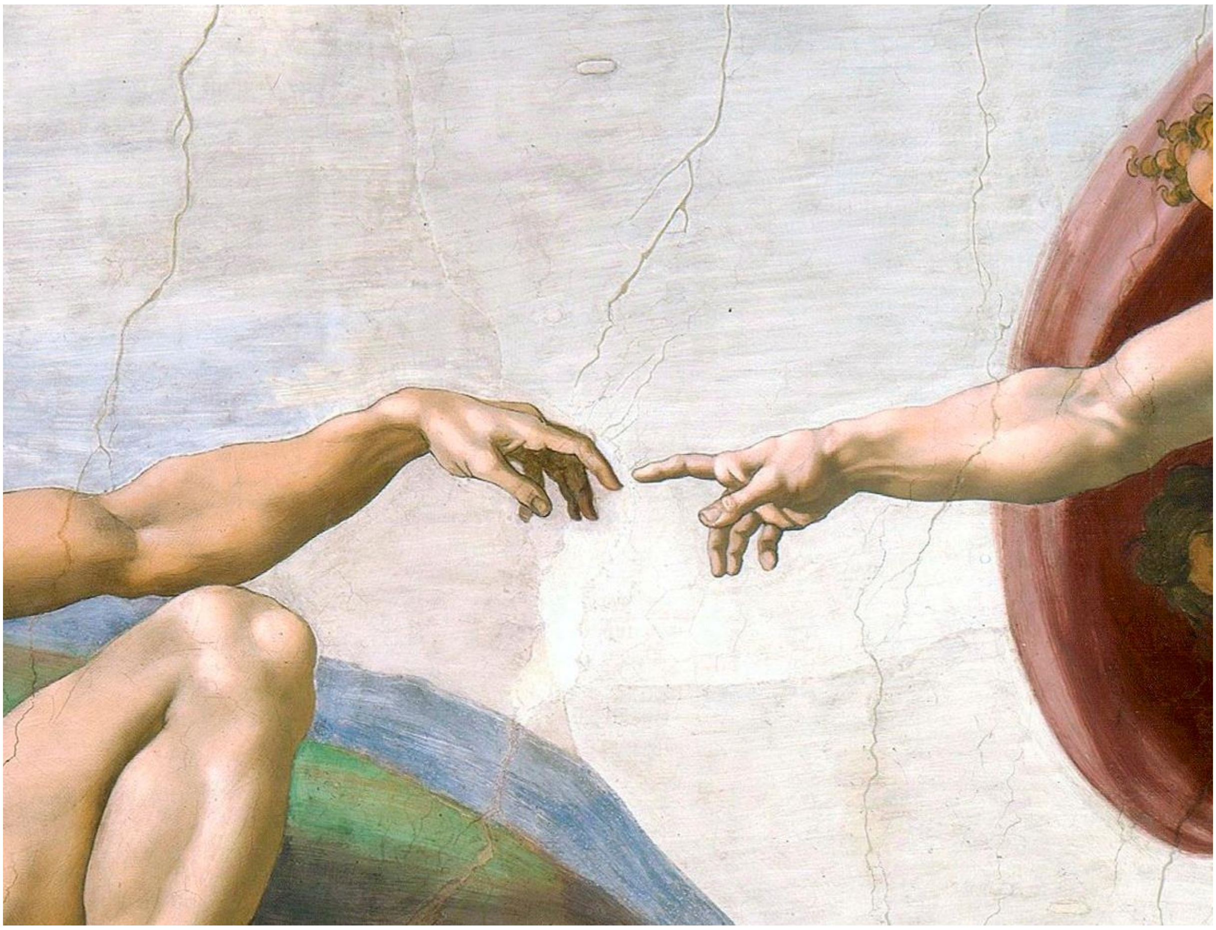
To Cooperate or Not To Cooperate

Using Focal Points to Enhance the Efficiency of Cooperation in Step-Level Public Good Games



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1. Introduction

1.1 Social Dilemmas: The Case of Public Goods

Many of today's global challenges – e.g. overpopulation, overfishing, and the over-emission of greenhouse gases – can be conceptualised as social dilemmas, which are situations that entail a conflict of (often short term) self-interest vis-á-vis (generally longer-term) collective interests. In social dilemma situations, it is often rational (i.e. in their best self-interest) for individuals to pursue a non-cooperative course of action because this generates superior outcomes given any possible strategy employed by others (Van Lange, Joireman, Parks & Van Dijk 2012). This means that it is more beneficial to not cooperate when others defect[1], as well as that it is more favourable to reap the rewards of others' contributions rather than to contribute yourself too. As such, social dilemmas tend to give rise to *deficient equilibria* (Kollock 1998). These equilibria are suboptimal, meaning that there is at least one alternative outcome that renders everyone better off, yet no individual has an incentive to unilaterally adjust their strategy.

However, despite this game-theoretical forecast of non-cooperation, there is a rich body of literature that shows significant levels of cooperation in social dilemma situations (e.g. Balliet, Daniel, Parks, Craig, Joireman 2009; Chaudhuri 2011). One branch of social dilemmas that has been studied extensively concerns the production of public goods. Public goods share the properties of non-excludability and non-rivalry, meaning that no one can be excluded from consuming the good, and many can do so simultaneously. These properties render them very susceptible to free riding. Nevertheless, there is ample evidence indicating that people contribute more to the public good than pure self-interest can explain (e.g. Andreoni 1995). Arguably the most profound findings regarding the production of public goods concern the decay in contributions over time (Isaac and Walker 1988) due to the interplay of free riders and conditional co-operators (e.g. Fischbacher, Gächter & Fehr 2001; Fischbacher & Gächter 2006; Fehr & Gintis 2007), as well as the potential of costly punishment to stymie this decay and, thus, to sustain high contribution levels (e.g. Fehr & Gächter 2000; Fehr & Gintis 2007; Gächter, Renner & Sefton 2008; Nikiforakis & Normann 2008). Yet, even though the opportunity to punish facilitates high cooperation levels, it does tend to reduce the efficiency of cooperation (Chaudhuri 2011).

1.2 Efficiency

In these linear public goods experiments, efficiency is defined as the sum of all participants' payoffs at the end of each round[2]. So, the higher the aggregate payoff, the more efficient a certain experimental condition is (e.g. Fehr & Gächter 2000). The payoffs for each player *i* are structured as follows (provided the absence of punishment opportunities):

$$\pi_i = y - g_i + a\Sigma^n{}_{j=1}\, g_j$$

Hereby, y denotes the number of tokens all n subjects are endowed with, whilst g_i indicates the number of tokens ($0 \leq g_i \leq y$) subject i contributes to the public good. Further, a is the marginal return per capita from a contribution to the public good with $0 < a < 1 < na$, whereby na is the social benefit of a contribution, i.e. the total marginal return of all players. Lastly, $\Sigma^n{}_{j=1}\, g_j$ denotes the aggregate contribution. This payoff function has two important implications. Firstly, it implies that complete free-riding (i.e. $g_i = 0$) is the dominant strategy for any player *i*, seeing as $\partial\pi_i/\partial g_i = -1 + a < 0$. Yet, secondly, the sum of all players' payoffs $\Sigma^n{}_{i=1}\, \pi_i$ is maximised when all players contribute their full endowment (i.e. $g_i = y$). This is because $\partial\Sigma^n{}_{i=1}\, \pi_i/\partial g_i = -1 + na > 0$. This implies that the aggregate payoff, and equivalently, the efficiency, is a monotonically increasing function of the contributions of all players.

