here when the allocation is over the vertical dimension. The first one is the aversion to inequality, which works in reducing the rich's in-group allocations and increasing the*

poor's in group allocations over the vertical dimension. The second one is the in-group favoritism, which works in increasing both the poor's and the rich's in-group allocations.

1.3.7 The Regression Analysis

All in all, our statistical analysis has thus far demonstrated the general level of affinity that one has towards an in-group recipient in the presence of multi-dimensional identity, and looked into several important factors that may influence the magnitude of one's token allocation decision to an in-group recipient relative to an out-group recipient. Among these factors, the relative degree of identity distance appears to be the most important factor that affects the degree of in-group favoritism. Another factor is the gap between groups along the vertical dimension, for which the effect seems to depend on the dimension over which the allocation is made and the allocator's vertical identity attribute. As we argued earlier, it appears that there are two factors at work here, namely the aversion to income inequality and the in-group favoritism. When the in-group favoritism exacerbated the income inequality, individuals would tend to reduce their in-group allocations. To verify the impacts of these various variables on the allocation decisions, we conducted a reduced form regression analysis to further look into the determinants of subjects' allocations to in-group members vis-a-vis out-group members.

Table 1.5 reports our regression results. In all estimations, we regressed tokens allocated to the in-group recipient on various variables that might affect subjects' allocation decisions, controlling for the session fixed effects and clustering standard errors at the individual level.

In Column (1), we regressed in-group allocations on *absolute*, a dummy variable which is equal to 1 if the in-group has exactly the same identity attributes with the allocator and 0 otherwise, *performance*, a dummy variable which is equal to 1 if the vertical identity attribute is acquired by performance in the real-effort task and 0 otherwise, *choice*, a dummy variable which is equal to 1 if the horizontal identity attribute is acquired by preferences on the abstract paintings and 0 otherwise,

enhanced, a dummy variable which is equal to 1 if the dimension over which the allocation is made is enhanced in the second stage of the experiment and 0 otherwise, *overkk*, a dummy variable which is equal to 1 if the allocation is made over the horizontal identity and 0 otherwise, and *scenario*, a variable equal to 1, 2, 3 or 4 corresponding to the Scenarios 1-4 in Table 1.2 respectively. Note that the income gap between the rich and the poor follows an arithmetic sequence, which increases from 50 to 200 with common increment of 50 across scenario. Thus, the regression analysis presented in Column (1) only include variables that are relevant for the in-group favoritism in general.

We find that, consistent to our findings from non-parametric statistical tests, the coefficient of *absolute* is statistically significant at the 1% significance level, implying that on average an absolute in-group recipient attracts nearly 10 more tokens than a relative in-group recipient; the coefficient of *scenario* is also statistically significant at the 1% significance level, implying that on average 2 more tokens are given to the in-group as the income gap between the rich and poor increases by every 50 tokens; the coefficients of the variables on identity acquisition methods *performance* and *choice*, identity enhancement *enhanced*, and the dimension over which allocation is made *overkk*, however, are statistically insignificant.

Table 1.5. Regression Results of In-group Allocations

	(1)	(2)	(3)	(4)
<i>absolute</i>	9.629*** (1.896)	9.629*** (1.897)	9.629*** (1.899)	9.629*** (1.897)
<i>performance</i>	2.991 (5.298)	3.399 (5.548)	2.477 (5.189)	3.388 (5.534)
<i>choice</i>	-0.478 (4.282)	-0.0805 (4.144)	-0.340 (4.493)	-0.0914 (4.137)
<i>enhanced</i>	2.002 (2.053)	2.130 (1.831)	2.120 (1.821)	2.127 (1.834)
<i>scenario</i>	2.022*** (0.640)	2.022*** (0.640)	2.022*** (0.641)	
<i>overkk</i>	-0.991 (2.053)			
$D_{ingroup>outgroup}$		-7.329*** (2.784)	-9.534* (5.595)	
$D_{ingroup<outgroup}$		9.056*** (2.492)	9.530** (4.002)	
$D_{ingroup>outgroup} \times performance$			9.261 (7.185)	
$D_{ingroup<outgroup} \times performance$			-5.255 (6.273)	
$D_{ingroup>outgroup} \times choice$			-1.563 (6.956)	
$D_{ingroup<outgroup} \times choice$			2.895 (5.726)	
$scenario \times overkk$				1.866*** (0.671)
$scenario \times D_{ingroup>outgroup}$				-1.059 (1.030)
$scenario \times D_{ingroup<outgroup}$				5.314*** (0.962)
<i>Constant</i>	56.09*** (4.570)	55.09*** (4.053)	55.65*** (3.894)	55.58*** (4.126)
Observations	2,048	2,048	2,048	2,048
Adjusted R-squared	0.040	0.077	0.084	0.082

Session fixed effects are controlled for. Robust standard errors clustered at the individual level are in parentheses. *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$.

Column (2) replaces *overkk* by two dummy variables, $D_{ingroup>outgroup}$ and $D_{ingroup<outgroup} \cdot D_{ingroup>outgroup}$ ($D_{ingroup<outgroup}$) indicates that the in-

group's income is higher (lower) than the out-group, implying that the allocation is made over the vertical dimension given our experimental design. In particular, $D_{ingroup>outgroup}$ equals 1 if the allocation is made by a rich allocator over the vertical identity and 0 otherwise, and $D_{ingroup<outgroup}$ equals 1 if the allocation is made by a poor allocator over the vertical identity and 0 otherwise. This regression thus looks into the interaction between the allocation dimension and the allocator's economic status in more details. The coefficient of $D_{ingroup>outgroup}$ is negative while that of $D_{ingroup<outgroup}$ is positive, both of which are statistically significant at the 1% level, implying that compared to the average in-group allocations over the horizontal identity, the rich (poor) on average made 7 less (9 more) tokens to the in-group in allocations over the vertical identity. In particular, the coefficient of $D_{ingroup<outgroup}$ and that of $D_{ingroup>outgroup}$ are significantly different from each other (p -value < 0.001), implying that the poor gave more to the in-group than the rich when allocating over the vertical identity, which could be explained by the aversion to inequality between the two recipients as discussed in the last subsection. These results are consistent with our previous findings from Figure 1.7.

Column (3) further includes four interaction terms, namely; 1) $D_{ingroup>outgroup} \times performance$, 2) $D_{ingroup>outgroup} \times choice$, 3) $D_{ingroup<outgroup} \times performance$, and 4) $D_{ingroup<outgroup} \times choice$, to dig into the potential interaction effects between the income disparity between the two recipients and the way the group differences were generated. However, none of the coefficients of these interaction terms are statistically significant, nor do the coefficients of *performance* and *choice*. This confirms that the identity acquisition methods, at most, have negligible effects on subjects' allocation decisions.

Column (4) further investigates the effect of income gaps by decomposing *scenario* in Column (1) to interaction terms $scenario \times overkk$, $scenario \times$

$D_{ingroup>outgroup}$ and $scenario \times D_{ingroup<outgroup}$.⁹ We find that $scenario \times overkk$ is positive and statistically significant, implying that the degree of in-group favoritism over the horizontal identity increases as income gap increases, consistent with the left panel of Figure 1.7. Meanwhile, the coefficient of $scenario \times D_{ingroup<outgroup}$ is positive and statistically significant, while that of $scenario \times D_{ingroup>outgroup}$ is statistically insignificant, suggesting that the poor give more to their in-group poor along the vertical identity as income gap increases, while the rich is not responsive to the change of income gaps when making allocations over the vertical dimension. These results confirm the findings from the right panel of Figure 1.7. Overall, our regression analysis lends support to Results 2-4.¹⁰

1.4 Concluding Remarks

In this paper, we report findings from a laboratory experiment on social identity in the mould of Chen and Li (2009), but with a two dimensional identity setting. While Chen and Li (2009) find in-group favoritism in economic decisions from a one-dimensional identity setting, people's identity attributes are often multi-dimensional and are embedded in different kinds of social structures. Our experiment elicits horizontal identity attributes in line with Chen and Li (2009) as well as vertical identity attributes with a hierarchical structure. Vertical identity attributes are materialized as income status in our experiment. This two-dimensional setting also creates an interesting measure that captures the identity distance between any two people. This measure is meaningful as in reality no two people have exactly the same identity attributes as in the one dimensional setting adopted in most of the existing experimental literature. We also manipulate the way the subjects obtain these identity attributes and the dimension of social identities to be enhanced by a team-building

⁹ Since *scenario* is decomposed to $scenario \times overkk$ (allocations over the horizontal identity), $scenario \times D_{ingroup>outgroup}$ and $scenario \times D_{ingroup<outgroup}$ (allocations over the vertical identity), the variable *overkk* is dropped in the regression.

¹⁰ In all of our regressions, adding a demographical variable indicating the gender of the allocator does not change the regression results qualitatively. Moreover, the coefficient of this variable is never statistically significant at the conventional levels.

group task in a between-subject design, as well as vary the income gap between different vertical identity groups in a within-subject design.

Subjects then made allocation decisions to two others differing in identities attributes. We find that in-group favoritism is robust in our two-dimensional setting, not only for the horizontal group identity as shown in Chen and Li (2009) but also for the vertical group identity, in the sense that subjects make more favorable allocation decisions to the recipient who is closer in terms of identity attributes to themselves in our experiment. Moreover, identity distance influences the degree of in-group favoritism. The closer in terms of identity attributes between the allocator and the recipient, the more favorable decisions will be made to the recipient.

However, the way that differences between people were generated does not substantially influence subjects' allocation decisions in our experiment. No matter whether the horizontal identity was generated randomly or by common preferences on artistic paintings, or whether the vertical identity was determined by luck or in a seemingly more fair way by performance in a real-effort task, the degree of in-group favoritism is robust and stable. A team-building group task is not necessary either for the emergence of in-group favoritism. These results seem to suggest that in-group favoritism might be a deeply embedded human tendency. Independent of the grouping processes, as long as there are divisions among people, people tend to favor the in-groups against the out-groups and the degree of this tendency is stable. This is in line with the insights in Chen and Li (2009) and other studies in identity and economics showing that a minimal way of grouping people would be sufficient to create in-group favoritism.

The gap between different groups along the vertical dimension also makes a difference. On the one hand, despite the prevalence of in-group favoritism, the subject allocators in our experiment also exhibit a certain degree of fairness concern in making allocations when there is an income difference between the two recipients. On the other hand, the bigger the gap between different groups along the vertical dimension is, the more favorable decisions allocators would make to the in-group in

seemingly irrelevant decisions (i.e. allocation decisions over the horizontal identity where there is no income difference between recipients). This result suggests that social inequality may deepen the tendency of in-group favoritism. As the hierarchical distinctions become more prominent, the in-group bonding is stronger. Inequality thus strengthens the tendency of clustering group members together.

1.5 Appendix

1.5.1 The Participants' Performance in Stage 2 Group-task

The following figure shows the average in-group allocations under different performance levels in the stage 2 group task. The stage 2 group task consists of four spot-the-differences puzzles which contain 20 differences in total. Group's scores, measured by the numbers of differences the group spotted, varied from 12 to 20.

Figure 1.8. In-group Allocations under Various Performances in the Group Task. This figure depicts the average number of tokens allocated to an in-group beneficiary broken down by different levels of group performance in the identity enhancement stage.

The graph suggests that there is no a clear pattern between the stage-2 performance in the group task and the stage-3 allocation decisions. The Kendall rank correlation test shows that the allocations over both dimensions of identities are not associated with group performance in the stage of identity enhancement (p -values > 0.2).

1.5.2 A Sample of Experimental Instruction: the Treatment Random_Performance_KK

General Information

You are now taking part in an interactive study on decision making. **Please pay attention to the information provided here and make your decisions carefully. If at any time you have questions to ask, please raise your hand and we will attend to you in private.**

Please note that unauthorized communication is prohibited. Failure to adhere to this rule would force us to stop the experiment and you may be held liable for the cost incurred in this experiment. You have the right to withdraw from the experiment at any point in time, and if you decide to do so your payments earned during this study will be forfeited and you will only receive your show up fee.

By participating in this study, you will be able to earn a considerable amount of money. The amount depends on the decisions you and others make.

At the end of this session, this money will be paid to you privately and in cash. It would be contained in an envelope (indicated only with your unique user ID). Please exchange the claim card given to you with this envelope.

General Instructions

After the experiment start, each of you will be given a unique numerical user ID randomly generated by the computer terminal. Your **anonymity will be preserved** for the study. You will **never be aware of** the personal identities of other participants **during or after** the study. Similarly, other participants will also **never be aware of** your personal identities **during or after** the study. You will only be identified by your user ID in our data collection. All information collected will **strictly be kept confidential** for the sole purpose of this study.

Specific Instructions

This experiment will consist of three (3) stages. Below we describe the details of these three stages.

Stage 1

There are two steps in this stage: Step A and Step B.

Step A

You will first be shown two pairs of paintings, each of which contains one painting by Paul Klee and one painting by Wassily Kandinsky. You will be told which one is

painted by Paul Klee and which one is painted by Wassily Kandinsky. They are popular abstract artists in the last century.

Subsequently, you will be shown five pairs of paintings sequentially, each of which contains one painting by Klee and one painting by Kandinsky, but you will not be told which one is which. Once all the paintings have been shown to you, **half of you will be grouped to Team Klee and the rest of you will be grouped to Team Kandinsky. The group assignment is random.**

Step B

Subsequently, you will be asked to participate in simple quantitative tasks individually. It contains 30 questions requiring you to sum up a sequence of numbers shown to you. You are given 90 seconds to complete as many questions as you can. You are not able to proceed to the next question until you answer the current question correctly. After the time ends, you will be randomly allocated into two groups, i.e. Group X and Group Y, according to your relative performances in the add-up tasks.

Specifically, the computer will count the numbers of questions you have correctly answered.

Half of you with **better** performances will be allocated into Group X and the other half will go to Group Y. In case of a tie, you will be assigned randomly to either Group X or Group Y in such a way that the two groups have the same size.

You will receive a certain amount of endowment tokens according to which group you belong to. **The sum of endowment tokens received by a member of Group X and a member of Group Y is fixed at 300, but the member from Group X will always receive at least 50 tokens more than the member from Group Y.**

The table below shows the four possible scenarios of endowment token allocations. At the end of this experiment, one of the scenarios will be randomly selected to be the binding scenario for all of you. Each scenario will have equal chance of being selected.

Table 1				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Group X	175	200	225	250
Group Y	125	100	75	50
(X-Y)	50	100	150	200

At the end of Stage 1, each of you will belong to one of the following combinations: (Team Klee & Group X); (Team Klee & Group Y); Team Kandinsky & Group X; and (Team Kandinsky & Group Y) . Your combination will remain the same throughout this experiment. That is, if you belong to (Team Klee & Group X), you will remain as (Team Klee & Group X) throughout this experiment.

Stage 2

In the second stage, you will be asked to participate in a series of team tasks. You will work with other members who belong to the same team as you (either **Team Klee** or **Team Kandinsky**) on some joint tasks involving spotting-differences puzzles. For each task, one member of your team will be randomly selected as the team representative whose task is to submit the final answer on behalf of the team.

You will be given opportunities to chat with your team members through a chat box which will be later shown on your computer screen. You are encouraged to actively participate in this chatting session by contributing your suggested answers and helping your team to solve these puzzles. After the team representative submits your team answer, you are able to proceed. After completing each puzzle, your team answer and the correct answers will be shown to each of you.

The followings are the details of the ‘Spot the Difference’ puzzles you will face. There are in total four (4) puzzles; the number of differences and the time limit allotted to you increase as you proceed to later puzzles.

Table 2

	Puzzle 1	Puzzle 2	Puzzle 3	Puzzle 4
No. of Differences	4	5	5	6
Time Limit (Minutes)	4	5	5	6

The time limit is also shown on the **right-hand-side top** corner. Please pay attention to that.

If you are selected as your team representative, when you submit your answer, you will **need to pin point the positions of the differences in the grid lines shown on each picture**. You will have to submit your answer before the time limit ends; otherwise your team will not have any answer recorded.

Stage 3

This is the main stage of this experiment. **You will make some economic decisions which will have an effect on the earnings of other participants, but not on your own earning.**

In this stage, for each decision you will have to make, you will be given **100 extra tokens**. You have **to allocate these 100 tokens to two other participants**. There are four (4) possible scenarios of endowment you will face. These scenarios are those which we have presented earlier in **Table 1** (please inspect Table 1 once again to familiarize yourself with these scenarios)

In **each scenario**, you will be asked to decide how to allocate tokens between another two participants under the following **four** cases.

Table 3

A member from {Team Kandinsky & Group X}	vs.	A member from {Team Kandinsky & Group Y}
A member from {Team Klee & Group X}	vs.	A member from {Team Klee & Group Y}
A member from {Team Klee & Group X}	vs.	A member from {Team Kandinsky & Group X}
A member from {Team Klee & Group Y}	vs.	A member from {Team Kandinsky & Group Y}

Thus, you will have to make $4 \times 4 = 16$ allocations in total. The first four (4) indicates the four allocation decisions in Table 3 and the second four (4) indicates the four possible scenarios of endowment tokens shown to you in Table 1. Once you have completed your token allocations in all of the four (4) decisions under each of the four (4) endowment token scenarios, the system will randomly select the binding scenario of endowment tokens for all of you. Under this scenario, you will receive your earning, which will be your endowment tokens under the binding scenario plus the average amount of the tokens allocated to you by the other participants in the relevant decisions of Stage 3. An example here illustrates the details.

For example, you are in {Team Klee & Group X}. Then any other participant's allocation decisions in Stage 3 to a member from {Team Klee & Group X} will affect your earning. You will receive your endowment as well as the average amount of the tokens allocated by each of the others in the decisions highlighted in the table below.

Table 4

A member from {Team Kandinsky & Group X}	vs.	A member from {Team Kandinsky & Group Y}
A member from {Team Klee & Group X}	vs.	A member from {Team Klee & Group Y}
A member from {Team Klee & Group X}	vs.	A member from {Team Kandinsky & Group X}
A member from {Team Klee & Group Y}	vs.	A member from {Team Kandinsky & Group Y}

The following formula summarizes how your earning is determined:

$$\text{Your Earning} = \text{Your endowment tokens allocated under the binding scenario} +$$

$$\frac{\sum_{\text{other participants}} \sum_{\text{the 2 decisions relevant to you made by other participants}}}{2 * (\text{number of participants} - 1)}$$

Hence your earning is ONLY dependent on your endowment and others' decisions in Stage 3. Your decisions in Stage 3 will not affect your personal earnings.

