Voluntary restrictions on self-reliance increase cooperation and mitigate wealth inequality

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Edited by Douglas S. Massey, Princeton University, Princeton, NJ, and approved September 16, 2020 (received for review July 1, 2020)

Humans are considered a highly cooperative species. Through cooperation, we can tackle shared problems like climate change or pandemics and cater for shared needs like shelter, mobility, or healthcare. However, cooperation invites free-riding and can easily break down. Maybe because of this reason, societies also enable individuals to solve shared problems individually, like in the case of private healthcare plans or private retirement planning. Such "self-reliance" allows individuals to avoid problems related to public goods provision, like free-riding or underprovision, and decreases social interdependence. However, not everyone can equally afford to be self-reliant, and amid shared problems, self-reliance may lead to conflicts within groups on how to solve shared problems. In two preregistered studies, we investigate how the ability of self-reliance influences collective action and cooperation. We show that self-reliance crowds out cooperation and exacerbates inequality, especially when some heavily depend on collective action while others do not. However, we also show that groups are willing to curtail their ability of self-reliance. When given the opportunity, groups overwhelmingly vote in favor of abolishing individual solutions to shared problems, which, in turn, increases cooperation and decreases inequality, particularly between group members that differ in their ability to be self-reliant. The support for such endogenously imposed interdependence, however, reduces when individual solutions become more affordable, resonating with findings of increased individualism in wealthier societies and suggesting a link between wealth inequality and favoring individual independence and freedom over communalism and interdependence.

cooperation | social dilemma | interdependence | endogenous choice | individualism

> No man is an island entire of itself.
>
> –John Donne

Amid global climate change and the outbreak of the COVID-19 pandemic, humans are increasingly faced with shared problems. Solving or mitigating such problems requires efficient collective action and cooperation, like reducing CO_2 emissions to mitigate the negative consequences of climate change and avoiding physical contact to curb the spread of COVID-19. However, cooperation poses a social dilemma: Individual agents have an incentive to free-ride on others' cooperative efforts. Due to this free-rider problem, collective action can easily break down, as research on laboratory and real-world social dilemmas indicates (1–8).

What has been largely overlooked so far is that collective action may also break down because individuals have the means to solve shared problems individually (9–11). For example, higher mobility allows some people to evade the social or economic consequences of climate change by moving away from areas that are most affected by rising temperatures (12). Furthermore, many people depend on public healthcare or social security systems, which are provided through public goods, but private insurance programs also provide for needs like healthcare and retirement planning through private good provision.

Such individual solutions to shared problems give rise to the ability of self-reliance and decrease the dependence on others and collective action. Self-reliance allows avoiding the free-rider problem that emerges with public goods provision (13). However, while self-reliance provides a solution to the social dilemma of cooperation, it may itself create a secondary social dilemma. This dilemma of self-reliance emerges when some are in favor of collective solutions while others want to be self-reliant (9). To illustrate this dilemma, imagine a small village that is faced with a flood. Without precautions, the flood will hit the village and reduce the welfare of all villagers. The villagers, however, can take precautions. Together, they can prepare for the flood by building a dam around the whole village. If they invest enough resources, everybody is saved. This solution has the properties of a public good: Everybody can benefit from the dam regardless of how much resources they individually invested. For each individual villager, it is therefore preferable if others invest their time and energy into building the dam while they themselves save their resources—the classic free-rider problem. Now assume there is a second solution to the shared problem: Each individual villager can invest resources toward building a dam around their own home. If completed in time, it will save the homeowner from the flood, but not the fellow villagers. Since the dam around the own home is a perfect substitute for the dam around the village,

Significance

Amid climate change and pandemics, humans increasingly face shared problems that require cooperation. However, cooperation is plagued with the free-rider problem and can fail. Self-reliance—the ability to solve shared problems individually—remedies the problem of cooperation but forgoes benefits of collective action and can lead to a divide between those that can afford to be self-reliant and those that cannot. Using an experimental paradigm, we show that groups endogenously increase social interdependence by voluntarily restricting self-reliance when faced with a shared problem, fostering both cooperation and wealth equality. This demonstrates how groups self-select institutions that increase their ability to cooperate. However, our results also point to factors that decrease this willingness to curtail freedom of choice.

Author contributions: J.G. and R.B. designed research; J.G. performed research; J.G. contributed new reagents/analytic tools; J.G. analyzed data; and J.G. and R.B. wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission.

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This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2013744117/-/DCSupplemental.

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a villager investing resources into her own dam does not benefit from another dam around the village. In other words, there is no additional personal benefit from completing a dam around the village for a group member who decides to build a dam around the own home. The other way around, there is no additional personal benefit from having a dam around the home when the water is already stopped at the village border. However, the individual solution to the shared problem creates a private good that is perfectly excludable, evades the problem of free-riding, and the risk of failing cooperation. In short, it allows the villager to become self-reliant.

Some individuals, however, may heavily depend on collective action, while others can afford to solve problems individually and refrain from taking part in collective action in the first place, creating a division between those that rely on cooperative solutions and those that do not (10). For instance, villagers may differ in the amount of resources they possess to build a private dam. This is particularly problematic when self-reliance is less efficient, i.e., when cooperative solutions save collective resources compared to individual solutions because working together creates synergies that are not utilized when solving shared problems individually. Possibly because of the problems of avoiding social interdependence, societies (some more than others) frequently restrict the ability of self-reliance and make public goods provision mandatory, for example by imposing public healthcare plans to all citizens, prohibiting home schooling, or enforcing gun control (14–16).

However, little is known 1) to what extent and under what conditions individuals are willing to curtail the ability of self-reliance and 2) how such endogenous choices influence collective action and inequality within groups. Here, we aim to tackle these questions in two preregistered and incentivized experimental studies. We confront participants with a shared problem that can either be solved collectively or individually—creating the dilemma of self-reliance. We allow groups to voluntarily restrict access to individual solutions and test how such self-imposed restrictions influence cooperation. We further investigate how attitudes toward restricting self-reliance change when group members differ in their ability to solve shared problems individually.

