The effect of subgroup homogeneity of efficacy on contribution in public good dilemmas

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Abstract

This paper examines how to maximize contribution in public good dilemmas by arranging people into homogeneous or heterogeneous subgroups. Past studies on the effect of homogeneity of efficacy have exclusively manipulated group composition in their experimental designs, which might have imposed a limit on ecological validity because group membership may not be easily changed in reality. In this study, we maintained the same group composition but varied the subgroup composition. We developed a public good dilemmas paradigm in which participants were assigned to one of the four conditions (high- vs. low-efficacy; homogeneous vs. heterogeneous subgroup) to produce their endowments and then decide how much to contribute. We found that individuals in homogeneous and heterogeneous subgroups made a similar amount and proportion of contribution, which was due to the two mediating effects that counteracted each other, namely (a) perceived efficacy relative to subgroup and (b) expectation of contribution of other subgroup members. This paper demonstrates both the pros and cons of arranging people into homogeneous and heterogeneous subgroups of efficacy.

Introduction

Group composition affects cooperation in public goods dilemmas (PGD) [1, 2]. One way to characterize the group composition is group homogeneity and heterogeneity (or group diversity), which are defined as the degree of similarity and difference of attributes of group members respectively [3, 4]. Research on group homogeneity and heterogeneity can largely be classified into a social categorization perspective that examines how ingroup/outgroup differences may disrupt the group processes; and an information
perspective that stipulates how diversity in knowledge and expertise may facilitate group
performance [5]. Past studies on organizational effectiveness have investigated the effects
of group homogeneity and heterogeneity based on attributes ranging from surface level
diversity (e.g., demographic characteristics of race, age, and gender) to deep level diversity
(e.g., attitude, personality, and values) [6], and such group homogeneity and heterogeneity
can have both positive and negative effects on organizational outcomes [7, 8]. This paper
focuses on the effect of subgroup homogeneity in distribution of efficacy on contribution in
social dilemmas.

Suppose we have a 12-person work team with six high-efficacy and six low-efficacy
members respectively, and they have to work on a specific task in a subgroup of three. How
can we split the team in order to maximize their contributions? On the one hand, we can
split the team into four homogeneous subgroups, with two subgroups each having three
high-efficacy members; and the other two subgroups each having three low-efficacy
members. On the other hand, we can also split the team into four heterogeneous
subgroups, with two subgroups each having one high-efficacy member and two low-efficacy
members; and the other two subgroups each having two high-efficacy members and one
low-efficacy member. Although several experimental studies have investigated the effect of
homogeneous distribution of efficacy on contribution in PGD, e.g., [9, 10], their findings may
not be sufficient to address the above question, because these studies manipulated the
group composition of efficacy such that the total number of high- and low-efficacy
individuals (i.e., the “total” efficacy) in a group was changed. However, in our case, just like
most situations in daily life, we are stuck with the people that we have. In such a
circumstance, the only way to change group homogeneity is to divide the group members
into subgroups. Therefore, it is important to examine by keeping the group members
unchanged, whether and how we can maximize group contribution by strategically changing the subgroup composition in organizations.

We first introduce the concept of “efficacy” that will be referred to throughout this paper. We then summarize some past research about the relation between homogeneity of efficacy and contribution. After that, we highlight the distinctive features of the present study, and finally we propose two potential mediators that could help us understand the underlying mechanisms behind the aforementioned relation, namely perceived efficacy and expectation of contribution.

**Efficacy**

Efficacy, criticality, and indispensability are similar constructs that describe an individual’s impact on PG provision in a PGD, e.g., [11 - 15]. Particularly, Yu et al. [15] proposed that Efficacy = Endowment × Efficiency, in which endowment is the resource that a person can contribute while efficiency is the impact brought about by each unit of endowment. For example, in a group project, a person is considered to have high efficacy if he or she has much time available to devote to the group project (endowment) and can do a lot of work per hour spent (efficiency). Varying group size will affect the efficacy of individuals [16]. Keeping individuals’ endowment constant, as group size increases, the relative impact of each unit of endowment (efficiency) decreases, so as efficacy. In this study, we kept the “total” efficacy of the group unchanged, manipulating only the composition of efficacy of each subgroup.

**Homogeneity of efficacy and group contribution**

Past studies examining the effect of group homogeneity of efficacy on contribution focused on endowment heterogeneity (also described as endowment asymmetry or
resource inequality by some researchers, e.g., [17, 18]). These findings, however, were rather mixed. On the one hand, Aquino et al. [17] found that high resource inequality led to less cooperation in social dilemmas. They argued that under high resource inequality, people with fewer resources tend to free ride because they perceive their contributions to be dispensable; while people with more resources also tend to free ride because they expect others to do so as well. Using a step-level paradigm with provision threshold, Rapoport and Suleiman [19] also concluded that heterogeneous groups were less successful in providing PG than homogeneous groups were. Similarly, Cherry et al. [20] showed that contribution levels were significantly lower when groups had heterogeneous rather than homogeneous endowments, irrespective of whether the endowments were determined by the performance of a task or were just randomly assigned. Fung and Au [10] also found that both the symmetrically heterogeneous and the hegemonic heterogeneous groups contributed less than homogeneous groups. Considering percentage contributions, Hargreaves Heap et al. [21] found that individuals with high endowment contributed proportionally less in heterogeneous groups than in homogeneous groups.