Your earning will be exchanged to Singapore dollars (SGD) with the exchange rate of 12 Experimental Tokens = 1 SGD. In addition, you will receive 3 SGD as show-up fee. At the end of the experiment, your total income will be shown on the computer screen. Please write down your ID and your total income on the claim card before you click the button to finish the experiment. Then please wait for your ID to be called for payment.

Chapter 2 Within- and Between-Group Identity

Diversity and the Power of Incentives in Team

Competition

2.1 Introduction

Organizations often spend a substantial amount of resources to build a distinct organizational *identity* that will enable their members to establish a cohesive group bound by a common view of who they are as an organization and by enduring identity-attributes that distinguish them from outsiders (Albert and Whetten 1985). Organizations that constantly endeavor to inculcate organizational identity are able to motivate their employees better and create stronger workplace cultures, thereby sustaining higher performance and stakeholders' satisfaction (MacGregor 1960).

Akerlof and Kranton (2005), in their seminal work on the economics of identity, further assert that identity plays an important role in supplementing the role of monetary incentives in organizations. That is, identity helps organizations to overcome unintended adverse impacts of monetary incentives on employees' motivations to engage in beneficial nonmonetary activities, such as promoting fair-minded attitudes, encouraging cooperative and reciprocal behaviors in the workplace, and adhering to the prevailing organizational norms.¹¹ Monetary incentive schemes and a strong sense of (group) identity go hand in hand. The latter can boost morale and induce a higher collective effort, making it less necessary for the principal to provide high wages to elicit high effort.

The design of monetary incentive schemes varies across firms and industries.

¹¹ See Prendergast (1999) and Gibbons (1998) for reviews on the crowding-out effects of monetary incentives on nonmonetary incentives.

In the public sector, most salaries and bonuses are independent of performance (Dixit 1997) , whereas that is usually not the case in the private sector. For example, how much a sales person in a firm earns is often based on a sales commission that is tied to the units of products she manages to sell.

One way to categorize monetary incentive schemes is by their power to elicit employees' effort (Williamson 1985, Lazear 2000). In particular, such schemes can be grouped into *high-powered* and *low-powered* monetary incentives. Sales commissions, which closely tie employees' earnings with employers' outputs, are examples of high-powered incentives. Fixed-salary schemes, or any other salary schemes that do not vary much with output or performance, are examples of low-powered incentives. The former is often more effective in boosting effort than the latter, but it may not always be feasible to implement it. For example, the performance indicator for teaching effectiveness is often based on the observed students' feedback on teaching, but simply converting that feedback into teachers' salaries may not be a good idea. How much a teacher can inspire students to learn is perhaps a better and more holistic measure of teaching effectiveness (Atkinson, Burgess et al. 2009, Lavy 2009), but it is usually more challenging to measure. This perhaps explains why teachers' salaries often remain low-powered (Murnane and Cohen 1986, Ballou 2001). Finally, when effort is not observable and output as a signal of effort is substantially noisy, a low-powered monetary incentive scheme would be a better choice than a high-powered monetary incentive scheme would (Bolton and Dewatripont 2005).

This paper uses a laboratory experimental methodology to investigate the interplay between organizational (group) identity and the power of monetary incentive schemes in a competitive environment. Specifically, we focus on the effect of identity diversity and its interplay with the power of a monetary incentive scheme on the elicited effort in a team competition. We investigate whether a low-powered or a high-powered incentive scheme is better for a work team with homogeneous identity composition, or diverse identity composition, when the team is competing with another team of unknown identity composition. From another angle, we can also evaluate which type of monetary incentive scheme – the low-powered or the high-

powered one – is more appropriate for a diverse (or homogeneous) identity organization.

Finally, this paper also presents the same analysis for a setting in which the identity composition of the competing team is no longer unknown. This allows us to observe the relationship between the intensity of competition, measured by the average amount of contest effort exerted by individuals, and the identity diversity between competing teams.

In our experiment, we induce group identities by using the *Minimal Group Paradigm*¹² (MGP) proposed by Tajfel, Billig et al. (1971) and Chen and Li (2009). Subjects are categorized into two groups according to their preferences for abstract paintings by Paul Klee and Wassily Kandinsky. Subjects are then assigned to a team of four members, in a team competition stage. Next, the subjects are given information about the identity composition of their own team. In one treatment, all team members are from the same identity group. In the other treatment, within the team there are two distinct identities and there are two members for each identity. The former constitutes a *homogeneous* within-team composition and the latter is a heterogeneous within-team composition. The *heterogeneous* within-team composition is not rare in reality, especially in multinational corporations (MNCs). Due to their cross-border business, MNC work teams are usually composed of employees with diverse backgrounds, such as different nationalities and religions. On the other hand, public sectors and state-owned enterprises (SOEs) commonly hire local laborers, and that creates a much higher probability of having a homogeneous work team in terms of social identity.

Next, we also have another two treatments where we assume that in both

¹² As early as 1970, socio-psychologist Henri Tajfel showed that the presence of minimal and somewhat meaningless group classification was sufficient to generate a discriminatory behavior toward people from the opposite group (Tajfel 1970). This method of group categorization and the resulting discriminatory behavior is known in the literature as the Minimal Group Paradigm. Inspired by this Paradigm, later experimental studies on the effect of social identity on economic decision making (Eckel and Grossman 2005, Charness, Rigotti et al. 2007, McLeish and Oxoby 2007, Chen and Li 2009, Heap and Zizzo 2009, Chen and Chen 2011) show that such a categorization based on minimal-meaning tasks could successfully inculcate polarized other-regarding preferences to in-groups and out-groups in economic decision making.

competing teams there is homogenous within-team composition, but across the competing teams the identities can differ. In the first of these two treatments, we have a setting where both competing teams have the same identity. In real life, this setting mimics an internal competition in which a company divides its employees into multiple work teams sharing the same identity and a common goal. Such an internal competition setting is often coined as “shark tank” competition, which modelled after a successful US reality TV show “Shark Tank”.¹³ In the other treatment, we have an external competition where a homogenous team belonging to an organization is competing against another homogenous team with differing group identity belonging to a competing organization.

We also run a benchmark treatment where no identity information is provided to both competing teams.

To proceed, we first develop a Tullock rent-seeking group-contest where social preferences and group identity are embedded into the setup. We allow for individuals to care about their team members and the opponent’s team members and assume that the degree of care depends on the identity similarity and also the way the prize is shared with other team members. The latter, in our context, is meant to capture the power of the incentive scheme. We derive a set of theoretical predictions which we then test experimentally in a lab setting.

In a nutshell, our results show that when contestants know that their team is homogenous but do not know the identity composition of the opponent team, they will increase their effort level under the equal sharing rule (low-powered incentive) relative to the effort level under a setting where the identity composition is unknown. However, under the proportional sharing rule (high-powered incentive) there is no change in their effort level. When the team is heterogeneous, under the former there will be no effect, but under the latter their effort level increases. Finally, conditional on having a homogenous competing team, when the opponent team is also composed of subjects with same group identity as the own team, the within-team effort level

¹³ See <http://abc.go.com/shows/shark-tank>.

substantially decreases under the equal sharing rule (low-powered incentive).

The paper is organized as follows. Section 2.2 establishes the theoretical models for Tullock group rent-seeking contests and also defines the concept of identity that is incorporated into the models. Section 2.3 outlines our experimental design and procedures. Section 2.4 presents the results of the experimental observations. Finally, Section 2.5 provides the conclusion.

2.2 Theory

To model the team competition, we adopt a group Tullock rent-seeking contest. In a simple contest, N teams, each of which consists of n members, compete against each other for a prize, on the basis of their team efforts. The team efforts are the sum of effort exerted by team members, thus for example, for team effort X_k from Team k , $X_k = \sum_i x_{ik}$ when x_{ik} is the individual effort from Player i of Team k . The winning team is determined by a contest success function (CSF) (Tullock 1980, Nitzan 1991, Nitzan 1994), as follows:

$$P_k = \begin{cases} \frac{x_k^\gamma}{x_k^\gamma + \sum_{j \neq k} x_j^\gamma} & \text{if } \sum_j X_j \neq 0, \\ \frac{1}{N} & \text{otherwise.} \end{cases} \quad (1)$$

A win probability for Team k , P_k , is the ratio of the own team's effort and the total efforts from all competing teams. The degree of discrimination γ in (1) indicates the marginal return of team effort on the win probability – in other words, how closely the outcome is related to the team's efforts¹⁴. In this study, we adopt a simple model of $\gamma = 1$ in which the win probability is equal to a linear proportion of one team's effort to the total effort. This is also known as a lottery contest.

¹⁴ With the extreme case of $\gamma = 0$, the outcome will not be affected by the team effort at all, and the prize will be randomly allocated. On the other hand, for $\gamma \rightarrow \infty$, the team with the highest effort wins the prize with certainty.

Members of the winning team split the prize internally. There are two factors influencing the effort level exerted by members in a team competition, namely the *sharing rule* and the *team impact function* (how individual efforts are aggregated and translated into the total team effort)¹⁵. In addition to these two factors, there are other factors that exist not only in the team competition but also in the individual contest setting, such as the number of players, the contest success function, and the cost function¹⁶.

Our study examines two commonly used sharing rules¹⁷ – a proportional sharing rule and an equal sharing rule – which to a certain extent resemble, respectively, a high-powered incentive and a low-powered incentive. A prize share for Player i from Team k , P_{ik} , is equal to

$$P_{ik} = \begin{cases} \frac{x_{ik}}{X_k} & \text{under the proportional sharing rule}^{18}, \\ \frac{1}{n} & \text{under the equal sharing rule.} \end{cases} \quad (2)$$

Under the equal sharing rule, all members of the winning team share an equal portion of the prize R : (R/n) . It is akin to a form of public goods game (Bergstrom, Blume et al. 1986), in which the members within each competing team are not incentivized to compete against other team members. Instead, they may wish to cooperate with the

¹⁵ See Sheremeta (2015) for a survey on the determinants of efforts in group contests.

¹⁶ Other group impact functions, such as weakest-link (Lee 2012) and best-shot (Chowdhury, Lee et al. 2013) are discussed in the literature. In addition to these two factors, there are other factors that exist not only in the team competition but also in the individual contest setting, such as the number of players, the contest success function, and cost function. See Konrad (2009) for a survey on contest theory. See Dechenaux, Kovenock et al. (2015) also for a survey on contest experiments.

¹⁷ Most existing experiments on group contests have also concentrated on the equal sharing rule (Nalbantian and Schotter 1997, Van Dijk, Sonnemans et al. 2001, Sutter and Strassmair 2009, Abbink, Brandts et al. 2010, Sheremeta and Zhang 2010, Cason, Sheremeta et al. 2012, Leibbrandt and Sääksvuori 2012). Studies on the proportional sharing rule were usually conducted for a comparison between the two sharing rules (Krueger 1974, Amaldoss, Meyer et al. 2000, Gunnthorsdottir and Rapoport 2006).

¹⁸ It is assumed that $X_k > 0$ here. If $X_k = 0$, Team k has no chance to win the contest prize ($P_k = 0$). In an extreme case of $\sum_j X_j = 0$, P_{ik} then becomes $1/n$.

others within the team, in order to win the prize in the inter-team competition. A concern with such a context is the free-riding problem, although the contestants in this situation theoretically should not shift from the equilibrium to free-riding. Any attempt to do so will yield a lower expected payoff.

The proportional sharing rule, which ties the payoff tightly to individual effort, mimics a high-powered incentive. The expected self payoff derived from (2) under the proportional sharing rule is equivalent to that of an individual contest with Nn contestants, conditional on the premise that the contest success function and P_{ik} are both linearly formed. As a result, this sharing rule generates another level of competition – an intra-team competition, in addition to the inter-team competition.

Let a common value of the contest prize be $R > 0$ and a homogeneous cost function, $c(x_{ik})$, of individual effort be equal to x_{ik} . Assuming there is an initial endowment E , the payoff to Player i from Team k can be expressed as:

$$\pi_{ik} = \begin{cases} P_{ik} \times R + E - x_{ik} & \text{if Team } k \text{ wins,} \\ E - x_{ik} & \text{otherwise.} \end{cases} \quad (3)$$

In a lottery contest with an assumption of self-payoff maximization and risk neutrality, equilibria under the two sharing rules can be straightforwardly derived as follows:

$$x^* = \begin{cases} (Nn - 1) \frac{R}{(Nn)^2} & \text{under the proportional sharing rule,} \\ (N - 1) \frac{R}{(Nn)^2} & \text{under the equal sharing rule.} \end{cases} \quad (4)$$

In our study, we manipulate the identity compositions of the competing teams, and those compositions may result in differentiated attitudes, in terms of the degree of altruism and spitefulness, toward other players. To capture such other-regarding preferences, we develop a model of social preferences as follows:

$$U(x_{ik}) = f(\pi_{ik}^e, \overline{\pi_{-ik}}^e, \overline{\pi_{-k}}^e) = \pi_{ik}^e + \alpha_i^g \times \overline{\pi_{-ik}}^e + \beta_i^g \times \overline{\pi_{-k}}^e. \quad (5)$$

in which, π_{ik}^e denotes the expected own-payoff of player i belonging to Team k ($\pi_{ik}^e =$

$P_k \times P_{ik} \times R + E - x_{ik}$). The remaining two terms are the average expected payoff of the teammates ($\overline{\pi_{-ik}}^e = \frac{\sum_{j \neq i} \pi_{jk}^e}{n-1}$) and the average expected payoff of the opponent team ($\overline{\pi_{-k}}^e = \frac{\sum_{l \neq k} \sum_{i=1}^n \pi_{il}^e}{(N-1)n}$).

Our model is akin to the model of social preferences developed by Levine (1998), where an individual internalizes the average payoffs of their own team mates and the opponent team's members.¹⁹ Their coefficients, a *teammate-regarding parameter* α_i^g and an *opponent-regarding parameter* β_i^g , measure how much individual contestants care about their teammates and their opponent team, respectively. Negative and positive parameter values imply, respectively, *spitefulness* and *altruism*. An increase in α_i^g and β_i^g implies, respectively, a higher degree of altruism toward teammates and toward the opponent team members, and a decrease in those parameters instead reflects a growing degree of spitefulness and sense of rivalry. An indicator variable $g \in \{I, O, N\}$ in α_i^g denotes whether the identity composition of own team is homogenous, heterogeneous, or unknown. The indicator variable $g \in \{I, O, N\}$ in β_i^g denotes whether the opponent team are in-groups, out-groups or identity-unknown. We impose the following set of assumptions on the teammate- and opponent-regarding parameter;

Assumption 1: $|\alpha_i^g| \leq 1$ and $|\beta_i^g| \leq 1$

The assumption implies that the preferences towards teammates' and opponents' payoffs are not stronger than the preferences towards own payoffs.

Assumption 2: $\alpha_i^O \leq \alpha_i^N \leq \alpha_i^I$

The assumption implies that individuals demonstrate the greatest altruistic concern toward other team members belonging to the same identity group (I) and the lowest

¹⁹ We are not the first to adopt other-regarding preferences in contest studies. Mago, Samak et al. (2016) incorporated a group-averaged payoff into one's utility function and identified a status-seeking motivation in an individual contest setting. In our study, we only provide the information about the general identity composition of own team and the opponent team.

altruistic concern toward other team members from diverse identity groups (O).

Assumption 3: $\beta_i^O \leq \beta_i^N \leq \beta_i^I$

The assumption implies that individuals demonstrate the greatest altruistic concern toward members from the opponent team belonging to the same identity group (I) and the lowest altruistic concern toward members from the opponent team belonging to a different identity group (O).

Assumptions 2 and 3 are based on the results of the parameter estimations in Chen and Li (2009)²⁰. In their study, subjects were shown to have a stronger positive attitudes, e.g. kinder and less envious, toward an in-group member than toward both an identity-unknown member and an out-group member.

With an assumption of risk neutrality, equilibria under the two sharing rules are as follows:

$$x^* = \begin{cases} (Nn - 1 - \alpha_i^g - \beta_i^g) \frac{R}{(Nn)^2} & \text{under the proportional sharing rule,} \\ ((1 + \alpha_i^g)(N - 1) - \beta_i^g) \frac{R}{(Nn)^2} & \text{under the equal sharing rule.} \end{cases} \quad (6)$$

First of all, the individual effort in equilibrium under the proportional sharing rule is higher than that under the equal sharing rule, by $\frac{R}{Nn^2} (n - 1 - \alpha_i^g)$. Given that $n \geq 2$ in a group contest and given that $|\alpha_i^g| \leq 1$ (Assumption 1), the proportional

²⁰ We also build another social preferences model in which individual payoff and others' average payoffs are weighted, following Charness and Rabin (2002). It has been widely used in many studies on the concept of identity (McLeish and Oxoby 2007, Chen and Li 2009, Chen and Chen 2011), and helps to explain one's concerns about fairness and efficiency. We adopt their model by incorporating an average payoff of teammates and an average payoff of the opponent team, as follows: $U(x_{ik}) = (1 - \alpha_i^g - \beta_i^g) \times \pi_{ik}^e + \alpha_i^g \times \bar{\pi}_{-ik}^e + \beta_i^g \times \bar{\pi}_{-k}^e$. Unfortunately, theoretical derivations of this model on the equilibrium do not give a clear indication of how the equilibrium level changes with the other-regarding parameters ($x^* = \frac{N-1-N\beta_i^g}{(1-\alpha_i^g-\beta_i^g) \times (Nn)^2} R$ under the equal sharing rule and $x^* = \frac{Nn-1-Nn\alpha_i^g-Nn\beta_i^g}{(1-\alpha_i^g-\beta_i^g)(Nn)^2} R$ under the proportional sharing rule). The effects of α_i^g and β_i^g depend on each other's scale. As a result, we choose to present Model (5) in the main body of this paper.

sharing rule definitely yields a lower equilibrium individual effort level than the equal sharing rule does.

Prediction 1 (Power of Incentives): *Based on Assumption 1 ($|\alpha_i^g| \leq 1$), the proportional sharing rule, serving as a high-powered incentive scheme, yields higher individual efforts than the equal sharing rule does.*

Next, from the comparative statics analysis on (6), the equilibrium effort level under the proportional sharing rule is negatively related to how much contestants care about other players, including both their own team members and those of the opponent team ($\frac{\partial x^*}{\partial \alpha_i^g} = \frac{\partial x^*}{\partial \beta_i^g} = -\frac{R}{(Nn)^2}$). This is intuitive, because the proportional sharing rule essentially generates intra-team and inter-team competitions. An increase in either the degree of teammate-regarding behavior or the opponent-regarding behavior would reduce the equilibrium effort, and thus soften the within- and between-team rivalry feeling.