Experimental Setup

Groups of $n = 5$ participants faced an abstract version of a collective action problem extending previous models of cooperation (9, 10, 13, 17–22). In study 1, each group member was endowed with 100 resource points (RP) in each round. They simultaneously had to decide how many of their RP to contribute 1) to a public solution, 2) to their own individual solution, and 3) how many RP to keep for themselves (Fig. 1*A*). If they, together, managed to reach the public threshold (c_p) by investing at least $c_p = 200$ RP into the public solution, everybody was saved and could keep the noninvested units. A fair solution to the shared problem is reached when each group member contributes 40 RP to the public solution. Since the public solution is nonexcludable, group members can also free-ride on the efforts of others. In the extreme case, one group member could keep all 100 RP for herself, while the other four group members take care of the shared problem by investing 50 RP each. To solve the problem individually, a group member had to invest enough resources into her individual solution and meet the individual threshold (c_i). The individual solution is perfectly excludable and is, hence, safe against free-riding or the risk that efforts to solve the problem collectively fail. However, it only saves the individual group member. Importantly, the individual solution is a perfect substitute to the public solution in our model. Hence, reaching, both, the public and individual threshold does not offer any more protection than reaching only one threshold. This also means that self-reliance differs from free-riding: People who solve the problem individually do not benefit from the group reaching the public threshold and creating a public good at the same time. Private vs. public healthcare insurance plans often have this property of substitution, although it is also conceivable that the private and public good supplement each other (like for example in "top-up" healthcare plans in which individuals can choose to pay for additional insurance plans that grant coverage beyond the public healthcare plan). Further note that as long as $c_i \geq c_p/n$, opting for self-reliance rather than the public solution can be motivated by "fear" (of others' free-riding) but not by attempts to take advantage of others' cooperation ("greed"), compared to free-riding in a standard public goods dilemma that can be motivated by both fear and greed (23–25). Especially when some group members favor public solutions and others opt for solving the problem individually, costly coordination failures can emerge—the dilemma of self-reliance (Fig. 1*B*). If a group member neither reached the public nor individual threshold, the problem was not solved and this group member lost all remaining resources for that round.

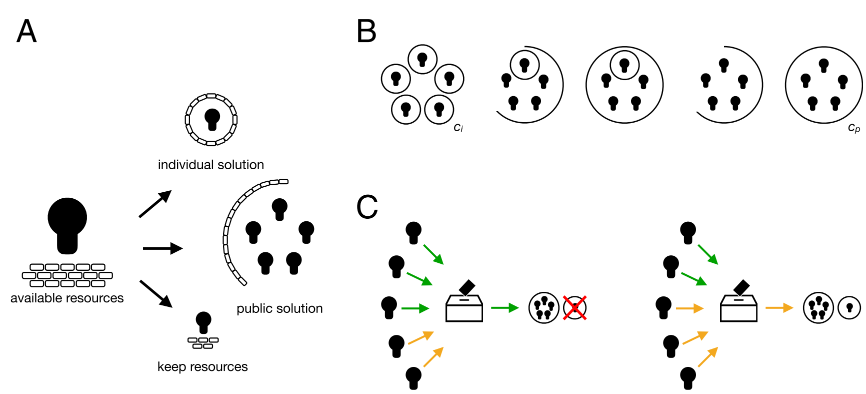

Fig. 1. The social dilemma of self-reliance. (*A*) Groups ($n = 5$) are faced with a shared problem that they can solve by investing resources toward an individual or public solution. If a group member either invests enough resources toward their individual solution, meeting their individual threshold c_i, or the group, together, invests enough resources toward the public solution, meeting the public threshold c_p, the group member can keep her remaining resources. If neither threshold is reached, the respective group member loses all of her remaining resources. (*B*) Groups can solve the problem through "self-reliance" (*Left*), or by finding a communal solution (*Right*), but can also converge to partial solutions in which only some are saved and resources are wasted. (*C*) In the experiments, one-half of the groups ($n = 20$ per treatment) had the possibility to vote on restricting access to the individual solution. If a majority voted in favor of such restrictions, solving the problem individually was not possible anymore (*Left*). If a majority was not found, individual solutions were maintained (*Right*).

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Across three blocks of 18 rounds, we manipulated the social interdependence (26–28) of groups by changing the individual threshold c_i. In one block, the cost of solving the problem individually was set to $c_i = 80$. If every group member would opt for self-reliance, a total investment of $80 \times 5 = 400$ RP is needed. In comparison, an efficient collective solution would only require 200 RP. Hence, we model a situation in which successful cooperation has strong efficiency gains (i.e., high benefits from working together). In another block, c_i was set to 40, modeling a situation in which cooperation has no efficiency gains over self-reliance. Finally, in a third block, c_i was set to an intermediate level of $c_i = 60$. The level of interdependence can be expressed as $i = c_i/(c_p/n) - 1$. Under $c_i = 80$, social interdependence is "high" since self-reliance is rather costly ($i = 1$; 100% potential efficiency gain through cooperation). Under $c_i = 60$, social interdependence is "medium" ($i = 0.5$; 50% potential efficiency gain through cooperation). Under $c_i = 40$, social interdependence is "low" ($i = 0$; 0% efficiency gain through cooperation). The order of blocks was counterbalanced across groups and treatments and controlled for in the regression analyses.

One-half of the groups ($n = 20$ groups, 100 participants) were confronted with the basic version of this collective action problem to investigate how the manipulation of interdependence and ability of self-reliance influences group cooperation, social welfare, and the coordination of collective action ("baseline" treatment). The other half of the groups ($n = 20$ groups, 100 participants) had the possibility to constrain their ability to solve the problem individually ("voting" treatment). At the beginning of each block and after every third round, each group member voted on whether they want to curtail the ability to solve the problem individually and abolish individual solutions or not. If a majority ($n \geq 3$) voted in favor of abolishing individual solutions, solving the problem individually was not possible anymore for any group member for the next three rounds and the group endogenously forced itself to solve the problem cooperatively. If a majority voted against this restriction of self-reliance, individual solutions were not abolished and each individual group member maintained their ability to solve the problem also on their own (Fig. 1*C*).

Study 1 Results

Core hypotheses were preregistered (labeled "pred"). In the baseline treatment, when social interdependence was high ($i = 1$) because self-reliance was rather costly, 70% of the groups managed to solve the problem cooperatively albeit individual solutions were possible. Only 6% of the participants opted to solve the problem individually (Fig. 2*A*). On the other extreme, when social interdependence was low ($i = 0$), an overwhelming majority of 94% opted to solve the problem individually. Hence, with decreasing social interdependence, cooperation was crowded out by self-reliance, in line with previous research (Fig. 2*A*; see also ref. 9). Especially under medium interdependence, groups struggled to find efficient solutions due to a conflict between group members who preferred individual solutions and others who preferred a public solution. Due to this miscoordination between collective action and self-reliance, groups wasted more resources (Fig. 2*B*; multilevel regression, $b_{i\,=\,0.5} = 28.25$, SE = 2.87, $P < 0.001$; see *SI Appendix* for model details). As a result, we observe an inverted U-shape relationship between level of interdependence and resource waste (multilevel regression, $b_{c_i^2} = -0.08$, SE = 0.006, $P < 0.001$). The emerging conflict between communalism and self-reliance also increased inequality in earnings under medium interdependence (Fig. 2*B*; multilevel regression, $b_{i\,=\,0.5} = 0.05$, SE = 0.02, $P = 0.004$).

