What's Right When You're Left?

The Impact of Minority Identity in Competitive and Cooperative environments

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Abstract

We theoretically and experimentally explore the impact of minority identity in two contrasting environments: one that encourages competition (all-pay auction contest) and one that encourages coordination (minimum-effort game). There are two types of decision makers and two corresponding types of skills: the majority type and the minority type. Decision makers first decide how to invest between their skill sets, and then they are randomly matched to interacting with each other. We find that in the competitive environment, the minority group members have an advantage compared to the majority group members, as decision makers invest more on the majority skill to maximize chance of winning against the majority group members. In the cooperative environment, by contrast, the minority group members have a disadvantage compared to the majority group members, as decision makers tend to invest on the majority skill to facilitate coordination with the majority group members.

Keywords: minority identity, competitive and cooperative environments, laboratory experiment

JEL classifications: C72, C91, D63

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1 Introduction

Our society comprises majority and minority groups based on diverse categories, such as gender, race, ethnicity and language. It is an important question whether majority or minority identity advances one's economic success or not. In many situations, minority group members are hurt by their identity. For example, in a multilingual society, linguistic minority group members bear a cost in daily interactions as well as in the job market for not speaking the majority's language. However, there also exist situations where minority group members enjoy advantages due to their identity. For example, the minority left-handed athletes are found to have higher ranks in sports such as boxing, tennis and fencing, compared to their right-handed counterparts.[1]

The existing literature has mostly attribute the negative impact of minority identity to discrimination. This literature finds that minority group members bear a cost in the labor market due to discrimination against their identity (e.g. Blau and Kahn 1992; Darity and Mason 1998; Altonji and Blank 1999; Bertrand et al. 2005). Such discrimination includes both statistical discrimination and taste discrimination (Riach and Rich 2002; de Haan et al. 2015). While discrimination can explain the minority disadvantage in such situations, it is not accountable for the minority disadvantage observed in many other situations, e.g. the two examples introduced in the previous paragraph. In such cases, an alternative explanation is that the minority disadvantage (or advantage) arises endogenously, and is caused by the majority and minority group members themselves.

Our goal in this study is to provide some insights of the sources of the impact of minority identity in different economic environments. We argue that minority advantage or disadvantage can endogenously arise within the environment, and the sign of the impact depends on the competitiveness or the cooperativeness of the economic environment. One key innovation in this study is that the decision makers are the majority and minority group members themselves. As explained in greater details below, when making decisions in a situation with majority and minority groups, people pay uneven weight to interactions with the majority and the minority group. This can eventually lead to a minority advantage in competitive environments and a minority disadvantage in cooperative environments.

In the theoretical model, there are two groups of individuals. These two groups differ in their size; the smaller group is called the minority group and the larger group is called the majority group. Each person belongs to either the minority or the majority group. In the decision-making stage (the first stage), individuals spend their time investing in skills. There are two types of skills, each of which is associated with the type of individuals: the majority skill and the minority skill. A key assumption is that investing in the skill different from one's own type is more costly. For convenience, we use in-group skill to refer to the skill set that is the same as ones own type, i.e. majority skill is the in-group skill of

[1] See Raymond et al. (1996), and Voracek et al. (2006) for left-handed advantage in sports; see Hardyck and Petrinovich (1977), Coren and Halpern (1991), and Aggleton et al. (1993) for the costs of being left-handed in a right-handed world.

the majority group members. Similarly, we use out-group skill to refer to the skill set that is different from one's own type, i.e. majority skill is the out-group skill of the minority group members. The key assumption here also implies that out-group skill is more costly than the in-group skill, regardless of the type of the decision maker. During the interaction stage (the second stage), we assume that people are randomly matched with each other. Their payoffs are detmined by their skill investment in the first stage and the competitiveness or cooperativeness of the environment.

The first setting is a competitive environment. This environment resembles interactions such as sports. In sports such as tennis, players can train different skills to compete against different types of opponents. In this setting, in-group skills are relevant whenever a person interacts with a member from her own group, while out-group skills are relevant for interactions with members from the other group. In the competition, only the person with the highest skill level wins and receives a positive payoff.

In such a setting, the model shows that people from the minority group have an advantage. Intuitively, if the minority group is sufficiently small, so that it is rare to meet a member from the minority group, it does not pay to invest in out-group skills for members of the majority group. People from the minority group, on the other hand, will find it profitable to invest in out-group skills, as they are often matched with out-group members. This implies that whenever a minority group member is matched with a majority group member, the minority group member will beat the majority group member. People from the majority group will nevertheless find it unprofitable to invest in out-group skills, as this would reduce their chances of winning when matched with another majority group member, which happens relatively often.

The second setting is a cooperative environment, which is motivated by interactions such as communication. Individuals can learn different languages. The ability to communicate is limited by the person with the lowest proficiency, and two persons will choose to converse in the language for which the common proficiency is highest. In this setting, two persons coordinate skills in their interactions. In coordination, both persons receive a payoff that is equal to the lowest skill level, and they coordinate the skills that yield the highest payoff.

In such a setting, the model predicts that people from the minority group have a disadvantage. Naturally, members of the majority group shy away from investing in out-group skills for two reasons: first, it is more costly compared to investing in in-group skills; and second, chances of meeting an out-group member are smaller than meeting an in-group member. People from the minority group, on the other hand, face a trade-off: though investing in out-groups skills is more costly, they are also more likely to meet an out-group member. If the minority group is sufficiently small, members of the minority group will prefer to invest only in out-group skills. This implies that whenever a minority group member is matched with a majority group member, they will use the majority skill to coordinate. Since members of the minority group invest in the most costly skills, they receive a lower payoff compared to those of the majority group in equilibrium. This is referred to as *conforming equilibrium*. Such a phenomena can be observed in societies with a dominant share of majority group. For instance, though US is a multilingual country, two persons from different language groups will most likely communicate in English. By contrast, if the minority group is large enough, another equilibrium exists in which members of the minority group invest everything in their in-group skills. In this equilibrium, coordination fails when two persons from different groups meet. This is referred to as *segregating equilibrium*. For instance, in Switzerland, there exists a language barrier between German-speaking and French-speaking citizens.

To test these predictions, the model is brought to the laboratory. The objective of using a laboratory experiment in this study is twofold. First, it allows us to perfectly control for the share of the minority group while keeping other things equal, whereas in the real world, it is virtually impossible to have two identical societies that only differ in their population composition. Second, with empirical data we often do not know the values of the model's parameters, e.g. it is hard to measure the cost difference between skills. In contrast, in the experiment all relevant parameters can be imposed.

In the experiment, the model is implemented in a straightforward manner. Subjects are either in a competitive environment or in a cooperative environment; they are assigned to a majority or a minority group, while the relative size of the minority group is either small or large. Subjects are endowed with a fixed budget to allocate between two skills and are then randomly paired within a matching group.

The experimental results reveal the predicted differences in majority-minority inequality: in the cooperative environment, a minority group member earns less than a majority group member. Yet, this result *reverses* in the competitive environment. As expected, in both environments an increase in the share of the minority group reduces the size of payoff inequality. In particular, in the cooperative environment, small minority groups always conform to the majority, whereas large minority groups sometimes choose to segregate from the majority. Hence, it appears that the majority-minority gap can arise in different environments, as individuals strategically invest between their skills to achieve economic success.

Apart from contributing to the understanding of the sources of majority-minority inequality, the results also provide important insights into the design of public policies. These results suggest that a policy-maker interested in reducing the majority-minority gap should help the disadvantaged group before they invest in skills, which is when the policy might be most effective. For example, worldwide immigrants and refugees fall behind their local counterparts in education, labor market as well as wellbeing. A significant part of the gap is due to cultural and linguistic barrier. A policy maker can narrow the gap by reducing the cost of assimilation upon them settling down in the host country, which can be realized by helping them learn local language and adapt to local culture. Not only can this policy reduce inequality gap, but it can also increase the total welfare of the society by preventing segregation.

Existing studies mostly focus on the negative impact of minority identity. A large body of literature finds that a negative impact of minority identity in the labor market is caused by discrimination (e.g. Blau and Kahn 1992; Darity and Mason 1998; Altonji and Blank 1999; Bertrand et al. 2005; De Haan et al. 2015). In particular, there is evidence on labor market discrimination against ethnic minority group (Reimers 1983; Riach and Rich 2002; Bertrand and Mullainathan 2004; Carlsson and Rooth 2007; Kaas and Manger 2012), linguistic minority group (Lang 1986; Dustmann and Fabbri 2003), and homosexual men (Badgett 1995; Elmslie and Tebaldi 2007; Drydakis 2009). Psychologists find that stereotype threat also contributes to the academic gap between the majority and minority groups (Spencer et al. 1999; Steele et al. 2002). All of these sources of the negative impact come directly or indirectly from the behaviors of a third party.

However, relatively little is known about the formation of the negative impact of minority identity without a presence of a third party. For example, minority group members bear a large cost by assimilating to the majority group with respect to languages, religions, and other cultural practices, while it rarely happens that majority groups assimilate to the minority groups (e.g. Lazear 1999; Bisin and Verdier 2000; Kuran and Sandholm 2008). Lazear (1999) uses the U.S. census data from 1900 and 1990 to show that immigrants' who are fluent in English tend to live in places where a smaller percentage of the county were born in their native land. The explanation is that the value of assimilation is larger to individuals from a small minority than to individuals from a large minority group. Bisin and Verdier (2000) finds evidence that minority groups in the US spend more effort in interactions within their cultural group, which could lead to segregation from the majority group. Kuran and Sandholm (2008) argues that people suffer a discomfort during integration due to inconsistencies between their actions and true preferences. From these studies, it is apparent that there is a cost of assimilation for the minority group members; yet, the cost is not caused by discrimination or other third-party behavior. In our paper, we investigate the sources of the negative impact of minority identity in such situations.

Moreover, while there are many studies addressing the negative impact of minority identity, we know very little about the positive impact of minority identity. Our study first acknowledges this effect by arguing that minority group members have an advantage against the majority group in competitive environments. One common observation is that left-handed athletes have an advantage in one-on-one competitive sports such as tennis, boxing and fencing (e.g. Raymond et al. 1996; Voracek et al. 2006; Abrams and Panaggio 2012). The most relevant paper is Abrams and Panaggio (2012), and they find that the proportion of left-handed elite athletes are highly correlated with the competitiveness of the sports. In this study, we argue that this advantage of minority group members can be generalized to any competitive environments, as long as individuals in such environments use different skills to compete against different types of opponents. The underlying idea is that people tend to pay less attention to compete against minority group members, and this leads to a comparative advantage for the minority group members when the environment calls for competition.