However, under the equal sharing rule, the reduction in effort only happens when the degree of opponent-regarding parameter decreases ($\frac{\partial x^*}{\partial \beta_i^g} = -\frac{R}{(Nn)^2}$). When instead the degree of teammate-regarding behavior decreases, the equilibrium effort would increase ($\frac{\partial x^*}{\partial \alpha_i^g} = \frac{R}{(Nn)^2}(N-1)$). Thus, the more the contestants care about their teammates, the more effort they wish to exert. This is intuitive. If they care about their team mates, they would want to help the team winning the prize by exerting higher effort. This leads us to the following set of predictions.

Prediction 2 (Within-Team Identity Composition under the Proportional Sharing Rules): *Based on Assumption 2 ($\alpha_i^0 \leq \alpha_i^N \leq \alpha_i^1$), individual efforts in a heterogeneous team (with α_i^0) are higher than those in a team with unknown identity composition (with α_i^N), i.e. our baseline treatment. Individual efforts in a homogenous team (with α_i^1) are lower than those in a team with unknown identity composition (with α_i^N).*

Prediction 3 (Within-Team Identity Composition under the Equal Sharing Rule):

Based on Assumption 2 ($\alpha_i^O \leq \alpha_i^N \leq \alpha_i^I$), individual efforts in a homogeneous team (with α_i^I) are higher than those in a team with unknown identity composition (with α_i^N). Individual efforts in a heterogeneous team (with α_i^O) are lower than those with unknown identity composition (with α_i^N).

In addition to the within-group team composition, the identity composition of the opponent team would also influence the equilibrium effort. When a competing team faces another competing team with a common identity, the degree of competitiveness between the competing teams may be moderated because individuals care also for the members of the opponent team. Such a concern will be reflected as a potential decrease in the value of the opponent-regarding parameter ($\beta_i^N \leq \beta_i^I$ in Assumption 3).

Contrary to the effects of α_i^g on individual effort, which rely on the sharing rule, the effect of β_i^g is independent of the sharing rule within the competing team. According to the comparative statics in (6), regardless of which sharing rule is adopted, an increase in the value of β_i^g reduces the individual effort level in equilibrium, and vice versa.

Prediction 4 (Identity Effect of the Opponent team): *Based on Assumption 3 ($\beta_i^O \leq \beta_i^N \leq \beta_i^I$), when one is facing a competing team with a common identity (with β_i^I), the inter-team competition is hampered. In contrast, when the competing teams carry different identity attributes (with β_i^O), the inter-team competition is escalated.*

2.3 Experimental Design

There are three stages in our experiment. They are as follows.

The Identity Inducement Stage. In this stage, the subjects are asked to review five pairs of paintings sequentially, each of which contains one painting by Paul Klee and

one painting by Wassily Kandinsky²¹. Subjects are not told any information about the paintings, including each painting's name, year, and the artist identity. Subjects are required to choose which painting in each pair they prefer. According to their *relative preferences*²², they are then categorized into two groups: Group Klee and Group Kandinsky. Subsequently, one pair of paintings, which consists of one painting by Klee and the other by Kandinsky²³, is shown to the subjects. They are then asked to guess the artist for each painting. A chat box is placed beside the pair of paintings, in which all the discussion history within each identity group will be displayed to all the in-group members (see the screenshot in Appendix A). The chat box will disappear automatically after five minutes, after which subjects must submit their guesses individually. We do not incentivize subjects in this identity inducement stage.

The Identity Enhancement Stage. In this stage, subjects are asked to make a series of decisions to allocate a certain amount of tokens between two other participants, not including themselves. There are five rounds, each of which has three scenarios: an allocation between two in-group members (*Scenario 1*), an allocation between two

²¹ The five pairs of paintings are: 1A Gebirgsbildung, 1924, by Klee; 1B Subdued Glow, 1928, by Kandinsky; 2A Dreamy Improvisation, 1913, by Kandinsky; 2B Warning of the Ships, 1917, by Klee; 3A Dry-Cool Garden, 1921, by Klee; 3B Landscape with Red Splashes I, 1913, by Kandinsky; 4A Gentle Ascent, 1934, by Kandinsky; 4B A Hoffmannesque Tale, 1921, by Klee; 5A Development in Brown, 1933, by Kandinsky; 5B The Vase, 1938, by Klee.

²² We follow the Minimal Group Paradigm used by (Chen and Li 2009) and make some slight modifications in order to have balanced competing teams in The Team Competition Stage. First, we categorize subjects according to their relative preferences instead of absolute preferences. In our post-experiment survey, there is a question asking each subject whether she or he has any prior knowledge about Paul Klee, or Wassily Kandinsky, or both. Among 240 participants, two (2) know both Kandinsky and Klee, four (4) know Kandinsky only, and two (2) know Klee only. From our observations, 71.35% of the subjects prefer Kandinsky to Klee. Among them, 33 subjects are assigned to the Klee identity group. However, none of these “misallocated” subjects has any prior knowledge about Kandinsky and Klee. Moreover, the second modification is that we did not provide any answer key for the five pairs of paintings before the subjects start their guessing about the artists. Only 90 out of these 192 subjects made correct guesses on the 6th pair of paintings, which is not much different from flipping a coin. According to these observations, most of the subjects are unable to distinguish the work of Klee and Kandinsky, so that a categorization based on relative preferences can work as effectively as a categorization based on absolute preferences, at least in this study.

²³ The two paintings for the guessing step are: 6A Monument in Fertile Country, 1929, by Klee, and 6B Start, 1928, by Kandinsky (shown in Appendix A).

out-group members (*Scenario 2*), and an allocation between one in-group member and one out-group member (*Scenario 3*). An in-group member here refers to a subject sharing the common identity with the allocator, and an out-group member refers to a subject carrying a different identity. From round 1 through 5, the number of tokens given in each allocation increases from 200 to 400, in an increment of 50 tokens per round.

The Team Competition Stage. In this stage, a team competition is conducted for 30 periods. In each period, subjects are assigned into teams of four members each ($n = 4$), to participate in a team competition. Two competing teams compete against each other ($N = 2$). Each contestant is endowed with 50 tokens ($E = 50$) at the beginning of each period, and then the contestant can choose to contribute a certain amount of tokens out of the endowment into her competing team. The tokens contributed by each member of the team are collected and pooled as the team effort. A prize worth 320 tokens ($R = 320$) will be given to the winning team, according to a probability equal to the team efforts divided by the overall effort from both teams. The prize will be further split among team members according to a certain sharing rule. At the end of each period, each subject is informed about her payoff, her team's winning probability, and the total effort of her team and that of the opponent team. The earnings from each period will not be carried forward to the next period. Eight periods are randomly chosen for payment at the end of the experiment. The treatments differ from each other by the identity composition of the competing teams in this stage. There are five experimental treatments; *Control*, *HeteroNI*, *HomoNI*, *HomoIdiff* and *HomoIsame*. In each experimental treatment, there are two experimental sessions; in one of them we employ a proportional sharing rule to divide the prize among members of the winning team, and in the other we employ an equal sharing rule to divide the winning prize.

Note that information about the identity compositions of members of the competing teams is common knowledge, and is explicitly stated in the written instructions. Table 1 provides further details of our experiment.

There is no information about the identity compositions of the competing

teams revealed to subjects in the *Control* treatment²⁴. The subjects in the *HeteroNI* and *HomoNI* treatments are informed that their team members are heterogeneous and homogeneous, respectively. Specifically, the subjects in *HeteroNI* are informed that their own competing team consists of two members from Group Klee and two from Group Kandinsky (See the sample of instruction provided in Appendix B).

Table 2.1. Identity composition of competing team

Treatment	Identity Composition*				Information Availability		Session (Sharing rules)	Female (%)
	Team A		Team B					
	Kandinsky	Klee	Kandinsky	Klee	Own Team	Opponent Team		
<i>Control</i>		N.A.			No	No	Equal Prop	45.8 41.7
<i>HeteroNI</i>	2	2	2	2	Yes	No	Equal Prop	37.5 37.5
<i>HomoNI</i>	4	0	0	4	Yes	No	Equal Prop	45.8 58.3
<i>HomoIdiff</i>	4	0	0	4	Yes	Yes	Equal Prop	62.5 45.8
<i>HomoIsame</i>	4	0	4	0	Yes	Yes	Equal Prop	33.3 41.7
Total								45

* Each contest consists of two teams, Team A and Team B, and their identity compositions, in terms of numbers of Group Klee members and numbers of Group Kandinsky members are summarized here.

From the comparison between the *Control* treatment and, respectively, the *HeteroNI* and *HomoNI* treatments, we are able to investigate the effect of identity composition of one's own team on individual effort. In both of these two treatments, the information about opponent teams is not revealed.

HomoIdiff and *HomoIsame* treatments are extensions of *HomoNI* treatment. In these two treatments, the own team's and the opponent team's identity composition are homogeneous, but across teams both teams may or may not have differing group identity. For example, in *HomoIdiff* all the own team's members may belong to Group

²⁴ In the *Control* treatment, subjects just review the five pairs of paintings and guess the artists for the sixth pair of paintings individually in the Identity Inducement Stage. They are not categorized or assigned to a certain identity group, and thus do not necessarily go through to the Identity Enhancement Stage.

Klee (Kandinsky), while all the opponent team's members belong to Group Kandinsky (Klee), or vice versa.

Essentially *Homodiff* resembles an inter-firm competition, while *HomolSame* resembles an intra-firm competition in which members of both teams share a common organizational identity. We are interested in evaluating the effect of identity composition of the two teams on members' incentive to exert effort.

Figure 2.1 illustrates the summary of our experimental treatments and our between-treatment comparisons.

Figure 2.1. the between-subject comparison, by treatment.

The outer big circle represents a competing team, while the inner small circle represents the team members. The blue or orange colors of the small circles denote the group identity, while the grey collar denotes an unknown identity.

At the end of the experiment, subjects are asked to complete a risk preferences task²⁵ (Holt, Laury et al. 2002) and a Cognitive reflective test²⁶ (CRT) (Frederick 2005), followed by a questionnaire that includes their demographic characteristics –

²⁵ There are 10 choice lines in the Risk Elicitation Task, and each of them has two options: a safe Option A of \$1 for sure and a risky choice with a payoff of either \$3 or \$0. Participants were asked to choose the option they preferred for each choice line.

²⁶ For the CRT test, we use the standard three-question format and give subjects 20 seconds for each question.

such as gender, university major, and prior knowledge about the artists. At the end of the experiment, each subject receives a cash payment in a closed envelope with her unique experiment ID on it. The ID is randomly generated at the beginning of the experiment and is not revealed to anyone else. Their earnings (ECUs) from the experiment is converted to cash payment at an exchange rate of 50 tokens to one Singapore dollar (S\$1), plus a show-up fee of S\$3. Overall, the subjects received 17.31 Singapore dollars on average, which was about 12.23 USD at the exchange rate during the time of our experiment.

In total, we conducted ten sessions, each of which took less than two hours. They were conducted in the economics laboratory at Nanyang Technological University Singapore in September 2015. Overall, we had 240 subjects, with a balanced gender composition in general (Table 2.1). All the subjects were undergraduate students from Nanyang Technological University. Each subject was only allowed to participate in one session of this experiment. We use z-Tree (Fischbacher 2007) to program an interface for our experiment.

2.4 Results

We first examine how individual subjects make their other-other allocation decisions in the second stage (the Identity Enhancement Stage) and also verify the salience of the induced identity. Our analysis then focuses on the contest effort level exerted by individual contestants within their team. Using the data on the contest effort levels, we then estimate the parameters of our Tullock group competition model with social preferences specified in the theory section.

Two common features apply throughout discussions in this section, unless otherwise specified. First, the nonparametric tests we used were conducted at an individual-averaged level. Second, our test results are established on the basis of a 5% significance level.

2.4.1 Other-other Allocations

Average allocations in the Identity Enhancement Stage are presented by *scenario* (identity type of recipients) and round (number of tokens given to allocators) in Figure 2. First of all, we notice that the allocation decisions in all three scenarios are not affected by the magnitude of the endowment (p -values > 0.3 by Kendall's tau tests). In the first two scenarios, when the two recipients share a common identity, subjects seem to be indifferent to these two recipients. Their average percentage of endowment tokens allocated to both is roughly equal (between 47.6% and 53.1%). However, in the third scenario, when the beneficiaries of the allocation are an in-group member and an out-group member, we observe a significant positive bias toward the in-group recipient (p -value < 0.01 by the Wilcoxon signed-rank test). The in-group member receives as many as 75% of the total tokens on average across the five rounds. The differences between the in-group allocations and out-group allocations in Scenario 3 (the bottom panel of Figure 2) are around 51.6% to 53.6% (normalized by the size of the endowment to be allocated to both parties), which are higher than those obtained in Chen and Li (2009) (around 32.2% to 38.4%). The finding illustrates a positive attitude toward an in-group member, reconfirming the salience of the induced identity shown by the MGP.

Figure 2.2. Average Other-other Allocation of Tokens, by Scenario.

The bars show the allocation between two in-group members (*Scenario 1*), an allocation between two out-group members (*Scenario 2*), and an allocation between one in-group member and one out-group member (*Scenario 3*). The height of the bars denote the total endowment available, the dark color portion denotes the share for the first beneficiary (A) and the light color portion denotes the remaining share for the second beneficiary (B). The identity of the beneficiaries is indicated in the legend. There are five rounds, and the number of tokens given in each allocation increases, in increments of 50, from 200 to 400.

Figure 2.3 illustrates the distribution of in-group allocation in Scenario 3 where subjects have to allocate tokens to an in-group member and an out-group members. It is obvious that allocators (93.23%) would in general allocate more than or equal to 50% of the endowment tokens to their in-group members showing in-group favoritism. However, the degree of in-group favoritism varies across these allocators implying that the MGP procedure, although effectively induces an in-group favoritism, generates a varying degree of in-group favoritism.

Figure 2.3. Histogram of Individual In-group Allocation in Scenario 3 of Stage 2. There are five rounds of play, and we take the average of in-group allocations across these five rounds for each individual. Percentage (%) here refers to the average percentage of the endowment tokens allocated to the in-group members in these five rounds.

2.4.2 Individual Effort

Given the parameter values we use in our experimental design, the Nash-equilibrium effort level under the two sharing rules when players care only about their own payoffs can be straightforwardly derived. They are, respectively, 35 and 5 tokens under the proportional sharing rule and under the equal sharing rule. We use these equilibrium effort levels as our benchmark.

Figure 2.4 summarizes the average individual effort level, by treatment, under the two sharing rules. Comparing the two sharing rules, the 2-sided Wilcoxon--Mann--Whitney tests show that the effort level under the proportional sharing rule is much higher than that under the equal sharing rule (p -values < 0.009 at the session level). This finding confirms Prediction 1, and it is in line with other existing experimental observations on these two sharing rules (Gunnthorsdottir and Rapoport 2006, Kugler, Rapoport et al. 2010). Moreover, according to Figure 2.4, the gaps between the two

sharing rules are 18.0, 22.0, and 13.7 for the *Control*, *HeteroNI*, and *HomoNI* treatments, respectively. Referring back to the theoretical predictions under the two sharing rules (6), the homogeneous team composition inculcates an in-group favoritism among team members, which helps to reduce the gap in the individual effort level under the two sharing rules.

Figure 2.4. Individual Effort, by Treatment and Sharing Rule

Result 1 *The individual effort level under the proportional sharing rule is much higher than that under the equal sharing rule (support for Prediction 1), and the gap between the two sharing rules in a homogeneous team composition is much smaller than that in a heterogeneous team composition.*

Next, we discuss the treatment effects under the two sharing rules. Table 2.2 presents the multilevel mixed-effects linear estimation on *individual effort* under the two sharing rules, without the identity information of the opponent team (in *Control*, *HomoNI*, and *HeteroNI*).

Table 2.2. Mixed-effect models for *Control*, *HeteroNI*, and *HomoNI*

Dependent Variable: <i>Individual Effort</i>	Sharing Rule			
	Proportional		Equal	
$d_{HeteroNI}$	5.001**	4.624**	1.208	1.930
=1 in <i>HeteroNI</i>	(2.281)	(2.250)	(2.964)	(2.958)
d_{HomoNI}	0.851	0.300	4.743	5.293*
=1 in <i>HomoNI</i>	(2.276)	(2.259)	(2.991)	(2.991)
<i>Gender</i>	0.890	0.0299	-2.504	-2.089
=1 if male	(1.883)	(1.918)	(2.468)	(2.579)
<i>CRT scores</i>		1.502		-1.612
		(0.940)		(1.110)
<i>Period</i>	-0.171***	-0.171***	-0.380***	-0.380***
	(0.0305)	(0.0305)	(0.0278)	(0.0278)
<i>Risk switching point</i>		-0.123		0.425
higher, more risk-seeking		(0.426)		(0.502)
Constant	33.56***	33.03***	20.71***	19.68***
	(1.963)	(2.967)	(2.578)	(3.374)
Observations	2,160	2,088	2,160	2,088
Log-Likelihood	-8574	-8573	-8397	-8396
Chi-square	37.15	40.16	191	193.7
Robust standard errors clustered at the individual level are in parentheses				
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$				

The results on the effect of own team's identity composition are as follows.

Result 2a *Under the proportional sharing rule (which we interpret as the high-powered incentive scheme), the individual effort level in a team with heterogeneous identity composition is higher than that in a team with unknown identity composition.*

Under the proportional sharing rule, the individual effort level in *HeteroNI* is significantly higher than that in *Control* (p -values < 0.040 in the regression results), but the individual effort level in *HomoNI* is not significantly different from that in *Control* (p -values < 0.895 in the regression results).

Result 3a *Under the equal sharing rule (the low-powered incentive scheme), the*

individual effort level in a team with homogenous identity composition is higher than that in a team with unknown identity composition, with a marginal significance level.

Under the equal sharing rule, the individual effort level in *HomoNI* is generally higher than in *Control*, with a marginal significance level (p -value=0.077 in the regression result with other factors controlled). We also find that individual contestants are much less likely to free ride in *HomoNI* (15.96%) than in *Control* (35.28%). Whereas, the treatment effect of *HeteroNI* under the the equal sharing rule is not significant (p -values>0.514 in the regression result).