Groups that had the ability to endogenously restrict access to individual solutions (voting treatment) overwhelmingly opted for such a restriction (Fig. 3*A*). Under high and medium interdependence, groups abolished individual solutions and endogenously forced themselves to find a communal solution in 95% and 91% of the cases, respectively. When self-reliance was more expensive than efficient collective action ($i = 1$ and $i = 0.5$), group members were also significantly more in favor of curtailing self-reliance compared to $i = 0$ (pred: multilevel logistic regression, $b_{i\,=\,0.5} = 2.27$, SE = 0.16, $P < 0.001$; $b_{i\,=\,1} = 2.46$, SE = 0.18, $P < 0.001$).

As further predicted, the ability to endogenously restrict self-reliance increased cooperation (pred: Mann–Whitney U test, $U = 62$, $P < 0.001$) and the share of groups creating a public good increased to 64% on average across interdependence levels in

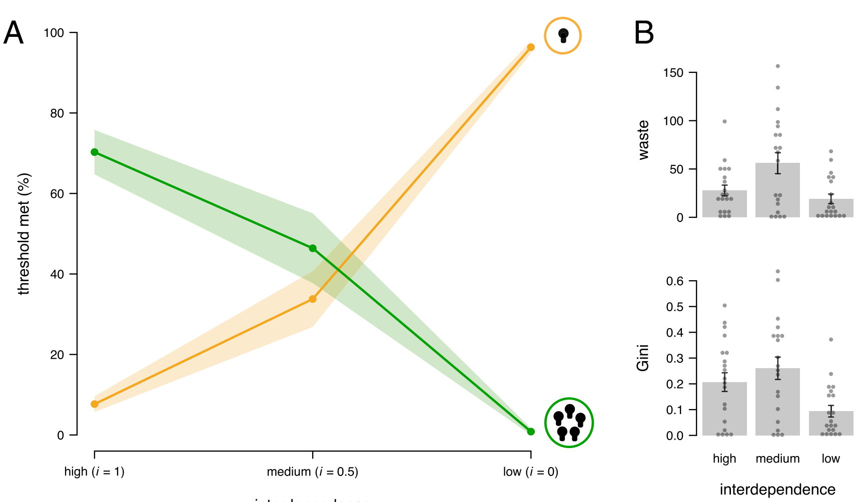

Fig. 2. Self-reliance and the crowding out of collective action. (*A*) Groups in the baseline treatment ($n = 20$) frequently managed to solve the shared problem cooperatively (green) when social interdependence was high, but collective action decreased and self-reliance (yellow) increased when individual solutions became cheaper. The bands around the averages indicate the SEM. (*B*) Especially under medium interdependence ($i = 0.5$), groups wasted more resources (measured as the deviation of investing 200 RP in total – the most efficient investment to solve the shared problem) and inequality in earnings (as measured by the Gini coefficient) was the highest due to an emerging conflict of solving the problem collectively vs. individually within groups. Error bars indicate the SEM. Individual points show averages per group.

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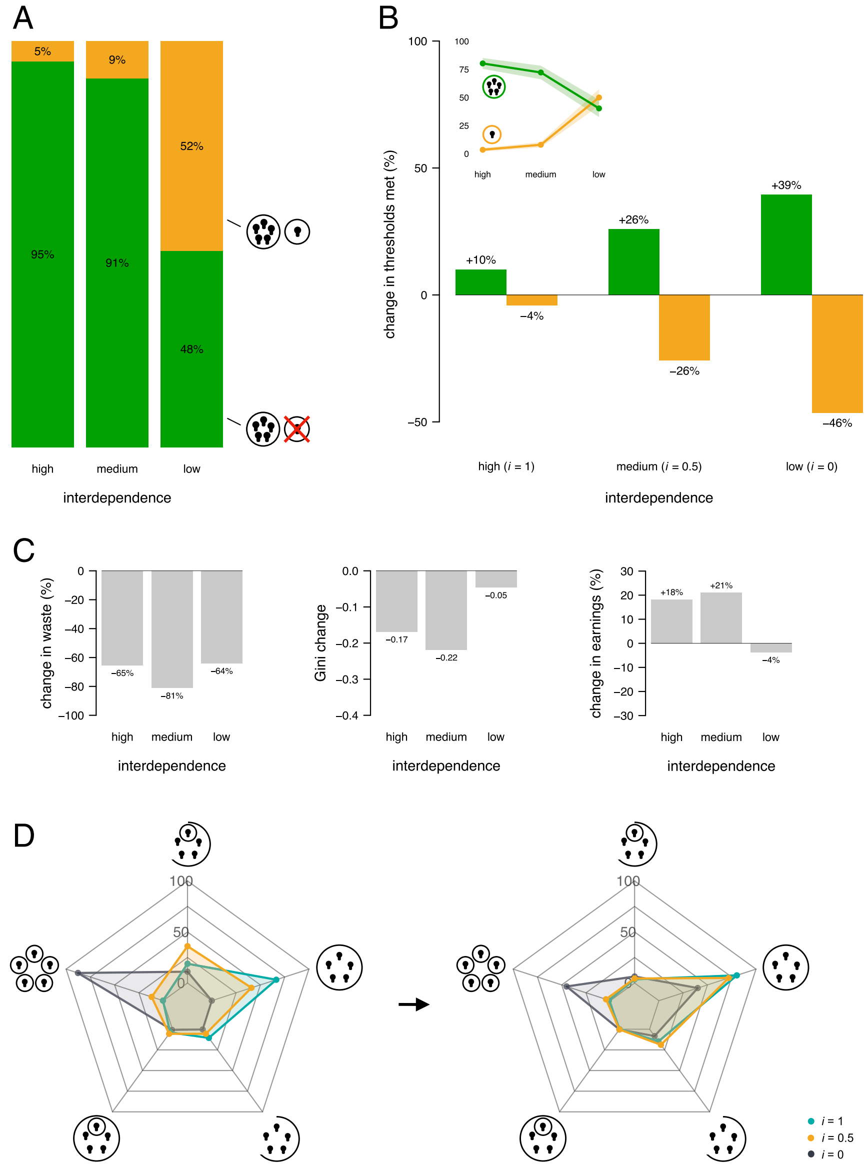