There are a few studies that investigate how the share of the minority group affects the likelihood they assimilate to the majority group (Lazear 1999; Advani and Reich 2015). Lazear (1999) argues that members of the minority groups will be assimilated more quickly when the mass of the minority group is smaller. In his model of culture, an individual either belongs to the majority culture, the minority culture or both, and two individuals with different culture fail to trade when they meet. As members of the minority group fail more often than members of the majority group, they gain more by adapting the culture of the majority group. Advani and Reich (2015) develop a different model, in which individuals make choices on their culture type, and also choose with whom they form a social tie. They find that minority groups above a certain critical mass may retain diversity from the majority. In both studies, cultural practices are modeled as a dummy variable, that is, individuals decide whether or not they learn a certain culture practice by incurring a cost. One major difference we make in our model is that culture practice is a continuous variable, as in most culture practices such as languages, individuals differ in their language skills. We argue that the outcome of the coordination between two individuals is not merely determined by their culture type, but rather their fluency in the mutual culture they share. Moreover, we argue that there is a trade-off between the investments of the two cultures, as individuals are often faced with limited time or efforts to develop their cultural practices to fit into each culture. Finally, in a recent paper, Michaeli and Spiro (2015) study how individuals conform to the mainstream norm in different types of societies, which shares the same spirit with our paper. Micheali and Spiro (2015) argue that individuals bear a cost, which is caused by not being true to their private opinions, by conforming to a social norm. In our model, minority individuals bear a different kind of cost, the learning cost, to coordinate with the majority culture.

Finally, the paper is related to the large body of literature on contests. In particular, the all-pay auction is the benchmark model for our setup of competitive environment. This is because the all-pay auction game captures the general sunk investments inherent in scenarios such as labor-market tournament and sports competition (Szymanski 2003; Siegel 2009). A comprehensive survey about all-pay auction model can be found in Dechenaux et al. (2014). The cooperative environment is captured by minimum-effort coordination games. This game provides the benchmark model because it is often used in situations where the weakest link determines the outcome of a joint task, such as public goods provision and language usage (Van Huyck et al. 1990; Anderson et al. 2001; Riechmann and Weimann 2008). Experimental surveys on this class of games can be found in Mehta et al. (1994), Devetag and Ortmann (2007).

The contribution of this paper can be summarized in the following three points: (1) it's the first paper that finds opposite impact of minority identity in competitive and cooperative economic environments (2) it uses a skill-investing model to show that the share of the minority group is a critical factor in terms of the size of its impact and (3) it is the first study that employs a controlled laboratory experiment to test the predictions of the theoretical model under such setups.

2 Model

This section presents a simple and stylized model of skill investment that abstracts from all but the bare essentials necessary to illustrate the motivating ideas. The baseline setup is that an individual may meet his or her in-group members or out-group members during interactions. The type of the paired person is *ex ante* unknown. Therefore, an individual's investment decision is a trade-off between in-group and out-group skills. Further, individuals are either in a competitive environment or a cooperative environment. In the competitive environment, in-group (out-group) skills promote success when interacting with in-group (out-group) members. In the cooperative environment, individuals coordinate skills with their paired partners.

Population structure. Consider a population consisting of n risk-neutral individuals indexed by $i \in \mathbf{N} := \{1, ..., n\}$. An individual's type is characterized by his or her population share: $t \in \{\theta, \tau\}$, with θ the *majority type* and τ the *minority type*. The population share of the minority type defines a *population state* ϵ with $\epsilon \in (0, \frac{1}{2})$.

Matching process. Consider a uniform random matching process, that is, the chance of meeting anyone in the population is equal. This matching process captures environments in which one cannot choose a specific partner, such as in sports competition and workplace interaction. When the population is large, the chance of meeting oneself is negligible. This implies that the probability of meeting a type θ is approximated as $1 - \epsilon$, and the probability to be matched with a type τ is approximated as ϵ. For the remainder of this section, this approximation is employed by assuming a large population size. For small populations, the robustness of the model is discussed in Appendix B.

Strategy. Individuals are endowed with ω units of time to allocate between two types of skills: in-group skills and out-group skills. Without loss of generality, let 1 and c denote the unit cost for in-group skills and out-group skills respectively. Assume that it is easier to invest in the in-group skills than to invest in the out-group skills, or, in mathematical form, $c > 1$.[2] Within the strategy set X, let $x \in X$ denote the level of out-group skills obtained by an individual, and the level of in-group skills acquired by the individual is simply $(\omega - cx)$. Levels of skills are integer numbers.[3] That is, $X = \{0, 1, ..., \bar{x}\}$, where $\bar{x}$ is the largest integer number such that $c \cdot \bar{x} \leq \omega$.

Payoff. When individual i of type t_i playing strategy x_i is matched with an individual j of type t_j playing strategy x_j, individual i receives payoff $\pi(t_i, t_j, x_i, x_j)$.

[2] This assumption is made due to the fundamental idea of in-group skill and out-group skills. In most social interactions, one tends to find it easier to obtain in-group skills than out-group skills. This can be caused by intrinsic difference or physical costs.

[3] The reason to restrict the strategy set to discrete choices is to induce the existence of Nash equilibrium. If the level of skill is a continuous choice variable, as is shown later in the competitive environment, members of the minority group will choose the smallest positive quantity to invest in out-groups skills. However, there does not exist a smallest positive number in the continuous choice set.

The expected payoff of individual i is the average payoffs of meeting everyone in the population. This implies that one's payoff is a function of n strategies used respectively by n individual in the population. For the following analysis, we consider only cases where individuals of the same type use the same strategy, or in other words, symmetric strategies. For each state $\epsilon \in (0, \frac{1}{2})$ and any strategy $x \in X$ used by θ and any strategy $y \in X$ used by τ, the resulting expected payoff of each type is

$$\begin{cases} \Pi_\theta(x,y,\epsilon) = (1-\epsilon)\cdot\pi(\theta,\theta,x,x) + \epsilon\cdot\pi(\theta,\tau,x,y) \\ \Pi_\tau(x,y,\epsilon) = (1-\epsilon)\cdot\pi(\tau,\theta,y,x) + \epsilon\cdot\pi(\tau,\tau,y,y) \end{cases} \tag{1}$$

2.1 Competitive environment

Consider a simple situation where individuals compete for limited resources, e.g. food, prizes, jobs, partners, etc. When two individuals meet, the one with higher skills wins and receives a higher payoff. This is captured by all-pay auction models. In all-pay auction models, a group of people compare one type of score. However, in many competitive situations such as sports, individuals acquire many different skills to compete against different types of opponents. This can be achieved by adding competitor types and skill types. In this model, there are two types of individuals, the majority and the minority. Each individual acquires two types of skills, in-group skills and out-group skills. Individuals use the in-group skills to compete against someone of the her own type and use the out-group skills to compete against someone of the other type.

More exactly, when two individuals from the same group are matched, they both use their in-group skills $(\omega - cx)$ to compete against each other. Therefore, individual with a higher level $(\omega - cx)$ wins and receives a payoff v while the other loses and receives nothing. When two individuals have the same level $(\omega - cx)$, chance decides the winner, with an expected payoff of $\frac{v}{2}$.

When two individuals from different groups are matched, they both use their out-group skills x to compete against each other. Therefore, individual with a higher x wins and receives a payoff v while the other loses and receives nothing. When two individuals have the same level x, chance decides the winner. The payoff function is summarized below:

$$\pi^{comp}(t_i,t_j,x_i,x_j) = \begin{cases} v \text{ if } (t_i = t_j \text{ and } x_i < x_j) \; or \; (t_i \neq t_j \text{ and } x_i > x_j) \\ \frac{v}{2} \text{ if } x_i = x_j \\ 0 \text{ if } (t_i = t_j \text{ and } x_i > x_j) \; or \; (t_i \neq t_j \text{ and } x_i < x_j) \end{cases} \tag{2}$$

Equilibrium. For the equilibrium strategies, consider only the possibility that individuals of the same type use the same strategy, which is referred to as *symmetric strategy*. The reason behind this is that this population game is considered to be played by *two types* of individuals, where individuals of the same type are not distinguishable. Eventually, only the difference between each type of individuals is observed. When individuals use symmetric strategies in an equilibrium, the equilibrium is referred to as *symmetric equilibrium*. Definition 1 characterizes the conditions of symmetric Nash equilibrium.

Definition 1 (**Nash Equilibrium**). In any state $\epsilon \in (0, \frac{1}{2})$, a strategy pair $(x^*, y^*) \in X^2$ is a *(symmetric) Nash Equilibrium* if

$$\begin{cases} x^* \in \underset{x \in X}{argmax}[(1-\epsilon) \cdot \pi(\theta, \theta, x, x^*) + \epsilon \cdot \pi(\theta, \tau, x, y^*)] \\ y^* \in \underset{y \in X}{argmax}[(1-\epsilon) \cdot \pi(\tau, \theta, y, x^*) + \epsilon \cdot \pi(\tau, \tau, y, y^*)] \end{cases} \tag{3}$$

Turning to equilibrium analysis, it can be argued that individuals of the majority group are only willing to invest on their out-group skills when the share of the minority is sufficiently large. Otherwise, when the share of the minority group is sufficiently small, a member of the majority group is better off by investing everything in the in-group skills, so that she can maximize chance of winning when matched to her in-group members. Subsequently, members of the minority group would easily beat a majority group member by investing more than zero on his out-group skills. But how much should he invest in his out-group skills? To note, a member of the minority group also tries to maximize his chance of winning when meeting his in-group members.[4] This implies that members of the minority group would eventually spend the smallest positive amount to invest in their out-group skills. Such a small share of the minority group yields the equilibrium $x^* = 0$, $y^* = 1$.

When the share of the minority group is sufficiently large, members of the majority group would find it profitable to invest in the out-group skills. Subsequently, members of the minority would also increase their investment on out-group skills. Under this condition, there exists no pure-strategy equilibrium. For subsequent sections, the symmetric mixed-strategy equilibrium that corresponds to the experimental setup will be characterized in Appendix C.

Proposition 1 (**Nash Equilibrium in competitive environment**). *In any state $\epsilon \in (0, \frac{1}{3}]$, there exists a unique symmetric equilibrium $x^* = 0$, $y^* = 1$. In any state $\epsilon \in (\frac{1}{3}, \frac{1}{2})$, there exists no symmetric pure-strategy equilibrium.*

The intuition behind Proposition 1 goes as follows. When the share of the minority is small enough, members of the majority spend nothing on their out-group skills, while members of the minority obtain the smallest positive level on their out-group skills. When two individuals from different groups meet, the one from the minority group wins. When two individuals from the same group meet, they make a tie. Note that this proposition is silent about any differences at individual level, rather, it focuses on the difference between the two groups. To capture individual difference, the model has to be extended

[4] For the sake of convenience, in this paper 'she' is referred to someone from the majority group, and 'he' is referred to someone from the minority group.

by adding heterogeneous individual abilities. Nevertheless, to resolve the question asked in this paper, we focus on the payoff difference between the two population groups.

According to Proposition 1, when their relative size is sufficiently small, members of the minority group has a higher chance of winning compared to members of the majority group. This leads to a minority advantage: in equilibrium a member of the minority group receives a higher payoff than a member of the majority group. This helps explain the puzzle of "left-handed advantage" in most interactive sports: As it is common knowledge that left-handed people consist of a small share among human population, athletes spend less time to practice against them than to practice against the right-handed majority. As a result, left-handed athletes enjoy a benefit since their opponents are unfamiliar with their strategies. They can thereby achieve a higher rank at group level, conditioning on their abilities.

2.2 Cooperative environment

Consider situations in which individuals coordinate with each other, e.g. communication, joint tasks, etc. When two individuals meet, the one with a lower skill level determines the payoffs of both. This is represented by minimum-effort models. In a minimum-effort game, a group of individuals compare a single score. However, in many cooperative situations such as communication, individuals possess many types of skills such as different languages. In these situations, they can choose to coordinate the skills that yield the best outcome. This can be achieved by adding cooperator types and skill types. In the cooperative environment of my model, two types of individuals invest in their in-group skills and out-group skills, and are then randomly matched with each other. When two persons meet, they can choose to coordinate the skills that yields the highest payoffs.