Regarding the identity composition of the opponent team, Table 2.3 presents the multilevel mixed-effects linear estimation on individual effort level, conditional on the homogeneous identity composition of one's own team (in *HomoNI*, *HomoIdiff*, and *HomoIsame*).

Result 4a *Under the equal sharing rule (a low-powered incentive scheme), when the competing teams share a common identity, there will be a lower individual effort level than in the case when no information about identity composition of the opponent competing team is available.*

The individual effort level under the equal sharing rule in *HomoIsame* is significantly lower than that in *HomoNI* (p -value<0.001 in the regression result), but not under the proportional sharing rule (p -values>0.669 in the regression result).

We also find that, regardless of which sharing rule is adopted, the individual effort level in *HomoIdiff* is not significantly different from that in *HomoNI* (p -values>0.110 in the regression result). We find that the individual effort level in *HomoIdiff* is not significantly different from that in an identity-unknown environment (in *Control*) (p -values>0.628). This finding is in line with a recent study by Chowdhury, Jeon et al. (2016). They shows that the intensity of an inter-team conflict; which, in their paper, is also modeled as a group contest with an equal sharing rule

where the group identity is induced using a random assignment, is not significantly different from that in a setting with unknown identity composition.

Table 2.3. Mixed-effect models for *HomoNI*, *HomoIdiff*, and *HomoIsame*

Dependent Variable: <i>Individual Effort</i>	Sharing Rule			
	Proportional sharing rule	Equal sharing Rule		
$d_{HomoIdiff}$	-0.964	-1.359	-4.140	-4.295
=1 in <i>HomoIdiff</i>	(2.948)	(2.930)	(2.755)	(2.687)
$d_{HomoIsame}$	0.124	-1.296	-10.16***	-11.89***
=1 in <i>HomoIsame</i>	(2.936)	(3.035)	(2.766)	(2.877)
<i>Gender</i>	-2.916	-3.547	2.006	2.319
=1 if male	(2.459)	(2.516)	(2.261)	(2.261)
<i>CRT scores</i>		1.276		-2.324**
		(1.022)		(1.122)
<i>Period</i>	-0.150***	-0.150***	-0.395***	-0.395***
	(0.0284)	(0.0284)	(0.0254)	(0.0254)
<i>Risk switching point</i>		0.696		0.279
higher, more risk-seeking		(0.566)		(0.480)
Constant	36.15***	31.78***	23.81***	25.06***
	(2.496)	(3.725)	(2.190)	(3.705)
Observations	2,160	2,088	2,160	2,088
Log-Likelihood	-8441	-8439	-8205	-8202
Chi-square	29.27	32.12	254.8	261.6
Robust standard errors clustered at the individual level are in parentheses				
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$				

The regression results in both Table 2.2 and Table 2.3 on the treatment effects generally confirm the effect of identity composition presented in the Theory Section. In the next subsection, we present the parameter estimation results based on our Tullock group contest with social preferences model (5) and provides insights into the connection between individual effort level, on the one hand, and the identity composition and other-regarding preferences on the other hand.

2.4.3 Estimation of Teammates- and Opponent-Regarding Parameter

To further explain the previous results on the individual effort level differences across treatments, we estimate the parameters of other-regarding preferences in the model of social preferences (5) at the individual level, as captured by the *teammate-regarding* parameter α_i^g and the *opponent-regarding* parameter β_i^g .

$$U(x_i) = f(\pi_{ik}^e, \overline{\pi_{-ik}}^e, \overline{\pi_{-k}}^e) = \pi_{ik}^e + \alpha_i^g \times \overline{\pi_{-ik}}^e + \beta_i^g \times \overline{\pi_{-k}}^e, \quad (5)$$

Figure 2.3 (the histogram of the individual-averaged in-group allocation in Scenario 3 of Stage 2) shows that individuals' responses to the induced identity are diverse. Some of them demonstrate a strong in-group favoritism by allocating all tokens to their in-group member, and some others prefer to make an equal split between an in-group member and an out-group member. For this reason, in our analysis we focus on the identification of the heterogeneous treatment effects. Specifically, we allow for the parameters of other-regarding preferences to differ across individuals in the same treatment, and we assume that these differences are captured by their innate degree of in-group favoritism (ρ_i) as proxied by the distance between their average in-group allocation in *Scenario 3* and the 50% allocation. The value is positive if the individual i exhibits an in-group favoritism. We denote a treatment by $c \in \{HeteroNI, HomoNI, HomoIsame, \text{ or } HomoIdiff\}$ and the individual treatment effect for individual i in Treatment c by $T_{i,c} = \rho_i$. If instead individual i is not in Treatment c then $T_{i,c} = 0$.

We assume that parameters α_i^g and β_i^g depend on; 1) the employed sharing rule for α_i^g , 2) $T_{i,c}$ ($T_{i,HeteroNI}$ and $T_{i,HomoNI}$ for α_i^g , and $T_{i,HomoIdiff}$ and $T_{i,HomoIsame}$ for β_i^g), 3) the interactions between the sharing rule and $T_{i,c}$, 4) the time period, and 5) gender.

Because the sharing rule determines whether there is competition or cooperation within each group, a dummy variable of the sharing rule is embedded into the formula of the teammate-regarding parameter α_i^g . We assume, however, that the sharing rule will only *directly* affect the interactions among individuals in their own

teams, but not between competing teams. Nevertheless, the treatment effects $T_{i,c}$ can potentially be influenced by the sharing rule, and to capture this we incorporate the interaction effect between the treatments and the sharing rules in our estimation.

We estimate Model (5) by using a conditional logit model (McFadden 1973). From the data we collected, 87.83% of individual contributions are exact multiples of 5 – specifically, 0,5,10,...,50 – so the conditional logit likelihood function – namely, the probability function of choosing option l out of these 11 options– is constructed as

$$\sigma_l(x_{ik,l}) = \frac{\exp(U(x_{ik,l}))}{\sum_{j=0,5,\dots,50} \exp(U(x_{ik,j}))}. \quad (7)$$

We first look at the estimation results for the *teammate-regarding parameter* (α_i^g).

$$\begin{aligned} \alpha_i^g = & \underset{(0.131)}{0.742^{***}} + \underset{(0.243)}{0.453^*} \times d_{equalsharing} - \underset{(0.453)}{2.012^{***}} \times T_{i,HeteroNI} + \\ & \underset{(0.461)}{0.324} \times T_{i,HomoNI} + \underset{(0.707)}{2.575^{***}} \times T_{i,HeteroNI} \times d_{equalsharing} + \underset{(0.754)}{3.459^{***}} \times T_{i,HomoNI} \times \\ & d_{equalsharing} \end{aligned} \quad (8)$$

We thus have the following result for the proportional sharing rule.

Result 2b *Under the proportional sharing rule (which we interpret as the high-powered incentive scheme), the teammate-regarding parameter (α_i^g) in a team with heterogeneous identity composition is higher than that in a team with unknown identity composition.*

We can see from equation (8), that in the control treatment where no identity information is provided, the teammate-regarding parameter (α_i^g) is significant and equals to 0.742 (p -value<0.001) implying that individuals in general care about their teammates.

The coefficient for the heterogeneous treatment effects in *HeteroNI* ($T_{i,HeteroNI}$) shows that the teammate-regarding parameter is significantly weaker than that in the

control treatment. For example, consider individual i in Treatment *HeteroNI* who allocated 70% of her endowment to her in-group member, which is close to the average in-group allocation of all participants across all treatments. In this case, we have $T_{i,HeteroNI} = 20\%$ and thus the value of α_i^g for this person is equal to $\alpha_i^g = \underset{(0.131)}{0.742^{***}} - \underset{(0.467)}{2.012^{***}} \times T_{i,HeteroNI} = 0.339$ ($p\text{-value}=0.025$). Still another example, suppose the allocation to the in-group is 100% of the endowment. In this case, we have $T_{i,HeteroNI} = 50\%$ and thus the value of α_i^g for this person is equal to $\alpha_i^g = \underset{(0.131)}{0.742^{***}} - \underset{(0.467)}{2.012^{***}} \times T_{i,HeteroNI} = -0.264$. The linear combination test to evaluate whether this value is equal to 0 produces an insignificant result ($p\text{-value}=0.289$), implying that in *HeteroNI* her teammate-regarding behavior vanishes. Therefore, we can see the treatment effect of the heterogeneous identity composition on the teammate-regarding parameter (α_i^g) changes with the degree of in-group favoritism.

In the meantime, the coefficient for the heterogeneous treatment effects in *HomoNI* ($T_{i,HomoNI}$) shows that the teammate-regarding parameter is not significantly different from that in the control treatment ($p\text{-value}=0.482$).

Next, we focus on the equal sharing rule case. First, the value of teammate-regarding parameter α_i^g under the proportional sharing rule is larger than that under the equal sharing rule with a marginal significance ($p\text{-value}=0.062$). As shown in the prize share function (2), the sharing rule determines how team members of the winning team share the prize, that can influence their preferences towards teammates. According to the theoretical predictions (6), an increase in α_i^g helps to improve the individual effort level under the equal sharing rule but reduce the effort level under the porportional sharing rule. The increment here we observed, however, is not large enough to completely remove the difference in the equilibrium effort level between the two sharing rules.

Under the equal sharing rule, when no identity information is provided (in *Control*), the teammate-regarding parameter (α_i^g) is significant and equals to 1.195

(p -value<0.001) implying that individuals in general care about their teammates.²⁷ It can be seen that the coefficient for the heterogeneous treatment effects in *HeteroNI* ($T_{i,HeteroNI}$) shows that the teammate-regarding parameter is not significantly different from that in the control treatment (p -value=0.300).

Result 3b *Under the equal sharing rule (the low-powered incentive scheme), the teammate-regarding parameter (α_i^g) in a team with homogenous identity composition is higher than that in a team with unknown identity composition.*

The coefficient for the homogenous treatment effects in *HomoNI* ($T_{i,HomoNI}$) shows that the teammate-regarding parameter (α_i^g) in *HomoNI* is significantly higher than that in the control treatment. For example, consider individual i in Treatment *HomoNI* who has $T_{i,HomoNI} = 20\%$, which is close to the average in-group allocation of all participants across all treatments. In this case, the value of α_i^g for this person is going to be equal to $\alpha_i^g = \underset{(0.131)}{0.742^{***}} + \underset{(0.243)}{0.453^*} \times d_{equalsharing} + \underset{(0.461)}{0.324} \times T_{i,HomoNI} + \underset{(0.754)}{3.459^{***}} \times T_{i,HomoNI} \times d_{equalsharing} = 1.952^{28}$ (p -value<0.001), implying that in *HomoNI* under the equal sharing rule, she cares more about the teammates than she were in *Control*. In general, across individuals in this treatment, a care for one's teammates is found to be positively correlated with her degree of in-group favoritism.

We next focus on the *opponent-regarding parameter* β^g . Under the proportional sharing rule, it is as follows:

$$\beta_i^g = \underset{(0.145)}{-0.932^{***}} - \underset{(0.544)}{0.223} \times T_{i,HomoDiff} - \underset{(0.653)}{0.615} \times T_{i,HomoIsame} - \underset{(0.517)}{0.399} \times T_{i,HomoDiff} \times d_{equalsharing} + \underset{(0.401)}{1.467^{***}} \times T_{i,HomoIsame} \times d_{equalsharing}, \quad (9)$$

²⁷ Statistical test shows that this parameter value is not significantly different from 1.

²⁸ This parameter captures the teammate-regarding parameter at the beginning of period 1. In the estimation results, the effect of the time period is statistically significant in both other-regarding parameters (see details in Appendix D). Specifically, the teammate-regarding parameter decreases over the periods of time, and when we take into account the periods we find that this estimated parameter is not significantly different from 1 in the later periods.

Result 4b *Under the equal sharing rule (a low-powered incentive scheme), when the competing teams share a common identity, there will be a much higher opponent-regarding parameter than in the case when no information about identity composition of the opponent competing team is available.*

The coefficient for the heterogeneous treatment effects in *HomoIsame* ($T_{i,HomoIsame}$) shows that the opponent-regarding parameter (β_i^g) is significantly stronger than that in the control treatment ($p\text{-value} < 0.001$). For example, consider individual i in Treatment *HomoIsame* who has $T_{i,HomoIsame} = 20\%$ and thus the value of β_i^g for this person is going to be equal to $\beta_i^g = -0.932^{***}_{(0.145)} + 1.467^{***}_{(0.401)} \times T_{i,HomoIsame} = -0.639$ ($p\text{-value} < 0.001$). Still another example, suppose the allocation to the in-group is 100% of the endowment. In this case, we have $T_{i,HeteroNI} = 50\%$ and thus the value of α_i^g for this person is going to be equal to $\beta_i^g = -0.932^{***}_{(0.145)} + 1.467^{***}_{(0.401)} \times T_{i,HomoIsame} = -0.199$ ($p\text{-value} = 0.416$). It implies that when one is facing an opponent team which is composed of her in-group members, the sense of rivalry against opponents is weakened, and even vanishes when one's in-group favoritism is strong enough.

The coefficients for the rest heterogeneous treatment effects of the opponent team's identity composition are all insignificant (under the proportional sharing rule $p\text{-value} = 0.681$ for $T_{i,HomoIdiff}$ and $p\text{-value} = 0.346$ for $T_{i,HomoIsame}$; under the equal sharing rule $p\text{-value} = 0.440$ for $T_{i,HomoIdiff}$).

To summarize, under the equal sharing, the opponent-regarding parameter (β_i^g) in the *HomoIdiff* treatment is not significantly different from that in the *HomoNI* treatment. Under the proportional sharing rule, individuals do not care about the identity of opponents at all. Combining with the previous result, the individual contestants under the proportional sharing rule only care about whether their own team has a heterogeneous identity composition or not.

2.5 Concluding Remarks

This study focuses on the effect of intra- and inter-team identity on individual's effort level exerted in an inter-team competition, modeled as Tullock group rent-seeking contest, with two different sharing rules incorporated into the model to capture various powers of incentives. In order to tease out the interplay between the power of incentive and the identity composition of the competing teams, we constructed a social preferences model, which allows decisions of individuals to be based on their attitudes toward teammates and opponent teams. The theoretical predictions derived from the social preferences model show that the effect of identity composition within a competing team depends on the power of the incentive.

Using the data from our experiment, we conduct the regression analysis to evaluate how the individual effort level is influenced by the identity composition of the competing teams, followed by the estimations of the other-regarding parameters in the model. By focusing on these teammate- and opponent-regarding parameter estimates, we are able to provide an explanation to the observed relative effort level across treatments.

We find that under the equal sharing rule (the low-powered incentive scheme), sharing a common identity within one's own team helps to improve the individual effort level and promote intra-team cooperation (Result 2a). The intra-team cooperation under the equal sharing rule is enhanced by an in-group favoritism among in-group team members, which leads to a stronger care about one's teammates than that in the identity-unknown situation (Result 2b). As discussed in the theory section, the contest under the equal sharing rule shares a similar incentive mechanism with public goods games in which cooperation is socially optimal. Our result is in line with previous experiments, which also show that participants are more likely to cooperate with other members from the same group (Eckel and Grossman 2005, Goette, Huffman et al. 2006, Simpson 2006, Chen and Li 2009).

Under the proportional sharing rule (the high-powered incentive scheme),

when people know some of their teammates carry different identity attributes, their effort level is higher than that in the identity-unknown situation, and the competition among the team members are escalated (Result 3a). The proportional sharing rule induces the competitive feeling within the team, and the competitive feeling is enhanced by the presences of the out-group members in one's own team (Result 3b).

Applying these above findings into real-life applications, we can draw some recommendations for organizations and firms, if they are keen to elicit employees' effort through establishing a common organizational identity. Building a common organizational identity, which essentially serves to enhance a bonding among employees, may not work well with a high-powered incentive scheme. When one's pay is highly related to one's efforts and performances, a sense of rivalry among employees could effectively prevent shirking by itself. A better way to improve productivity or elicit employees' input is to allow for an identity diversity in a work team. Nevertheless, when incentives are not so high-powered, and employees need to cooperate to achieve a common goal, building a common identity would still be very helpful in eliciting employees' effort and promoting the cooperation.

We also study the effect of the opponent's team identity composition. Based on our experimental observations under the equal sharing rule, when the two competing teams share a common identity, the individual effort level is significantly lower than that when the identity composition of the opponent team is unknown (Result 4a), as sharing a common identity with the members of the opponent team has the effect of dampening the competitive feeling between teams (Result 4b). Especially for those with strong innate in-group favoritisms, their effort levels will be substantially reduced, and they may start to shirk when they realize that the opponent team is composed of their in-group members.

Therefore, our results suggest that the internal competition ("shark tank") in which all the competing teams share a common organizational identity, may not be a fitting choice for a company with strong organizational identification among employees, especially when a high-powered incentive is absent. Some elements of

corporate trainings, such as the identity building activities and the internal competition, may not be universally compatible to all types of firms. They have to be delicately designed to match the firms' existing incentive schemes.

2.6 Appendix

2.6.1 Appendix A: Screenshots for the experimental procedure

2.6.2 Appendix B: Sample Instructions (HeteroNI under the proportional sharing rule)

General Information

You are now taking part in an interactive study on decision making. **Please pay attention to the information provided here and make your decisions carefully. If at any time you have questions to ask, please raise your hand and we will attend to you in private.**

Please note that unauthorized communication is prohibited. Failure to adhere to this rule would force us to stop the experiment and you may be held liable for the cost incurred in this experiment. You have the right to withdraw from the experiment at any point of time, and if you decide to do so your payments earned during this study will be forfeited and you will only receive your show-up fee.

By participating in this study, you will be able to earn an amount of money. The amount depends on the decisions you and others make.

At the end of this session, this money will be paid to you privately and in cash. It would be contained in an envelope (indicated only with your unique user ID). Please exchange the claim card given to you with this envelope.

General Instructions

After the experiment starts, each of you will be given a unique numerical user ID randomly generated by the computer terminal. Your anonymity will be preserved for the study. You will never be aware of the personal identities of other participants during or after the study. Similarly, other participants will also never be aware of your personal identity during or after the study. You will only be identified by your user ID in our data collection. All information collected will strictly be kept confidential for the sole purpose of this study.

Specific Instructions

Stage 1

In the first stage, you will first be shown five pairs of paintings. Each of the first **two** pairs contains one painting by Paul Klee and one painting by Wassily Kandinsky. They were abstract artists in the last century. You will not be told which one is painted by Paul Klee and which one is painted by Wassily Kandinsky. You will then be asked to choose which painting in each pair you prefer. **According to your relative**

preferences, you will then be classified into one of two groups, i.e., Group Klee and Group Kandinsky.