On the other hand, there has also been research showing that heterogeneous groups contributed more [9]. A study found that heterogeneity of endowment had a positive effect on aggregate contribution, but the effect was moderated by whether communication was allowed, whether participants received complete information about the payoff, and whether the marginal return was the same for each member [22]. Another study showed that in a best-shot PGD where the provision was determined by the highest contribution instead of sum of all contributions, endowment heterogeneity resulted in better coordination as it provided a shared expectation among group members [23].
Still, Warr [24] illustrated mathematically that the distribution of resources should have no effect on the contribution of PG. In line with this prediction, Levati et al. [25] found that homogeneous groups had similar contribution compared to heterogeneous groups. Table 1 shows the summary of these previous findings.
Table 1. Summary of studies of the effect of homogeneity of efficacy on contribution in public good dilemmas.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Sample size</th>
<th>Group size</th>
<th>Provision threshold</th>
<th>Fixed/Continuous return</th>
<th>Major findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquino et al.</td>
<td>1992</td>
<td>96</td>
<td>4</td>
<td>Yes</td>
<td>Continuous</td>
<td>Resource inequality led to decreased contribution.</td>
</tr>
<tr>
<td>Chan et al.</td>
<td>1996</td>
<td>75</td>
<td>3</td>
<td>No</td>
<td>Continuous</td>
<td>Endowment heterogeneity increased contribution for high, but not low degree of heterogeneity.</td>
</tr>
<tr>
<td>Chan et al.</td>
<td>1999</td>
<td>72</td>
<td>3</td>
<td>No</td>
<td>Continuous</td>
<td>Endowment heterogeneity increased aggregate contribution, but the effect was moderated by whether communication was allowed, whether participants received complete information about the payoff, and whether the marginal return was the same for each member.</td>
</tr>
<tr>
<td>Cherry et al.</td>
<td>2005</td>
<td>124</td>
<td>4</td>
<td>No</td>
<td>Continuous</td>
<td>Contribution levels were significantly lower when groups had heterogeneous rather than homogeneous endowments, irrespective of whether the endowments were earned or randomly assigned.</td>
</tr>
<tr>
<td>Cherry et al.</td>
<td>2013</td>
<td>192</td>
<td>4</td>
<td>No</td>
<td>Continuous</td>
<td>In a best-shot PG in which the provision level is determined by the highest contribution instead of the sum of all contributions, endowment heterogeneity resulted in better coordination.</td>
</tr>
<tr>
<td>Fung &amp; Au (Study 1)</td>
<td>2014</td>
<td>96</td>
<td>3</td>
<td>No</td>
<td>Continuous</td>
<td>Both the symmetrically heterogeneous and the hegemonic heterogeneous groups contributed less than homogeneous groups.</td>
</tr>
<tr>
<td>Hargreaves Heap et al.</td>
<td>2016</td>
<td>210</td>
<td>3</td>
<td>No</td>
<td>Continuous</td>
<td>Individuals with high endowment contributed proportionally less in heterogeneous groups than in homogeneous groups.</td>
</tr>
<tr>
<td>Levati et al.</td>
<td>2007</td>
<td>328</td>
<td>4</td>
<td>No</td>
<td>Continuous</td>
<td>No significant differences in contribution between homogeneous and heterogeneous groups.</td>
</tr>
<tr>
<td>Rapoport &amp; Suleiman</td>
<td>1993</td>
<td>60</td>
<td>5</td>
<td>Yes (vary across conditions)</td>
<td>Fixed</td>
<td>Heterogeneous groups were less successful in providing public goods than homogeneous groups were.</td>
</tr>
</tbody>
</table>
The present study

In the present study, participants role-played a member in a work team of a social enterprise that consisted of six high-efficacy and six low-efficacy members. With the explicit knowledge of this group composition, each participant was either assigned into a three-person homogeneous subgroup (i.e., either all high-efficacy or all low-efficacy members) or a three-person heterogeneous subgroup (i.e., either two high- and one low-efficacy members or two low- and one high-efficacy members). Participants were required to produce cell phone straps and decide how much to contribute to the social enterprise.