More precisely, when two persons from the same group are matched, they can use both of their in-group skills $(\omega - cx)$ or both of their out-group skills x to coordinate. In either case, the one with a lower skill level determines the payoffs of both persons. Thus, the maximal payoff is realized when two persons choose the skills that yield the highest payoffs.

When two persons from different groups are matched, one person can use his in-group skills $(\omega - cx)$ to coordinate with the other person's out-group skills x; or the other way around. In any case, the person with a lower skill level determines the payoff of both persons. To maximize their payoffs, two persons eventually coordinate the skills that yield the highest payoffs. The payoff function is summarized below.

$$\pi^{coop}(t_i, t_j, x_i, x_j) = \begin{cases} Max\{Min\{\omega - cx_i, \omega - cx_j\}, Min\{x_i, x_j\}\} \text{ if } t_i = t_j \\ Max\{Min\{\omega - cx_i, x_j\}, Min\{x_i, \omega - cx_j\}\} \text{ if } t_i \neq t_j \end{cases} \tag{4}$$

Equilibrium. By Definition 1, in equilibrium none of the individuals can gain by deviating. When the share of the minority group is very small, both groups of individuals would match their strategies with the majority group. This implies that it is optimal for a majority group member to do the same as her group members, while it is optimal for members of the minority group to match their strategies with the strategies used by the majority group. There are two possible types of equilibria: (1) when two individuals meet, they use the in-group skills of the majority group and (2) when two individuals meet, they use the in-group skills of the minority group. In both cases, one group conform to the other by investing an adequate amount in the out-group skills. As investing in out-group skills is more costly than investing in in-group skills, members of the conforming group receive a lower payoff.

When the share of the minority group is sufficiently large, members of the minority group will find it too costly to mirror the strategies used by members of the majority group. This is because investing in out-group skills is more costly than investing in in-group skills. Given that the minority group is large enough, it is more profitable to focus on in-group coordination. As a result, another set of equilibria arises: both types invest an adequate amount of time in their in-group skills, and the two groups fail to coordinate with each other.

Proposition 2 (**Nash Equilibria in cooperative environment**). *In any state $\epsilon \in (0, \frac{1}{2})$, there exists two sets of equilibria:*
(1) the minority group conform to the majority group: $x^* \leq \frac{\omega}{c+1}$, $y^* = min(\omega - cx^*, \bar{x})$,
(2) the majority group conform to the minority group: $x^* = min(\omega - cy^*, \bar{x})$, $y^* \leq \frac{\omega}{c+1}$,
In any state $\epsilon \in [\frac{1}{1+c}, \frac{1}{2})$, there exists another set of equilibria:
(3) the two groups segregate from each other: $x^* \leq \frac{\omega}{c+1}$, $y^* \leq \frac{\omega}{c+1}$.

Due to the characteristics of the minimum-effort game, there are multiple equilibria in each set of (1), (2) and (3). This is because unilateral deviations often pays exact the same payoff: no loss, but no gain either. Such equilibria can be eliminated by implementing a refinement of strict Nash equilibrium (described in Definition 2).

Definition 2 (**Strict Nash Equilibrium**). In any state $\epsilon \in (0, \frac{1}{2})$, a strategy pair $(x^*, y^*) \in X^2$ is a *strict (symmetric) Nash Equilibrium* if

$$\begin{cases} x^* = \underset{x \in X}{argmax}[(1-\epsilon) \cdot \pi(\theta, \theta, x, x^*) + \epsilon \cdot \pi(\theta, \tau, x, y^*)] \\ y^* = \underset{y \in X}{argmax}[(1-\epsilon) \cdot \pi(\tau, \theta, y, x^*) + \epsilon \cdot \pi(\tau, \tau, y, y^*)] \end{cases} \tag{5}$$

In mathematical form, strict Nash equilibrium differs from Nash equilibrium in that, given the strategies used by other players, the equilibrium strategy is the *unique* optimal strategy. To put it differently, in Nash equilibrium, a pair of strategies consists an equilibrium if unilateral deviation is unprofitable. In strict Definition 2, by contrast, a pair of strategies is a strict equilibrium *if and only if* any unilateral deviation yields a strict loss. This strengthens the equilibrium condition and thereby reduce the set of the equilibria: By Definition 2, only one equilibrium ($x^* = 0$, $y^* = \bar{x}$) in set (1) survives as a strict equilibrium. Likewise, in set (2) only equilibrium ($x^* = \bar{x}$, $y^* = 0$) survives. In these two equilibria, one group invest only in out-group skills while the other group invest only in in-group skills. Finally, one equilibrium ($x^* = 0$, $y^* = 0$) in set (3) survives under Definition 2. (Proofs are provided in Appendix A.)

Proposition 3 (**Strict Nash Equilibrium in cooperative environment**). *In any state $\epsilon \in (0, \frac{1}{2})$, there exists two equilibria:*
(a.1) the minority group conform to the majority group ($x^* = 0$, $y^* = \bar{x}$),
(a.2) the majority group conform to the minority group ($x^* = \bar{x}$, $y^* = 0$).
In any state $\epsilon \in [\frac{1}{1+c}, \frac{1}{2})$, there exists another equilibrium:
(b) the two groups segregate from each other ($x^* = y^* = 0$).

In Proposition 3, both (a.1) and (a.2) consist of one group conforming to the other. In (a.1), the majority group invest in their in-group skills, whereas (a.2) occurs when the majority group invest in the out-group skills. As is established in Van Huyck et al. (1990), coordination in the minimum-game becomes harder to achieve as the cost of effort (c) increases. Arguably, (a.2) is unlikely to occur as it requires the majority group to coordinate on the most costly skills, while a less costly skill is available. Therefore, though sustaining as a strict equilibrium, (a.2) has little predicting power compared to (a.1).[5] In the following analysis and experimental sections, we focus on the two strict equilibria (a.1) and (b). These two equilibria are referred to as *conforming equilibrium* and *segregating equilibrium* respectively.

Finally, to compare the conforming equilibrium (a.1) and the segregating equilibrium (b), we look at the payoff gap and the efficiency of each equilibrium. The payoff gap is represented by $\Pi_\theta - \Pi_\tau$.[6] The efficiency is represented by the total payoffs of all players in the population, and is presented by $n(1-\epsilon)\Pi_\theta + n\epsilon\Pi_\tau$.

Figure 1 plots the payoff gap (left panel) and the efficiency (right panel) of each equilibrium. As can be seen from the left panel, in the conforming equilibrium, members of the majority earn more than members of the minority, and the payoff gap decreases in the share of the minority group (ϵ). This also holds for the segregating equilibrium. Comparing these two equilibria, it can be seen that the payoff inequality is always bigger in the conformity equilibrium at any $\epsilon \in (\frac{1}{4}, \frac{1}{2})$. Interestingly, the payoff gap only reaches zero in the segregating equilibrium when the share of the minority approaches half. At this point, the size of the majority and minority group is (almost) equal, and therefore the payoff gap vanishes in segregation.

Turning to efficiency, as can be seen in the right panel, the rank of the equilibrium is clear: the efficiency is always higher in the conforming equilibrium. In both equilibria, the efficiency decreases

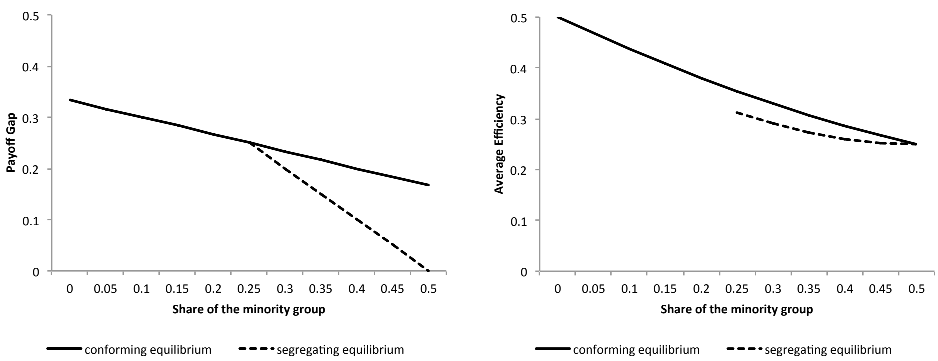
[5] This conjuncture is supported by the experimental results in this paper. The subjects never converged to the equilibrium in (a.2).
[6] Since $\Pi_\theta \geq \Pi_\tau$ in both equilibria, this is equivalent to a more general form $|\Pi_\theta - \Pi_\tau|$.

in the share of the minority and eventually equalize when the share of the minority group is half. Intuitively, the society reaches highest efficiency when there is only one type present.

To conclude, if equilibrium is selected according to efficiency, the conforming equilibrium will stand out. However, if the society cares about equality as well, one may expect the segregating equilibrium to be selected when the share of the minority is large. In both equilibria, a minority disadvantage can be expected.

To this extent, the model establishes a minority advantage in the competitive environment and a minority disadvantage in the cooperative environment. To note, these results are derived under two critical assumptions. First, it is more costly to invest in the out-group skills than the in-group skills. Second, individuals in a population are matched uniformly randomly. These two assumptions can in turn set limitations to the results.

Figure 1: Payoff gap and efficiency



Notes: The left panel shows the payoff gap $(\Pi_\theta - \Pi_\tau)$ between the majority type and the minority type in each equilibrium. The right panel shows the efficiency $(n(1-\epsilon)\Pi_\theta + n\epsilon\Pi_\tau)$ in each equilibrium. In both panels, the x-axis is the population share of the minority group. Values of parameters in this plot are $c = 3$ and $\omega = \frac{1}{2}$, tie-breaking point is $\bar{\epsilon} = \frac{1}{1+c} = \frac{1}{4}$, and the population size n is normalized to 1.

The assumption that the out-group skills is more costly holds by its nature: individual are physically or socially less familiar with the out-group skills, or have less available resources to obtain such skills compared to their in-group skills. For instance, it is more difficult for right-handed people to train their skills against the left-handed people, as they naturally play in a different way; or, it is more costly for the children of the immigrants to learn the local language than the children of native-born parents, as it is harder for them to obtain equal resources. Therefore, as cost relationship which is not captured by this assumption is irrelevant within the scope of this study, it is sensible to leave them.

The uniform random matching process captures situations in which one cannot or does not select his or her counterparts in interactions. This perfectly resembles some situations. For instance, on the tennis court, one cannot choose his opponent; on the job market, one also does not choose against whom to compete. However, in some other scenarios people may actually choose their interacting counterparts. For example, in a multilingual environment, it is common that people from the same language group are more likely to interact with each other. To capture this, the model needs to incorporate an assortative matching process.[7] Depending on the degree of the assortativity, the magnitude of the minority advantage or disadvantage is expected to be reduced. Nevertheless, the direction of the results would remain intact. Furthermore, assortative matching in the cooperative environment would favor the segregating equilibrium over the conforming equilibrium. The intuition is that if one is less likely to meet people from the other group, one is then less motivated to invest in the out-group skills. After all, the assortative matching process can be added to the model and may give rise to some interesting results.