Subsequently, you will be shown a pair of paintings that consists of one painting by Klee and the other by Kandinsky. You will not be told which one is painted by whom. You are asked to guess the painter. **Before submitting your guess, you are given 5 minutes of discussion within your Group.** For example, if you are from Group Klee, you can discuss with other Group Klee members, in order to help you figure out the answer. Likewise, a Group Kandinsky member can discuss with other Group Kandinsky members.

After the five minutes of discussion ends, you will be asked to make your guess individually. Then, you will proceed to the next stage.

Stage 2

In the second stage, you will be asked to allocate a given amount of tokens between two other participants. From **round 1 to round 5**, the total number of tokens to be allocated will increase from 200 to 400 by an increment of 50 tokens in each period. The identities of the two other participants to whom you will allocate the tokens will vary according to the following three scenarios:

1. Both of them come from your group.
2. Both come from the other group.
3. One comes from your own team and the other from a different group.

Only one round of your decisions will be randomly selected by the computer to compute your earnings.

Your earnings will be calculated in tokens. They will be converted into Singapore Dollars at the rate of

50 tokens = 1 SGD

Stage 3

In this stage, you will be assigned to a team of **four (4)** participants (including you). Your team will interact with another team of four (4) participants for multiple periods. Your team composition will **differ from period to period, but it is always the case that two of your team members are from Group Klee and the other two are from Group Kandinsky.** In each period, both your team and your opponent team will compete for a prize.

Specifically, in each period, each team member will have to decide how many tokens to contribute into his (her) team account. The total amount of tokens contributed in the team account will then be used to compete against an opponent team. The winning team will receive a prize worth 320 tokens in that period. The losing team will receive

0 tokens. To begin with, every team member is given **50 endowment** tokens in every period. **Eight (8)** of the periods will be randomly chosen to determine your earnings.

You proceed by deciding how many tokens out of your initial endowment to contribute to your team account. Your contribution can range from 0 up to 50 tokens. The remaining endowment tokens not contributed will be kept in your private account.

Your team account will then consist of all tokens contributed by your team members. Likewise, your opponent team's account will consist of all tokens contributed by your opponent team's members.

All tokens in your team account will be spent to win the prize. The more tokens a team spends, the higher the team's probability of winning. Specifically, your team's winning probability is equal to the proportion of your team's tokens to the total sum of tokens of both teams.

If your team's tokens are equal to your opponent team's tokens, your team and your opponent team will have an equal chance of winning the competition. In this case, one of the teams will be randomly picked as the winner. **Note that a higher team account will increase the team's chance of winning the prize; however, it does not lead to a definite win.**

If your team wins the prize, the prize of 320 tokens will be distributed among your team members according to **a proportional sharing rule**. Thus, each team member's payoff is proportional to his/her tokens contributed to the team account. Your earning will be the sum of your share of the prize and the remaining tokens in your private account.

If your team does not win the prize, you will just receive the remaining tokens left in your private account.

Your earnings will be calculated in tokens. They will be converted into Singapore Dollars at the rate of

50 tokens = 1 SGD

To summarize,

Your private account = $(50 - \text{your contribution to your team account})$

Earning from this period

If your team wins in this period, your earning for this period is equal to: your private account + $(\text{your contribution}) / (\text{your team account}) \times 320$ tokens

If your team does not win in this period, your earning for this period will only be whatever amount left in your private account

The following is a hypothetical numerical illustration of the decision in our experiment.

Suppose that you put **30** tokens in your team account, and assume that the total tokens in your team account are **100** and that the total tokens in the opponent team's account

are **50**. Your team's probability of winning the prize can then be calculated as $\frac{100}{100+50} = 67\%$.

Your earnings from your private account are equal to $50 - 30 = 20$ tokens. With the proportional sharing rule, your share of earning from winning the contest is $(30/100) \times 320 = 96$. If, however, your team does not win the competition, there are no tokens to share with you. Your earning will just be equal to 20, which is the amount of tokens in your private account.

In sum, your team will win the contest with the probability of 67% and you will then earn $20 + 96 = 116$ tokens. With the probability of 33% for your team losing the contest, you will earn only 20 tokens.

After all participants have made their decisions for each period, the results for that period will be reflected on your computer screen. You will be informed of the total allocation to your team account, the opponent team's account, your team's probability of winning, and your earning for this period.

This is the end of the decision making process for one period. After that, a new period begins. You will have to do the same exercise for several periods. **Eight periods of your decisions will be randomly selected by the computer to compute your earnings from this stage.**

Stage 4

In this part of the study you will be asked to make a series of choices. How much you receive will depend partly on chance and partly on the choices you make. The decision problems are not designed to test you. What we want to know is what choices you would make in them. The only right answer is what you really would choose.

For each line in the table you will see in this stage, please indicate whether you prefer option A or option B. There will be a total of 10 lines in the table, but just one line will be randomly selected for payment. You will not know which line will be paid when you make your choices. Hence you should pay attention to the choice you make in every line.

After you have completed all your choices, the computer will randomly determine which line is going to be paid out.

Your earnings for the selected line depend on which option you chose: If you chose option A in that line, you will receive 20 tokens. If you chose option B in that line, you will receive either 60 tokens or 0. To determine your earnings in the case of your choosing option B, there will be a second random draw. The computer will randomly determine if your payoff is 0 or 60, with the chances set by the computer as they are stated in Option B.

Your earning from Stage 3 will be added to your final earnings from this experiment

when the experiment is completed.

After you have completed all your choices, the computer will randomly generate a number, which determines which scenario is going to be paid out.

Then you will be asked to complete a short individual task, which consists of 3 questions. In total, you will be given 1 minute to answer them. The time allocated into each question is given as follows,

	Q1	Q2	Q3
Time given (seconds)	20	20	20

Please keep a close watch of the time shown at the top right-hand corner of your screen. If you manage to answer all questions correctly, you will receive 50 tokens.

This is the end of Stage 3. After that, you will be asked to complete a post-experimental survey. **At the end of the survey, your total tokens and your earnings after conversion will be shown to you on your computer screen.**

2.6.4 Appendix C: Effort Levels over the Time Periods

Individual Efforts under the Proportional Sharing rule, over 30 Periods

Individual Efforts under the Equal Sharing Rule, over 30 Periods

2.6.3 Appendix D: Estimation Results

$$U(x_i) = f(\pi_{ik}^e, \overline{\pi_{-ik}^e}, \overline{\pi_{-k}^e}) = \pi_{ik}^e + \alpha_i^g \times \overline{\pi_{-ik}^e} + \beta_i^g \times \overline{\pi_{-k}^e}, \quad (7)$$

$$\text{where } \alpha_i^g = \alpha_1 + \theta_1 \times d_{\text{equal}} + \delta_1 \times T_{i,\text{HeteroNI}} + \delta_2 \times T_{i,\text{HomoNI}} \\ + \delta_3 \times T_{i,\text{HeteroNI}} \times d_{\text{equal}} + \delta_4 \times T_{i,\text{HomoNI}} \times d_{\text{equal}}$$

$$\text{and } \beta_i^g = \beta_1 + \delta_5 \times T_{i,\text{Homoldiff}} + \delta_6 \times T_{i,\text{Homolsame}} + \delta_7 d_{\text{equal}} \times T_{i,\text{Homoldiff}} \\ + \delta_8 \times d_{\text{equal}} \times T_{i,\text{Homolsame}}$$

The following table exhibits the Conditional logit estimation result based on all treatments in Column (1), the treatments without the identity information of the opponent team (in *Control*, *HomoNI*, and *HeteroNI*) in Column (2), and the treatments with the identity information of the opponent team (in *HomoNI*, *Homoldiff*, and *Homolsame*) in Column (3).

Dependent Variable: <i>Individual Effort</i>	Specification (7)		
	(1)	(2)	(3)
α_1	0.742*** (0.131)	0.798*** (0.178)	0.726*** (0.160)
d_{equal} in α^g	0.453* (0.243)	0.648* (0.332)	0.859** (0.334)
d_{gender} in α^g =1 if male	0.0188 (0.101)	-0.148 (0.123)	0.0745 (0.146)
d_{HeteroNI}	-2.012*** (0.453)	-1.858*** (0.470)	
d_{HomoNI}	0.324 (0.461)	0.415 (0.474)	
$d_{\text{HeteroNI}} \times d_{\text{equal}}$	2.575*** (0.707)	1.772** (0.707)	
$d_{\text{HomoNI}} \times d_{\text{equal}}$	3.459*** (0.754)	2.672*** (0.767)	
β_1	-0.932*** (0.145)	-1.014*** (0.192)	-0.875*** (0.178)
d_{gender} in β^g	0.0833 (0.103)	0.0630 (0.124)	0.111 (0.148)
$d_{\text{HomoIdiff}}$	0.223 (0.544)		0.0467 (0.555)
$d_{\text{HomoIsame}}$	0.615 (0.653)		0.401 (0.675)
$d_{\text{HomoIdiff}} \times d_{\text{equal}}$	-0.623 (0.750)		0.129 (0.861)
$d_{\text{HomoIsame}} \times d_{\text{equal}}$	0.852 (0.766)		1.638* (0.910)
period in α^g	-0.0216*** (0.00282)	-0.0189*** (0.00362)	-0.0242*** (0.00376)
period in β^g	0.0587*** (0.00283)	0.0607*** (0.00365)	0.0611*** (0.00377)
Observations	79,200	47,520	47,520
Robust standard errors clustered at the individual level are in parentheses			
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$			

Chapter 3 : Firing the Right “Bullets”: Centralized Punishment in the Provision of Public Goods

3.1 Introduction

Not all law breakers are punished as law enforcement naturally is subject to resource constraints. For instance, not every car on road exceeding the speed limit gets a speeding ticket. It is more common that the ticket is issued to the fastest car going over the limit. Tax authorities are prone to pursue tax evasion cases against big corporations rather than small businesses. Law enforcement agencies often devote the resources to prosecuting the most heinous crimes (e.g., murder) instead of misdemeanors. It is a common practice to punish the largest deviator. One being the second largest deviator therefore dodges sanction. Intuitively, the competition of not being the largest deviator should eventually drive out any deviations and lead to a socially optimal outcome.

Following this line of reasoning, Andreoni and Gee (2012) the hired gun mechanism to overcome the free rider problem in a voluntary contribution setting. It is a centralized and automatic mechanism which punishes the lowest contributor to an extent that she would rather have been the second lowest. It has been shown to be effective in promoting contribution (Andreoni and Gee 2012, Andreoni and Gee 2015). An overlooked but paramount issue is how to assign an appropriate size of punishment. If punishment is too small, it is not enough to discourage free-ride. On the opposite side, unnecessarily large punishment results in societal welfare loss²⁹.

We adopt the hired gun mechanism as the centerpiece to explore the right size of punishment. The punishment in the hired gun mechanism consists of the unilateral

²⁹ Though in our experiment, the mere presence of severe punishment in the hired gun mechanism deters free-riding. As a result, the punishment is rarely implemented. One might argue that severe punishment does not necessarily cause social welfare loss. We would argue that this might not be the case in general. Due to limited rationality, noisy information, judicial errors and various other factors, it is not uncommon that severe punishment does happen, e.g., life sentence and other felony convictions. The actual implementation of severe punishments causes societal welfare loss.

punishment, which aims to discourage people from being the lowest contributor, and the tie punishment, which is to prevent people from coordinating on a tie at a below full-contribution level. We generalize the mechanism by introducing flexibility of these two components and derive a wide range of classes of effective mechanisms with various sizes of punishment. We also run experiments to test the generalized mechanism. The experimental results are mostly consistent with the theory except for the mechanism with lenient punishment parameters. This discrepancy between theory and experimental results is successfully explained by individual evolutionary learning (IEL hereafter). The results from IEL simulations without sample size and time horizon constraints square with the experimental results. Besides contribution behavior in public goods game, IEL has been used to study various economic behaviors in the literature, for instance, the firm's production decision in competitive markets (Arifovic, 1994), and the effects of information on call markets (Arifovic & Ledyard 2007).

The free rider problem in public goods provision has received the lion's share of attention in the literature. It is a classic social dilemma where collective interests are at odds with individual interests, leading to a non-socially optimal outcome. Mounting studies have explored the mechanisms to mitigate free riding in public goods provision. Exhausting this literature is beyond the scope of this paper, we only focus on the strand of literature that investigates the role of punishment in promoting cooperation.

There has been a burgeoning literature on punishment mechanisms in improving cooperation in public goods provision (see Chaudhuri (2011) for an excellent survey). Depending on the administration body of punishment, there are informal punishment and formal punishment. Informal punishment, which is also commonly referred to as peer-to-peer punishment, is usually administrated by fellow group members. Though it is costly to exercise such punishments, people are willing to punish free-riders, which results in higher contribution levels (Fehr and Gächter 2000, Fehr and Gächter 2002, Cason and Gangadharan 2015). This finding has been replicated by dozens of studies later on (surveyed by Chaudhuri (2011)). Despite its

effectiveness, informal punishment system suffers from some drawbacks. The punishment exerted by peers may trigger revenge or anti-social punishment. Its existence has been supported by various experimental studies (Denant-Boemont, Masclet et al. 2007, Herrmann, Thöni et al. 2008, Nikiforakis 2008). This is commonplace in reality as well. For example, there are laws in place to protect whistleblowers from retaliation (e.g., Whistleblower Protection Act in United States). In addition to revengeful punishment, there could be second-order free-riding problem (Panchanathan and Boyd 2004, Fowler 2005, Gross, Méder et al. 2016). As punishment is only costly to the punisher and benefits the whole group, individuals could free ride on others who do punish free-riders. Despite the drawbacks, the merits of peer punishment are obvious. It is self-autonomous and that the cost of its implementation is relatively low.

Formal punishment or centralized punishment mechanism provides an alternative to solve free rider problems in social dilemmas. Its “state” nature and that it is usually exercised according to pre-set rules make it clear of anti-social punishment and second-order free ride problems existed in informal punishment systems. Moreover, the concentration of power in a centralized body is a hallmark of civilization (Mann 1986). That being said, it is usually substantially costly to set up a centralized punishment system (court system, police force). This could be one of the reasons why centralized punishment systems have received much less attention than informal punishment systems in the literature.

There are a handful of experimental studies exploring the centralized punishment systems. Putterman, Tyran et al. (2011) ask subjects to vote on formal punishment systems which could improve or worsen cooperation in public goods games. They find that people mostly learn to choose the system that helps to resolve the free-rider problem. Markussen, Putterman et al. (2014) and Kamei, Putterman et al. (2015) explore the choice between informal and formal sanction systems. It is shown that people prefer informal sanctions if implementing formal sanctions is costly. If it is one’s choice to design the formal sanction system, the low-cost and deterrent formal sanctions are preferred. The abovementioned formal sanctions are meted out on all

deviators and thus are absolute punishment systems. The relative punishment system instead only punishes the largest deviator. The punishment exerted is dependent on the group's contributions. Yamagishi (1986) and Andreoni and Gee (2012) propose formal punishment systems which only target the lowest contributor (see also DeAngelo and Gee. (2017); Xiao and Houser (2011)). They show that these mechanisms are successful in mitigating free-rider problems. Kamijo, Nihonsugi et al. (2014) compare the use of absolute and relative punishment systems theoretically and experimentally. They find that the relative punishment system results in equal or higher contributions than that in absolute punishment systems.

A key question in relation to the formal punishment mechanism is how to define the right size of punishment. If the punishment is too lenient, the sanction system fails to improve cooperation (Tyran and Feld 2006). It obviously hurts societal welfare if the punishment is too harsh. The punishment in Yamagishi (1986) depends on the punishment fund raised by the group. In Andreoni and Gee (2012), the punishment meted out on the lowest contributor depends on the difference between the lowest and the second lowest contributions. Kamijo et al. (2014) use a fixed penalty in the centralized punishment systems. In addition to punishment size considerations, a good centralized sanction system should be low cost to implement as the low-cost and deterrent sanction system is preferred by voters (Markussen, Putterman, and Tyran 2014; Kamei, Putterman, and Tyran 2015). The hired gun mechanism proposed by Andreoni and Gee (2012) is a relatively low-cost centralized mechanism. Its implementation only relies on the information on the lowest and second lowest contributions. It punishes the lowest contributor to the extent that she would rather have been the second lowest contributor. In other words, the system does not require the enforcer to document all norm violators and instead only the largest and the second largest violator. It thus reduces the cost of implementation.³⁰

We adopt the hired gun mechanism as the framework to address an important but overlooked question, i.e., what should be the right size of punishment? We add to

³⁰ In the speeding ticket example, if there are a number of cars exceeding the speed limit, the police could focus on the most reckless drivers instead of documenting the speed of every car.

the thin literature on the centralized punishment mechanisms. Specifically, we contribute to the literature in the following ways: Firstly, to the best of our knowledge, our study is the first one to explore the right size of punishment in such a low-cost and relative punishment mechanism; Secondly, we go beyond specifying a limited number of punishment conditions (e.g., no, mild and severe sanction conditions in Tyran and Feld (2006)). We theoretically derive a wide range of classes of punishment mechanisms which would lead to full contribution equilibrium. It points to a possibility of using less punishment compared to Andreoni and Gee (2012) to achieve the same full contribution outcome. Thirdly, we employ the individual evolutionary learning model to successfully explain the discrepancy between theory and experimental results. The theory predicts that the treatment with more lenient punishment parameters would end up with the full contribution equilibrium. However, the experimental results indicate a decaying trend in contribution. The reason behind the discrepancy is that the theory assumes people to be fully rational and smart. That is to say, people are perceived to be able to play the dominant strategy even if it is very difficult to identify such a strategy. This is not the case in the actual play of the game. As a matter of fact, if the best strategy is too difficult to identify, people evolve to play the second best strategy. In our experimental setting, if the best strategy is to increase contribution by some amount which falls into a narrow range, the difficulty in identifying such a range may make people decrease their contributions instead. In a broader sense, the same reasoning could be extended to many other contexts in explaining the discrepancy between theory and empirically results.

The rest of this paper proceeds as follows. Section 3.2 details our generalized model of the hired gun mechanism, followed by the experimental design and procedures in Section 3.3. Section 3.4 discusses the results and section 3.5 concludes the paper.