Fig. 3. Voluntary restrictions on self-reliance. (*A*) Especially under high and medium interdependence, groups in the voting treatment (n = 20) overwhelmingly voted in favor of abolishing individual solutions (green). (*B*) This forced them to find a collective solution, increased the likelihood to create a public good (green), and decreased the rate at which the problem was solved individually (yellow) compared to groups in the baseline treatment without the ability to restrict self-reliance (n = 20). *Inset* shows the pattern of collective action vs. private goods creation across interdependence levels in the voting treatment only. (*C*) Restrictions on self-reliance also decreased resource waste, within-group inequality (as measured by the Gini coefficient), and increased earnings compared to the baseline treatment, especially under medium interdependence. (*D*) The ability to restrict self-reliance changed the solution profile of groups. Especially under $i = 0.5$, groups frequently miscoordinated collective actions because some group members solved the problem individually (*Left*, upper axis). In groups that could vote to abolish individual solutions (*Right*), the solution profile under $i = 0.5$ (yellow) converged to the solution profile under high interdependence (blue).

the voting treatment compared to 39% in groups without the ability to curtail self-reliance (Mann–Whitney U test, $U = 86$, $P = 0.002$). When groups were highly codependent ($i = 1$), restricting access to already unattractive individual solutions did not increase cooperation much further (increase by 10%, see Fig. 3*B*; multilevel logistic regression, $b_{\text{voting}} = -0.15$, SE = 1.67, $P = 0.93$). However, especially under medium interdependence, the self-imposed restriction on self-reliance increased public goods creation to 72% (compared to 46%) and significantly decreased resource waste across interdependence levels (Fig. 3*C*; multilevel regression, $b_{\text{voting}} = -18.13$, SE = 6.13, $P < 0.001$). Being able to curtail self-reliance also decreased within-group inequality (Fig. 3*C*; multilevel regression, $b_{\text{voting}} = -0.17$, SE = 0.03, $P < 0.001$), and increased group earnings (Fig. 3*C*; pred: multilevel regression, $b_{\text{voting}} = 7.44$, SE = 3.14, $P = 0.02$).

The effects of self-reliance and its self-imposed restriction are illustrated in Fig. 3*D*. The *Left* panel shows the solution pattern of groups without the ability to abolish individual solutions by classifying and computing the frequency of five prototypical group outcomes (i.e., full self-reliance, partial self-reliance combined with failed collective action, successful collective action, failed collective action and no self-reliance, and successful collective action and partial self-reliance). As can be seen, groups with rather affordable individual solutions often converged to an outcome in which all group members opted for self-reliance (Fig. 3 *D*, *Left*, black profile). When increasing the costs

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of self-reliance to $c_i = 80$ ($i = 1$), groups switched to collective action and successfully cooperated in most of the rounds (Fig. 3 *D*, *Left*, blue profile). However, especially under medium interdependence, groups, in 36% of the cases, only found a partial solution in which some group members opted for self-reliance and some group members opted for a communal solution without reaching the public threshold (Fig. 3 *D*, *Left*, yellow profile, upper axis). However, when groups were able to restrict self-reliance, the solution profile of $c_i = 60$ ($i = 0.5$) became indistinguishable from the solution profile of $c_i = 80$ ($i = 1$) (Fig. 3 *D*, *Right*). The conflict between communalism and individualism almost disappeared, i.e., wasteful partial solutions decreased from 36 to 4%. In other words, the voting decisions of group members endogenously transformed the medium interdependence environment into high interdependence environment, which helped groups to cooperate and find efficient cooperative solutions amid the shared problem.

Study 2 Results

Study 1 showed that groups are willing to endogenously restrict access to individual solutions of collective action problems, which increased cooperation and social welfare especially when groups are likely to be trapped in a wasteful conflict between communalism and individualism—the first problem of self-reliance. The second problem that may emerge with self-reliance is that not everyone may be equally able to solve shared problems individually. That is, people differ in their ability, wealth, or access to individual solutions, which, for example, results in asymmetric access to private healthcare plans or asymmetric dependence on social security systems and public goods in general (10, 29–31).

To investigate how such asymmetric access to individual solutions influences the social dilemma of self-reliance and the willingness to restrict self-reliance, we manipulated the amount of resources available to an individual group member in study 2. Specifically, three group members were endowed with $e = 80$ RP ("poorer" players), while the other two group members had $e = 130$ RP at their disposal ("richer" players). Everything else remained as in study 1, and we again invited 20 groups (100 participants) in a baseline treatment without the ability to self-restrict individual solutions and 20 groups (100 participants) in a voting treatment with the ability to vote whether or not to abolish individual solutions in their five-person group.

As shown in Fig. 4*A*, we replicated the general pattern from study 1. In the baseline treatment, cooperation was crowded out with cheaper individual solutions, and especially under medium interdependence ($i = 0.5$), groups wasted resources due to the emerging conflict between self-reliance and collective action (see *SI Appendix* for model results). Importantly, the resulting coordination failures also increased within-group inequality because group members unequally benefitted from reducing the cost of self-reliance. With cheaper individual solutions, earnings disparity between poorer and richer group members increased (Fig. 4*B*; see also ref. 10). Under high interdependence ($i = 1$), relative earnings only differed by 6.3% between poorer and richer group members, which increased to 12.1% under $i = 0.5$, and to 17.3% under $i = 0$ (pred: multilevel regression, $b_{i \times e130} = -0.11$, SE = 0.017, $P < 0.001$). Hence, richer group members benefitted more from cheaper individual solutions than their poorer fellows (see refs. 32–36 for related findings in the standard public goods game).

Even under high interdependence ($i = 1$), richer group members took advantage of their position. As illustrated in Fig. 4*C*, they were more likely to switch to self-reliance when their poorer fellows did not cooperate enough in the previous round (Fig. 4 *C*, *Left*; multilevel logistic regression, $b = -0.05$, SE = 0.02, $P = 0.02$). Opting out of cooperation is particularly bad for poorer group members in this situation because they can only refrain to self-reliance themselves by investing all of their 80 RP (which is essentially the same as not solving the problem from a welfare perspective). The more richer group members opted for self-reliance, the more poorer group members increased their cooperation in the next round (Fig. 4 *C*, *Right*; multilevel regression, $b = 4.36$, SE = 0.77, $P < 0.001$). Hence, especially when poorer group members heavily depended on collective action ($i = 1$), richer group members were able to use self-reliance as a coercion or punishment device that they could use to force their poorer fellows into higher levels of cooperation.