3 Experimental design and procedures

3.1 General setup

The design of the experiment closely follows the theoretical model described in section 3. The parameters in the model are chosen to generate comparative statistics. The size of the population is $n = 12$, as this size allows both small minority group and large minority group.[8] Members of the majority group receive a role color "Red" and members of the minority group receive a role color "Blue".[9] The minority group has two different sizes. The large minority group consists of 5 individuals while the small minority group consists of 3 individuals.

Individuals are endowed 30 points to distribute between two types of skills: skill blue and skill red.[10] Skill blue is the in-group skill for Blue individuals and is the out-group skill for Red individuals. Likewise, skill red is the in-group skill for Red individuals and is the out-group skill for Blue individuals. The unit cost of out-group skills is 3 and the unit cost of in-group skills is 1. When restricting the levels of skills to integers, each subject is faced with a finite choice sets. In each choice, the first number represents the level of the in-group skill and the second number represent the level of the out-group skill. For example, individuals who choose a bundle (21, 3) has level 21 of in-group skill and level 3 of out-group skill. There are in total eleven choice bundles, in which the level of out-group skill takes a value from $\{0, 1, .., 10\}$. Finally, the winning payoff in the competitive environment is 30 points.

[7] It is also possible that people are more likely to interact with someone from the other group than someone from her own group, this can be captured by disassortative matching process. This is not commonly observed nor studied in sociology or economic literature.

[8] As is mentioned later, the small minority group has 3 individuals. It is problematic to have only 2 subjects in the minority group, as they will be able to identify each other's strategy.

[9] The model's predictions is robust with small population, the analysis is presented in Appendix B.

[10] 'Point' is the experimental currency.

Figure 2: Decisions overview

Red players	Blue players
0, 30	30, 0
0, 30	18, 4
0, 30	3, 9
0, 30	
0, 30	
0, 30	
0, 30	
3, 27	
6, 12	

Notes: This figure shows a screenshot of decisions overview of the previous round within a matching group in treatment S-comp. The column separates the players by their role color. Each cell indicates the level of skill blue and the level of skill red of one player. The blue (red) number indicates the level of skill blue (red).

The experiment consists of four parts. The first part provides the instructions. The second part assigns a role color to each player, and the same color is kept throughout the experiment.[11] Then, players make decisions and payoffs are obtained. This part is repeated for 30 rounds. At the beginning of each round, every player chooses from the eleven bundles to determine their skills. After everyone made their decisions, the players are randomly and anonymously matched into pairs. At the end of each round, players learn the role color of the paired player, the decision of the paired player and the realized payoff. To allow for learning, they are also provided with a table illustrating the decisions in the previous round within their matching group. An example of the decisions overview is shown in Figure 2. Finally, the experiment is finished by a short questionnaire.

3.2 Treatments

The experiment consists of a two-by-two factorial design. Treatments are varied between subjects. The structure of the treatments is shown in Table 1. The first dimension determines the size of the minority group. The second dimension determines the competitive or the cooperative setting. Varying the population composition between treatments enables us to investigate whether the share of the minority group matters. Varying the competitive or cooperative setting allows us to look whether the economic environment matters. This simple design tests the two central predictions of the model. First, how does

[11] An alternative design is to randomly assign the role color to each player in each round. However, the advantage of using fixed role is twofold. First, to exclude the possibility that subjects adopt a strategy that maximizes their overall payoffs. For example, in the cooperative environment, it is possible that the minority subjects converge to the conforming equilibrium because they expect to receive a majority role color in the other rounds. Second, since the reason to implement repeated rounds is to allow for learning, assigning role color in each round would reduce the possibility of learning.

Table 1: Experimental Design

Conditions	Competitive	Cooperative
Small minority group (3 Blue players, 9 Red players)	S-comp (N=6)	S-coop (N=6)
Large minority group (5 Blue players, 7 Red players)	L-comp (N=6)	L-coop (N=6)

Notes: The cell entries show the acronyms used for the between subjects treatments (N = the number of matching groups).

a change in the share of the minority affect the equilibrium; second, how does the environment bring advantage or disadvantage to different types of individuals.

3.3 Theoretical predictions

Table 2 presents the theoretical predictions, including both predicted payoffs and predicted choices for each type of players. In treatment L-comp, the predicted choice is that both types of players mix between two pure strategies, and the corresponding probability distribution of the strategies is included in Table 2.[12]

Table 2: Predictions Overview

Treatment	Blue players		Red players	
	Payoffs	Choices	Payoffs	Choices
S-comp	27.3	0.1	10.9	0
L-comp	18	$(0.1:\frac{1}{5}, 1:\frac{4}{5})$	12.9	$(0:\frac{4}{7}, 1:\frac{3}{7})$
S-coop	10	1	24.5	1
L-coop	10 or 10.9	1 or 0	20.9 or 16.4	1

Notes: This table shows the predicted payoffs and choices for each type of player. Choices are represented by the proportion of endowment spent on skill red (majority skill). In L-comp, decisions are in mixed-strategy format; probabilities are presented next to the choices.

As in shown in Table 2, Blue players have higher payoffs in the competitive treatments and lower payoffs in the cooperative treatments, compared to Red players. The payoff difference between the two types of players is larger in S-comp and S-comp, compared to L-comp and L-coop respectively.

3.4 Experimental Procedures

The experiment was conducted in the CREED laboratory of the University of Amsterdam in May 2015. In total, 312 subjects participated in the experiment, of which 24 subjects participated in the pilot and 72 subjects participated in each of the four treatments.[13] Subjects were recruited from the CREED database, which consists mostly of undergraduate students from various fields of studies. Of the sub-

[12] The calculation procedure is provided in Appendix C.

[13] In the pilot session, treatment L-coop was ran with an alternative design, where subjects were not provided with the decisions overview table. However, learning hardly took place: decisions did not converge to the prediction even till the last round. It implied that with this setup, subjects may not be able to select any equilibrium. The rest of the sessions were ran with providing the decisions overview tables. Therefore, the 24 subjects in the pilot session were excluded from the analysis.

jects in my experiment, 56% were female, and approximately 68% were majoring in economics or business. Every subject received 7 euros show-up fee in addition to his or her earnings in the experiment. During the experiment, 'point' was used as currency. These points were exchanged to euros at the end of each session at an exchange rate of 50 points per euro. The experiment lasted between 50 to 70 minutes with average of one hour; the earnings varied between 9.7 to 24.7 euros with average of 16 euros.

The experiment was computerized using PHP/MySQL and was conducted in English.[14] After all subjects arrived at the laboratory, each was randomly assigned to a cubicle. Once everyone was seated instructions appeared on their screen. Subjects had to answer control questions to make sure that they fully understood the instructions. Communication between subjects was prohibited during the experiment. In case of questions, subjects raised hand and the experimenter answered them privately. After everyone had successfully answered the control questions, a printed summary of the instructions was distributed. After distributing the summary handouts to everyone, the experimenter announced and started the experiment. At the end of each session, subjects answered a short questionnaire and were subsequently paid their earnings privately. The same experimenter was always present in the experiment for all sessions.

In each session of the experiment, either 12 or 24 subjects participated, which formed either 1 or 2 matching groups. Subjects kept their role color and stayed in the same matching group throughout the entire session. In each round, matching is random and independent, i.e. the probability of meeting any of the other 11 players in the matching group is the same in every round.

4 Experimental Results

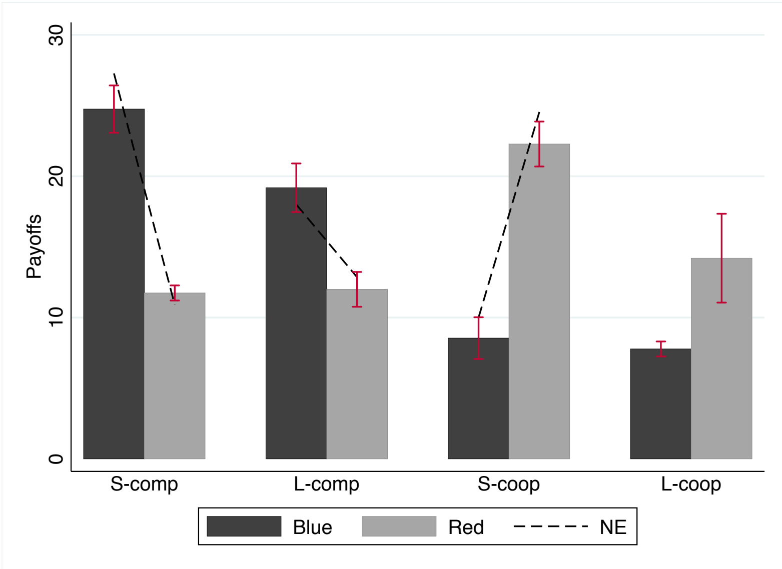
4.1 Payoffs

Members of the majority group and members of the minority group earn significantly different payoffs in all treatments. Figure 3 presents the mean payoffs of the Blue players (minority) in black bars, the mean payoffs of the Red player (majority) in grey bars, and the Nash equilibrium predictions of the two types are connected by dashed lines. In treatment S-comp, the Blue players earn 24.8 on average, while the Red players only earn 11.8 on average (Wilcoxon signed rank test, $p = 0.028$). In treatment L-comp, the difference between the two groups is smaller: the mean payoff of the Blue players and the Red players is 19.2 and 12.0 respectively (Wilcoxon signed rank test, $p = 0.028$). In S-coop, the Blue players earn about one third as much as the Red players, the mean payoffs are 8.5 and 22.3 respectively (Wilcoxon signed rank test, $p = 0.027$). In L-coop, the Blue players earn about half as much as the Red

[14] Experimental instructions are available upon request.

players, the mean payoffs are 7.8 and 14.2 respectively (Wilcoxon signed rank test, $p = 0.028$).[15]

Figure 3: Payoffs



Notes: The figure shows the average payoffs of by type and treatment. The dark bars represent the payoffs of the Blue players (minority), the light bars represent the payoffs of the Red players (majority). The 95% interval levels are added on each bar. The (Nash equilibrium) predictions are connected by the dashed lines.

The aggregate results on payoffs are qualitatively supported by the theoretical predictions. First, payoffs of the Blue players are higher in the competitive treatments but lower in the cooperative treatments, compared to the payoffs of the Red players. Second, the payoff differences between the two types of players are larger when the share of the minority group are smaller.

However, as can be seen in Figure 3, the actual payoffs quantitatively deviate from the theoretical predictions to some extent. In S-comp, the Blue players earn less than predicted (Wilcoxon signed rank test, $p = 0.028$), whereas the Red players earn more than predicted (Wilcoxon signed rank test, $p = 0.028$). In L-comp, the Blue players earn slightly more than predicted (Wilcoxon signed rank test, $p = 0.116$), whereas the Red players earn slightly less than predicted (Wilcoxon signed rank test, $p = 0.116$). In S-coop, both the Blue players and the Red players earn less than predicted (Wilcoxon signed rank test, $p = 0.027$ and 0.028, respectively). Finally, in L-coop, the Blue players earn less than either of the two theoretical predictions (Wilcoxon signed rank test, $p = 0.027$), whereas the Red players earn less than the predictions of the conforming equilibrium (Wilcoxon signed rank test, $p = 0.028$), but not less than the prediction of the segregating equilibrium (Wilcoxon signed rank test, $p = 0.116$).