3.2 Theoretical background

We start by introducing the hired gun mechanism proposed by Andreoni and Gee (2012), followed by our generalization of the model.

3.2.1 The model

In the classic linear public goods game, players form a group of n and each is endowed with w . All group members decide independently and simultaneously how much of w to contribute to the public goods. Each unit contributed to the public goods generates a payoff of α ($\frac{1}{n} \leq \alpha < 1$) for each group member regardless of each individual's contributed amount. α is referred to marginal per capita return (MPCR). Suppose player i contributes g_i ($0 \leq g_i \leq w$), her payoff π_i can be expressed as:

$$\pi_i = w - g_i + \alpha \sum_{j=1}^n g_j \quad (1)$$

Given that $\partial \pi_i / \partial g_i = -1 + \alpha < 0$, the dominant strategy would be not to contribute at all, which leads to the zero-contribution inefficient equilibrium. Everyone would be better off if all group members contribute the whole endowment. It is referred to as the socially optimal outcome, which is usually hard to achieve.

Andreoni and Gee (2012) proposed the hired gun mechanism, which has been shown to be effective in promoting contribution. The idea is to punish the lowest contributor so that she would rather have been the second lowest contributor. Define the set of contributors as S and $L(g) \subseteq S$ as a set of contributors with the lowest contributions. The size of $L(g)$ could range from 1 to n . For example, if $g_z \leq g_j$ holds for all $j, z \in L(g)$. Also let g_y be the second lowest contribution. That is to say, $y \notin L(g)$ and that $g_y \leq g_j$ holds for all $j \notin L(g)$. For a player who contributes g_i when the choice vector is g of all players, the hired gun mechanism administers the punishment $P(g_i, g)$ as follows:

$$P(g_i, g) = \begin{cases} 1, & \text{if } L(g) = S \text{ and } g_i < w \\ 0, & \text{if } L(g) = S \text{ and } g_i = w \\ g_y - g_i + 1, & \text{if } L(g) \subset S \text{ and } i \in L(g) \\ 0, & \text{if } L(g) \subset S \text{ and } i \notin L(g) \end{cases} \quad (2)$$

Equation (2) depicts the punishment rule: 1) If all contributors are tied at a below full-contribution level, all are punished by 1 unit; 2) If all contributors contribute the full endowment, no one is punished; 3) If player i belongs to the set of the lowest contributors, then player i together with other lowest contributors will be punished and the punishment amount for player i is equal to the difference between the second lowest contribution amount and the lowest contribution amount plus 1 unit. It is straightforward that full contribution is the unique equilibrium, reasoned from the repeated elimination of dominated strategies.

The punishment could be dissected into two parts: the unilateral punishment and the tie punishment. The former is to discourage people from being the lowest contributor, that is, for $P(g_i, g) = g_y - g_i + 1$ if $L(g) \subset S$ and $i \in L(g)$, the 1 unit punishment on top of the difference between the second lowest and the lowest contribution is defined as the ‘unilateral’ punishment. The ‘tie’ punishment is to discourage people from settling at a below full-contribution tie, that is, for $P(g_i, g) = 1$, if $L(g) = S$ and $g_i < w$, the 1 unit punishment is defined as the tie punishment. Andreoni and Gee (2012) assume both the unilateral punishment and the tie punishment to be 1 unit for convenience. We relax this assumption by allowing the unilateral and the tie punishment to be different and by removing the 1 unit restriction. The two parts of punishment in principle have different roles. We are interested in whether or not and to what extent these two parts are connected and that if it is possible to achieve full contribution with less punishment. Should the answer be yes, there might exist a class of such mechanisms which are effective in promoting contribution and wherein punishment is minimized to reduce potential welfare loss. Let u ($u \geq 0$) be the unilateral punishment and t ($t \geq 0$) be the tie punishment. Equation (2) could be rewritten as:

$$P(g_i, g) = \begin{cases} t, & \text{if } L(g) = S \text{ and } g_i < w \\ 0, & \text{if } L(g) = S \text{ and } g_i = w \\ g_y - g_i + u, & \text{if } L(g) \subset S \text{ and } i \in L(g) \\ 0, & \text{if } L(g) \subset S \text{ and } i \notin L(g) \end{cases} \quad (3)$$

3.2.2 Equilibrium analysis

For the purpose of this analysis, we are going to assume $\alpha \geq 0.5$ which encompasses the cases analyzed in Andreoni and Gee (2012).³¹ The relative magnitude of the tie punishment (t) and the unilateral punishment (u), together with the value of MPCR (α) will determine the equilibrium outcome. The following proposition summarizes the result when both the tie punishment and the unilateral punishment are sufficiently harsh such that $t > 1 - \alpha$ and $u > 1 - 2\alpha$.

Proposition 1. *If both the tie punishment (t) and the unilateral punishment (u) are harsh enough, such that $t > 1 - \alpha$ and $u > 1 - 2\alpha$, then the unique equilibrium of the game is characterized by everyone contributing the full endowment.*

Proof. Following Andreoni and Gee (2012), we also adopt the repeated elimination of dominated strategies to find equilibrium. Let Δ_{-1} be the payoff change from decreasing contribution by 1 unit and Δ_{+1} be the payoff change from increasing contribution by 1 unit. It is informative and tractable, and without loss of generality, to start with 2 players. Since the player's payoff varies depending on the distribution of contributions in the group, we discuss the player's move separately in these different cases.

Case 1 *The group ties at a below full-contribution amount.*

This is the case where $L(g) = S$ and $g_i < w$ in (3). Both players receive a punishment $P = t$. Increasing contribution by 1 unit incurs a loss of $1 - \alpha$ based on (1) but avoids the punishment t . Decreasing contribution by 1 unit increases payoff by $1 - \alpha$ and avoids the punishment t , but a punishment $(1 + u)$ kicks in. That is to say,

³¹ See appendix A for the equilibrium analysis for the case of $\alpha < 0.5$.

$$\Delta_{+1} = t - (1 - \alpha) \quad (4)$$

$$\Delta_{-1} = t - (\alpha + u) \quad (5)$$

To encourage people only to move contribution upward, it is necessary to have

$$\Delta_{+1} > 0 \Rightarrow t > 1 - \alpha \quad (6)$$

$$\Delta_{+1} > \Delta_{-1} \Rightarrow u > 1 - 2\alpha \quad (7)$$

It would be informative to construct a payoff matrix with two players tied. Each player has 3 strategies: decreasing contribution by 1 unit, remaining the same or increasing contribution by 1 unit. The payoff matrix is as follows:

	-1	0	1	
-1	$1 - 2\alpha, 1 - 2\alpha$	$t - \alpha - u, t - \alpha$	$t - 1 - u, t - 1$	
0	$t - \alpha, t - \alpha - u$	0,0	$t - 1 + \alpha - u, t - 1 + \alpha$	(8)
1	$t - 1, t - 1 - u$	$t - 1 + \alpha, t - 1 + \alpha - u$	$2\alpha - 1, 2\alpha - 1$	

If (6) and (7) are both satisfied, players would have incentive to increase contribution to break the tie.

Case 2 *The group has heterogeneous contributions (no-tie).*

If the difference in contribution is more than 1 unit, it is straightforward to see that the higher contributor will decrease contribution and the lower contributor will increase contribution as doing so would improve the payoff for both before the relative position of contributions changes. Therefore, we discuss the case where the difference in contribution has been shortened to 1 unit. As $t > 1 - \alpha$ according to (6), the higher contributor does not have incentive to decrease contribution by 1 unit to reach a tie. For the lower contributor, the change in payoff from 1 unit contribution increase is $\Delta_{+1_lower} = \alpha + u - t$. If $\Delta_{+1_lower} = \alpha + u - t < 0$, then the lower contributor is better off by staying put rather than increasing contribution by 1 unit to reach a tie. If $\Delta_{+1_lower} = \alpha + u - t > 0$, then the lower contributor should increase contribution by

1 unit. Besides the option of increasing contribution by 1 unit to reach a tie, the lower contributor could also increase contribution by 2 units to avoid any kind of punishment. The resulting payoff change $\Delta_{+2_lower} = 2\alpha + u - 1 > 0$ always holds according to (7). The lower contributor is thus better off by increasing contribution by 2 units rather than remaining status quo. When the contribution is close to the full contribution level, which prevents the lower contributor from increasing contribution by 2 units, the lower contributor is better off by increasing contribution by 1 unit only. As tie punishment no longer applies if the two players tie at the full contribution level, the payoff change from 1 unit contribution increase is $\Delta_{+1_lower} = \alpha + u > 0$. All in all, the lower contributor always has incentive to increase contribution until they both reach the full contribution level. ■

To summarize, in the 2-player case, as long as $t > 1 - \alpha$ and $u > 1 - 2\alpha$, the game has the unique full contribution equilibrium. In other words, the tie punishment and the unilateral punishment need to be harsh enough to reach the full contribution equilibrium. The same reasoning applies to the case with more than two players. It is straightforward to see that increasing the group size does not change the theoretical prediction.

Next, we analyze the case where the tie punishment is lenient while the unilateral punishment is sufficiently harsh, such that $t < 1 - \alpha$ and $u > 1 - 2\alpha$. The following proposition summarizes the result.

Proposition 2. *If the tie punishment (t) is lenient and the unilateral punishment (u) is harsh enough or $t < 1 - \alpha$ and $u > 1 - 2\alpha$, the game becomes a coordination game.³²*

Proof. We start with the tie case. If $t < 1 - \alpha$ and $u > 1 - 2\alpha$, then $\Delta_{-1} < \Delta_{+1} < 0$, which means deviating from the tie in either direction tends to decrease one's payoff. Next, we discuss the no-tie situation next. In a no-tie situation $\Delta_{+1_lower} = \alpha + u -$

³² Note that it is not possible to have lenient unilateral punishment when $\alpha \geq 0.5$ as $u < 1 - 2\alpha$ and $u \geq 0$ cannot be satisfied simultaneously. This is possible for $\alpha < 0.5$, which results in 4 propositions. See details in appendix A.

$t > 1 - \alpha - t > 0$, which indicates that the lower contributor always has incentive to increase contribution to a tie. Alternatively, the change in the relative ranking of contributions could come from the higher contributor's actions. If she decreases contribution by 1 unit to reach a tie, her change in payoff would be $\Delta_{-1_higher} = 1 - \alpha - t > 0$. Thus it is in the higher contributor's best interest to decrease contribution to reach a tie. If the decrease goes beyond what is needed to reach a tie (e.g., 2 units), she becomes the lower contributor, and the payoff change would be $\Delta_{-2_higher} = 1 - 2\alpha - u < 0$. In other words, the higher contributor is better off by decreasing contribution just enough to reach a tie. From both players' perspectives, the tied situation is beneficial and that no one has incentive to break from the tie. Players could be tied on any contribution level, which indicates that there are multiple equilibria in this game. Therefore, it ends up with a coordination problem. ■

Note that the theory does not give a clear prediction on which contribution level people would coordinate on in equilibrium. It depends on the starting contribution level. They would coordinate on a contribution level that is no lower than the starting point. The tie could be reached by either the lower contributor increasing or the higher contributor decreasing the contribution.

3.3 Experimental design and procedures

3.3.1 Design and predictions

In Andreoni and Gee (2012), the contribution level is close to the full contribution equilibrium where the hired gun mechanism was implemented. They had an endowment of 5 with contributions being integers and $u = 1, t = 1$. The relatively small choice set of contributions might have had impacts on the outcome. For instance, it might be easier for people to play the equilibrium strategy without realizing it. It would be more difficult to guess it right with a relatively large choice set. Evidence of equilibrium outcome with a large choice set would further substantiate the effectiveness of the hired gun mechanism. In light of this, we run our treatments with an endowment of 20 to expand the choice set. We also replicate the hired gun

treatment in Andreoni and Gee (2012) as our *control* treatment, where the endowment is 5 and $u = 1, t = 1$. Likewise, we set α to $2/3$ following Andreoni and Gee (2012). This case falls into the range of α we analyze in the equilibrium analysis presented in sub-section 3.2.2.

Specifically, we vary the unilateral punishment (u) and the tie punishment (t) across treatments in the following way: 1) Treatment *Rescale*: we only rescale the endowment to 20, but keep $u = 1$ and $t = 1$ (u and t are normalized based on the size of the endowment, the same logic applies hereafter) the same as Andreoni and Gee (2012); 2) Treatment *Coordination*: $u = 1$ and $t = 0$; 3) Treatment *LoTNoU* (low t no u): $u = 0$ and $t = 0.5$. Treatment *Control* is the same as treatment *Rescale* except that the endowment is 5 instead of 20. Treatments *Control*, *Rescale*, and *LoTNoU* follow Proposition 1 presented in sub-section 3.2.2 of the equilibrium analysis. Treatment *Coordination* follows that of Proposition 2 presented in the same sub-section.

Figure 3.1. Game outcomes conditional on t, u and the treatments

Figure 3.1 illustrates all possible cases described in the equilibrium analysis for various parameter values for the unilateral punishment (u) and the tie punishment (t), with $\alpha = 2/3$. It also positions the 4 treatments in the game outcome map based on the relationship between t and u . The dark-shaded area on the right represents the

required condition for an effective hired-gun mechanism where the unique full contribution Nash equilibrium is achieved. The light-shaded area on the left indicates the case where the game degenerates into a coordination problem. Table 3.1 summarizes the parameter conditions and their corresponding game outcomes.

Table 3.1. Game outcomes conditional on t and u

Area	t	u	Outcome
A	$t < 1 - \alpha$	$u > 1 - 2\alpha$	Coordination
C	$t > 1 - \alpha$	$u > 1 - 2\alpha$	Full contribution

Treatment Control, Rescale and LoTNoU locate in the dark-shaded area where the conditions for an effective hired gun mechanism are satisfied. The predicted outcome would be full contribution in these 3 treatments. Treatment Coordination locates in the light-shaded area where the game becomes a coordination game. Table 3.2 outlines the theoretical predictions.

Table 3.2. Predictions across treatments

Treatment	Endowment	t	u	Predicted outcome
Control	5	1	1	Full contribution
Rescale	20	1	1	Full contribution
LoTNoU	20	0.5	0	Full contribution
Coordination	20	1	0	Coordination

3.3.2 Procedures

The experiment was conducted at Nanyang Technological University, Singapore. Subjects were recruited through mass university emails and were from various majors. The experiment was programmed in Z-tree (Fischbacher 2007). There were 4 sessions for each treatment. Each session has a size of 12 with the exception of one being 8. In total, there were 188 participants in 16 sessions for the experiment. The between-subject design was implemented, that is, no subjects participated more than 1 session. We followed the procedure in Andreoni and Gee (2012) closely, including the instructions. A sample of instructions used is available in Appendix B.

Instructions were read out aloud at the beginning of the session and questions were answered privately. Subjects had to answer some control questions correctly before proceeding to the real experiment. They played the public goods game for 20 periods in total. The first 10 periods were the public good game without the hired-gun mechanism. Starting period 11, subjects played the game with the introduction of the hired gun mechanism for another 10 periods. They played in groups of 4 and were randomly re-matched from period to period within the session. Subjects were informed of each individual's contribution and earnings in the group at the end of every period. 1 out of 20 periods was randomly selected for payment. After 20 periods, subjects filled in a post-experiment questionnaire before collecting payments. The average payment for this experiment was around 15 Singapore Dollars (equivalent to around 11 US Dollars).

3.4 Results

3.4.1 Experimental results

We start with descriptive results, followed by econometric analysis. Figure 3.2 depicts the mean contribution over time across treatments. Note that subjects played the same standard linear public goods game in the first 10 periods in all treatments. The only difference is that the endowment in the Control treatment is 5 tokens instead of 20 tokens in the other 3 treatments. Though the first 10 periods are not the focus of this study, we present the results for completeness. The decaying trend is consistent with the classic findings in the literature (e.g. (Houser and Kurzban 2002); (Fischbacher and Gächter 2010)). Contributions across treatments are remarkably similar and none of the difference between any two treatments is significant (two-sided Mann-Whitney tests³³), which makes it fair to speculate that there is no

³³ Using independent sessions as the unit of observation, $p > 0.5$ for comparisons between any two treatments. The rest of non-parametric tests in this article use the same unit of observation unless noted otherwise.

substantial difference in individual idiosyncrasy across treatments. Obviously, difference in the amount of endowment does not affect the contribution.

Figure 3.2. Mean contribution over time

The introduction of the hired gun mechanism in period 11 boosts contribution substantially regardless of the size of the unilateral and the tie punishment. Such a boost in contribution squares with the findings of Andreoni and Gee (2012). In the Control treatment replicating Andreoni and Gee (2012) with 5-token endowment, the contribution is close to the full contribution equilibrium, which is consistent with their finding. In the Rescale treatment with 20-token endowment but the same unilateral and tie punishment ($u=1$ and $t=1$) as those employed in Andreoni and Gee (2012), the results remain comparable. The overall contributions are very similar in the Control and Rescale treatments. The difference is not statistically significant (two-sided Mann-Whitney tests, $p = 0.248$). The results in these two treatments are in line with theoretical predictions. This evidence further substantiates the robustness of the hired gun mechanism.

Contribution in the Coordination treatment is consistent over time in the last 10 periods. The contribution is not significantly different from the Rescale treatment (two-sided Mann-Whitney tests, $p = 0.564$). The theory predicts it to be a coordination

outcome but it fails to predict the specific contribution level that people will coordinate on. It, to a large degree, depends on the starting contribution level. The theory prediction does not find its support in the LoTNoU treatment. The predicted outcome is contribution converging to the full contribution equilibrium. In contrast, contribution shows a decaying trend over time especially in the last few periods. The contribution level is significantly lower than that in the Rescale treatment (two-sided Mann-Whitney tests, $p = 0.043$). We will explore the possible explanations for this in later parts.