The relationship between self-reliance (of richer group members) and future cooperation (of poorer group members) reversed when individual solutions became cheaper ($i = 0.5$ and $i = 0$). In other words, poorer group members reacted to self-reliance of richer group members with becoming self-reliant themselves (*SI Appendix*, Fig. S12). However, while more affordable individual solutions stopped the possibility of coercing poorer group members into higher levels of cooperation, this did not help with lowering the wealth gap. To the opposite, since self-reliance requires every group member to solve the problem on their own, it does not allow any redistribution in wealth between group members as opposed to a public solution. This explains why lowering the cost of the individual solutions magnified rather than decreased the preexisting wealth gap.

When provided with the possibility to abolish individual solutions, groups overwhelmingly restricted the access to individual solutions (Fig. 5*A*), similar to study 1. The support for such self-restrictions decreased when individual solutions became cheaper (multilevel logistic regression, $b_{i = 0.5} = -1.18$, SE = 0.19, $P < 0.001$; $b_{i = 0} = -2.79$, SE = 0.20, $P < 0.001$). Importantly, across all interdependence levels and in line with our hypothesis, poorer group members were significantly more in favor of restricting the ability of self-reliance compared to richer group members (Fig. 5*B*; pred: multilevel logistic regression, $b_{e = 80} = 2.09$, SE = 0.40, $P < 0.001$).

The self-imposed restrictions on individual solutions significantly increased cooperation and public goods creation, in particular under medium and low interdependence, replicating the pattern of study 1 (Fig. 6*A*; multilevel logistic regression, $b_{i = 0.5 \times \text{voting}} = 1.06$, SE = 0.24, $P < 0.001$; $b_{i = 0 \times \text{voting}} = 3.68$, SE = 0.53, $P < 0.001$). Also similar to the first study, restrictions significantly decreased resource waste (Fig. 6*B*; multilevel regression, $b_{\text{voting}} = -19.94$, SE = 5.60, $P < 0.001$). Importantly, it also reduced within-group inequality across all dependence levels (Fig. 6*B*; multilevel regression, $b_{\text{voting}} = -0.18$, SE = 0.03, $P < 0.001$). Overall, inequality reduced by 0.18 points. To put these numbers into perspective, the estimated Gini was around 0.35 to 0.46 in the baseline treatment, which corresponds to the 5th to 10th decile of countries with the highest inequality in the world (like Burkina Faso or Ecuador). In contrast, the Gini dropped to around 0.17 to 0.25 in the voting treatment, which corresponds to countries with the lowest inequality in the world (like Norway or Belgium, first decile), according to data from the World Bank.

The ability to impose restrictions on self-reliance especially benefitted poorer group members. Having only 80 RP, these group members earned 21% more compared to poorer group members in the baseline treatment under high interdependence (Fig. 6*C*; $c_i = 80/i = 1$; multilevel regression, $b_{\text{voting}} = 6.15$, SE = 2.21, $P = 0.007$) and 53% more under medium interdependence (Fig. 6*C*; $c_i = 60/i = 0.5$; $b_{i = 0.5 \times \text{voting}} = 5.96$, SE = 1.42, $P < 0.001$). Also, in rounds in which the individual solution was successfully abolished, earnings between poorer and richer group members remained closer together, whereas when groups did not find a majority to restrict individual solutions, inequality exacerbated (Fig. 6 *C*, *Inset*; multilevel regression, $b = -38.86$, SE = 4.57, $P < 0.001$). This demonstrates how the public solution can serve as a redistribution device between group members with

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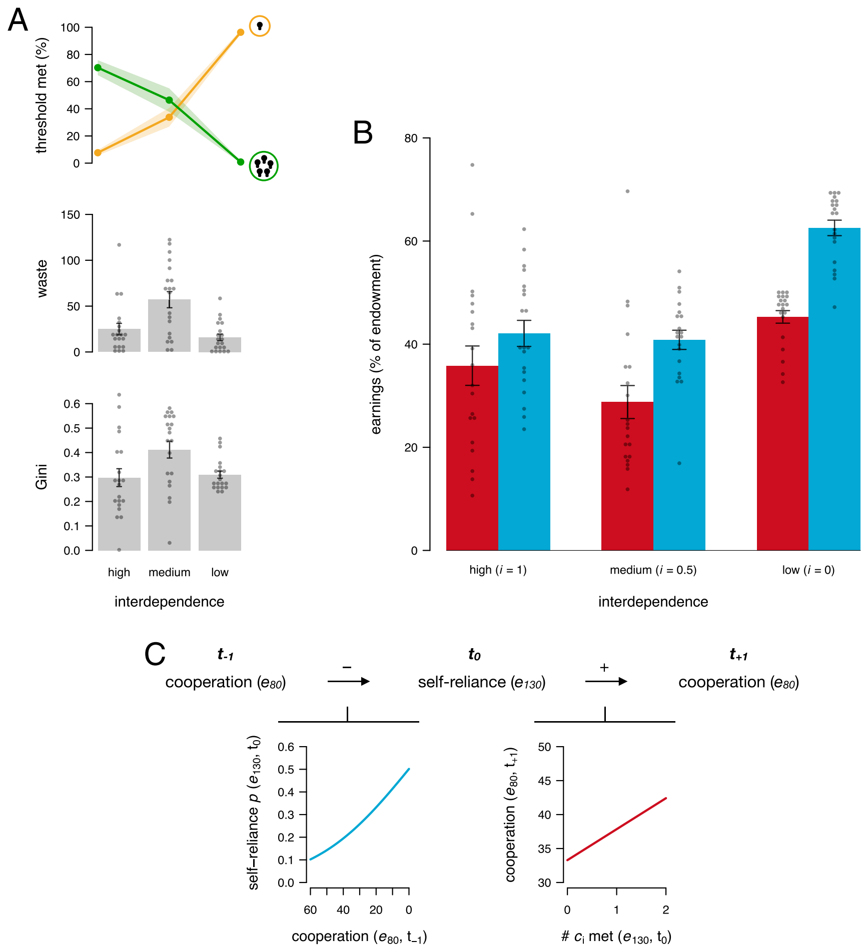

Fig. 4. Cooperation and self-reliance with asymmetric access to individual solutions. (*A*) As in study 1, successful collective action (green) decreased and solving the problem individually (yellow) increased when lowering social interdependence (the bands around the averages indicate the SEM) (based on $n = 20$ groups, baseline treatment). Furthermore, resource waste and within-group inequality (as measured by the Gini coefficient) were particularly high under medium interdependence. (*B*) With more affordable individual solutions, earnings disparity between "poorer" ($e = 80$, red) and "richer" group members ($e = 130$, blue) increased (error bars indicate the SEM; individual points show averages per group). (*C*) Under high interdependence ($i = 1$), self-reliance was only a viable option for richer group members. In this situation, group members with $e = 130$ reacted to lower levels of cooperation by group members with $e = 80$ (in the previous round, t_{-1}) with opting for self-reliance more frequently (in the current round t_0). The more group members with $e = 130$ chose to solve the problem individually (0, 1, or 2 members, *x* axis, *Right*), the more resources group members with $e = 80$ contributed to a public solution in the next round (t_{+1}), revealing that richer group members could use self-reliance to coerce poorer group members into higher levels of cooperation.

different wealth levels, but only when individual solutions are not available.