Result 1. *In the aggregate, members of the minority group earn more than members of the majority group in the competitive environment, and members of the minority group earn less than members of the majority group in the cooperative environments. When the share of the minority group increases, the payoff difference decreases in both environments.*

[15] Unless mentioned otherwise, the statistical tests are performed at matching group level.

Table 3 presents more detailed information about the outcomes in the competitive environments. In S-comp, two Blue players more often result in winning pr losing (78%) than tying (22%). When a Blue player is matched with a Red player, the Blue players are much more likely to win (90%). When two Red players meet, they mostly result in tying (83%).

Table 3: **Outcome distribution in competitive treatments**

	% of each outcome					
	S-comp			L-comp		
	Win	Tie	Lose	Win	Tie	Lose
(Blue, Blue)	39	22	39	42	17	42
(Blue, Red)	90	3	7	65	11	24
(Red, Red)	9	83	9	32	35	32

Notes: Entries are frequencies of each outcome. Rows distinguish the compositions of the matching pairs. Columns distinguish the outcome of the pairs, while win/tie/lose refers to the outcome of the first player within the pairing.

In L-comp, when two Blue players are matched, they result in winning or losing most of the time (84%). When a Blue player meets a Red player, the Blue players are more likely to win (65%) against the Red players than to lose from them (24%). Finally, two Red players are equally likely to result in any outcomes.

The outcome distribution between treatments are qualitatively consistent with the predictions. First, when two players of the same type are matched, they are more likely to tie in S-comp (22% among Blue players, 83% among Red players) than in L-comp (17% among Blue players, 35% among Red players). Second, when different types of players meet, the Blue players are more likely to win in S-comp (90%) than in L-comp (65%). This results confirms that the Blue players have a bigger advantage when their share is smaller.

Table 4 presents more detailed information about the outcomes in the cooperative environments. In S-coop, two Blue players almost always receive a payoff equal or less than 10 (95%), with a mean of 9.0. When a Blue player is matched with a Red player, both players always earn equal or less than 10 with a mean of 8.4. When two Red players meet, they almost always earn more than 20 (88%), with a mean of 27.1.

In L-coop, two Blue players receive a payoff equal or less than 10 for about half of the time (46%), and is equally likely to earn between [11,20] and [21,30] (both 26%). Note that there are two different predictions here. In the conforming equilibrium, Blue players earn at most 10, while they will earn more than 20 in the segregating equilibrium. This result thereby suggests that none of the two equilibria dominates in the experiment. When a Blue player is matched with a Red player, both players always earn equal or less than 10 (4.9 on average). When two Red players meet, they tend to earn more than 20 (69%), with a mean of 23.0, which is significantly less than 30 (p=0.028, Wilcoxon signed rank test).

The mean payoffs between treatments are *not* qualitatively consistent with the predictions. When two Blue players are matched, they earn significantly more in L-coop than in S-coop (14.0 versus 9.0, p=0.037, Mann-Whitney test). When a Blue player meets a Red player, they both earn significantly less in L-coop than in S-coop (4.9 versus 8.4, p=0.016, Mann-Whitney test). In both S-coop and L-coop, two Red players in a pair are predicted to earn 30. However, they are less likely to achieve this high payoff in L-coop and they earn a lower mean payoff (p=0.078, Mann-Whitney test). This result suggests that though the coordination payoffs between Red players shall not be influenced by the share of the Blue players, it is in fact affected by the relatively high proportion of the minority group. In the next section, we look into their choices to understand why this is the case.

Table 4: **Outcome distribution in cooperative treatments**

	% of each payoff interval and mean							
	S-coop				L-coop			
	[0,10]	[11,20]	[21,30]	Mean	[0,10]	[11,20]	[21,30]	Mean
(Blue, Blue)	95	4	2	9.0 (10)	47	26	26	14.0 (-)
(Blue, Red)	100	0	0	8.4 (10)	100	11	24	4.9 (-)
(Red, Red)	5	7	88	27.1 (30)	18	13	69	23.0 (30)

Notes: Entries are frequencies of each outcome. Rows distinguish the compositions of the matching pairs. Columns distinguish the outcome of the pairs, while [a,b] refers to the payoffs of both players within the pairing. Theoretical predictions are in parentheses.

Result 2. *In the competitive environments, Blue players are more likely to win compared to Red players, and their chance of winning is larger when their share in the population is smaller. In the cooperative environments, with a higher share of the Blue players, Blue players earn more when meeting their own type but earn less when meeting the other type, Red players earn less when meeting their own type.*

4.2 Choices

What drives the payoff differences between the majority type and the minority type in competitive and cooperative environments? In this section, we turn to the choices made by the subjects. We ask two major questions: (1) Are choices consistent with the theoretical predictions? (2) How are choices affected by the share of the minority group and the characteristics of the environment?

4.2.1 Are choices consistent with the theoretical predictions?

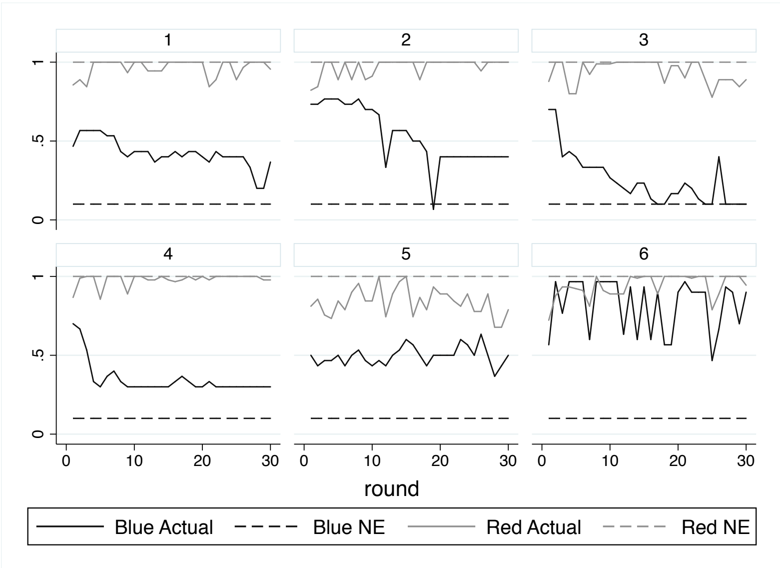
Figures 4-7 present the over-rounds average choices of the Blue players and the Red players. Each panel presents the averages of a matching group.[16] The choices are represented by the proportion of endowment spent on skill red. These figures provide both actual choices of the subjects and theoretical predictions. This makes it possible to see whether subjects' decisions converge to the predictions; and if not, in which direction they deviate to. Table 5 presents the aggregate percentages spent on skill red.

[16] Figure 5 is an exception, as each panel presents the choices of each subject in one of the six matching groups.

Treatment S-comp

The theoretical prediction is that the Red players spend 100% on skill red and that the Blue players spend 10% on skill red. As can be seen from Figure 4, the Red players spend most of their endowment on skill red starting from early rounds. The Blue players spend more on skill red than predicted.[17] From Table 5, we can see that the Red players spent 94% of their total endowment on skill red, and the Blue players spend 48%. Using Wilcoxon signed-rank test with the group average as unit of observation, it is found that the Red players spend a higher proportion on skill red than the Blue players ($p = 0.028$).

Figure 4: Decisions in S-comp



Notes: The figure shows the average fraction of endowment spent on skill red. The solid line represents the actual decisions of the subjects over rounds. The dashed line represents the predictions of Nash equilibrium. The dark lines represent the Blue players. The light lines represent the Red players. Each diagram shows the averaged decisions within one group.

As can be seen from Table 5, the Red players use choices that are very close to the prediction (94% versus 100%), while the Blue players hardly converge to the prediction even in the last 5 rounds (41% versus 10%). This suggests that the Red players mostly spend in skill red as predicted, while the Blue players spend more in skill red than predicted. One plausible explanation is that the Blue players do not meet the other Blue players sufficiently often to realize that they could done better by investing less in skill red. Another possibility is that Blue players exhibit a bias towards investing in skill red as it is very likely to meet them (though they can still win by choosing the equilibrium strategy).

Treatment L-comp

The theoretical prediction is that there exists no pure-strategy Nash equilibrium, and players use a mixed-strategy. Table 2 provides a benchmark prediction, in which the Blue players mix between spending either 10% or 100% on skill red and the Red players mix between spending either 0 or 100%

[17] In groups 1 and 3, decisions converge to the equilibrium over rounds. In groups 2 and 4, decisions stabilize at points that are substantially above the equilibrium. In groups 5 and 6, decisions do not seem to converge.

Table 5: Percentages spent on skill red

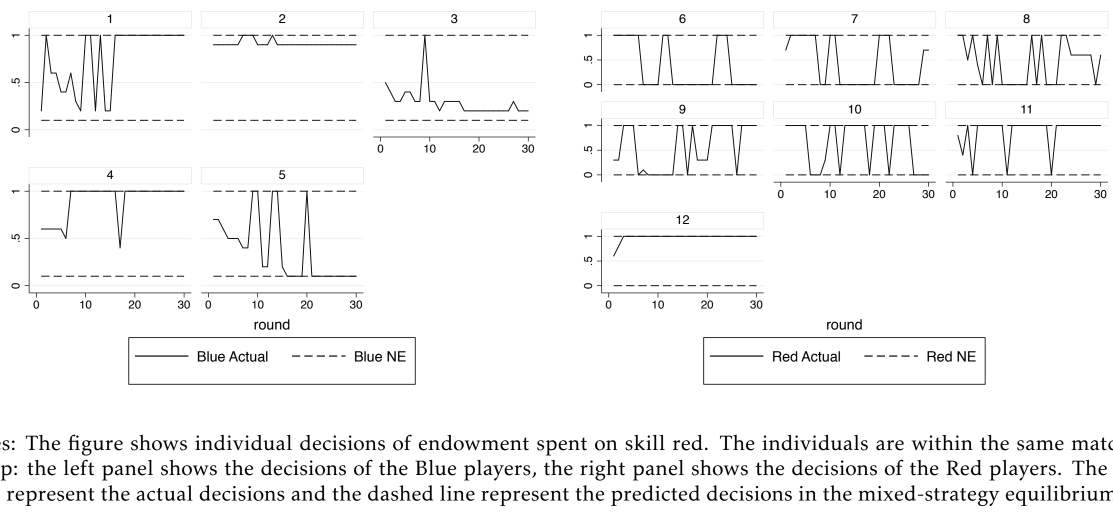
	Red players			Blue players		
	all rounds	last 5 rounds	Prediction	all rounds	last 5 rounds	Prediction
S-comp	94	93	100	48	41	10
L-comp	68	66	43	55	49	82
S-coop	95	99	100	84	93	100
L-coop	87	97	100	44	55	0 or 100

Notes: Each cell shows the average rate subjects spend on skill red.

on skill red. To provide an example of how individuals formulate strategies, decisions in one of the six matching groups is presented in Figure 5.

As can be seen from the five panels on the left, Blue players adopt different strategies. Players 3 and 5 converge to invest 10% on skill red, while players 1, 2 and 4 converge to invest 100% on skill red. On the other hand, we can see from the seven panels on the right that all the Red players mix between spending either nothing or 100% on skill red except for player 12. Overall, the Blue players mix between the two predicted pure strategies at group level, while the majority of the Red players mix between the two predicted pure strategies at individual level. However, they fail to mix (at group level) the predicted strategies with the predicted probability distribution: the Red players spend more on skill red than predicted (68% versus 43%), and Blue players spend less on skill red than predicted (55% versus 82%). This result suggests that when the equilibrium becomes more complicated, subjects do not use the strategies literally. Still, they seem to be able to choose the correct actions but fail at the probability distribution.