There are two main objectives of the present study. The first objective is to see whether and how we can maximize contribution by strategically changing the subgroup compositions into either homogeneous subgroups or heterogeneous subgroups while keeping group members unchanged. Research to date that compared the effects of homogeneity and heterogeneity of efficacy on contribution has yielded conflicting findings. Notably, these studies cannot address our research question well because they focused on the effects with respect to groups instead of subgroups, e.g., [9, 17, 20]. The first distinction between past studies and our present study is that the former manipulated homogeneity of efficacy by changing the initial endowment of group members. In real life situations, say in an organization, we cannot always change the composition of group members at will. Consider again the 12-person work team with six high-efficacy and six low-efficacy members as an example. The team cannot be made a homogeneous team unless we dismiss half of the members. We can, however, split the initially heterogeneous team into several homogeneous subgroups given that task is divisible.
More importantly, the distinction between group and subgroup lies on the interdependence of task outcome [26]. For past studies comparing the contributions of homogeneous groups and heterogeneous groups, the PG was shared among people in their own homogeneous group or heterogeneous group only. In other words, a participant’s outcome is independent of the contributions of other groups. However, in our scenario, all subgroups are nested within the same group. Participants in all subgroups receive the same PG that is jointly determined by all members in the group, including members of other subgroups. Therefore, a participant’s outcome is dependent on the contributions of other subgroups as well.

The second objective of the present study is to understand the underlying mechanisms that may explain how subgroup homogeneity can increase or decrease contribution. Specifically, we tested two potential mediators that are known to influence cooperation in social dilemmas, namely perceived efficacy of oneself and expectation of contribution towards others.

**Underlying mechanisms**

**Perceived efficacy**

A person’s absolute efficacy may not be equal to one’s perceived efficacy. We define absolute efficacy as the actual impact to the PG provision and perceived efficacy as the personal belief about one’s impact relative to the affiliated group or subgroup. For example, in a symmetric PGD with homogeneous endowment, the absolute efficacy of each individual increases when endowment increases, but the perceived efficacy relative to the group may not change because no one is comparatively more efficacious than the others. In the
present study, we randomly assigned participants into either high or low absolute efficacy conditions. For simplicity, we use “high-efficacy individuals” and “low-efficacy individuals” to refer to the participants being assigned to high and low absolute efficacy conditions, respectively.

Perceived efficacy has been shown to be effective in inducing cooperation through enhancing a sense of social responsibility [27]. Research under the rubrics of efficacy and criticality all pointed to the same conclusion that a person who perceives a larger impact on PG provision contributes more. Beyond the laboratory settings, perceived efficacy also impacts various kinds of organizational behaviors including job performance [28].

Various factors can influence cooperation rate through efficacy. For example, a large group size decreases cooperation drastically because it diminishes one’s perceived efficacy [29]. Kerr [16] also demonstrated that people in a small group reported higher perceived efficacy and hence cooperated more than those in a large group, despite the fact that their impacts on the outcome were made objectively the same in both the small and large groups.

While subgroup configuration does not affect the absolute efficacy of individuals, it does affect the perceived efficacy. Indeed, an individual’s perceived efficacy relative to the group may be different from that relative to the subgroup. Intuitively, subgroup configuration may not affect the perceived efficacy relative to the group, because individuals acknowledge that the efficacy levels of other members in the group remain the same, regardless of the subgroup composition. However, in terms of perceived efficacy relative to the subgroup, subgroup homogeneity matters. Among high-efficacy individuals, those in heterogeneous subgroups shall perceive higher efficacy relative to the subgroup than those in homogeneous subgroups, because they can make downward comparison with
low-efficacy individuals within the same subgroup. On the contrary, among low-efficacy
individuals, those in homogeneous subgroups shall perceive higher efficacy than those in
heterogeneous subgroups because in homogeneous subgroups everyone is of low-efficacy
and there is no upward comparison. We thus predict an absolute efficacy \( \times \) subgroup
homogeneity interaction effect on perceived efficacy, and higher perceived efficacy relative
to the subgroup will in turn lead to higher contribution. Specifically, we hypothesize that
high efficacy individuals will perceive higher efficacy and will hence contribute more in
heterogeneous subgroups than in homogenous subgroups, whereas low efficacy individuals
will perceive higher efficacy and will hence contribute more in homogeneous subgroups
than in heterogenous subgroups (Hypothesis 1).

**Expectation of contribution**

Expectation of contribution refers to the amount that one expects the other
members to contribute. Expectation of others’ contributions does affect our own
contribution. For instance, worrying that others are not going to contribute may induce fear
of being a sucker. We may also develop a sense of greed to free ride on others if we think
that others are going to contribute a lot [30, 31]. Furthermore, expectation of contribution
was central to Pruitt and Kimmel’s Goal/Expectation Hypothesis [32], which stated that in
addition to adopting a mutual goal of cooperation, developing mutual expectation of
cooperation is essential in enhancing cooperation. Previous findings did support the
Goal/Expectation Hypothesis that cooperation increases when we expect others to
cooperate [33, 34].