[1] I will use *to defect* as a synonym for *to not cooperate/not contribute/not invest*.

[2] Throughout this paper, I will adhere to this definition of efficiency, i.e., efficiency equals aggregate payoff.

That is, an increase in the aggregate contribution will always cause the aggregate payoff to rise as well; the more the merrier. Accordingly, efficiency is maximised when everyone contributes everything.

However, in practice, this monotonic relationship between efficiency and contributions does not always hold; the more is not always necessarily the merrier. Rather, in many instances, too many cooks tend to spoil the broth. Consider a fundraiser that aims to raise money for research into COVID-19 vaccines. This research would arguably benefit human society as a whole because it would bring 'us' one step closer to producing a vaccine against the coronavirus. Moreover, the resulting knowledge enhancement would comprise a public good, since everyone can reap its rewards regardless of whether they contributed to funding the research project. This creates a cooperation dilemma as to who will donate their valuable resources to the fundraiser. The logic inherent in linear public goods games implies that the cooperation will be more successful and efficient the more people donate to the fundraiser.

Yet, as often is the case with fundraisers, the researchers have set a certain target, a threshold, which they need to reach to cover the costs associated with the research. That is, they can conduct their research only if the sum of donations amounts at least to the threshold. Notwithstanding the researchers would likely be very happy if they raise more money than they targeted, this threshold element implies that every donation over and above the threshold will reduce the efficiency of cooperation. Namely, if the researchers can already conduct their study without an individual's contribution, and we assume that the quality of their research will not increase with contributions beyond the threshold, then this contribution merely represents unnecessary costs incurred by that particular individual. This is because, since the research can be conducted regardless of this individual's contribution, their contribution will not affect the benefits of others, whereas contributing will reduce their personal net benefit. Thus, overall, their contribution will cause the aggregate payoff, and equivalently, the efficiency of cooperation, to decrease. This implies that, in threshold cooperation dilemmas, more contributions do not always lead to more efficient cooperation outcomes. Rather, contributions above and beyond the threshold will deteriorate the efficiency*: too many cooks will spoil the broth*. Applied to the COVID-19 fundraiser, this means that donations beyond the threshold represent money that could have been spent more efficiently elsewhere. In fact, this money could have even been used to fund other research projects that endeavour to create a COVID-19 vaccine.

Note that the above assumes that people are unaware of other people's donations when making their own contribution decision. This is always the case in simultaneous public goods games[3], which are studied in this paper. Yet, fundraisers are inherently sequential because not everyone makes their decision at the same time. Some of these fundraisers publish the running sum of donations, whilst others do not purvey this information. In the second case, this means that donating sequentially or simultaneously are basically the same since, in both situations, one has no information on what others did. Donation campaigns on websites like GoFundMe often display a running total of donations, whereas this information is generally absent when donating to charities through their own website. This may be because campaigns on GoFundMe tend to have a very specific purpose while charities need donations on more of an ongoing basis, but it does render it hard to infer which charities are most in need of money. In this paper, I will assume that the (hypothetical) COVID-19 research project is conducted by a research institute that needs donations on an ongoing basis to conduct its projects, and that people can donate on their website, where there is no display of the running total of donations. By assumption, this example, therefore, fits with the simultaneous games studied in this paper.

1.3 Step-Level Public Goods Games

In behavioural game theory, threshold dilemma situations are often simulated by Step-Level Public Good Games (SPGs). In SPGs, the provision of a public good materialises only when a certain level of

[3] In simultaneous games, as the name implies, players make their decisions at the same time.

cooperation is attained (e.g. Van de Kragt, Orbell & Dawes 1983). They differ fundamentally from linear public good games in that they do not have one but several Nash equilibria[4] (NE), seeing as players do not have a dominant strategy; no strategy permanently yields superior outcomes irrespective of the others' decisions (Abele, Stasser & Chartier 2010). This means that, contrary to linear public good games, not cooperating does not always result in higher payoffs. In fact, if a player's contribution exactly completes the threshold, contributing is more profitable than defecting. So, when one's contribution is both sufficient and necessary for the production of the collective good, it is in their best self-interest to cooperate. This implies that the rationality[5] of cooperation is contingent on the behaviour of others, creating a situation of strategic uncertainty (Dijkstra & Bakker 2017). To illustrate this, I refer to Table 1, which represents the payoff matrix as employed in Dijkstra and Bakker (2017).

Table 1 – Payoff Matrix for SPG

		Behaviour of others		
		(a) Sum of shares of other players < (51 – Own Share)	*(b) Sum of shares of other investors = (51 – Own Share)*	*(c) Sum of shares of other investors > (51 – Own Share)*
Own behaviour	*Contribute*	0	15	15
	Not Contribute	10	10	25

The matrix reflects an SPG in which players, in groups of 5, all have an endowment of 10 tokens. They can decide either to keep all their tokens, or to invest everything in the public good. Moreover, each player is assigned a share between 1 and 50. These shares can differ across players and are distributed such that the shares of each group of 5 players sum to 100. The collective good will be produced only when the shares of contributing players amount to at least 51. If the SPG is produced, all players, irrespective of whether they invested, receive 15 tokens. This means that, when a player's share exactly completes the threshold, it is rational to cooperate rather than to defect, since 15 > 10. However, when their contribution either does not suffice *(a)* or is not necessary *(c)* to produce the SPG, individual rationality dictates that players defect, since (respectively) 10 > 0 and 25 > 15.

Furthermore, the above matrix showcases the story of efficiency in threshold situations, since the relationship between contributions and efficiency (as measured by the aggregate payoff) evidently is not monotonically increasing. First of all, in the event of *(a)*, players fare better when they do not contribute (10 > 0), meaning that the efficiency of cooperation decreases as more players contribute. Secondly, in the case of *(c)*, cooperation is more efficient than in *(a)* because 15 > 0, but players are still better off when they do not invest (25 > 15). This means that also in *(c)*, the efficiency of cooperation is negatively related to contributions. In fact, the only case in which it is efficiency-enhancing to contribute, is when the SPG can be produced when player *i* contributes, but cannot be produced when she does not: case *(b)*. Hence, efficiency is maximised when the sum of contributions just about satisfies the threshold. Applied to the COVID-19 fundraiser example, this means that the efficiency is maximised when the threshold is not met (and thus the research cannot be conducted) when an individual does not contribute, but is just about satisfied when this individual does decide to donate. Specifically, as donators can choose the magnitude of their contribution, the efficiency is maximised when the donations sum exactly to the threshold. Accordingly, all post-threshold donations are unnecessary costs incurred by the donators, thus reducing the efficiency of the fundraiser.