Figure 5: Decisions in L-comp

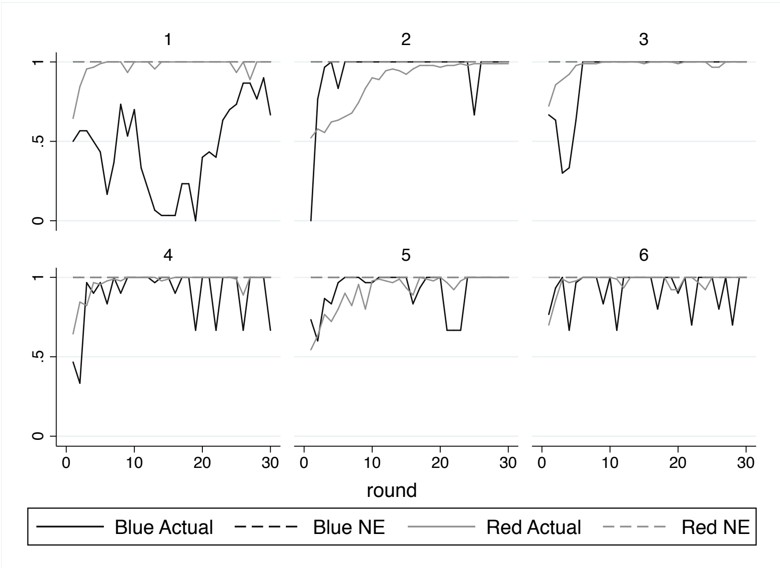


Notes: The figure shows individual decisions of endowment spent on skill red. The individuals are within the same matching group: the left panel shows the decisions of the Blue players, the right panel shows the decisions of the Red players. The solid lines represent the actual decisions and the dashed line represent the predicted decisions in the mixed-strategy equilibrium.

Treatment S-coop

The theoretical prediction is that both types spend everything on skill red. As can be seen from Figure 6, decisions of both types converge to the equilibrium in all matching groups. Table 5 shows that the Red players spend 95 percent on skill red in all rounds, and this rate reaches 99 percent in the last 5 rounds; the Blue players spend 84 percent on skill red in all rounds and 93 percent in the last 5 rounds. The Wilcoxon sign rank test rejects that the Red players spend a higher proportion on skill red than the Blue players ($p = 0.345$). Though Blue players' decisions converge to the equilibrium just like the Red players, they take these decisions with a grain of salt. In the equilibrium, they are disadvantaged and they could not improve their welfare by using other strategies.

Figure 6: Decisions in S-coop



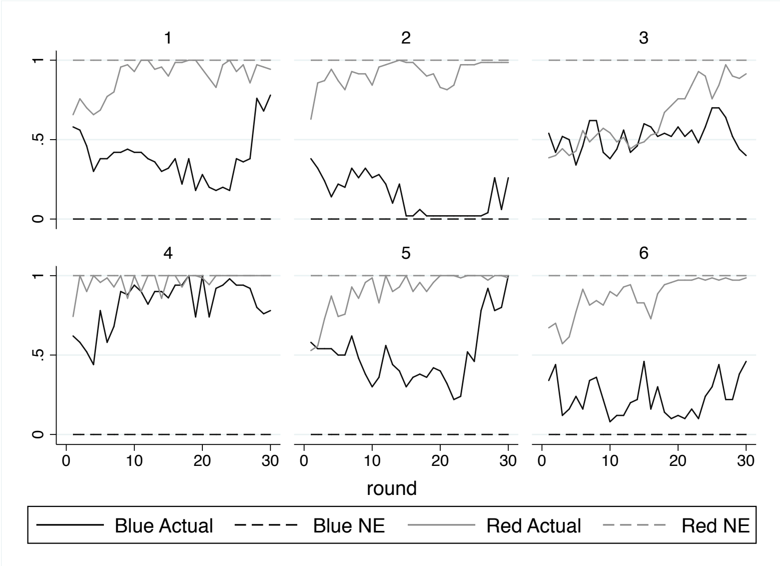
Notes: The figure shows the average fraction of endowment spent on skill red. The solid line represents the actual decisions of the subjects over rounds. The dashed line represents the averages of predictions in Nash equilibrium. The dark lines represent the Blue players. The light lines represent the Red players. Each diagram shows the averaged decisions within one group.

Treatment L-coop

There are two equilibria in this treatment: the conforming equilibrium and the segregating equilibrium. In the conforming equilibrium both types spend everything on skill red. In the segregating equilibrium both types spend everything on their own skill. To see whether a matching group select one of these two equilibria, a criterion is imposed with the following conditions: the conforming equilibrium is selected if (i) Blue players spent on average at least 75% on skill red and (ii) the equilibrium strategy is selected at least 40% of the time; the segregating equilibrium is selected if (i) Blue players spent on average at least 75% on skill blue and (ii) the equilibrium strategy is selected at least 40% of the time.

Using this criterion, as can be seen in Figure 7, the conforming equilibrium is selected by group 4. In this case, both types converge to the equilibrium, but the Red players converge faster and closer to the equilibrium than the Blue players. The segregating equilibrium is selected by groups 2 and 6. Here, both the Red players and the Blue players converge to the equilibrium after a sufficient number of rounds, while the Red players converge closer to the equilibrium. For the other three groups, it can be seen qualitatively that groups 1 and 5 start with a segregating pattern but turning to a conforming trend in the last few rounds; group 3 does not show a clear pattern for either of the two equilibria.

Figure 7: Decisions in L-coop



Notes: The figure shows the average fraction of endowments spent on skill red. The solid line represents the actual decisions of the subjects over rounds. The dashed line represents the predictions of Nash equilibrium. The dark lines represent the Blue players. The light lines represent the Red players. Each diagram shows the averaged decisions within one group.

Finally, as can be seen from Table 5, the Red players spend 87% on the skill red in all rounds and 97% in the last 5 rounds, whereas the Blue players spend on average 44% in all rounds and 55% in the last 5 rounds. These are not surprising given that the Blue players in different matching groups choose different equilibrium.

These results suggest that none of the equilibrium is favored over the other by the subjects: both equilibria have a bite in the laboratory, while the segregating equilibrium is selected slightly more often than the conforming equilibrium.[18] It implies that the segregating equilibrium, which only arises when the minority group is sufficiently large, is of empirical importance. It further suggests that efficiency is not a primary factor in the selection of the equilibrium, as segregating equilibrium is always less efficient than conforming equilibrium.

Result 3. *In S-comp, the Red players' decisions converge to the equilibrium strategy but the Blue players' do not. In L-comp, both types are able to mix with the equilibrium strategies but fail to mix with the equilibrium probabilities. In S-coop, the strategies of both types converge to the equilibrium. In L-coop, there are groups that converge to the conforming equilibrium, the segregating equilibrium or neither of them.*

[18]Since there are only six matching groups and the frequency of each equilibrium being selected is sensitive to the criterion, I would not claim that one equilibrium is favored over the other.

4.2.2 How do choices differ across treatment?

How do behaviors differ with respect to the treatment variable? Are choices responsive to the characteristics of the environment or the share of the minority group? In this section, we look at these questions for both types of players. Table 6 presents the choices of each type of players across treatments.

First, we look at how the choices of the Blue players differ across treatments. In the competitive environments, the Blue players spend 48% on skill red if the share of the minority is small, and spend 55% on skill red if the share of the minority is large (p=0.262, Mann-Whitney test). In the cooperative environment, the Blue players spend less on skill red when the share of the minority group is large than when the share of minority group is small (44% versus 84%, p=0.262, Mann-Whitney test). When the share of the minority group is small, the Blue players spend more on skill red in the cooperative environment (84%) compared to the competitive environment (68%, p=0.016, Mann-Whitney test). When the share of the minority group is large, the Blue players spend no different amount on skill red in both environment (p=0.200, Mann-Whitney test). These results show that for the Blue players, the share of the minority group seems to only have effect in the cooperative environment, whereas the type of the environment only have an effect when minority group is relatively small.

Table 6: **Choices across treatments**

Treatment	*Competitive*	*Cooperative*	p-value
Blue players			
Small minority group	48	84	0.016
Large minority group	55	44	0.200
p-value	0.262	0.016	
Red players			
Small minority group	94	95	0.631
Large minority group	68	87	0.025
p-value	0.004	0.078	

Notes: Entries are the choices (percentage points spent on skill red) in each treatment. The column separates the treatments by the setup of the environment, the row separates the share of the minority group. Two-sided Mann-Whitney tests are performed between treatments in the same row or column.

Next, we look at how choices of the Red players differ across treatments. In the competitive environments, the Red players spend more on skill red if the share of the minority is small (94%), compared to when the share of the minority is large (48%, p=0.004, Mann-Whitney test). In the cooperative environments, the Red players spend less on skill red when the share of the minority group is large than when the share of minority group is small (87% versus 95%, p=0.078, Mann-Whitney test). When the share of the minority group is small, the Red players spend the same amount on skill red in both environments (94% versus 95%, p=0.631, Mann-Whitney test). When the share of the minority group is large, the Red players spend more in the cooperative environment than in the competitive one (87 % versus 48%, p=0.200, Mann-Whitney test). These results suggest that for Red players, the share of the minority group is effective in both environments, whereas the type of the environment only has an effect when the minority group is relatively large.

Overall, our results show that both the population distribution and the environment are essential in determining the behavior of both types of players. In particular, as can be seen from Table 6, when we modify one treatment variable and control for the other variable, at least *one* type of players change their choices substantially.

Result 4. *In the competitive environments, the Red players spend significantly less in skill red when the minority group grows larger, while the Blue players do not change their choices. In the cooperative environments, both types of players spend less in skill red when the minority group grows larger. Keeping the share of the minority group equal, the Blue players spend more in the cooperative environments when the share of minority group is small, while the Red players spend more in the cooperative environments when the share is large.*

4.3 Learning

Since the game is complicated, subjects may have to learn how to make use of the feedback choices of the matching group, and how to make their choices accordingly. In this section, we briefly look at learning effects.

We do find some evidence of learning. From Figures 4-7, we can see the choices of each type of players over time. There is discernible time trend in treatment S-comp, S-coop and L-coop. In particular, choices converge to the equilibrium strategies in both S-coop and L-coop. In S-comp, on the other hand, there is no clear trend. In L-coop, the choices do not always converge to the equilibrium strategies. Moreover, as can be seen from Table 5, the Red players make choices towards equilibrium play in S-coop and L-coop, while the Blue players make choices towards equilibrium play in S-comp and S-coop.

5 Discussion

When and why do minority groups have an advantage or a disadvantage? In this study we offer a new mechanism behind the formation of majority-minority inequality by testing a skill investment model in the laboratory. It is shown that in the competitive environment, members of the majority group invest predominately in beating their in-group members, which leads to a winning position for the minority group members. In the cooperative environment, by contrast, members of the minority group maximize profit at the cost of conforming to the majority group, which puts them at a disadvantaged position.