A person who possesses higher efficacy can potentially make a stronger impact on
PG provision. Therefore, it is reasonable to expect that a person with higher efficacy will
contribute more. In terms of expectation of *group* contribution, because the group has a
fixed configuration (e.g., six high-efficacy and six low-efficacy members, as in the previous example), subgroup homogeneity should not affect the expectation of contribution towards the group. However, in terms of expectation of subgroup contribution, subgroup homogeneity matters. Among high-efficacy individuals, those in the homogeneous subgroups shall develop a higher expectation of subgroup contribution than those in the heterogeneous subgroups, because in high-efficacy homogeneous subgroups other members are also of high-efficacy. On the contrary, among low-efficacy individuals, those in the heterogeneous subgroups shall develop a higher expectation of subgroup contribution than those in the homogeneous subgroups, because in heterogeneous subgroups there are at least one other high-efficacy members who are supposed to contribute a lot. We thus predict an absolute efficacy × subgroup homogeneity interaction effect on expectation of subgroup contribution, and higher expectation of subgroup contribution will in turn lead to higher contribution. Specifically, we hypothesize that high efficacy individuals will expect other subgroup members to contribute more and in turn they themselves will also contribute more in homogenous subgroups than in heterogenous subgroups, whereas low efficacy individuals will expect other subgroup members to contribute more and in turn they themselves will also contribute more in heterogenous subgroups than in homogenous subgroups (Hypothesis 2).

Taken together, we proposed a moderated mediation model in which subgroup homogeneity and individual efficacy interact to affect contribution through two pathways, namely perceived efficacy of oneself relative to subgroup and expectation of subgroup contribution towards others (Fig 1).
Fig 1. Proposed moderated mediation model stipulating how subgroup homogeneity influences contribution.

Method

Participants

A total of 336 undergraduate students (63% female) participated in this study that was presented as an individual and group decision making experiment. Participants received a flat-rate of HK$50 (approximately US$6.5) for participation with a chance to earn an extra bonus according to their performance. The bonus ranged from HK$111 to HK$368 (US$14-47) with an average of HK$215 (US$28). This study was approved by the Survey and Behavioural Research Ethics Committee of The Chinese University of Hong Kong.

Design
The experiment embedded a 2 × 2 between-subject design with two levels of efficacy (high vs. low) and two levels of subgroup composition (homogenous vs. heterogeneous).

**Procedures**

Six students participated in each session that lasted for around an hour. After participants have given their informed consent, the experimenter described the task scenario to them with visual aids. The PGD was presented as a social enterprise scenario. Participants role-played a member of a 12-person group in which their group members consisted of the participants from the present and the previous one session. Their business was to produce cell phone straps using plastic beads. The completed cell phone straps could be sold through either the participants’ own private stalls at a price of HK$5 per piece or the social enterprise at HK$15. The profit made by the social enterprise was a PG which would be shared equally among all 12 participants. The total payoff for each participant was calculated as the sum of the profits earned from the private stall and the social enterprise. Participants were then presented with four examples illustrating the characteristics of a PGD, such that everyone contributing a lot to the social enterprise is better than everyone contributing only a little; however, they could earn the most if they contribute only a little while others contribute a lot, and vice versa. The instructions stated clearly that there was no competition among participants and that there was also no competition between the social enterprise and private stalls. Participants’ first task was to manually produce these cell phone straps within a time limit. Their second task was to decide how many straps to sell through their own private stalls (non-contribution) and the social enterprise (contribution), respectively.
The experimenter then demonstrated how to make the cell phone straps using beads—by inserting beads into a plastic strap and then bending the end of the strap to fix the beads. Participants were given one minute as a practice trial to make the cell phone straps and then to make an allocation decision. Participants were also given a calculator to compute the profits of themselves and other members based on a hypothetical scenario. The experimenter checked their answers to ensure that all of them understood the instructions clearly.

Afterwards, participants were told that just in everyday life, some people would have more time and they could work more efficiently. In order to simulate these individual differences, half of the 12 members in the social enterprise (i.e., the high-efficacy individuals) would be granted more time (six minutes) and higher working efficiency (requiring only three large beads to produce a strap); whereas the other six members (i.e., the low-efficacy individuals) would be granted less time (three minutes) and lower working efficiency (requiring six small beads to produce a strap) (Fig 2). S1 Appendix shows the instructions and illustrations of the task as presented to the participants.

Fig 2. Example of the cell phone straps to be made by high-efficacy individuals and low-efficacy individuals respectively.
The six participants in each experimental session that constituted half of the 12-person social enterprise were assigned to two subgroups of three and were seated in two adjacent rooms. They were told that the 12-person group was put into two different sessions and each session was conducted in two separate rooms simply because of physical space constraints, in which we could not assemble a 12-person group at the same physical location simultaneously (cf. Tajfel’s minimal group paradigm [35]). Inside each room, the three participants were seated face-to-face but were three meters apart from each other, such that they could not see others’ responses on the questionnaires. However, they could notice whether the other participants were given six or three minutes to produce the straps, and whether they had large or small beads. Because low-efficacy individuals had only three minutes to produce the cell phone straps, they were asked to complete an English-to-Chinese translation for a cell phone strap advertisement as a filler task while the high-efficacy individuals were still producing the cell phone straps in the remaining three minutes.