Hitherto, a rich body of literature has found several factors that seem to influence cooperation in SPGs (Chen, Au & Komorita 1996). For example, it appears that uncertainty as to the situation (e.g. the size of the resource pool) and the decisions of other players causes cooperation rates to deteriorate (Rapoport, Budescu, Suleiman & Weg 1992; Sniezek, May, Sawyer 1990). Another prominent and

[4] For further clarification, a Nash equilibrium is a solution concept for non-cooperative games. It comprises a strategy profile (i.e. a set of strategies for all players) in which each player's strategy is the best response to others' played strategies. Thus, at a Nash equilibrium, no rational (i.e. purely self-interested) player has an incentive to unilaterally change their strategy.

[5] Note that this concerns individual rationality. Whenever, in this paper, I refer to rationality this means that players pursue courses of action that are in their best self-interest.

robust finding concerns the effect of pre-play communication (e.g. Van de Kragt et al. 1983; Bornstein & Rapoport 1987; Kerr & Kaufman-Gilliland 1994). For instance, Van de Kragt et al. (1983) found that the ability to communicate prior to making contribution decisions dramatically increases cooperation. They reasoned that this effect may be due to the elicitation of a group identity and an enhanced sense of commitment. Moreover, they discussed the potential effect of criticality, which concerns one's relative impact in satisfying the minimal threshold, their *efficacy*. Kerr (1992; 1996) further investigated the effects of criticality, which laid the foundation for the *efficacy-cooperation hypothesis*. This hypothesis implies a monotonically increasing relationship between individuals' estimated impact on assuring the production of the public good and their contribution. Thus, the more convinced one is that their contribution is vital in ascertaining the production of the public good, the more likely they are to cooperate.

Dijkstra and Bakker (2017) further elaborate on the efficacy concept by identifying two separate components: material efficacy and contextual efficacy. This is because one's efficacy is not just determined by their relevant objective characteristics such as resources, power, or skills (*material efficacy*), but also by the value of their contribution relative to the contributions of others (*contextual efficacy*). In this vein, contextual efficacy comprises a player's expectations as to the distribution of material efficacies within her group, as well as her beliefs about the behaviour of other group members as a function of these material efficacies (Dijkstra and Bakker 2017). In practice, this means that, even though player *i* may have very little material efficacy in that she only contributes 2 euros to the COVID-19 fundraiser, she is still highly efficacious if these 2 euros perfectly complement the contributions of others, thus fulfilling the 1-million-euro benchmark. Dijkstra and Bakker's (2017) findings justified this dichotomous conceptualisation of efficacy.

So, all in all, there is a vast body of research on factors that appear to promote cooperation in step-level games. However, in examining ways to foster cooperation, these studies tacitly assume that higher cooperation levels equate to better production outcomes, as is the case in linear public good games, but not with SPGs. This results from the emphasis they place on issues pertaining to cooperation levels, causing them to miss out on the fact that SPGs are structurally analogous to coordination problems. Viz., recall that a key characteristic of SPGs concerns the multitude of Nash equilibria resulting from players' lack of a dominant strategy. Accordingly, in addition to the NE in which everyone contributes nothing, every contribution combination that just about satisfies the production threshold induces a Nash equilibrium (Dijkstra & Oude Mulders 2014; Abele et al. 2010). Moreover, in terms of social interdependence theory, step-level games entail both reflexive control and behavioural control (Abele et al. 2010). This means that each player holds individual preferences that partly determine the payoffs associated with the possible outcomes of the game (*reflexive control*), yet each player's decision also directly influences the payoffs corresponding to others' decisions (*behavioural control*) (Kelley and Thibaut 1978). Namely, in step-level games, every player prefers to contribute less instead of more, ceteris paribus. However, the condition of ceteris paribus does not always hold, because the payoffs associated with contributing vary dependent on the levels of contribution shown by others. Accordingly, the properties of reflexive and behavioural control, in concert with the variety of NEs, render SPGs functionally equivalent to coordination games; all benefit if they manage to coordinate their contributions to minimally satisfy the production threshold (Abele et al. 2010).

This implies that maximizing the efficiency of SPG cooperation requires the coordination of contributions towards combinations that exactly satisfy the threshold. Therefore, this bachelor thesis will consider the coordination aspect inherent in step-level games by examining factors that facilitate the coordination of cooperation in SPGs. Analysing the factors that have been found to affect cooperation in SPGs, a common denominator can be distilled: expectations concerning the behaviour of others. Namely, uncertainty about other players' contribution decisions inherently complicates forming expectations about their behaviour, whereas pre-play communication allows players to agree on a certain strategy profile, greatly enhancing the ability to form expectations concerning the contributions of others. In addition, the context-dependency of players' efficacy implies that people form expectations about others' behaviour based on the expected material efficacies. All of this suggests that expectations regarding the behaviour of other players vastly impact the contribution decisions made in SPGs, and thus affect the efficiency of the resulting cooperation. As such, these expectations constitute a reference point for the coordination of cooperation in step-level games. To elucidate this process, these expectations can be elicited in a controlled fashion in experimental settings. One way to elicit such expectations is by providing information about the distribution of material efficacies across group members (Dijkstra & Bakker 2017; Dijkstra & Oude Mulders 2014). *So, the purpose of this bachelor thesis is to examine whether providing information that facilitates coordination can enhance the efficiency of cooperation in SPGs.* After discussing the experimental design and the results of Study 1, I will construct a research proposal for a follow-up study to further examine the efficiency of cooperation in SPGs.

2. Theoretical Model

2.1 SPG as a Coordination Problem

The plurality of Nash equilibria inherent in SPGs constitutes an equilibrium selection problem. In pure coordination games, such as matching pennies, this issue is often resolved by having rational players randomise over their available pure strategies (e.g. Harsanyi & Selten 1988). However, several experiments (e.g. Bacharach & Bernasconi 1997; Mehta, Starmer & Sugden 1984a,b) have shown that individuals tend to do much better than randomisation when confronted with everyday coordination games. This coordination may be guided by what Schelling (1960) coined as *focal points*. The focal point principle posits that individuals are capable of organizing their behaviour in the face of a coordination dilemma by relying on the consensually perceived salience of a certain strategy profile. For example, consider a matching game where spouses have to write down (independently and without communicating) a day of the year; if the days match both receive 100 dollars, but if they differ there will be no benefits. This means that there are 365 Nash equilibria, rendering coordination extremely difficult. Nevertheless, married couples are (somewhat) likely to pick the same day: their wedding day, which is evidently more salient to them than most other days of the year. Namely, their wedding day entails some element of saliency that induces a "*focal point for each person's expectation of what the other expects him to expect to be expected to do*" (Schelling 1960, p. 57).

Ergo, players may solve the equilibrium selection problem in step-level games by playing the *focal* strategy profile. In essence, focal points concern expectations as to the behaviour of others; they harmonize expected responses, reducing the uncertainty inherent in the coordination game (Leeson, Coyne & Boettke 2006). Therefore, in SPGs, players will look for characteristics that distinguish others, such that they can form differential expectations regarding the behaviour of different 'types' of others. These characteristics then constitute points of application for a focal point (Dijkstra & Bakker 2017). Applied to the COVID-19 fundraiser example, the focal point principle thus suggests that people focus on certain personal characteristics, such as income and generosity, in forming expectations about others' donations and making contribution decisions.