Table 3.3. Contribution and ties across treatment

Treatment	Male	Game	Contribution		Ties		
			Mean	Std Dev.	Below Full	At Full	Total
Control	39.6%	LPG	26.3%	0.264	4.2%	0.0%	4.2%
		HG	98.3%	0.029	0.0%	87.5%	87.5%
Rescale	50.0%	LPG	35.7%	0.247	5.0%	0.0%	5.0%
		HG	94.6%	0.079	0.0%	53.3%	53.3%
LoTNoU	41.7%	LPG	23.7%	0.254	5.0%	0.0%	5.0%
		HG	72.0%	0.195	0.0%	4.2%	4.2%
Coordination	38.6%	LPG	23.9%	0.241	10.9%	0.0%	10.9%
		HG	79.6%	0.118	0.9%	20.9%	21.8%

Table 3.3 summarizes the distribution of contributions. As shown in Figure 3.2, the mean contribution substantially increases after the introduction of the hired gun mechanism. The contribution in the Control and the Rescale treatments is very close to full contribution (98.3% and 94.6%) and that it shows lower standard deviations compared to other treatments. The distribution of ties indicates that the majority (87.5%) are tied at full contribution in the Control treatment, which is also the theoretical prediction. Though this percentage is lower (53.3%) in the Rescale treatment, the average contribution remains close to full contribution. That is to say, the larger endowment size in the Rescale treatment makes full-contribution tie more difficult to reach within the time horizon in the experiments, but it does not change the tendency to approach full contribution equilibrium. We will revisit this applying longer time horizon in simulations. In the LoTNoU, full contribution ties are

surprisingly rare (4.2%), which is at odds with the theoretical prediction. The theory predicts that people coordinate on contribution levels no lower than the starting point. Except for those who coordinate on the full contribution (20.9%), successful coordination on below-full-contribution is rare (0.9%).

Table 3.4 reports the regression analysis of contribution by treatment in the last 10 periods where the hired gun mechanism is introduced. Multilevel mixed-effects linear estimation is adopted and that observations are clustered by session and by subject. The dependent variable is defined as the percentage of endowment contributed. Explanatory variables include period (*Period*), a dummy variable taking value 1 if the payoff in the previous period was the group's minimum and the group did not tie at full contribution and taking value 0 otherwise (*If_min_profit_notiefull_t-1*), a dummy variable taking value 1 if the payoff in the previous period was the group's maximum and the group did not tie at full contribution and taking value 0 otherwise (*If_max_profit_notiefull_t-1*)³⁴, a dummy variable indicating if there was a tie in the previous period (*Tie_t-1*), a dummy variable taking value 1 if one was punished in the previous period and 0 otherwise (*Ifpunish_t-1*), overall belief about others' contribution for the last 10 periods (*Belief*) and male taking value 1 for male and 0 otherwise (*Male*). In an attempt to follow the exact procedure of Andreoni and Gee (2012), which did not elicit belief during the experiment, we only elicited belief³⁵ at the end of the experiment to avoid any potential effects on contribution. The variable has been normalized as a percentage of endowment.

³⁴ Since the punishment is exerted in a specific way so that the relative payoff position may or may not be altered (i.e., the lowest contributor might no longer has the highest payoff as a result of punishment), the resulting payoff ranking should be more relevant for the decisions on the future contributions. We want to capture how people respond to the relative payoff position. In light of this, we use the minimum and maximum profit dummies instead of lowest and highest contributor dummies as independent variables. As a robustness check, we also ran regressions using lowest and highest contributor dummies, the results remain qualitatively similar. However, the regression we adopted in the paper appears to be a better fit in terms of overall model significance.

³⁵ Subjects were asked how much they expect other group members to contribute on average for the first 10 periods and the last 10 periods respectively.

Table 3.4. Determinants of contribution: Multilevel mixed-effects linear estimation

Dependent variable: contribution percentage				
	Control	Rescale	LoTNoU	Coordination
	(1)	(2)	(3)	(4)
Period	0.00163 (0.00195)	0.00287 (0.00212)	-0.0160*** (0.00323)	-0.00283 (0.00256)
If_min_profit_notiefull_t-1	-0.0399* (0.0209)	0.0433** (0.0220)	0.123*** (0.0224)	-0.00107 (0.0181)
If_max_profit_notiefull_t-1	0.0103 (0.0202)	0.0634*** (0.0235)	0.0686*** (0.0238)	-0.00416 (0.0202)
Tie_t-1	0.0510** (0.0202)	0.0605** (0.0252)	0.141*** (0.0450)	0.0164 (0.0286)
Ifpunish_t-1	0.0261 (0.0317)	-0.0110 (0.0237)	-0.0718*** (0.0252)	-0.0254 (0.0227)
Belief	-0.00679 (0.0335)	0.223 (0.199)	0.158 (0.0997)	0.280*** (0.0866)
Gender	-0.00272 (0.00973)	0.0276 (0.0246)	-0.0115 (0.0463)	-0.0789*** (0.0256)
Constant	0.927*** (0.0475)	0.615*** (0.195)	0.749*** (0.133)	0.648*** (0.120)
Observations	480	480	480	440
Log. Likelihood	446.6	292.6	51.99	185.9
Chi-squared	39.71	19.20	91.45	26.51

Standard errors in parentheses

* p<0.10 ** p<0.05 *** p<0.01

Period does not have significant effects on contribution in the Control, Rescale and Coordination treatments, which is consistent with findings in Figure 3.2. The negative coefficient speaks to the decaying trend in the LoTNoU treatment. Being the group minimum payoff or the group maximum payoff in the previous period has significantly positive effects on contribution in both the Rescale and LoTNoU treatments. The highest contributors increase contribution might be because they expect others to do so. Since in the Rescale treatment the lowest contributor is punished in the way that her payoff is lower than the second lowest contributor, the second lowest contributor has the maximum payoff in the group. Regression (2) suggests that the second lowest contributor tends to increase her contribution, possibly expecting that the lowest will increase hers as well. Those who have the group maximum payoff in the LoTNoU treatment are the lowest and the second lowest

contributors as the unilateral punishment is zero. Those people on average tend to increase contribution in the next period.

The positive effect of being tied in the previous period is universal except in the Coordination treatment. This is expected because the tie punishment exists in all treatments, except in the Coordination treatment. The presence of tie punishment creates a pull to the full contribution equilibrium as the theory predicts. The significant and negative sign of $I\bar{f}punish_{t-1}$ suggests that the lowest contributor tends to decrease contribution in the next period, which might explain the declining trend in the LoTNoU treatment. We explore possible explanations for the lowest contributor's behavior in later parts. None of the variables discussed above has significant effects in the Coordination treatment. Belief is significant and positive in the Coordination treatment, which very much squares with the nature of coordination games.

3.4.2 Simulations: Individual Evolutionary Learning (IEL)

Following the discussion on the game outcome theoretically and empirically, we explore the evolution path under the hired gun mechanism with different parameters. The evolution path is interesting for several reasons. Firstly, contribution in the LoTNoU treatment has a decaying trend instead of converging to the full contribution equilibrium as the theory would predict. The individual evolutionary learning model is an attempt to explain this deviation from the theory. Secondly, the theory cannot predict the speed of convergence to the equilibrium, it would be intriguing to learn about the convergence path and speed in general.³⁶ Thirdly, the experiments shed light on how people actually behave in the hired gun context but they are bounded by the number of subjects and periods one could use. Simulation provides a robustness check using a longer horizon and a larger sample.

We adopt the individual evolutionary learning (IEL) approach (see more details in Arifovic and Maschek 2006; Arifovic and Ledyard 2012, 2011). IEL has

³⁶ The experimental results do not provide much information on convergence as the starting contribution level is close to the full contribution equilibrium. Though the experiment is not designed to study different convergence speeds across treatments, simulations could provide valuable insights in this regard.

been shown to be successful in explaining all the five stylized facts in public goods games simultaneously (Arifovic and Ledyard 2012). The idea of IEL is that subjects carry a finite set of remembered strategies, which are evaluated and replicated in a certain way, and the better strategies have better chances of being carried forward to future periods. As a result, subjects evolve to play the optimal strategies over time.

Following the definition of IEL in Arifovic and Ledyard (2012), we let X^i be subject i 's action space, $I^i(x_t)$ be the information revealed to i at the end of period t , A_t^i be i 's remembered set of strategies (contribution levels) in period t and ψ_t^i be the probability measure on A_t^i . Next, A_t^i has a dimension of J , which represents the subject's memory capacity. In period t , each subject chooses a strategy (a contribution level) randomly from A_t^i based on the probability measure ψ_t^i and ends up with the action $x_t^i = a_{j,t}^i$ ($j \in \{1, \dots, J\}$). A^i and ψ^i are updated from period to period. At the end of period t , subjects use a process to compute A_{t+1}^i , ψ_{t+1}^i based on A_t^i , ψ_t^i , $I^i(x_t)$. Experimentation, replication and selection are the three crucial steps in this process. We next describe this process to explain how the decision is made at $t + 1$ based on what happened at t .

The process starts with experimentation. Experimentation introduces a dash of randomness into the remembered strategy set, which contributes to some level of diversity in the process. For each strategy in A_t^i ($a_{j,t}^i, j = 1, \dots, J$), a new strategy (contribution) from X^i is randomly chosen with probability ρ to replace the existing strategy $a_{j,t}^i$. The new strategy has a normal distribution $N(a_{j,t}^i, \sigma)$. In other words, the mean of the normal distribution where the new contribution is drawn from equals the value of the existing strategy $a_{j,t}^i$ to be replaced. This normal distribution has a standard deviation σ and that σ is normalized as the proportion of endowment. ρ and σ are free parameters which could be set to various numbers in the simulations.

Replication follows experimentation. It reinforces strategies that would have been relatively high-paying in the past. It is also an opportunity for the potentially better strategies to replace less-paying ones. The key is to identify potentially good

strategies. A strategy $a_{j,t}^i$ is evaluated based on the corresponding payoff if $a_{j,t}^i$ had been played at t regardless of the strategy actually played. Let $p^i(a_{j,t}^i|I^i(x_t))$ be subject i 's payoff at t if she had played strategy $a_{j,t}^i$ given the information $I^i(x_t)$, $p^i(a_{j,t}^i|I^i(x_t))$ is used to screen good strategies. For each strategy in A_t^i ($a_{j,t}^i, j = 1, \dots, J$), $a_{j,t}^i$ is replicated in the following way. Two strategies in A_t^i are randomly selected with replacements and that the selection uses uniform probability. Let those two selected strategies be $a_{k,t}^i$ and $a_{l,t}^i$, the strategy set for period $t + 1$ is updated as follows:

$$a_{j,t+1}^i = \begin{cases} a_{k,t}^i, & \text{if } p^i(a_{k,t}^i|I^i(x_t)) \geq p^i(a_{l,t}^i|I^i(x_t)) \\ a_{l,t}^i, & \text{if } p^i(a_{k,t}^i|I^i(x_t)) < p^i(a_{l,t}^i|I^i(x_t)) \end{cases} \quad (9)$$

The replication repeats for $j = 1, \dots, J$. It is straightforward that strategies with more replicates at t , and those that would have resulted in higher payoffs had they been used at t , are more likely to be carried forward into $t + 1$. If the information $I^i(x_t)$, i.e., other group members' contribution at t , makes strategy $a_{j,t}^i$ a high paying strategy, this strategy tends to have more replicates in the strategy set. In other words, this strategy is favorably remembered and thus has higher chance of being actually played. As a result, the replication process averages over the past periods. In the long term, the remembered strategy set consists of best-response strategies.

Selection happens after replication and is the last step in the process. Each strategy $a_{k,t+1}^i$ in A_{t+1}^i is selected with a probability $\psi_{k,t+1}^i$. The probability is decided by its relative fitness in the strategy set, which is measured by the proportional payoff.

$$\psi_{k,t+1}^i = \frac{p^i(a_{k,t+1}^i|I^i(x_t))}{\sum_{j=1}^J p^i(a_{j,t+1}^i|I^i(x_t))} \quad (10)$$

Those 3 steps constitute the process describing how an IEL subject proceeds from t to $t + 1$. The last piece missing is the initial values in period 1, A_1^i and ψ_1^i .

Following the practice in Arifovic and Maschek (2006), Arifovic and Ledyard (2011), and Arifovic and Ledyard (2012), we also use the same simple initialization in period 1. Every strategy forming A_1^i is drawn randomly with uniform probability from the action space X^i . Each strategy in A_1^i stands an equal chance of being selected in period 1. That is to say, $\psi_{k,1}^i = \frac{1}{J}$ for all k .

We now have a complete picture of the IEL model from the very beginning. We set the free parameters $\rho = 1, J = 5, \sigma = 0.2$ in our simulations. Figure 3.3 shows the simulation results for all treatments with 1000 repetitions and $t = 80$. As we use the same simple initialization across treatments, the contribution always starts at 50% of endowment. There is a decaying trend in the linear public goods game and that contributions converge to zero in the long run. This phenomenon is robust regardless of the size of endowment.

Figure 3.3. Simulation results with 1000 repetitions

Endowment size plays a role in evolution trend when the hired-gun mechanism is introduced. Contributions (%) in the Control treatment (5-token HG when $t = 1$ and $u = 1$ in Figure 3.3) converge much more quickly to the full contribution than that in the Rescale treatment (20-token HG when $t = 1$ and $u = 1$ in Figure 3.3). It indicates

that if subjects start at the same medium contribution level (50%), smaller endowment size results in faster convergence to the equilibrium in the hired-gun mechanism. This is intuitive as the smaller set of choices available associated with the smaller endowment makes it easier to locate the dominant strategy and thus leads to a quicker convergence to the equilibrium. The difference in convergence speed is not as obvious in experiments as that in simulations. It might be because the starting contribution level is already very high (91%) for both treatments in experiments, which limits the presence of different convergence speeds. That said, we do observe substantial difference in the percentage of full-contribution ties as shown in Table 3.3 (87.5% in Control vs 53.3% in Rescale).

There is not much difference in the evolution trend between the Rescale (20-token HG when $t = 1$ and $u = 1$) and the Coordination treatments (20-token HG when $t = 0$ and $u = 1$) in simulations. This is consistent with experimental results. The difference between these two treatments is the removal of tie punishment in the Coordination treatment. The removal of tie punishment theoretically would make people coordinate on a certain contribution level depending on the starting point and that the game therefore ends up with a tie. However, this is not the case in simulations. It might be because in reality achieving below-full-contribution successful coordination is difficult, which is a solid finding in the literature Devetag and Ortmann (2007). It turns out tie also rarely exists in both of our simulation data and experimental observations (only 1 out of 470 groups under the hired-gun mechanism).

Intriguingly there is a decaying trend in the LoTNoU treatment (20-token HG when $t = 0.5$ and $u = 0$). It is in line with experiment results but at odds with theoretical predictions. Recall that the game is predicted to end up with a full contribution equilibrium. This divergence from theory might result from subjects' difficulty in locating the dominant strategy. Subjects are assumed to be rational and smart in the sense that they are always able to find the dominant strategy and that the decision environment is irrelevant. For instance, suppose 1 out of 5 strategies is the dominant strategy in situation A, 1 out of 20 strategies is the dominant strategy in situation B, theoretically there would not be any difference in the outcome as the

dominant strategy will be played in both situations. However, this might not be the case empirically. In situation B, subjects might not be able to pick up the dominant strategy over the choice set. In the same spirit, if it is not easy for subjects to locate the “right” choice, they would end up with playing the less optimal strategy. This is indeed the case in the LoTNoU treatment.

We use an example where the contributions in the group are not a tie to illustrate what might have happened in the LoTNoU treatment. Let the contribution difference between the lowest and the second lowest be j_1 , the contribution difference between the second lowest and the third lowest be j_2 , the change in the lowest contributor’s contribution be k , the change in the lowest contributor’s payoff resulting from the contribution change k be Δ . It is straightforward that one is never better off by decreasing contribution when one is already the lowest contributor. Therefore, we assume $k > 0$. There are several possibilities of k : 1) The lowest contributor can increase contribution but remain the lowest contributor, i.e., $k < j_1, \Delta = \alpha k > 0$; 2) She can increase contribution to the second lowest contributor’s contribution, i.e., $k = j_1, \Delta = \alpha j_1 - j_2$; 3) She can increase contribution so that she becomes the second lowest contributor, i.e., $k > j_1, \Delta = j_1 + u - k(1 - \alpha)$. In the second case, if $j_2 < \alpha j_1$, increasing contribution by exact j_1 would make her better off rather than staying put. In the third case, if $k > (j_1 + u)/(1 - \alpha)$, increasing contribution by k would make her worse off. Therefore, any one condition from (11) to (13) would be a sufficient condition to ensure increasing k is a dominant strategy.

$$k < j_1 \tag{11}$$

$$k = j_1 \text{ and } j_2 < \alpha j_1 \tag{12}$$

$$j_1 < k < \frac{j_1 + u}{1 - \alpha} \tag{13}$$

When u is small, the range of k in (13) becomes small. If this is the case, the lowest contributor could easily increase her contribution too much, which in turn decreases her payoff. Figure 3.4 is a pseudocolor (checkerboard) plot of contributions in the 20th period with $\sigma = 1$, $w = 5$ and 100 repetitions. In the pseudocolor plot,

both the tie punishment t (x -axis) and the unilateral punishment u (y -axis) are in increments of 0.02. The color represents contribution percentage as indicated in the color bar on the right. It seems that the proper size of both u and t are necessary for a high contribution outcome. It might be the case that for a small choice set associated with the 5-token endowment, it is relatively easy to find the dominant strategy. Therefore, both harsh enough tie punishment and unilateral punishment are needed to discourage people from settling at below full-contribution ties and being the lowest contributor. When u is sufficiently small, increasing k runs the risk of k being too much and therefore it backfires. The blue band at the bottom supports this conjecture.

Figure 3.4. Contribution with 5-token endowment in the 20th period (100 repetitions)

Figure 3.5 plots the contributions in the 40th period with $\sigma = 4$, $w = 20$ and 100 repetitions.³⁷ When endowment increases to 20, the tie punishment no longer matters that much and that the contribution level is substantially affected by the unilateral punishment. This could be due to the fact that a large choice set associated with 20-token endowment makes ties rare and therefore subjects do not have many chances to learn to avoid the tie punishment empirically. As a result, tie punishment

³⁷ We use the same standard deviation parameters as that in the IEL simulations. Since it takes longer to converge to the equilibrium for the 20-token endowment situations, we prolong the time frame to 40 periods.

loses its function. Similar to the 5-token case, the lowest band at the bottom colored with darker blue indicates lower contributions when u is very small. There are also clear cut-offs at $u = 1 - \alpha$ and $u = \alpha$. It is consistent with (13) that the range of k is sensitive to the size of u , which affects contribution levels.