What are the drivers of the results? The experimental design makes it possible to disentangle behavioral factors from strategic reasons. In the competitive environment, the majority spends nothing on the out-group skills only when it is strategically optimal to do so; they start to invest a sufficient amount on the out-group skills when the share of the minority group is large. This can only be attributed to strategic reasons. On the other hand, members of the minority learn to converge to the equilibrium strategy but hardly reach it, possibly because they do not lose much by not playing optimally. In the cooperative environment, the contrast is clear: the segregating equilibrium is selected only when the minority group is large. This is again explained by strategic reasons; that is, when it is strategically beneficial to stay segregated, the minority groups are able to resist conforming. Finally, according to the observed large payoff inequality, inequality aversion does not seem to have a bite in explaining the experimental results.

What are the welfare implications of the results? The Pareto efficiency criterion is silent about which equilibrium, in the cooperative environment, is better; the conforming equilibrium and the segregating equilibrium cannot be ranked on this criterion. From the perspective of total efficiency in society, one would rather conclude that when there are two (or more) population types, society is well served with conformity towards the majority group. This holds because conformity may efficiently solve the coordination problem of which type of skills to be invested in. For example, if two group speaking different languages are merged to a single society, in the most efficient equilibrium everyone learns the language of the bigger group. For another, most tools in our society are designed for right-handed majority and the lefties have to conform and use them in a right-handed way. However, the maximization of total welfare goes together with substantial social inequality. Therefore, some societies start to converge to the segregating equilibrium instead, despite its inefficiency. On the other hand, societies driven by efficiency may make the conforming equilibrium more focal by changing the beliefs of people.

Beyond the specific setting of the experiment, the results may help explain many daily life observations. For instance, a higher proportion of left-handers are seen in top ranks of many sports such as tennis, boxing, baseball and fencing, but not in sports such as golf or swimming (Hagemann 2009). The difference between these two kinds of sports is that the first class involves direct interaction between two or more athletes, whereas the latter are individual sports. For another, left-handed people brought up in the western culture use their right hands to hold knives but use left hands to hold chopsticks in dining; the opposite is observed among left-handed people brought up in eastern culture. The difference between these two types of left-handed people lies in the dining culture they grow up with – they both conform to the majority habits in their culture.

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Appendix

A Proofs

Proposition 1 (**Nash Equilibrium in competitive environment**). *In any state $\epsilon \in (0, \frac{1}{3}]$, there exists a unique symmetric equilibrium $x^* = 0$, $y^* = 1$. In any state $\epsilon \in (\frac{1}{3}, \frac{1}{2})$, there exists no symmetric pure-strategy equilibrium.*

Proof. For any $\epsilon \in (0, \frac{1}{3}]$, $x^* = 0$ and $y^* = 1$, a type θ ties with other θ and loses against all type τ, her payoff is $(1-\epsilon)\frac{v}{2}$; a type τ ties with other τ and beats all type θ, his payoff is $(1-\epsilon)v + \epsilon\frac{v}{2}$. If a type θ deviates to $x > x^*$, she will lose against other type θ, tie with or beat all type τ, she can gain a maximum of: $-(1-\epsilon)\frac{v}{2} + \epsilon v = (3\epsilon - 1)\frac{v}{2} < 0$. If a type τ deviates to $y < y^*$, he will tie with all type θ and beat other τ, and gains $-(1-\epsilon)\frac{v}{2} + \epsilon\frac{v}{2} = (2\epsilon - 1)\frac{v}{2} < 0$. If a type τ deviates to $y > y^*$, he still beats all type θ but loses against other τ, and this yields a strict loss. Thus, $x^* = 0$ and $y^* = 1$ is Nash equilibrium.

For any $\epsilon \in (0, \frac{1}{3}]$, suppose that there exists a pure-strategy equilibrium x and y, with $x \neq 0$ or $y \neq 1$. If $x > 0$, a type θ can gain by deviating to $x = 0$, as she will beat all other type θ, which ensures a gain of at least: $(1-\epsilon)\frac{v}{2} - \epsilon v = (1-3\epsilon)\frac{v}{2} > 0$. If $x = 0$ and $y = 0$, a type τ can gain by deviating to $y = 1$, as he will beat all type θ and lose against other type τ, which yields a strict gain of $(1-2\epsilon)\frac{v}{2}$. If $x = 0$ and $y > 1$, a type τ can gain by deviating to $y = 1$, as he will still beat all type θ as well as other type τ, which yields a strict gain of $\epsilon\frac{v}{2}$. Thus, no other pure-strategy equilibrium exists.

For any $\epsilon \in (\frac{1}{3}, \frac{1}{2})$, suppose that there exists a pure-strategy equilibrium x and y. If $x < y < \bar{x}$, a type θ can gain by deviating to $y+1$:$\epsilon v - (1-\epsilon)\frac{v}{2} > 0$. If $0 < x < y = \bar{x}$, a type θ can gain by deviating to 0, as she will beat other type θ. If $0 = x < y = \bar{x}$, a type τ can gain by deviating to 1, as he will beat other type τ. If $x = y < \bar{x}$, a type τ can gain by deviating to $x+1$, as he will beat type θ. If $x = y = \bar{x}$, a type θ can gain by deviating to 0, as she will beat other type θ. If $y < x < \bar{x}$, a type τ can gain by deviating to $x+1$, as he will beat type θ. If $0 < y < x = \bar{x}$, a type τ can gain by deviating to 0, as he will beat other type τ. If $0 = y < x = \bar{x}$, a type θ can gain by deviating to $x-1$, as she will beat other type θ. Thus, no pure-strategy equilibrium exists. □

Proposition 2 (**Nash Equilibria in cooperative environment**). *In any state $\epsilon \in (0, \frac{1}{2})$, there exists two sets of equilibria:*

(1) the minority group conform to the majority group: $x^* \leq \frac{\omega}{c+1}$, $y^* = min(\omega - cx^*, \bar{x})$,

(2) the majority group conform to the minority group: $x^* = min(\omega - cy^*, \bar{x})$, $y^* \leq \frac{\omega}{c+1}$,

In any state $\epsilon \in [\frac{1}{1+c}, \frac{1}{2})$, there exists another set of equilibria:

(3) the two groups segregate from each other: $x^* \leq \frac{\omega}{c+1}$, $y^* \leq \frac{\omega}{c+1}$.

Proof. The Nash equilibria can be distinguished by the skills that is used by indviduals from the same group. There are four different cases:

Case 1. Suppose that there exists pairs of x^* and y^*, such that two type θ individuals use their in-group skills to coordinate ($\omega - cx^* \geq x^*$), two type τ individuals use their out-group skills to coordinate ($\omega - cy^* \leq y^*$).

As $\omega - cx^* \geq x^*$ and $\omega - cy^* \leq y^*$, it follows that $min[x^*, \omega - cy^*] \leq min[\omega - cx^*, y^*]$. Therefore, a type θ and a type τ use type θ's in-group skills to coordinate and both receive $min[\omega - cx^*, y^*]$.

In equilibrium, any unilateral deviation yields the same or a lower payoff. Consider deviation $x > x^*$, it yields a lower payoff when meeting type θ and no gain when meeting type τ. Consider deviation $x < x^*$, it yields equal payoff when meeting type θ and no gain when meeting type τ if $\omega - cx^* \geq y^*$. Consider deviation $y > y^*$, it yields no gain when meeting θ if $y^* = \bar{x}$ or $y^* = \omega - cx^*$. Finally, deviation $y < y^*$ yields no gain when meeting θ or meeting τ. Together the following conditions are required for the equilibrium set:

$$\begin{cases} x^* \leq \frac{\omega}{c+1} \\ y^* = min(\omega - cx^*, \bar{x}) \end{cases} \tag{1}$$

Case 2. Suppose that there exists pairs of x^* and y^*, such that two type θ individuals use their out-group skills to coordinate ($\omega - cx^* \leq x^*$), two type τ individuals use their in-group skills to coordinate ($\omega - cy^* \geq y^*$).

Mirroring case 1, the equilibria set is characterized by the following conditions:

$$\begin{cases} x^* = min(\omega - cy^*, \bar{x}) \\ y^* \leq \frac{\omega}{c+1} \end{cases} \tag{2}$$

Case 3. Suppose that there exists pairs of x^* and y^*, such that two type θ individuals use their in-group skills to coordinate ($\omega - cx^* \geq x^*$), two type τ individuals use their in-group skills to coordinate ($\omega - cy^* \geq y^*$).

In equilibrium, any unilateral deviation yields the same or a lower payoff. Consider deviation $x > x^*$, it yields a loss of $(1-\epsilon)c\Delta x$ when meeting type θ and a maximal gain of $\epsilon\Delta x$ when meeting type τ, and the net is always negative. Consider deviation $x < x^*$, it yields equal payoff when meeting type θ and a loss when meeting type τ. Consider deviation $y > y^*$, it yields a gain of $(1-\epsilon)\Delta y$ when meeting θ and a loss of $\epsilon c\Delta y$ when meeting type τ, and the net is non-positive if $\epsilon \geq \frac{1}{1+c}$. Finally, deviation $y < y^*$ yields equal payoff when meeting θ and meeting τ.

Together the following conditions are required for the equilibrium set:

$$\begin{cases} x^* \leq \frac{\omega}{c+1} \\ y^* \leq \frac{\omega}{c+1} \\ \epsilon \in [\frac{1}{1+c}, \frac{1}{2}) \end{cases} \tag{3}$$

Case 4. Suppose that there exists pairs of x^* and y^*, such that two type θ individuals use their out-group skills to coordinate ($\omega - cx^* \leq x^*$), two type τ individuals use their out-group skills to coordinate ($\omega - cy^* \leq y^*$).

In equilibrium, any unilateral deviation yields the same or a lower payoff. Consider deviation $x > x^*$, it yields equal payoff when meeting type θ and when meeting type τ. Consider deviation $x < x^*$, it yields a loss when meeting type θ and no gain when meeting type τ. Consider deviation $y > y^*$, it yields a loss when meeting θ and equal payoff when meeting type τ. Finally, deviation $y < y^*$ yields a gain of $(1-\epsilon)c\Delta y$ when meeting θ and a loss of $\epsilon\Delta x$ when meeting τ, the net is always positive.

Thus, no equilibrium exists in this case. □

Proposition 3 (**Strict Nash Equilibria in cooperative environment**). *In any state $\epsilon \in (0, \frac{1}{2})$, there exists two equilibria:*
(a.1) the minority group conform to the majority group ($x^* = 0$, $y^* = \bar{x}$),
(a.2) the majority group conform to the minority group ($x^* = \bar{x}$, $y^* = 0$).
In any state $\epsilon \in [\frac{1}{1+c}, \frac{1}{2})$, there exists another equilibrium:
(b) the two groups segregate from each other ($x^* = y^* = 0$).

Proof. By Definition 2, a pair of strategies consists a strict equilibrium if and only if any unilateral deviation yields a strict loss. This implies that, for equilibria characterized in sets (1)-(3), the ones in which unilateral deviations may yield the same payoff can be eliminated.

In set (1), for any $x^* > 0$, a type θ receives the same payoff by deviating to $x = 0$. For any $y^* < \bar{x}$, a type τ receives the same payoff by deviating to $y = \bar{x}$. Therefore, strict equilibrium consists only $x^* = 0$ and $y^* = \bar{x}$.

Similarly, in set (2), only $x^* = \bar{x}$ and $y^* = 0$ survives as a strict equilibrium.