2.2 Focality and Efficiency

The facilitating effect of focal points in the selection of equilibria does not merely entail that a certain Nash equilibrium will likely be chosen over the others, however. As they help to form expectations about others' behaviour, focal points also increase the likelihood that players end up in a Nash equilibrium in the first place. That is, if spouses play the 'match the day' game, the saliency of their wedding day does not just mean that players will likely end up at the NE (wedding day, wedding day) rather than at any of the other 364 NEs; it also increases the likelihood that they will write down the same day in the first place – compared to, say, strangers from different cultures. Evidently, this has implications for the efficiency of cooperation as well.

As just noted, there is always one *everyone contributes nothing* Nash equilibrium in SPGs, in addition to several *just enough players contribute* NEs. In terms of efficiency, this means that there is one relatively inefficient NE and a variety of NEs in which efficiency is maximised. Thus, the efficiency implications depend on whether the focalised strategy profile is cooperative or one of complete defection. That is, if the focal strategy profile is cooperative, this will enhance the likelihood that efficiency is maximised; yet, if the *everyone contributes nothing* NE is focalized, the resulting cooperation will more likely be relatively inefficient. Moreover, as in the model of Dijkstra and Bakker (2017), it may be that both the *everyone contributes nothing* NE and one of the *just enough players contribute* NEs are focalised. In this case, it is ambiguous whether the resulting cooperation is likely to be relatively inefficient or maximally efficient. However, this ambiguity may be partly resolved by the so-called principle of *payoff dominance*, which ascertains the selection of Pareto-dominant equilibria (Harsanyi & Selten 1988). This implies that, if both a non-cooperative and a cooperative NE are focalised, the Pareto-dominance of the cooperative equilibrium may render it even more salient, 'guiding' players towards efficiency maximisation.

2.3 Focal Point Elicitation: The Experiments

So, all in all, the expected effect of focal points on the efficiency of cooperation in step-level games is contingent on whether the focalized NE is of a cooperative or defective nature. To elucidate how focal points may impact efficiency, and which factors elicit the focalisation of cooperative rather than defective strategy profiles, it is very useful to conduct experimental studies. In these experiments, it is possible to control the expectations participants form about the contribution behaviour of others. Namely, if players are indistinguishable but for one characteristic, the only point of application for a focal point revolves around that very differential characteristic. Moreover, when including multiple differential characteristics in the experimental design, it is possible to deduce how they individually affect the cooperation levels (and thus the efficiency) as well as how they interact. As such, it can be tested which focal point design(s) will focalise cooperative strategy profiles such that participants' contributions are predictably efficient and, thus, induce an efficient Nash equilibrium. Accordingly, this design should circumvent selfish motivations that guide players to a non-cooperative NE, as well as discourage certain players from contributing to prevent overproduction.

In the endeavour to get towards such a focal point design, this bachelor thesis includes two studies that employ various differential characteristics. In the first study, I used data from Dijkstra and Bakker (2017), whose subjects were indistinguishable but for their shares (i.e. their material efficacy). Hence, a focal point could merely be applied to the differences in shares amongst group members. The focalisation of a certain (NE inducing) strategy profile, thus, occurred by providing information concerning the distribution of material efficacies. The second study concerns a research proposal building on Study 1. The focal point design rests on the information as to the efficacy distribution, the principle of payoff dominance, and the urgency of the collective good.

3. Study 1[6]

3.1 Methods

3.1.1 Design

Study 1 consists of data from Study 2 and Study 3[7] in Dijkstra and Bakker (2017). These studies were conducted as online experiments utilising the Qualtrics online survey software. Subjects were recruited through the Sociological Laboratory at the University of Groningen, The Netherlands, and were male and female undergraduates from various disciplines. The general (relevant) design of both studies was

[6] Note that the original experiment contained several other variables and conditions that are irrelevant to this study and consequently have been left out for the sake of conciseness and clarity – as they were excluded from the analysis. For more details on the original experiment, refer to Dijkstra and Bakker (2017).
[7] For clarification, these studies will be referred to as Experiment 2 & 3 from now on.

as follows. In the SPG game, subjects, divided into groups of N players, have to decide independently whether to contribute to the production of a collective good. The production of this collective good materialises only when a certain cooperation threshold is reached; in this case, all players receive the corresponding benefits. On the other hand, if too few players contribute, the production fails, meaning that there are no benefits and, thus, that contributors incur a net loss.

In the implementation utilised in Dijkstra and Bakker (2017), participants play a one-shot SPG in groups of 5 players and are all endowed with 10 points. All players have to decide (anonymously) whether to keep or invest *all* their points. So, if players opt to contribute, they lose all their 10 points. If a group's aggregate contribution suffices to produce the SPG, all players are awarded 15 points; this yields a payoff of 15 for investors and 25 for defectors. However, if they fall short and production fails, players receive no points, generating a payoff of 0 for investors and 10 for defectors. The success of the SPG production is contingent on the sum of players' shares. That is, within a group, each player is assigned a share of 50, 16 or 2 such that the sum of shares amounts to 100; i.e., one share-2 player, three share-16 players, and one share-50 player. The production of the SPG succeeds only if the sum of shares amounts to at least 51. This implies that the contribution combination of the share 50-player and any other player will both suffice and be necessary to produce the SPG.

Further, players are assigned to either the *incomplete information* or the *complete information* condition (IIC; CIC). In the IIC, players merely know their own share, that each player is assigned a share between 1 and 50, and that the shares of all group members sum to 100. In the CIC, on the other hand, participants know the exact distribution of shares in their group.

3.1.2 Procedure

Participants were randomly assigned to either the IIC or the CIC. Furthermore, all subjects were randomly allocated a share: 2, 16, or 50. At the start of the experiment, players were informed as to the structure of the experiment, the potential for monetary reward, and the estimated duration of the experiment. After participants were notified of the experiment and their share (plus the shares of others in the CIC), they decided anonymously whether to invest in the SPG or not. Participants did not get to know whether the SPG production had succeeded or not; thus, they were not informed as to their experimental payoffs. This was because participants were randomly divided into groups only after the experiment took place.[8]

3.2 Hypothesis

In the incomplete information condition, all players know is their own share and the sum of all shares (i.e. 100); thus, the efficacy-cooperation hypothesis implies that players' propensity to contribute increases along with their share. In the complete information condition, on the other hand, players are cognizant of the distribution of shares, elucidating the game's nine Nash equilibria (Dijkstra & Oude Mulders 2014): one *everyone contributes nothing* NE and eight *just enough (i.e. 2) players contribute* NEs, four in which two players contribute with certainty, and four in which two players contribute with sufficiently high probability. This also implies that, since every combination of the share-50 and any other player will suffice as well as be necessary to produce the SPG, share-2 and share-16 players are equally efficacious. Hence, per the efficacy-cooperation hypothesis, share-2 and share-16 are equally likely to contribute in the CIC.

However, the focal point principle implies that if players are cognizant of the distribution of material efficacies, the resulting cooperation – if there is any at all – will likely consist of contributions by the share-2 and the share-50 players. This is because, in the CIC, players are indistinguishable but for their

[8] Note that, in the original experiment, half of the participants played a different treatment of the SPG (in which players were assigned signs rather than shares) prior to this implementation, which may have influenced their contribution behaviour. For further information, refer to Dijkstra and Bakker (2017).

shares, rendering the players' shares the only point of application for a focal point. This, in turn, primes the selection of *symmetric equilibria*, which means that players with the same share behave alike. Accordingly, there are only two focal (symmetric) equilibria: (1) the share-2 player and the share-50 player contribute with high probability or certainty, and (2) everyone contributes nothing. Thus, consistent with the focal point principle, share-16 players are never expected to invest, for there is no focal point specifying whom of the three players ought to invest.