Discussion

We experimentally replicate the finding that individual solutions to shared problems can crowd out cooperation (9, 10). Particularly under intermediate levels of social interdependence between group members, a value conflict emerges in which some prefer to be self-reliant, while others prefer communal solutions, leading to inefficient collective action and inequality. Humans are, however, uniquely able to shape their social environment, thereby creating and modifying formal and informal institutions (4, 37–40). Supporting this notion, we show that groups are willing to restrict their freedom of choice by voluntarily imposing restrictions on self-reliance and endogenously forcing themselves to solve shared problems cooperatively, even though this may introduce the problem of free-riding.

However, we also show that preferences for self-restrictions depend on the ability to be self-reliant in the first place. For people with more resources that depend less on collective action, the support for creating higher interdependence is lower. Especially in this situation, a successful restriction of self-reliance not only increases collective action but also decreases wealth inequality. Being forced to solve the problem together, the public good solution mitigates a widening of preexisting inequality. In our experiment, a majority of people had a low endowment, modeling the right-skewed wealth distribution in society at large (41, 42). This made it easier for poorer group members to find a majority in favor of abolishing individual solutions and allowed us to observe what happens when individual solutions are indeed abolished in these groups (in comparison to the baseline treatment, where individual solutions could not be abolished). However, it is conceivable that wealth and voting power are not always independent (43, 44). For example, people can spend money on lobbying and try to use their resources to influence the election in their favor, despite being the numerical minority. In our experiment, if richer group members would have had 2.8× of the voting power of poorer group members on average, they would have swayed the vote in favor of retaining individual solutions. Hence, especially in societies marked by high inequality and an imperfect decoupling of wealth and political power, we should expect a higher degree of institutions

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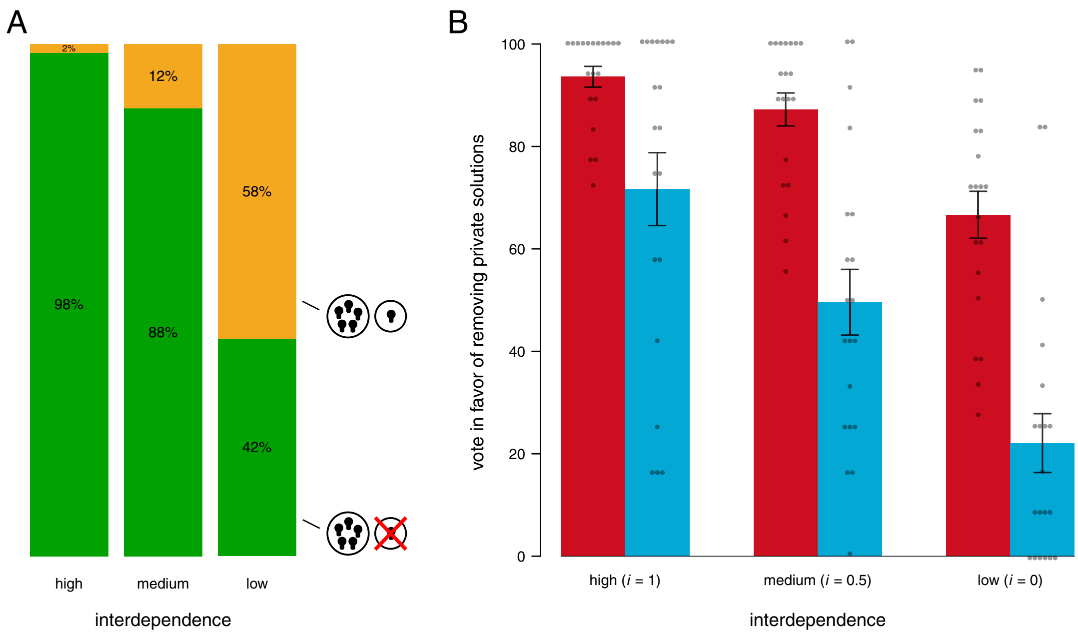

Fig. 5. Voluntary restrictions on self-reliance with asymmetric access to individual solutions. (*A*) As in study 1, under high and medium interdependence, groups ($n = 20$, voting treatment) overwhelmingly voted in favor of abolishing individual solutions (green). (*B*) Poorer group members ($e = 80$, red) were more in favor of restricting the access to individual solutions compared to richer group members ($e = 130$, blue). Error bars indicate the SEM. Individual points show averages per group.

that allow to solve shared problems individually or even the abolishment of public solutions (like favoring a private healthcare system over a public healthcare system). Also, decreasing the cost of individual solutions generally decreased the support for restricting their access and increased self-reliance, resonating with the finding that wealthier societies become more individualistic (45–47).

Our studies also yield theoretical insights that could advance further research. By extending standard social dilemmas, the private–public goods game can reveal different motivations behind abstaining from group cooperation, like trying to take advantage of others' cooperation or becoming self-sufficient to avoid exploitation or group failure. The private–public goods game also highlights that free-riding is not the only challenge to cooperation and that different social institutions may gain in importance when group members can solve shared problems individually. Furthermore, our results suggest that individuals are willing to restrict their strategy space, potentially in order to ease group coordination. This can be seen as a type of "paradox of choice" (48) in a social context: Having additional options decreases social welfare.