In set (3), for any $x^* > 0$, a type θ receives the same payoff by deviating to $x = 0$. And for any $y^* > 0$, a type τ receives the same payoff by deviating to $y = 0$. Therefore, strict equilibrium consists only $x^* = y^* = 0$. □

B Small population size

This section discusses the robustness of the model with small population size. Note that if the population size is large, the probability that one meets oneself is negligible. If the population size is small, on the other hand, the probability to meet each type of individual is affected by one's own type. The population state is defined by both n and ϵ. The matching probabilities for a population state (n, ϵ) are presented in the following equations.

$$\begin{cases} Pr[\tau|\theta, n, \epsilon] = \epsilon \frac{n}{n-1} \\ Pr[\theta|\theta, n, \epsilon] = (1 - \epsilon - \frac{1}{n})\frac{n}{n-1} \\ Pr[\theta|\tau, n, \epsilon] = (1 - \epsilon)\frac{n}{n-1} \\ Pr[\tau|\tau, n, \epsilon] = (\epsilon - \frac{1}{n})\frac{n}{n-1} \end{cases}$$

This modifies Propositions 1-3 regarding the tie-breaking population share. Recall that in Proposition 1, the tie-breaking point is $\frac{1}{3}$. This point occurs when a type θ finds it profitable to deviate from $x^* = 0$. The equilibrium payoff at $x^* = 0$ and $y^* = 1$ can be derived using the probability system: $\frac{1}{2}(1 - \epsilon\frac{n}{n-1})$. The maximum payoff by deviating is achieved when a type θ beats all type τ, which is equal to $\epsilon\frac{n}{n-1}$. By equalizing these two payoffs, the tie-breaking point is obtained as $\frac{n-1}{3n}$. Note that this number approaches $\frac{1}{3}$ as n increases, and can be approximated by $\frac{1}{3}$ for a fairly large n.

Similarly, in Propositions 2 and 3, the tie-breaking population share occurs when a type τ finds it unprofitable to deviate in the segregating equilibrium ($x^* = y^* = 0$). Using the matching probability, the payoff of a type τ in the segregating equilibrium is equal to $(\epsilon - \frac{1}{n})\frac{n}{n-1}\omega$, and the maximum deviation payoff is achieved when a type τ deviates to $y = \bar{x}$, which yields $(\epsilon - \frac{1}{n})\frac{n}{n-1}\omega + y\frac{n}{n-1}$. By equalizing these two payoffs, the tie-breaking population share is obtained: $\frac{n+c}{nc+n}$. Again, when n is sufficiently large, this point can be approximated by $\frac{1}{1+c}$.

The rest predictions of the model hold for small population size.

C Experimental predictions

In the experimental setup, the parameter values are: $\omega = 30$, $c = 3$, $\bar{x} = \frac{\omega}{c} = 10$, $n = 12$, $v = 30$, and the size of the minority group is 3 or 5. The detailed calculation for the experimental predictions are presented for each treatment.

Competitive environment. In treatment S-comp, the population state yields a unique Nash equilibrium $x^* = 0$ and $y^* = 1$. In equilibrium, the minority type receives a higher payoff than the majority type, and the payoff ratio $\frac{\Pi_\theta^*}{\Pi_\tau^*} = 0.4$.

In treatment L-comp, the population state yields a mixed-strategy Nash equilibrium. The mixed-strategy Nash equilibrium can be derived from the pure-strategy Nash equilibrium in S-comp. As $x = 0$ is no longer an equilibrium strategy for members of the majority, they are motivated to mix $x = 0$ with $x = 10$ to win against members of the minority. As a result, $y = 1$ is no longer an equilibrium strategy by members of the minority, and they are motivated to win against or tie with members of the majority by mixing $y = 1$ with $y = 10$.

In such a mixed-strategy Nash equilibrium, players mix between two pure strategies. To compute this Nash equilibrium, probability $(p_0, 1-p_0)$ is assigned to strategies $x = 0, x = 10$ for the majority type, probability $(q_0, 1-q_0)$ is assigned to strategies $y = 1, y = 10$ to the minority type. This strategy pair is a mixed-strategy Nash equilibrium if it satisfies the following conditions: (1) $x = 0$ and $x = 10$ yields the same expected payoff, while all other strategies yield a lower payoff (2) $y = 1$ and $y = 10$ yields the same expected payoff, while all other strategies yield a lower payoff.

These conditions leads to the mixed-strategy Nash equilibrium $x^* = (0 : \frac{3}{7}, 10 : \frac{4}{7})$, $y^* = (1 : \frac{1}{5}, 10 : \frac{4}{5})$. In this Nash equilibrium, the minority type receives a higher payoff than the majority type, and the payoff ratio $\frac{\Pi^*_\theta}{\Pi^*_\tau} = 0.71$. This equilibrium is used as the benchmark theoretical predictions for the experiment.

Cooperative environment. In treatment S-coop, the population state yields a conforming equilibrium $x^* = 0$ and $y^* = 10$. In equilibrium, the minority type receives a lower payoff than the majority type, and the payoff ratio $\frac{\Pi^*_\theta}{\Pi^*_\tau} = 2.45$.

In treatment L-coop, the population state allows another segregating equilibrium $x^* = y^* = 0$. In this equilibrium, the minority receives a lower payoff than the majority type, and the payoff ratio $\frac{\Pi^*_\theta}{\Pi^*_\tau} = 1.5$. In the conforming equilibrium $x^* = 0$, $y^* = 10$, the payoff ratio is 2.1.

The above illustration serves the comparative statics for the experiment and the results provide the theoretical predictions for the experiment.

D Experimental instructions

WELCOME PAGE

Welcome to this experiment on decision-making. You will be paid 7 euro for your participation plus what you earn in the experiment. During the experiment you are not allowed to communicate with each other. If you have any question at any time, please raise your hand. An experimenter will assist you privately. In this experiment you will make a number of decisions. Your earnings depend on your own decisions and the decisions of other participants. During the experiment, all earnings are denoted in points. Your earnings in points are the sum of the payoffs in every round. At the end of the experiment, your earnings will be converted to euros at the rate: 1 point = 0.02 euro. Hence, 50 points are equal to 1 euro. Your earnings will be privately paid to you in cash.

INSTRUCTIONS PAGE 1

The instructions are given in 2 pages. While reading them, you will be able to go back and forth by using the menu on top of the screen. A summary of these instructions will be distributed before the experiment starts.

Roles and Rounds At the beginning of the experiment, each participant will be randomly assigned to a role denoted by a color: Blue player or Red player. These roles will remain fixed throughout the experiment. For example, if you are assigned the color Blue, you will be a Blue player in each round of the experiment. Participants are divided into groups. Each group has 12 players. Among these 12 players, 3 are Blue players and 9 are Red players. Your group will stay the same throughout the experiment. The experiment consists of 30 rounds. In each round, these 12 players are randomly paired. The pairing is completely random in each round. Thus, in each round, one player is equally likely to be paired with any of the other 11 players in the group. At the end of each round, you will receive feedback about the role and the decision of the other player, your earnings and the group decisions overview in that round.

Decisions In each round, you will be asked to make one decision. The decision is about how to train your skills. There are two types of skills: skill blue and skill red. At the beginning of each round, each player receives an endowment of 30 skill points. This endowment will be the same in each round and for every player. You decide how to allocate the points on skill blue and skill red. The skill points associated with a given skill indicates how difficult it is to train that is, how many points it will require to reach each level. The skill points per level are given below.

- Skill blue: 1 point for Blue players; 3 points for Red players
- Skill red: 1 point for Red players; 3 points for Blue players

For example, if you are a Blue player, the points required to train skill blue is 1 point per level; the points required to train skill red is 3 points per level that is, it is more difficult for you to train the skill that is different from your color.

You must spend your entire endowment to train these two skills. It is completely up to you how many levels you want to reach for either of the two. For example, you may spend the entire points in skill blue, or the entire points in skill red, or any possible combination of the two. During the experiment, you will be given a list of all the possible choices. As soon as everyone has finished making a decision, you will be randomly paired with someone from the group and the payoff will be determined.

INSTRUCTIONS PAGE 2 (COMPETITIVE TREATMENTS)

Each player has two skills: blue and red. These skills are used in different situations. Skill blue is used when the player is paired with a Blue player; skill red is used when the player is paired with a Red player. Two players in a pair compete for a prize of 30 points. The winner receives the entire 30 points and the loser receives nothing. In case of a tie, both players receive half of the prize =15 points. We will now describe how it works.

- If two Blue players are in a pair, their skills blue are compared; whoever has the higher level wins. If the skill levels are equal, it is a tie.
- If two Red players are in a pair, their skills red are compared; whoever has the higher level wins. If the skill levels are equal, it is a tie.
- If a Blue player and a Red player are in a pair, the Blue players skill red and the Red players skill blue are compared; whoever has the higher level wins. If the skill levels are equal, it is a tie.

Examples (notice that all the numbers in the examples are randomly chosen and do not provide any indication about how to play the game):
Two Blue players in a pair. The first (skill blue: level 12, skill red: level 6) The second (skill blue: level 3, skill red: level 9) The first has the higher level skills blue than the second (12 > 3), and so the first receives 30 points, the second receives nothing.
One Blue player and one Red player in a pair. The Blue player (skill blue: level 12, skill red: level 6) The Red player (skill blue: level 3, skill red: level 21) The Blue player has the higher level skills red than the Red players skill blue (6 > 3), and so the Blue player receives 30 points, the Red player receives nothing.
One Blue player and one Red player in a pair. The Blue player has (skill blue: level 12, skill red: level 6) The Red player has (skill blue: level 6, skill red: level 12) The Blue players has the same level skill red as the Red players skill blue (6 = 6), and so both players receive half of the prize =15 points.

INSTRUCTIONS PAGE 2 (COOPERATIVE TREATMENTS)

Each player has two skills: blue and red. The two skills have different purposes. Skill blue is only used to work on project blue; skill red is only used to work on project red.Two players in a pair work on one of the two projects: blue or red. The outcome of project blue is equal to the minimum of the two skills blue. The outcome of project red is equal to the minimum of the two skills red. We will now describe the payoffs.

- If project blue yields a better outcome than project red, each player receives payoff = minimum of the skills blue;
- If project red yields a better outcome than project blue, each player receives payoff = minimum of the skills red;

- If project blue yields the same outcome as project red, each player receives payoff = minimum of the skills blue = minimum of the skills red.

Examples (notice that all the numbers in the examples are randomly chosen and do not provide any indication about how to play the game):
Two Blue players in a pair. The first (skill blue: level 12, skill red: level 6) The second (skill blue: level 3, skill red: level 9) Project blue yields outcome 3 (min of 12 and 3) and project red yields outcome 6 (min of 6 and 9), and so the two players work on red and each receives 6 points.
One Blue player and one Red player in a pair. The Blue player (skill blue: level 12, skill red: level 6) The Red player (skill blue: level 3, skill red: level 21) Project blue yields outcome 3 (min of 12 and 3) and project red yields outcome 6 (min of 6 and 21), and so the two players work on red and each receives 6 points.
One Blue player and one Red player in a pair. The Blue player has (skill blue: level 12, skill red: level 6) The Red player has (skill blue: level 6, skill red: level 12) Project blue yields outcome 6 (min of 12 and 6) and project red yields outcome 6 (min of 6 and 12), and so the two players work on blue or red and each receives 6 points.