After participants had finished producing the cell phone straps within their allotted time, they completed a short questionnaire and allocated their straps to the social enterprise and their private stalls respectively by putting the straps into two separate compartments inside an opaque box that other people could not see their allocation decisions.

After the game, participants completed questionnaires concerning their experiences regarding the game. Full debriefing on the game was given to the participants upon completion of all experimental procedures. In order to motivate participants to make the allocation decisions seriously, one out of six participants from each session was randomly selected to receive a bonus which was equal to his or her earning in the game. They were
told that the profit made by the social enterprise was calculated as the sum of the current
and the previous session because the two sessions belonged to the same social enterprise.
S2 Appendix describes how the bonus payments were computed.

**Manipulation of efficacy**

Efficacy was manipulated in terms of both endowment (amount of time granted to
produce the cell phone straps) and efficiency (number of beads required to produce a strap)
[15]. Participants were randomly assigned as either the low-efficacy or high-efficacy
individuals. Low-efficacy individuals were given three minutes to produce the straps and six
small beads were required to construct each strap; while high-efficacy individuals were
given six minutes to produce the straps and each strap only required three large beads to
construct.

**Manipulation of subgroup homogeneity**

Although all social enterprises were identically comprised of six high-efficacy and six
low-efficacy individuals, we systematically constructed subgroups of three people by
assigning different numbers of high- and low-efficacy individuals to produce cell phone
straps in separate rooms. There were two types of homogenous subgroups that consisted of
either (a) three high-efficacy individuals or (b) three low-efficacy individuals; and two types
of heterogeneous subgroups that consisted of either (a) two high- and one low-efficacy
individuals or (b) one high- and two low-efficacy individuals.

**Psychological measures**

After participants had finished making the cell phone straps, they reported their
perceived efficacy and expectation of contribution before making the allocation decisions.

**Perceived efficacy**
Participants’ perceived efficacy relative to the subgroup was measured by the item “Compared to other members in the room, please estimate the amount of straps that you have made”, and participants’ perceived efficacy relative to the group was measured by the item “Compared to the other 11 members in the social enterprise, please estimate the amount of straps that you have made” on a 9-point scale with 1 = “The least in the group” and 9 = “The most in the group”.

**Expectation of contribution**

Participants also estimated the number of straps to be contributed by the other two members in the same room (expectation of subgroup contribution) and the other 11 members of the social enterprise (expectation of group contribution).

**Results**

**Descriptive statistics**

Table 2 shows the means and standard deviations of the number of straps produced, the number of straps contributed, and the proportion of straps contributed across different groups respectively. The average number of straps produced, average number of straps contributed, and average proportion of straps contributed by each individual were 23.3, 10.0, and 42.4% respectively.
Table 2. Means (Standard deviations) of the number of straps produced and contributed, and the proportion of straps contributed across different subgroup homogeneity and efficacy conditions (N=336).

<table>
<thead>
<tr>
<th>Subgroup Homogeneity</th>
<th>Efficacy</th>
<th>Homogeneous</th>
<th>Heterogeneous</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>(N = 87)</td>
<td>(N = 81)</td>
<td>(N = 168)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td>11.68 (1.63)</td>
<td>12.04 (1.56)</td>
<td>11.85 (1.60)</td>
</tr>
<tr>
<td>Contribution</td>
<td></td>
<td>4.60 (3.55)</td>
<td>5.16 (3.55)</td>
<td>4.87 (3.55)</td>
</tr>
<tr>
<td>Proportion</td>
<td></td>
<td>39.56% (30.20%)</td>
<td>43.05% (28.69%)</td>
<td>41.24% (29.45%)</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>(N = 87)</td>
<td>(N = 81)</td>
<td>(N = 168)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td>34.52 (3.72)</td>
<td>35.10 (4.31)</td>
<td>34.80 (4.02)</td>
</tr>
<tr>
<td>Contribution</td>
<td></td>
<td>16.07 (9.17)</td>
<td>14.10 (10.20)</td>
<td>15.12 (9.70)</td>
</tr>
<tr>
<td>Proportion</td>
<td></td>
<td>46.77% (26.56%)</td>
<td>39.89% (28.26%)</td>
<td>43.45% (27.53%)</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td>(N = 174)</td>
<td>(N = 162)</td>
<td>(N = 336)</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td>23.10 (11.81)</td>
<td>23.57 (12.01)</td>
<td>23.32 (11.89)</td>
</tr>
<tr>
<td>Contribution</td>
<td></td>
<td>10.33 (9.01)</td>
<td>9.63 (8.83)</td>
<td>9.99 (8.92)</td>
</tr>
<tr>
<td>Proportion</td>
<td></td>
<td>43.16% (28.59%)</td>
<td>41.47% (28.43%)</td>
<td>42.35% (28.48%)</td>
</tr>
</tbody>
</table>

*Note.* “Production” indicates the mean number of straps produced. “Contribution” indicates the mean number of straps contributed. “Proportion” indicates the mean of individuals’ proportion of straps contributed.