Conclusion

Humans are considered a highly codependent species (49–51). It has been argued that this has coevolved with human's unique abilities to solve collective action problems, to create public goods, and to cooperate even among genetically unrelated individuals (52–57). Cooperation can increase social welfare and allows to transcend what individuals can achieve alone (49, 58). However, especially in modern societies—characterized by a money-based economy, abundance of resources, and a high degree of division of labor and specialization—individual solutions for shared problems can substitute public goods provision and reduce the immediate dependence on cooperation and collective action, at least for some. Self-reliance can avoid the free-rider problem of cooperation, increases individual freedom and choice, and may mitigate negative effects of social interdependence, like group-think or group pressure (59, 60). Ironically, individual solutions to shared problems make the conjected evolutionary preparedness of groups to solve shared problems cooperatively obsolete. When people can shape their social institutions, they can and in fact do choose to increase their social interdependence by abolishing the possibility for individual solutions. Such a self-imposed restriction enables groups to find efficient solutions to shared problems that everybody benefits from and reduces wealth inequality.

Materials and Methods

Subjects and General Procedure. In the first study, 200 participants ($m_{age} = 22.3 \pm 4.0$, 150 females) from Leiden University (The Netherlands) were invited to take part in a "decision-making experiment" via an online recruitment system. Each experimental session comprised 10 to 25 participants. The study took place at the Leiden Social Interaction Laboratory in a large room in front of personal computers in cubicles that are separated by divider walls such that people cannot see each other once seated. After arrival at the laboratory, participants were randomly assigned to fixed groups of five, making up 40 groups in total. Each participant randomly drew a number that determined their cubicle. Participants were assigned to cubicles such that they could not deduce who else was part of their group. After the experiment, participants were paid one by one in a separate room to further avoid that they learn who else was part of their group. One-half of the groups were randomly assigned to the baseline treatment. The other half of the groups were assigned to the voting treatment. In the second study, we invited another 200 participants ($m_{age} = 23.0 \pm 3.7$, 156 females) making up 40 groups in total of which one-half were randomly assigned to the baseline treatment and the other half to the voting treatment. Total sample size ($n = 400$) was based on feasibility concerns and standards in the field rather than a priori power analyses (for a sensitivity analysis, see *SI Appendix*). A group size of five participants per group was chosen to avoid voting draws in the voting treatments. The sample was skewed toward female participants due to the distribution of our subject pool. We therefore also analyzed potential gender effects (see *SI Appendix*, Fig. S22 for details) but did not find strong statistical evidence that gender influenced cooperation rates, voting choice, or self-reliance investments.

Both studies were approved by the Psychology Research Ethics Board of the University of Leiden. We obtained informed consent from all participants prior to taking part in the experiment. No observations were excluded from the analysis. Study design, sample sizes, and hypotheses were preregistered, available at https://aspredicted.org/z8d5u.pdf (study 1) and https://aspredicted.

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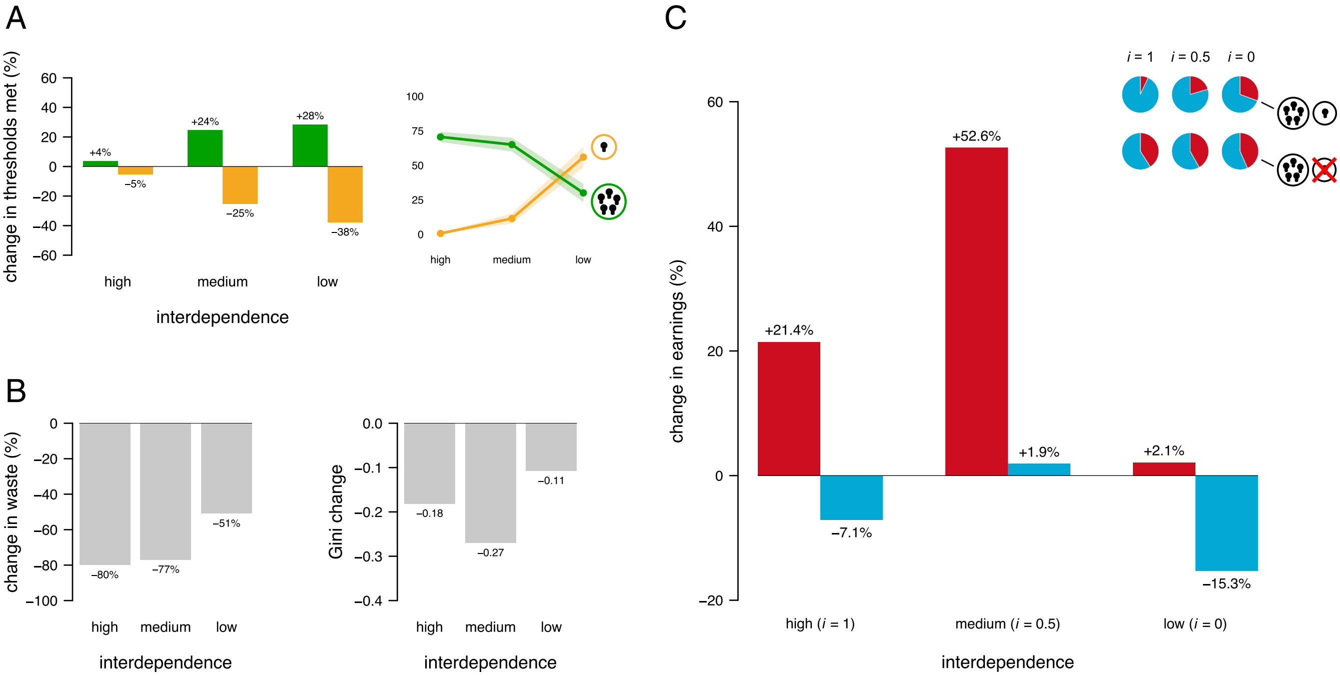

Fig. 6. Consequences of restricting self-reliance for richer and poorer group members. (*A*) The ability of groups to restrict access to individual solutions increased the rate at which groups solved the problem cooperatively (green) and reduced the creation of private goods (yellow) especially under medium and low initial interdependence (based on $n = 40$ groups, comparison between baseline and voting treatment). *Right* shows the pattern of collective action vs. private goods creation across interdependence levels in the voting treatment only. The bands around the averages indicate the SEM. (*B*) Groups wasted less resources and inequality decreased compared to groups without the ability to restrict individual solutions. (*C*) Especially poorer group members that only had 80 RP at their disposal (red) benefitted from restricting access to individual solutions, while richer group members ($e = 130$ RP) did not benefit from self-imposed social interdependence (blue). *Inset* shows the post hoc wealth distribution between poorer (red) and richer (blue) group members for rounds in which groups successfully abolished individual solutions (lower row) or not (upper row) across initial interdependence levels.

org/nh5rf.pdf (study 2). The data, analysis code, and code to run the experiments is available via the Open Science Framework at https://osf.io/ejqzm/. Note that we registered the hypothesis that we will observe higher social welfare in the voting treatment compared to the baseline treatment for study 1. However, we failed to register the corresponding analysis for this hypothesis. The test of this hypothesis is based on a comparison of individual earnings between treatments in a multilevel regression (*SI Appendix*, Table S6), following the same procedure as for the other preregistered analyses.