Ergo, all this implies that, compared to the IIC, share-16 players are less likely to contribute in the CIC, whereas share-2 are more likely to contribute. Moreover, share-50 players are expected to infer their essential role in the production process in either condition, because the threshold of 51 is impossible to reach without their contribution. Since there are three share-16 players and only one share-2 player, the combination of these effects suggests that there will be less overproduction in the CIC. Therefore, in line with the focal point principle, efficiency is likely to be greater in the complete information condition.

Focal point hypothesis. In the complete information condition, cooperation will be more efficient than in the incomplete information condition.

3.3 Results

3.3.1 Descriptives

Table 2 summarises the distribution of participants across shares and information conditions in Experiment 2 and Experiment 3. Moreover, it conveys participants' probability/propensity to contribute per experiment, information condition, and share. The table indicates that, both in Experiment 2 and in Experiment 3, participants contributed more in the IIC than in the CIC (Exp 2: 63.3% vs 54% & Exp 3: 51.5% vs 49.3%). In Experiment 2, this was due mostly to the increase in contribution propensity of the share-16 players in the IIC relative to in the CIC (70.4% vs 44.4%). In Experiment 3, the difference in contribution propensity between the IIC and the CIC mainly resulted from the contribution behaviour of share-50 players (88.2% vs 63.3%, respectively).

Table 2
Distribution of participants & contribution behaviour, broken down by experiment, information condition, and share; parenthesised numbers denote column percentages, i.e., propensities to (not) invest.

Experiment	Information Condition	Contribution Behaviour	Share 2	Share 16	Share 50	*Total*
Experiment 2	*Complete*	Invest	11 (37.9%)	12 (44.4%)	24 (77.4%)	47 (54%)
		Not invest	18 (62.1%)	15 (55.6%)	7 (22.6%)	40 (46%)
		Total	*29*	*27*	*31*	*87*
	Incomplete	Invest	12 (38.7%)	19 (70.4%)	26 (81.3%)	57 (63.3%)
		Not Invest	19 (61.3%)	8 (29.6%)	6 (18.8%)	33 (36.7%)
		Total	*31*	*27*	*32*	*90*
	Total	Invest	23 (38.3%)	31 (57.4%)	50 (79.4%)	104(58.8%)
		Not Invest	37 (61.7%)	23 (42.6%)	13 (20.6%)	73 (41.2%)
		Grand Total	*60*	*54*	*63*	*177*
Experiment 3	*Complete*	Invest	9 (29%)	46 (51.7%)	19 (63.3%)	74 (49.3%)
		Not Invest	22 (71%)	43 (48.3%)	11 (36.7%)	76 (50.7%)
		Total	*31*	*89*	*30*	*150*
	Incomplete	Invest	7 (22.6%)	48 (48%)	30 (88.2%)	85 (51.5%)
		Not Invest	24 (77.4%)	52 (52%)	4 (11.8%)	80 (48.5%)
		Total	*31*	*100*	*34*	*165*
	Total	Invest	16 (25.8%)	94 (49.7%)	49 (76.6%)	159(50.5%)
		Not Invest	46 (74.2%)	95 (50.3%)	15 (23.4%)	156(49.5%)
		Grand Total	62	189	64	315

However, this table does not tell the whole efficiency narrative. This is because the efficiency of cooperation does not just depend on the number of contributors and which 'types' of players (i.e. share-2, share-16, or share-50) contribute, but also on how these contributors are distributed across groups. Therefore, the macro-level explanandum (i.e. the efficiency/aggregate payoff) cannot be analysed by simply adding up or averaging out individual micro-level behaviours (i.e. contribution decisions). That is, the macro-level phenomenon at hand rests on a relatively complex constellation of interdependent individual behaviours, rendering mere aggregation insufficient (e.g. Coleman 1990; Hedström 2005; Dijkstra, Bouman, Bakker & Van Assen 2019). This can be resolved by utilising observed groups as units of analysis; however, this entails low statistical power. Therefore, I will employ Dijkstra et al.'s (2019) methodology of testing macro-level outcomes by means of randomisation tests on micro-level data. [9] This method rests on the intuitive rationale that experimental groups are arbitrary if participants are randomly assigned to treatments (*random permutations*) and groups within these treatments are formed randomly (*random partitions*) as well. Therefore, this method considers all possible *permutations* and *partitions* of participants by utilising randomisation tests, given the null hypothesis that both treatments are identical. This method entails the following process.

3.3.2. Hypothesis Testing

First of all, the macro outcomes must be expressed in terms of micro behaviour, which requires stipulating the micro-macro link. The macro-level explanandum (*E*) concerns the *group aggregate payoff*. This comprises the sum of five individual payoffs, which are contingent on the contribution decisions of all group members. The aggregate payoff, thus, ought to be articulated as a function of contribution decisions. Consider an arbitrary group consisting of 5 players. Let $\pi_{s,i,g,c}$ denote the payoff of share *s* player *i* in group *g* and condition *c*. The payoff of player *i* depends on their contribution c_i to the collective good as well as whether the sum of contributions (including player *i's* contribution) meets the production threshold, i.e. $\Sigma^5_{a=1} c_a \geq 51$. The sum of all players' payoffs in group *g* in condition *c* constitutes the efficiency, $E_{g,c}$. This results in the following formula.

$$E_{g,c} = \pi_{2,i,g,c} + \pi_{16,j,g,c} + \pi_{16,k,g,c} + \pi_{16,l,g,c} + \pi_{50,m,g,c} \text{ where} \quad (1)$$

$$\pi_{2,i,g,c} = \begin{cases} contribute \begin{cases} 15 \text{ if } \Sigma ca \geq 51 \\ 0 \text{ if } \Sigma ca < 51 \end{cases} \\ defect \begin{cases} 25 \text{ if } \Sigma ca \geq 51 \\ 10 \text{ if } \Sigma ca < 51 \end{cases} \end{cases}, \quad \pi_{16,k/l/m,g,c} = \begin{cases} contribute \begin{cases} 15 \text{ if } \Sigma ca \geq 51 \\ 0 \text{ if } \Sigma ca < 51 \end{cases} \\ defect \begin{cases} 25 \text{ if } \Sigma ca \geq 51 \\ 10 \text{ if } \Sigma ca < 51 \end{cases} \end{cases}, \quad \pi_{50,i,g,c} = \begin{cases} contribute \begin{cases} 15 \text{ if } \Sigma ca \geq 51 \\ 0 \text{ if } \Sigma ca < 51 \end{cases} \\ defect \quad 10 \end{cases}$$

Note that *i, j, k, l,* and *m* index the individual players composing group *g*. The ensuing statistical testing requires programming. Therefore, the software environment R will be used to test for differences in the efficiency between the IIC and CIC. In doing so, it was more convenient to use the group average rather than the aggregate payoff. Functionally, these are equivalent, as they both depend on the micro-level contribution decisions of all group members; the average payoff is simply the aggregate payoff divided by five. Therefore, although efficiency has been defined as the aggregate payoff up to this point, I will now use the group average payoff to denote the efficiency of cooperation. This results in the following equation for the efficiency of cooperation in group *g* and condition *c*.