Figure 3.5. Contribution with 20-token endowment in the 40th period (100 repetitions)

3.5 Conclusion

In this paper, we explore the right size of punishment in the context of the centralized punishment modeled after the hired gun mechanism proposed by Andreoni and Gee (2012). We are interested in the hired gun mechanism because it is effective in promoting cooperation and that it is relative low-cost to implement. The hired gun mechanism punishes the lowest contributor to the extent that the person would rather have been the second lowest contributor. The suggested punishment involves two components; a unilateral punishment and a tie punishment. The former is imposed to discourage people from wanting to be the lowest contributor and the latter is added on to prevent people from coordinating on a tie at a below full-contribution level. There is essentially a range of values for the relative magnitude of these two components that would sustain full contribution equilibrium. We aim to examine how severe the

unilateral and tie punishment should be to achieve the full-contribution equilibrium. Specifically, we are interested in investigating the size of the “bullets” that the “hired gun” should carry. We vary the magnitude of the unilateral and tie punishment in such a way that full contribution equilibrium sustains. We derive theoretically a class of punishment mechanisms which would lead to full contribution equilibrium, which are tested by experiments. We also run an experimental treatment wherein we only eliminate the tie punishment but keep the unilateral punishment intact so that the voluntary contribution game is transformed into a coordination game. Our experimental results generally substantiate the theoretical prediction on the full cooperation equilibrium and the coordination outcome, except for the more lenient punishment parameters. This discrepancy is successfully explained by individual evolutionary learning.

We conclude by suggesting some promising directions for future research. It would be interesting to explore if the generalized mechanism applies to other types of public goods games, such as public goods games with provision point mechanism (i.e., the public good is provided only when a certain threshold of contribution is met), public goods games with asymmetric payoffs, sequential public goods games, etc. One could also study endogenously chosen hired gun mechanisms. Subjects decide endogenously on the size of the unilateral punishment and the tie punishment. It would be interesting to see what the parameters of the hired gun mechanism end up with and if the endogenously chosen mechanism has different effects compared to the exogenously imposed mechanism.

3.6 Appendix

3.6.1 Appendix A: Equilibrium analysis with $\alpha < 0.5$

In this appendix, we provide equilibrium analysis with $\alpha < 0.5$. When $\alpha < 0.5$, $u < 1 - 2\alpha$ and $u \geq 0$ could be satisfied simultaneously, therefore, lenient unilateral punishment is a possibility. We next discuss cases where both types of punishment are harsh enough, one type is lenient and one type is harsh enough and both types are lenient.

Proposition A1. *If both the tie punishment the unilateral punishment are harsh enough, or $t > 1 - \alpha$ and $u > 1 - 2\alpha$, the game's unique equilibrium is everyone contributes the full endowment.*

Proof. It follows the proof of proposition 1. ■

Proposition A2. *If the tie punishment is lenient and the unilateral punishment is harsh enough, or $t < 1 - \alpha$ and $u > t - \alpha$, the game becomes a coordination game.*

Proof. Part (i). $t < 1 - \alpha$ and $u > 1 - 2\alpha$, it is the same as the proof of proposition 2.

Proof. Part (ii). $t < 1 - \alpha$ and $t - \alpha < u < 1 - 2\alpha$, it leads to $\Delta_{+1} < 0$ and $\Delta_{-1} < 0$, which suggests that players are better off by staying at tie rather than breaking from the tie. In the no-tie case, $\Delta_{+1_lower} = \alpha + u - t > 0$ and the lowest contributor has incentive to increase contribution to a tie. In other words, the game becomes a coordination game. ■

Proposition A3. *Both the tie punishment and the unilateral punishment are lenient, or $t < 1 - \alpha$ and $u < t - \alpha$, the game's unique equilibrium is everyone makes zero contribution.*

Proof. When $\alpha < 0.5$, it is possible to satisfy $0 < u < 1 - 2\alpha$. It leads to $\Delta_{+1} < 0$ and $\Delta_{-1} > \Delta_{+1}$. $u < t - \alpha$ leads to $\Delta_{-1} = t - \alpha - u > 0$. In the tie case, players are better off by decreasing 1-unit contribution to break from the tie. In the no-tie case (the difference in contribution has been shortened to 1 unit), $\Delta_{+1_lower} = \alpha + u - t < 0$ and $\Delta_{+2_lowest} = 2\alpha + u - 1 < 0$, which means the lowest contributor is better off by staying at status quo rather than increasing contribution to a tie or to be the second lowest contributor. Besides the possible change in relative payoff positions caused by actions of the lowest contributor, that of the second lowest contributor could also cause such changes. If the second lowest contributor decreases contribution by 1 unit and the resulting payoff change is $\Delta_{-1_second\ lower} = 1 - \alpha - t > 0$, which means the second lowest contributor has incentive to decrease contribution to a tie. The game ends up with the zero-contribution equilibrium following elimination of dominated strategies. ■

Proposition A4. *The tie punishment is harsh enough and the unilateral punishment is lenient, or $t > 1 - \alpha$ and $u < 1 - 2\alpha$, the game outcome is dependent on the starting point.*

Proof. As discussed earlier, it is possible to satisfy $u < 1 - 2\alpha$ only if $\alpha < 0.5$. These two conditions of t and u lead to $0 < \Delta_{+1} < \Delta_{-1}$, i.e., players are better off by deviating 1 unit negatively from the tie. In the no-tie case $\Delta_{+1_lower} = \alpha + u - t < 0$, which means the lowest contributor is better off by staying at the lowest rather than increasing contribution to a tie. It is straightforward to see that the higher contributor is better off by staying where she is rather than decreasing contribution to a tie ($\Delta_{-1_higher} = 1 - \alpha - t < 0$). In this case, there is no single dominant strategy and thus the logic of elimination of dominated strategies does not apply. The game outcome is dependent on the starting contributions in the group. Specifically, if both players start with full contribution, neither of them would have incentive to deviate. If they start with different individual contributions, they would stay with the initial contribution as no one has incentive to deviate from the starting point. If they start with a below full-contribution tie, they would deviate negatively until difference in contributions is restored. ■

Figure A1. Game outcomes conditioned on t and u ($\alpha = 1/3$)

Figure A1 summarizes and illustrates all possible cases described above for various parameter values for the unilateral punishment (u) and the tie punishment (t), with $\alpha = 1/3$. Area C represents the required condition for an effective hired-gun mechanism where the unique full contribution Nash equilibrium is achieved. Area A indicates the case where the game degenerates into a coordination problem. Area B represents the situation where the game outcome is dependent on the starting point. The blank area represents the situations where the game ends up with the zero-contribution equilibrium. Table A1 summarizes the games outcomes and parameter conditions.

Table A1. Game outcomes conditioned on t and u

Area	t	u	Outcome
A	$t < 1 - \alpha$	$u > t - \alpha$	Coordination
B	$t > 1 - \alpha$	$u < 1 - 2\alpha$	Dependent on the starting point
C	$t > 1 - \alpha$	$u > 1 - 2\alpha$	Full contribution
Blank	$t < 1 - \alpha$	$u < t - \alpha$	Zero contribution

3.6.2 Appendix B: A Sample of Experimental Instruction: Treatment LoTNoU

General Information

Welcome to all of you! You are now taking part in an interactive study on decision making. **Please pay attention to the information provided here and make your decisions carefully. If at any time you have questions to ask, please raise your hand and we will attend to you in private.**

Please note that **unauthorized communication is prohibited**. Failure to adhere to this rule would force us to stop this study and you will be asked to leave the experiment without pay. You have the right to withdraw from the experiment at any point in time, and if you decide to do so your payments earned during this study will be forfeited.

By participating in this study, you will be able to earn a considerable amount of money in addition to your show-up fee of \$5. The amount of your earnings depends on the decisions you and others make.

At the end of this session, your earnings will be paid to you privately and in cash. It would be contained in an envelope (indicated with your unique user ID). You will need to sign a claim card given to you and exchange your claim card with your payment.

General Instructions

Each of you will be given a **unique user ID** and it **will be clearly stated on your computer screen**. At the end of the study, you will be asked to fill in your user ID and other information, pertaining to your earnings from this study, in the claim card. **Please fill in the correct user ID to make sure that you will get the correct amount of payment.**

Rest assured that your **anonymity will be preserved** throughout the study. You will **never be aware of** the personal information of other participants **during or after** the study. Similarly, other participants will also **never be aware** of your personal identities **during or after** the study. You will only be identified by your user ID in our data collection. All information collected will **strictly be kept confidential** for the sole purpose of this study.

Specific Instructions

You have been organized into groups of 4 people. Each group will consist of 4 different randomly assigned persons in each period. There will be 20 periods in this session. In each period you will be required to make some decisions and what you earn from each decision will depend on what you and the other 3 people in your group decide.

Once all your decisions in the 20 periods have been made, we will randomly select one of the 20 periods as the period that counts. We will use the period-that-counts to determine your actual earnings. Note, since all periods are equally likely to be chosen, you should make your decision in each period as if it will be the period-that-counts.

First, we will describe the instructions for the first 10 periods.

First 10 Periods: Investment Decision

At the beginning of each period you will be randomly assigned to a new group of 4 players, and you will be given an automatic payment of \$0.40.

In each period you will be choosing how to divide 20 tokens between two investment opportunities:

THE RED INVESTMENT

Each token you invest in the RED investment will earn you a return of \$0.30.

Example: Suppose you invest 16 tokens in the RED investment, then you would earn \$ 4.80 from this investment.

Example: Suppose you invest 0 token in the RED investment, and then you would earn \$ 0.00 from this investment.

THE BLUE INVESTMENT

What you earn from the BLUE investment will depend on the total number of tokens that you and the other 3 members of your group invest in the BLUE investment. The more the group invests in the BLUE investment, the more each member of the group earns. Each token you invest in the BLUE investment will earn you and all your group members a return of \$0.2.

The process is best explained by a number of examples.

Example: Suppose that you decided to invest no tokens in the BLUE investment but that the 3 other members invest a total of 36 tokens. Then your earnings from the BLUE investment would be \$7.20 (which is 36 tokens multiplied by \$0.20). Everyone else in your group would also earn \$7.20.

Example: Suppose that you invest 8 tokens in the BLUE investment and that the 3 other members of your group invest a total of 36 tokens. This makes a group total of 44 tokens. Your return from the BLUE investment would be \$8.80 (which is 44 tokens multiplied by \$0.20). The other 3 members of the group would also get a return of \$ 8.80.

Example: Suppose that you invest 12 tokens in the BLUE investment and the other 3 members invest nothing. Then you, and everyone else in the group, would get a return from the BLUE investment of \$2.40 (which is 12 tokens multiplied by \$ 0.20).

As you can see, every token invested in the BLUE investment will earn \$0.20 for every member of the group, not just the person who invests it there. *It does not matter who invests tokens in the BLUE investment. Everyone will get a return from every token invested there—whether they invest tokens in the BLUE investment or not.*

YOUR TASK

Your task is to decide how many of your tokens to invest in the RED investment and how many to invest in the BLUE investment. You are free to invest some of your tokens in the RED investment and some in the BLUE investment. Alternatively, you can invest all of them into the RED investment or all of them into the BLUE investment.

Earnings

Once you and the other 3 members of your group have made your decisions, you will receive an **Earnings Statement** for that period. You will be given anonymous details of all your group's investments and earnings.

Your earnings have been computed using the following simple formula:

$$\text{1st Stage Earnings} = (\$0.30) * (\text{Your investment to the RED investment}) + (\$0.20) * (\text{Total group investments to the BLUE investment})$$

For example imagine you invested 16 to the BLUE investment, your other group members invest 8, 12, and 12 to the BLUE investment.

In this example 1st stage earnings are computed as follows:

$$\text{1st Stage Earnings} = (\$0.30) * (20 - 16) + (\$0.20) * (16 + 8 + 12 + 12)$$

$$\text{1st Stage Earnings} = (\$0.30) * (4) + (\$0.20) * (48)$$

$$\text{1st Stage Earnings} = \$1.20 + \$9.60$$

$$\text{1st Stage Earnings} = \$ 10.80$$

Your earnings will be your 1st Stage earnings plus your \$0.40 automatic payment. You will also be given a summary of your current and previous earnings. **You must make your investment decisions without knowing what the others in your group are deciding. Do not discuss your decision with any other participant.**

Your Group

For each decision period you will be in a group of 4 people in the room today. **After each decision period we will randomly re-match you with a new group of 4 people in the room.** As a result, each decision you make will be with a new group of 4 participants. The probability that you will ever be in the same group of 4 participants again is extremely remote. After 10 periods of this one stage investment decision, you will be given directions for another type of decision.

Things to remember

- You will be in a group of 4 people
- You will have automatic earnings of \$0.40 each period
- You will have 20 tokens to invest each period
- Each token you invest in the RED investment earns you \$0.30
- Each token you invest in the BLUE investment earns you and every member of your group \$0.20
- There will be a total of 10 decision periods.
- The groups will be randomly re-matched every decision period.
- Please feel free to use the calculator, and scratch paper provided to help you with your calculations.

If you have any questions about the instructions please raise your hand and someone will come and speak with you privately about your question.

Thank you. Please wait to be told when you can begin making decisions for the first 10 periods.

Next 10 Periods: Two Stage Investment Decision

The investment decision is exactly the same as the decision you made in the first 10 periods. At the beginning of each period you will be randomly assigned to a new group of 4 players, and you will be given an automatic payment of \$0.40. In each period you will be choosing how to divide 20 tokens between two investment opportunities:

THE RED INVESTMENT

Each token you invest in the RED investment will earn you a return of \$0.30.

THE BLUE INVESTMENT

Each token you invest in the BLUE investment will earn you a return of \$0.20 for you and all the members of your group.

Administrator

In these 10 periods your group will be overseen by a *computer-simulated* Administrator, the Administrator will examine the number of tokens you invest in the BLUE investment. The computer-simulated Administrator may take a deduction from your payoff according to these rules:

- 1) Only the lowest investor (or investors in case of a tie) to the BLUE investment will have a deduction taken from their payoff by the Administrator.
- 2) The size of the deduction will depend on the investment choices of your group members. The deduction will be the difference between the payoff of the lowest investor *and* the payoff of the second lowest investor to the BLUE investment in your group.
- 3) If there is a tie for the lowest investor, all those who tied will have the deduction taken from their payoff.
- 4) If all 4 members of your group tie for the lowest investor, then all of you will have \$0.15 taken from your payoffs.
- 5) If all members of your group allocate the whole of their 20 tokens to the BLUE investment, then no one will have a deduction taken from their payoffs.

Thus, with the Administrator the only way you can avoid having a deduction is to avoid being the lowest investor to the BLUE investment. With the Administrator, the only way everyone in the group can avoid a deduction is if everyone invests all 20 tokens to the BLUE investment.

Earnings:

Example: Suppose that you invest 12 tokens in the RED investment and 8 tokens in the BLUE investment. Suppose that the 3 other members of your group invest 16, 16, and 4 tokens in the BLUE investment respectively. This makes a group total of 44 tokens. Your return from the BLUE investment would be \$8.80. The other 3 members of the group would also get a return of \$8.80 from the BLUE investment. Your initial payoff from this stage would be: $12 * (\$0.30) + (8 + 16 + 16 + 4) * (\$0.20) = \$12.40$

You invested 8 tokens to the BLUE investment, while another player invested only 4 token, so you are **not** the lowest investor to the BLUE investment. Thus, you will **not** have a payoff deduction. Your earnings for Stage 2 of this period will be your initial earnings of \$12.40.

Example: Suppose that you invest 12 tokens in the RED investment and 8 tokens in the BLUE investment. Suppose that the 3 other members of your group invest 12, 16, and 8 tokens in the BLUE investment respectively. This makes a group total of 44 tokens. Your return from the BLUE investment would be \$8.80. The other 3 members of the group would also get a return of \$8.80 from the BLUE investment. Your initial payoff from this stage would be: $12 * (\$0.30) + (12 + 8 + 16 + 8) * (\$0.20) = \$12.40$

You invested 8 tokens to the BLUE investment, so you and the other player that invested 8 tokens tied for being the lowest investors to the BLUE investment. Thus, you (and the other player that invested only 8 in the BLUE investment) will have a payoff deduction. The size of the deduction will be the difference between your initial earnings and the next lowest investor in the BLUE investment. The next lowest investor in your group invested 12 tokens in the BLUE investment and earned \$11.20. In this example that would mean your deduction would be $\$12.40 - \$11.20 = \$1.20$. Your Stage 2 net earnings will be your initial earnings of \$12.40 minus your deduction of \$1.20, which in total equals \$11.20. You will be told that you were the lowest investor when your period earnings are reported to you.

Example: Suppose that you invest 0 tokens in the RED investment and 20 tokens in the BLUE investment. Suppose that the 3 other members of your group invest 20, 20, and 20 tokens in the BLUE investment respectively. This makes a group total of 80 tokens. Your return from the BLUE investment would be \$16.00. The other 3 members of the group would also get a return of \$16.00 from the BLUE investment.

Everyone invested all their 20 tokens to the BLUE investment, so there is no lowest investor to the BLUE investment. In this specific case even though there is a computer simulated Administrator, no one will have a payoff deduction. Your payoff for Stage 2 of this period will be \$16.00.

Your earnings for the last 10 periods are computed by the following formula:

Earnings = $(\$0.30) \times (\text{Your investment to the RED investment}) + (\$0.20) \times (\text{Total group investments to the BLUE investment}) - (\text{Payoff Deduction if you are the lowest investor to the BLUE investment})$

Your Group

For each decision period you will be in a group of 4 people in the room today. As a result, each period you will be with a new group of 4 participants. The probability that you will ever be in the same group of 4 participants again is extremely remote.

Your Earnings

Once all your decisions in the 20 periods have been made, we will randomly select one of the 20 periods as the period that counts. We will use the period that counts to determine your actual earnings. Note, since all periods are equally likely to be chosen, you should make all your decision in each period as if it will be the period that counts.

Things to Remember

- You will be in a group of 4 people
- You will have automatic earnings of \$0.40 each period
- You will have 20 tokens to invest each period
- Each token you invest in the RED investment earns you \$0.30

- Each token you invest in the BLUE investment earns you and every member of your group \$0.20
- The groups will be randomly re-matched every decision period.
- You group will be monitored by a computer-simulated Administrator
 - The Administrator will be responsible for taking a deduction from the earnings of the lowest investor in the BLUE investment.
 - The deduction will equal to (the earnings of the lowest BLUE investor) – (the earnings of the second lowest BLUE investor).
 - If several people are tied for the lowest investor, all will receive a deduction from their earnings.
 - If all people in the group invest all 20 tokens in the BLUE investment, then no one will receive a deduction.
- Please feel free to use the calculator, and scratch paper provided to help you with your calculations.

If you have any questions about the instructions please raise your hand and someone will come and speak with you privately about your question

Thank you. Please wait to be told when you can begin making decisions for the next 10 periods.

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