**Effect of subgroup homogeneity on strap production and contribution**

Before examining the effect of subgroup homogeneity on contribution, we tested whether the number of straps produced was different for individuals in homogeneous and heterogeneous subgroups. Welch’s t-test revealed that there was no significant difference in strap production, \( t(331.38) = -0.36, p = .72 \). In order to provide more convincing evidence that individuals in homogeneous subgroups produced a similar number of straps as...
compared to that of heterogeneous subgroups, we followed the two one-sided tests (TOST) procedure proposed by Lakens [36] to conduct an equivalence test on strap production. We set the upper and lower equivalence bounds as Cohen’s $d = \pm .3$. Power analysis showed that at least 145 participants per condition are required to achieve a power of .95 for this equivalence bound. Our sample size ($N = 336$) was adequate to perform this analysis. Using $\alpha = .05$, the equivalence test was significant, $t(331.38) = 2.39, p < .01$, implying that the difference in strap production between homogeneous and heterogeneous subgroups was sufficiently close to zero to be considered practically equivalent [37].

Next, we tested the effect of subgroup homogeneity on strap contribution to the PG. Welch’s t-test revealed that there was no significant difference in strap contribution, $t(333.10) = 0.72, p = .47$. In order to test whether homogeneous subgroups contributed a similar number of straps as compared to that of heterogeneous subgroups, we also conducted the same equivalence test on strap contribution. The equivalence test on strap contribution was significant, $t(333.10) = -2.03, p = .02$, implying that homogeneous and heterogeneous subgroups contributed similar number of straps.

We also tested the effect of subgroup homogeneity on the proportion of straps contributed to the PG. Welch’s t-test revealed that there was no significant difference in proportion of straps contributed, $t(332.54) = 0.55, p = .59$. The equivalence test on proportion of straps contributed was significant, $t(332.54) = -2.21, p = .01$, implying that homogeneous and heterogeneous subgroups contributed similar proportion of straps.

In sum, individuals in homogeneous and heterogeneous subgroups produced similar number of straps, and contributed similar number and proportion of straps to the PG.
Perceived efficacy and expectation of contribution as mediators

In order to test the proposed moderated mediation model stipulated in Fig 1, we performed a multilevel moderated mediation analysis [38] using Mplus 7.31 [39]. Multilevel modeling was employed because each low-efficacy or high-efficacy individual was nested within a homogeneous or heterogeneous subgroup. We assumed random effects in the model with efficacy as a level-1 predictor, subgroup homogeneity as a level-2 predictor, perceived efficacy relative to subgroup and expectation of subgroup contribution as two level-1 mediators, strap contribution as a level-1 dependent variable, and subgroup number as a cluster variable. The parameters in the model were estimated using maximum likelihood (ML). Three responses were excluded from this moderated mediation analysis because the participants did not indicate their expectation of subgroup contribution. S3 Appendix shows the Mplus code of this analysis.

Hypothesis 1 states that absolute efficacy moderates the effect of subgroup homogeneity on perceived efficacy, such that high-efficacy individuals in heterogeneous subgroups will have higher perceived efficacy than those in homogeneous subgroups; whereas low-efficacy individuals in homogeneous subgroups will have higher perceived efficacy than those in heterogeneous subgroups. Supporting Hypothesis 1, we found that the effect of subgroup homogeneity on perceived efficacy relative to subgroup was significantly different for high-efficacy and low-efficacy individuals, $b = 3.19, p < .001, 95\% \text{ CI } [2.24, 4.13]$. High-efficacy individuals in heterogeneous subgroups had higher perceived efficacy than those in homogeneous subgroups, $b = 1.52, p < .001, 95\% \text{ CI } [0.93, 2.10]$; low-efficacy individuals in homogeneous subgroups had higher perceived efficacy than those in heterogeneous subgroups, $b = -1.67, p < .001, 95\% \text{ CI } [-2.41, -0.94]$ (Fig 3). Hypothesis 1
further states that there would be a moderated mediation effect in which subgroup homogeneity and efficacy interact to affect perceived efficacy relative to subgroup, which in turn mediates the effect of subgroup homogeneity on contribution. For high-efficacy individuals, the conditional indirect effect of subgroup homogeneity on strap contribution through perceived efficacy as a mediator was significant, $b = 1.13$, $p < .01$, 95% CI [0.35, 1.91], such that high-efficacy individuals in heterogeneous subgroups had higher perceived efficacy and hence contributed more straps. For low-efficacy individuals, the conditional indirect effect was also significant, $b = -1.24$, $p = .01$, 95% CI [-2.19, -0.30], such that low-efficacy individuals in homogeneous subgroups had higher perceived efficacy and hence contributed more straps. The index of moderated mediation [40] was significant, $b = 2.37$, $p < .01$, 95% CI [0.79, 3.95]. These results supported Hypothesis 1 that perceived efficacy was a mediator of the effect of subgroup homogeneity on strap contribution, and that the mediating effects were in opposite directions for high-efficacy and low-efficacy individuals.