$$E_{g,c} = (\pi_{2,i,g,c} + \pi_{16,j,g,c} + \pi_{16,k,g,c} + \pi_{16,l,g,c} + \pi_{50,m,g,c})/5 \quad (2)$$

Secondly, a statistical model predicting individual behaviour has to be specified as a function of the experimental treatments and other possible covariates. Thus, in this study, a model of contribution decisions as a function of players' experiment, shares, and information conditions is required. Table 2 summarises all contribution decisions made by participants per experiment, share and treatment. Each colourized cell conveys the proportion of invest/not-invest decisions for participants, given their

[9] There is both a homogeneous and a heterogeneous version of this methodology. I employed the homogeneous version because no covariates were included in this analysis. See Dijkstra et al. (2019) for more information.

experiment, share and treatment. Accordingly, the table predicts the contribution propensity of participants based on their experiment, their assigned share, and their treatment (IIC or CIC).

Thirdly, I must define the test statistic (*S*) that represents the macro-level explanandum, and compute its sample value (*S**) based on the first two steps – thus given the current permutation and partition of participants. In this study, I test the H0 that $E_{g,CIC} = E_{g',IIC}$ against the alternative that $E_{g,CIC} > E_{g',IIC}$ for two arbitrary groups *g* and *g'*. The test statistic then follows from $S = E_{g,CIC} - E_{g',IIC}$. To calculate S*, programming was required, to which end I employed the software environment R. This was complicated because the R data files did not contain the original grouping of the data. However, as the original groups were random and only composed after the experiment, group composition was irrelevant to participants' behaviour. Accordingly, picking any grouping and grounding the statistical testing on it would introduce unnecessary randomness in the results anyway. Hence, while still respecting treatment assignment[10], I drew many (N=300) possible groups from the sample pool and calculated their average payoff. Then I took the average of all group-averaged payoffs to find the overall average payoff in each treatment. The difference in the overall average payoffs between the CIC and the IIC constitutes the sample value *S**. In Experiment 2, *S**= 0.11; in Experiment 3, *S**= -3.76. This indicates that, in Experiment 2, the efficiency was slightly higher in the CIC than in the IIC. Yet, in Experiment 3, running counter to the focal point hypothesis, efficiency was greater in the IIC.

Lastly, I need to compare these sample statistics to the null distribution, which is generated through iterated (N=200) permuting and partitioning of the data. Each time, participants are randomly assigned to either the IIC or the CIC, assuring the same number of share-2, share-16, and share-50 players in each treatment as in the original sample. For each permutation, the difference in efficiency (*S**) between the IIC and CIC is computed. This generates a sampling null distribution of the difference in efficiency, with the centre of the distribution at 0. Juxtaposing the test statistics to the null distributions yields that, in Experiment 2, the difference in efficiency is insignificant (p=0.495, one-tailed); in Experiment 3, efficiency is significantly greater in the IIC than in the CIC (p=0.005, one-tailed). So, in Experiment 2, I fail to reject the H0, seeing as there is no significant difference in efficiency between the two experimental conditions. In Experiment 3, on the other hand, I do manage to reject the H0, albeit in the direction opposite to the *focal point hypothesis*. Therefore, all in all, I found no support for the *focal point hypothesis* in this study.

3.4 Discussion Study 1

Study 1 suggests that there is no clear-cut effect of coordination-facilitating information on the efficiency of cooperation. On the one hand, in Experiment 2, the average payoff was only slightly, insignificantly greater in the CIC than in the IIC, suggesting no effect of information on efficiency. In Experiment 3, on the other hand, efficiency was significantly lower in the CIC, suggesting a negative effect of information on the efficiency of cooperation. Although the latter effect runs counter to my focal point hypothesis, it is consistent with Dijkstra and Bakker's (2017) finding in Experiment 3 that the probability of SPG production is higher in the incomplete (versus the complete) information condition. Namely, as shown in Table 2 too, share-50 players have a lower propensity to contribute in the CIC than in the IIC in Experiment 3 ($p_{50,\ IIC}$=88.2% vs $p_{50,\ CIC}$=63.3%). This inevitably reduces the probability of SPG production considering the production threshold of 51. And seeing as failed productions generate the lowest payoffs, this lower contribution propensity inevitably reduces the efficiency of cooperation too.

In line with the theoretical model, the results imply that the provision of information as to the material efficacy distribution did not focalise the (share-50, share-2) strategy profile, or at least not sufficiently. This is verified in Table 2. In Experiment 2, both share-50 and share-2 players contribute slightly less in the CIC than in the IIC ($p_{2,IIC}$= 38.7%, $p_{50,IIC}$=81.3% vs $p_{2,CIC}$=37.9%, $p_{50,CIC}$=77.4%). Moreover, in Experiment 3, although share-2 players do contribute more in the CIC ($p_{2,IIC}$=22.6% vs $p_{2,CIC}$=29%),

[10] Of course, the groups had to consist of players from the same treatment.

share-50 players contribute less once cognizant of others' shares ($p_{50,IIC}$=88.2% vs $p_{50,CIC}$=63.3%). In fact, seeing as $E_{CIC} \leq E_{IIC}$, it seems like none of the cooperative Nash equilibria – which comprise the contribution combinations consisting of the share-50 player and any other player, and yield the highest aggregate payoff – were induced. Thus, the study design may have to be adapted to better focalize (one of) the efficient strategy profiles, i.e., (one of) those strategy profiles that induce a cooperative NE. Therefore, in the Study 2 section, I will write a research proposal for a follow-up study that endeavours to 'up its focalisation game' by explicitly appealing to the principle of payoff dominance (Harsanyi & Selten 1988).

4. Study 2[11]

4.1 Motivation for Study 2

In Study 1, the effect of providing information that facilitates coordination on the efficiency of cooperation was ambiguous: in one experiment, the effect was insignificantly positive, whereas it was significantly negative in the other. This implies that, contrary to the *focal point hypothesis*, the (share-50, share-2) strategy profile was not focalised, or at least not sufficiently. This may, in part, have resulted from the payoff equivalence of the (share-50, share-2) and (share-50, share-16) contribution combinations. This may have prevented the (share-50, share-2) strategy profile from really standing out. Therefore, in this experiment, I will appeal to the intuition that the (share-50, share-2) strategy profile is more efficient than any of the (share-50, share-16) combinations, especially when applied to the case of a fundraiser. Namely, if the last, threshold-satisfying donation constitutes an excess of 10 euros (relative to the threshold needed to conduct proper research), this is arguably more efficient than if this donation results in a 1000-euro surplus.

This intuition further develops as we consider the possibility of spillover effects to (the efficiency of) other step-level cooperation dilemmas. That is, the overproduction of one public good may decrease the stock of resources available to other public goods, thus compromising their production. In the example of the COVID-19 fundraiser, this means that donations beyond the threshold are inefficient not only in that they are unnecessary for the researchers to conduct their research, but also in that this money could have been spent elsewhere, e.g., to fund other research projects.