The Private–Public Goods Game. Groups were faced with a shared problem that could be either solved individually or collectively. Each group member had a private endowment of e RP and could distribute these resources across an "individual pool," a shared "public pool," and a "savings account." Any RP invested into the individual and public pool were lost. However, if the group, together, invested enough resources into the public pool and reached the public target c_p, the problem was solved on the group level and each group member earned the RP left in her savings account. Alternatively, a group member could also keep the RP in the savings account if she invested enough resources into the individual pool and reached the individual target c_i. If neither the individual nor public threshold was reached, the group member lost all RP left in her savings account and earned 0, leading to the following payoff function:

$$\pi_k = \begin{cases} e\text{-}y_{k,p}\text{-}y_{k,i} & \text{if } \sum_{j=1}^{n} y_{j,p} \geq c_p \ \vee y_{k,i} \geq c_i \\ 0 & \text{if } \sum_{j=1}^{n} y_{j,p} < c_p \ \wedge y_{k,i} < c_i. \end{cases}$$

In other words, the shared problem could be solved individually or through cooperation. The public pool constitutes a step-level public good. Since it is not excludable, everybody can benefit from its creation regardless of the own contribution, which invites free-riding. It also carries the risk of failure due to underprovision. Meeting the individual threshold c_i creates a private good that only solves the problem for the respective group member (self-reliance). Since it is perfectly excludable, it is safe against free-riding and coordination failure. The private good is a perfect substitute of the public good: While group members cannot be excluded from the protection granted by the public good (if it is created), opting for self-reliance makes the protection from the public good redundant. In our setup, there is no additional benefit from solving the problem individually and as a group at the same time. This is important because this way, we can differentiate self-reliance from free-riding: A group member who is opting for the individual solution does not benefit from the group (also) meeting the public threshold and creating a public good. For a formal game-theoretical analysis of this game, see *SI Appendix*.

General Implementation. Groups were repeatedly confronted with this collective action problem. Specifically, each group completed three blocks of 18 consecutive rounds. Blocks differed in their cost structure. While the cost of the collective solution (c_p) was fixed to 200 RP, we varied the cost of the individual solution between $c_i = \{80, 60, 40\}$. Hence, across blocks, we manipulated the relative cost of self-reliance. The order of blocks was counterbalanced across groups and treatments and we controlled for the order in all regression models. Before each block, the cost structure was announced. Before the first round, we also elicited beliefs about the investment strategy of other participants (see *SI Appendix* for details). Each round consisted of a decision stage in which participants simultaneously decided how to assign their RP and a feedback stage. In the feedback stage, participants learned about how group members allocated their resources, whether the public target was reached, which group members reached their individual target, and earnings for this round.

Before the experiment, participants completed an incentivized measure of social preferences, the social value orientation slider task (61). In this task, participants decide how to allocate points between themselves and an unknown other person. Points can be allocated self-servingly or prosocially (sacrificing points to benefit the other person), allowing to estimate a participant's social preferences/other-regarding concerns (for further information, see *SI Appendix*). Then, participants received instructions for the main experiment, followed by comprehension questions to make sure that everybody understood the rules of the experiment (for screenshots, see *SI*

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Appendix). After the experiment, participants completed an incentivized lottery task based on the Preference Survey Module (62) measuring risk-preferences, a four-item questionnaire measuring horizontal individualism (63), and provided demographics information (see *SI Appendix* for results on personality and preference measures). The experiment took around 60 min and participants earned 11.60€ on average.

Experimental Manipulations. In the first study, each group member had 100 RP at their disposal in each round of the experiment. Across treatments, we manipulated the ability to restrict access to individual solutions. Specifically, one-half of our groups could vote on whether they want to abolish individual solutions. At the beginning of the first round and every third consecutive round (i.e., round 4, 7, 10, 13, 16), each group member could vote against or in favor of removing the individual solution. If a majority voted in favor of removing the individual solution, group members were not able to invest RP into the individual pool and hence could only solve the problem by, together, investing enough RP into the public pool for the following three rounds. Groups only learned about the voting outcome but not who voted in support or against restricting access to individual solutions (i.e., voting was anonymous).

In the second study, we manipulated the RP distribution across group members, making it relatively easier to solve the shared problem individually for some, while making it harder for other group members. Specifically, two group members had 130 RP ("richer" group members) in each round, while the other three group members only had an endowment of 80 RP ("poorer" group members). Note that groups, together, had the same amount of resources as in the first study (i.e., 500 RP). Hence, we manipulated resource distribution and kept the wealth level of groups constant. Participants were randomly assigned to be "rich" or "poor" and remained in this role for the entire experiment to avoid reciprocity or perspective-taking that could emerge if people switch roles.

For study 2, we collected data from 28 groups (14 groups in the voting treatment and 14 groups in the baseline treatment) in the laboratory. Due to the outbreak of the COVID-19 pandemic, we were forced to finish study 2 online (six groups in the voting treatment and six groups in the baseline treatment). To do so, we adapted the experiment (which was already programmed in HTML/PHP and jQuery) by adding a chat functionality. This allowed participants to contact the experimenters during the experimental session and ask questions while reading the instructions or answering comprehension questions (similar to the laboratory environment; communication was only possible between participant and experimenter but not between participants). We used the same subject pool and recruitment protocol as in the laboratory. Participants signed up for individual sessions and time slots through our laboratory recruitment system and received a link before the start of the experiment. After logging in, each individual participant was greeted by the experimenters and was given general instructions over the chat box that was displayed in the bottom right corner. Hence, we tried to simulate the laboratory environment as much as possible.

Data Availability. Materials, data, and associated protocols have been deposited on the Open Science Framework (DOI: 10.17605/OSF.IO/EJQZM).

ACKNOWLEDGMENTS. Financial support was provided by the Netherlands Science Foundation VENI Award (016.Veni.195.078) to J.G., by the Gratama Foundation and the Leiden University Fund to J.G., and by internal funds from the Faculty of Social Sciences, Department of Psychology, at the University of Copenhagen to R.B. We thank Luuk Snijder and Martina Colombo for assistance with data collection.

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