![Fig 3. Perceived efficacy relative to subgroup across different conditions.](image-url)
Hypothesis 2 states that absolute efficacy moderates the effect of subgroup homogeneity on expectation of subgroup contribution, such that high-efficacy individuals in homogeneous subgroups will have a higher expectation of subgroup contribution than those in heterogeneous subgroups; whereas low-efficacy individuals in heterogeneous subgroups will have a higher expectation of subgroup contribution than those in homogeneous subgroups. Supporting Hypothesis 2, we found that the effect of subgroup homogeneity on expectation of subgroup contribution was significantly different for high-efficacy and low-efficacy individuals, $b = -21.76, p < .001, 95\% CI [-27.30, -16.22]$. High-efficacy individuals in homogeneous subgroups had a higher expectation of subgroup contribution than those in heterogeneous subgroups, $b = -12.83, p < .001, 95\% CI [-16.98, -8.69]$; low-efficacy individuals in heterogeneous subgroups had a higher expectation of subgroup contribution than those in homogeneous subgroups, $b = 8.92, p < .001, 95\% CI [4.82, 13.03]$ (Fig 4). Hypothesis 2 further states that there would be a moderated mediation effect in which subgroup homogeneity and efficacy interact to affect expectation of subgroup contribution, which in turn mediates the effect of subgroup homogeneity on contribution. For high-efficacy individuals, the conditional indirect effect of subgroup homogeneity on strap contribution through expectation of subgroup contribution as a mediator was significant, $b = -4.32, p < .001, 95\% CI [-6.33, -2.31]$, such that high-efficacy individuals in homogeneous subgroups had higher expectation and hence contributed more straps. For low-efficacy individuals, the conditional indirect effect was also significant, $b = 3.00, p < .001, 95\% CI [1.37, 4.64]$, such that low-efficacy individuals in heterogeneous subgroups had higher expectation and hence contributed more straps. The index of moderated mediation was significant, $b = -7.33, p < .001, 95\% CI [-10.31, -4.34]$. These results supported Hypothesis 2 that the expectation of subgroup contribution was a
mediator of the effect of subgroup homogeneity on strap contribution, and that the mediating effects were in opposite directions for high-efficacy and low-efficacy individuals.

As an exploratory analysis, we tested a similar moderated mediation model in which the two mediators (i.e., perceived efficacy relative to the subgroup and expectation of subgroup contribution) were substituted by perceived efficacy relative to the group and expectation of group contribution respectively. None of the moderated mediation effects were significant. These null results further demonstrated that it was the subgroup variables but not the group variables that affected the contributions to the group.

Discussion

This study investigates whether we can maximize contribution through manipulating subgroup homogeneity in PGD that the whole group shared the same PG. Our results
suggested that splitting groups members into homogeneous or heterogeneous subgroups can at the same time enhance and reduce contribution through two different mechanisms. Consider the high-efficacy individuals in homogeneous subgroups, they had lower perceived efficacy relative to subgroup than those in heterogeneous subgroups, which led them to contribute less. However, they had higher expectation of subgroup contribution than those in heterogeneous subgroups, which led them to contribute more. The effects of perceived efficacy and expectation of contribution hence counteracted each other and resulted in similar amounts of contribution for high-efficacy individuals. Similarly, among low-efficacy individuals, those in homogeneous subgroups had higher perceived efficacy, but lower expectation of contribution than those in heterogeneous subgroups. The effects of perceived efficacy and expectation of contribution again counteracted each other and resulted in similar amounts of contribution for low-efficacy individuals. The effects of perceived efficacy and expectation of cooperation that nullified each other may explain why homogeneous subgroups contributed a similar amount as heterogenous subgroups did.

In an organization, it is common to divide workers into different subgroups to work on a specific task. Often, members of a subgroup have different levels of efficacy. Our results suggested that different strategies may be needed to motivate high- and low-efficacy workers to contribute to the organization. For high-efficacy workers, although they supposedly have high perceived efficacy, they may expect other low-efficacy workers to contribute only a little, making them reluctant to contribute more. Hence, interventions should focus on enhancing their expectation of contribution of other members, for instance, by trying to convince them that all members, regardless of their levels of efficacy, are equally willing to devote to the organization. For low-efficacy workers, although they may expect other workers to contribute a lot, they may not perceive themselves to be critical to
the organization. Hence, interventions should focus on increasing their perceived efficacy, for instance, by emphasizing their strengths and uniqueness so as to make them feel that they can have a critical impact on the organization.

The negligible differences between groups composing of homogeneous subgroups and groups composing of heterogeneous subgroups should not be surprising or disappointing after all. Research in work group diversity has long been reporting mixed findings, e.g., [5, 41]. A social categorization or identity related perspective advocates that homogeneous groups are better because having members of similar characteristics promotes a positive affective state like stronger group identity, cohesiveness and trust. An information processing or decision-making perspective, however, advocates that heterogeneous groups are better because members with a diverse background promotes a positive cognitive state of differences in knowledge and expertise leading to higher quality decision making. Our work nicely demonstrated that how different emergent states like perceived efficacy and expectation of cooperation nullified the effects of each other as a result of the interaction between group diversity and member characteristics (i.e., subgroup configuration and absolute efficacy in the current study).