Thus, this study will allow for more variance in the aggregate payoff as well as account for spillover effects of overproduction. It will do so by confronting players with the possibility of contributing in either of two separate public goods. This means that overproduction in one SPG compromises the production of another SPG, thus reducing the overall aggregate payoff compared to when both SPGs are produced (efficiently). The effect this induces on players' contribution decisions may depend on the relative urgency – i.e. the extent that production of the collective good is considered necessary – of the pertinent SPGs. Hence, this study will employ SPGs with either similar or different levels of urgency.

4.2 Methods

4.2.1 Design

Akin to the studies in Dijkstra and Bakker (2017), Study 2 will be conducted as an online experiment utilising the Qualtrics online survey software. Subjects will again be recruited through the Sociological Laboratory at the University of Groningen, The Netherlands, and will be male and female undergraduates from various disciplines. The general design of the SPG is as follows. Subjects, divided into groups of N players, have to decide independently whether to contribute to the production of either one of two collective goods. This means that players have three options: defect, contribute to good A, or contribute to good B. The production of A and B will materialise only if a certain cooperation

[11] Again, this concerns a research proposal, meaning the study has not yet been conducted. Hence the use of the future tense in this part of the paper.

threshold is reached. This means that, if only the cooperation threshold for A is reached, all players will receive the benefits corresponding to A; if only the cooperation threshold for B is satisfied, all players will be awarded the benefits corresponding to B; if both cooperation thresholds are met, subjects will receive the benefits of both A and B. However, if too few players contribute to both A and B, both productions fail, meaning that there are no benefits and, thus, that contributors incur a net loss.

In this implementation of the SPG, participants play a twofold one-shot SPG in groups of 5 players. Each player receives an endowment of 10 points, which they (in anonymity and isolation) can either keep or invest in one of the two collective goods. Thus, if players contribute to one of the two step-level public goods, they lose all their 10 points. In the event that contributions satisfy only the production threshold of either SPG A or SPG B, all players are awarded 15 points. This yields a payoff of 25 for non-contributors, 15 for contributors (regardless of to which SPG). Moreover, if both SPGs are produced, players will receive a total of 30 points, which generates a payoff of 30 for contributors (regardless of to which SPG) and 40 for non-contributors. However, in case the productions of both SPGs fail, players receive no points, generating a payoff of 0 for investors and 10 for defectors. The success of SPG production is contingent on the sum of players' shares. That is, within a group, each player is assigned a share of 50, 16 or 2 such that the sum of shares amounts to 100; i.e., one share-2 player, three share-16 players, and one share-50 player. The production of SPG A (B) succeeds only if the sum of shares amounts to at least 52 (48). Players will have the same share for both SPGs. So, if player *i* is a share-50 player in the production of SPG A, they will also be a share-50 player in the production of SPG B. This implementation yields the payoff matrix as shown in Table 3.

Table 3 – Payoff Matrix Study 2

		Behaviour of Others		
		A: Sum of shares of others < (52 – Own Share)		
		B: Sum of shares others < (48 – Own Share)	*B: Sum of shares others = (48 – Own Share)*	*B: Sum of shares others > (48 – Own Share)*
Own Behaviour	*Contribute to A*	0	0	15
	Contribute to B	0	15	15
	Not Contribute	10	10	25
		A: Sum of shares of others = (52 – Own Share)		
		B: Sum of shares others < (48 – Own Share)	*B: Sum of shares others = (48 – Own Share)*	*B: Sum of shares others > (48 – Own Share)*
Own Behaviour	*Contribute to A*	15	15	30
	Contribute to B	0	15	15
	Not Contribute	10	10	25
		A: Sum of shares of others > (52 – Own Share)		
		B: Sum of shares others < (48 – Own Share)	*B: Sum of shares others = (48 – Own Share)*	*B: Sum of shares others > (48 – Own Share)*
Own Behaviour	*Contribute to A*	15	15	30
	Contribute to B	15	30	30
	Not Contribute	25	25	40

Further, players are assigned to either the *incomplete information* or the *complete information* condition (IIC; CIC). In the IIC, players merely know their own share, that each player is assigned a share between 1 and 50 for both SPGs, and that the shares of all group members sum to 100. In the CIC, on the other hand, participants know the exact distribution of shares in their group. Additionally, players are assigned to either the *differential urgency* or the *equivalent urgency* condition (DUC; EUC). In the DUC[12], players can decide between contributing to either an urgent SPG (i.e. COVID-19 research) or, notwithstanding its importance, a less critical SPG (i.e. an animal shelter). On the other hand, in the EUC, players can decide between contributing to two equally 'urgent' SPGs (i.e. between two COVID-

[12] In the DUC, the urgent SPG will be assigned the 52-threshold, and the 'trivial' SPG the 48-threshold.

19 research projects). This generates a 2 x 2 design with *information* and *urgency* as two between-subjects factors, creating a total of 4 between-subject treatments. This study will aim to have about 10 groups of 5 players (i.e. one share-2 player, three share-16 players, and one share-50 player) for each treatment.

4.2.2 Procedure

Participants will be randomly assigned to one of the four treatments. Moreover, each player will randomly be allocated a certain share ($Share_A$, $Share_B$): (2, 2), (50, 50), (16, 16), (16, 16), or (16, 16). At the start of the experiment, players will be informed as to the structure of the game, the potential for monetary reward, and the estimated duration of the experiment. Furthermore, players will get to know their shares (plus the shares of their group members in the CIC). Besides, participants will be informed as to what the relevant collective goods entail, i.e., what (hypothetically) will be done with their investments and how this will benefit them. This intends to convey the urgency of the respective SPGs. Once the players are fully informed, they can decide whether or not they want to invest in either one of the two SPGs. The experiment ends after players have made their contribution decision. Participants will not get to know whether the SPG productions have succeeded or not.

4.3 Hypotheses

As in Study 1, players in the CIC are only distinguishable by their shares in the respective SPGs. Consistent with the focal point principle, this will lead to the selection of symmetric equilibria: (a) everyone contributes nothing, or (b) the share-50 and the share-2 player will contribute with high probability or certainty in A, whilst the three share-16 players contribute with high probability or certainty in B. This implies that, if players will contribute in the CIC at all, the share-2 and share-50 player will invest in SPG A, and the three share-16 players will contribute to SPG B. The fact that any other combination of contributions will yield a lower overall payoff, further magnifies the focality induced by the selection of symmetric equilibria (Harsanyi & Selten 1988). So, in the CIC, the focalisation of the (A(50, 2); B(16, 16, 16)) strategy profile materialises through both the elucidation of the efficacy distribution and the payoff dominance of the focal strategy. In the IIC, on the other hand, the share-50 player, unaware of others' shares, is likely to contribute to SPG B because they can personally satisfy the threshold of 48. This would inevitably render the production of SPG A impossible. Therefore, the efficiency of cooperation is likely to be greater in the complete information condition.

Information hypothesis. In the complete information condition, cooperation will be more efficient than in the incomplete information condition.