In this experiment, participants made their contribution decision based on their number of straps produced. This effort task that required participants to manufacture cell phone straps in order to determine their endowment was similar to other public good experiments that examined the “house money effect” comparing endowments “given” by the experimenter versus endowments “earned” by the players. Some experiments determined endowments by asking participants to crack walnuts [42], answer Graduate Management Aptitude Test questions, e.g., [43], or stuff letters into envelops [44]. We anticipated that through random assignment of participants to experimental conditions,
heterogeneity in endowments (due to differences in ability in manufacturing cell phone straps) would be unsystematic random errors that affected both homogeneous and heterogenous subgroups similarly. We understand that this “earned endowment” manipulation adds another layer of heterogeneity. However, we believe that the heterogeneity arising from the “earned endowment” manipulation is not a confounding factor but instead it provides ecological validity that unlike other experiments in which endowments were fixed. Nonetheless, we addressed how the effect of subgroup homogeneity on strap contribution could be confounded by strap production. We examined and found that individuals in homogeneous subgroups produced similar number of straps as compared to those in heterogeneous subgroups. Furthermore, the effect of subgroup homogeneity on strap contribution remained non-significant even after controlling for strap production, \( F(1, 333) = 1.36, p = .24 \). We can therefore rule out the possibility that one type of subgroups may have produced more straps than another type of subgroups that have affected the strap contribution.

Due to physical space limitations, we conducted each experimental session with six participants only instead of twelve participants, which was the group size of the social enterprise. However, we reiterated various times during the experiment that the social enterprise was comprised of 12 participants. In addition, written descriptions of the task scenario presented in a large font size posted on the wall, which also stated that their group consisted of six high-efficacy and six low-efficacy members, were clearly visible to the participants throughout the experiment. During the practice trial, we also asked participants to make estimates and computations regarding the other 11 participants in their group. We are confident that participants understood clearly that it was the 12-person group, but not the 3-person group in their room nor the 6-person group in that session, that shared the PG.
There are several limitations in our study. Our moderated mediation analysis identified perceived efficacy relative to subgroup and expectation of subgroup contribution as two mediator variables. However, we are aware that such a “measurement-of-mediation” design does not imply causation between the mediators and the dependent variable [45]. Particularly, one may argue that the cause-and-effect relation between expectation of contribution and contribution may be unclear, because it is also possible that an individual who chooses to contribute a lot may be susceptible to a false consensus bias that others will also contribute a lot [46]. We attempted to minimize this effect by measuring the participants’ expectation before they made a decision on contribution. Furthermore, this effect presumably would not influence the interaction effects between efficacy and subgroup homogeneity, such that it should not have posed a significant impact on the validity of our results.

While homogeneous groups are conceptually simple and unambiguous in the sense that all members have the same efficacy, our treatment of heterogeneity, however, could have been overly simplified. The concept of group heterogeneity is complex because there are numerous qualitatively different distributions of group composition. Our heterogeneous subgroups belonged to the type of a “minority belief” distribution according to DeRue et al. [47]. It is difficult to assert how our findings may be generalized to other types of heterogeneous distributions, for instances, the bimodal distribution (equal number of high- and low-efficacy members), the fragmented distribution (all members having different efficacy [47]), or even a hegemony distribution [10]. Future research shall examine the robustness of our results across different subgroup compositions.

Past findings about the effect of group homogeneity of efficacy on contribution have been mixed. Our study showed that perceived efficacy and expectation of contribution are
two mechanisms that can counteract the effect of homogeneity of efficacy on contribution. It is possible that certain factors in past experimental designs, including the presentation methods of PGD scenarios, the existence of a provision threshold, the group size and the payoff structure, etc., can make either the effect of perceived efficacy or expectation of contribution more salient, which in turn causes either the homogeneous or heterogeneous group to contribute more. Because past studies did not measure the perceived efficacy and expectation of contribution of the participants, future research can fill in the gap by investigating how these factors may influence the effect of homogeneity of efficacy on contribution and their respective mechanisms. While we are cautious not to over-generalize our findings theoretically and empirically because of our relatively narrow operationalization of group heterogeneity and the specific subgrouping manipulation that was based on isolation in physical space, our findings are useful in showing how subgrouping according to efficacy levels of individuals can have both advantageous and detrimental effects at the same time on contribution in mixed-motive situations.

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References


Supporting information

S1 Appendix. Instructions and illustrations of the experimental task.

S2 Appendix. Computation of bonus payments.

S3 Appendix. Mplus code of the multilevel moderated mediation model.

S4 Appendix. Additional data analyses on subgroup configurations.

S1 Raw Data. Raw data of the reported study containing variables relevant to this paper.

The supporting information can also be found in https://osf.io/qy8c5/.