Moreover, per the *contribution model*, players contribute to the production of collective goods in proportion to the perceived urgency of the situation (Kahneman, Ritov, Jacowitz & Grant 1993). This implies that, in the DUC, players will be more likely to contribute to the fundraiser for research into COVID-19 than to the fundraiser funding the animal shelter. Thus, contributing to the urgent SPG is more focal for all players. In the EUC, on the other hand, both SPGs are equally urgent, which means that players are indifferent between the two collective goods concerning their urgency. Ergo, urgency-wise, contributing to either SPG is equally focal. This suggests that there will be more overproduction (of the urgent SPG) in the DUC, compared to the EUC, thus rendering it less efficient.

Urgency hypothesis. Cooperation will be more efficient in the equivalent urgency condition than in the differential urgency condition.

Furthermore, as this expected effect of urgency works in the opposite direction to the provision of information, the effect of information will likely be less pronounced in the DUC than in the EUC.

Urgency×Information hypothesis. The effect of providing information on the efficiency of cooperation will be greater in the EUC than in the DUC.

The hypotheses will, once again, be tested by means of Dijkstra et al.'s (2019) statistical method, for the efficiency of cooperation (macro-level explanandum) is explained as a function of contribution decisions (micro-level behaviours). Moreover, as the experimental groups are formed randomly, the second core-assumption of statistical independence is fulfilled too (Dijkstra et al. 2019).

5. Discussion

5.1 Conclusion

The results of Study 1 suggest an ambiguous effect of coordination-facilitating information on the efficiency of cooperation in step-level games. In Experiment 2, providing information about the distribution of shares led to a minor, insignificant increase in efficiency, thus suggesting no effect of information on the efficiency of cooperation. However, the results of Experiment 3 suggest that efficiency decreases when information about others' shares is purveyed. This decrease in efficiency, which runs contrary to my focal point hypothesis, mostly resulted from share-50 players' reduced propensity to contribute once cognizant of others' shares. In line with the theoretical model, this implies that providing information as to the material efficacy distribution did not focalise the (share-50, share-2) strategy profile. In fact, seeing as $E_{CIC} \leq E_{IIC}$, none of the cooperative Nash equilibria, which yield the highest possible aggregate payoff, seem to have been induced by publicizing the shares of all players. Therefore, the study design may have to be adapted to better guide players in coordinating their contributions towards efficient outcomes. The design proposed in Study 2 may be able to accomplish this, seeing as – appealing to the principle of payoff dominance – the focalized strategy profile strictly yields the highest aggregate payoff, which was not the case in Study 1.

In addition, it is noteworthy that the effect of information on the efficiency of cooperation differed quite a lot between the two experiments in Study 1, whilst both experiments employed the exact same experimental design. Namely, if these differences cannot be attributed to the respective experimental designs, they may result from sampling error. This sampling error, in turn, may originate from a sampling bias in the recruitment of participants for Experiments 2 and 3. Subjects were recruited through the Sociological Laboratory at the University of Groningen, which inevitably meant that the participant pool was limited in size. The resulting samples for Experiments 2 and 3 were self-selected, which allows for the possibility that participants were significantly different across groups and conditions. For instance, in Experiment 3 from Dijkstra and Bakker (2017), the share-50 players in the IIC may have, on average, been more prosocial than the share-50 players in the CIC, explaining why they contributed more in the IIC.

Yet, this does not necessarily explain the difference in the results between Experiments 2 and 3. One contributing factor may be that subjects who partook in a previous study from the same series were excluded from participating.[13] This implies that participants from Experiment 3 either did not register for Experiment 2 in time, or only joined the participant pool after Experiment 2 had been conducted. Accordingly, subjects in Experiment 2 may be different from participants in Experiment 3. For instance, participants in Experiment 2 may have been much quicker to participate in the study than participants in Experiment 3, perhaps because they were more interested in the study and much more motivated to partake. Such potential differences between participants may have contributed to the disparity in the results between Experiments 2 and 3.

5.2 Limitations

The results of this paper cannot be generalised to all real-life step-level public goods, seeing as they are contingent a specific set of assumptions and conditions. Before all else, I would like to reflect on the choice of knowledge paradigm in this thesis. Evidently, this thesis has been written from a game-

[13] This series concerns the three experiments in Dijkstra and Bakker (2017). So people who had participated in Experiment 1 were not allowed to partake in Experiments 2 and 3; participants from Experiment 2 were not allowed to partake in Study 3.

theoretical perspective, thus resting on mathematical models concerning strategic interactions between rational players. Accordingly, throughout this paper, I have assumed that participants will behave rationally in step-level games, meaning that they will pursue courses of action that, to their knowledge, will yield the highest personal payoff. Although this allows for elegant and straightforward hypothesis formation, I must concede that game theory has limited explanatory power when it comes to illuminating human behaviour. There is ample evidence (e.g. North, Hargreaves, & McKendrick 1997; Haushofer & Fehr 2014) that people's economic decision-making is influenced by factors beyond the mere pondering of costs and benefits. Some of these factors, such as the social value of status, are hard to quantify and dimension, and thus are difficult to account for within the game-theoretical paradigm.

Nevertheless, I do believe that the theoretical model employed in this study allows for the exploration of many social and ecological factors that may influence players' contribution decisions. Namely, the focal point principle states that players will pursue a certain strategy because it has a certain saliency associated with it. There is no single way in which this saliency can be induced; rather, there is a myriad of factors that can potentially prime players towards a certain strategy profile. Therefore, I believe that the theoretical model in this paper allows to explore many social factors that may impact people's contribution behaviour. For instance, status concerns may render the decision to contribute to the production of a collective good more 'salient', enhancing players' contribution propensity. These factors may be hard to quantify, but they can potentially be induced in a controlled fashion in experiments. Having elucidated their effect in an experimental setting, they may – through 'backward induction' – be linked back to, and incorporated in, the underlying utility functions; akin to how Fehr and Schmidt (1999) captured inequity aversion in their utility function.

This brings me to arguably the most profound tacit assumptions made in this thesis; namely, that efficiency is desirable and, if so, that the aggregate/average payoff of players is a good measure for efficiency. I personally think that the answer to the first question is contingent on the answer to the second, seeing as efficiency is inherently undesirable when wickedly measured. Hence, I will address the quality of aggregate/average payoffs as a measure of efficiency first. Measuring efficiency as the aggregate payoff of cooperation is consistent with the notion of Pareto efficiency, the most prominent efficiency concept in economics. Namely, when efficiency is maximised, there is no way one player can be better off without hurting the payoff of any other player. Of course, the concept of Pareto efficiency is not perfect, since it does not concern for an equal distribution of payoffs. However, in the step-level games in this thesis, everyone receives the same payoff from successful SPG production. Moreover, this payoff exceeds the cost of investment, which is equal for all players too. This implies that the payoffs are always relatively equally distributed across players, which means Pareto efficient outcomes will also be relatively fair. Therefore, I believe that the average/aggregate payoff is a good measure for efficiency, at least in this paper. Further, seeing as a high level of efficiency corresponds to high payoffs for everybody, I believe that efficiency is desirable as well.

In addition, within the game-theoretical paradigm employed in this thesis, there were some more assumptions and conditions that further confine the merit of my results. First of all, I assumed homogeneity of quality of the collective good. This means that the quality of the SPG, once its production is ascertained, is the same regardless of the magnitude of the contributions. Thus, the benefits people receive from producing the good will be the same for all *Σcontributions ≥ threshold*. However, in reality, it may be that the quality of the SPG increases as contributions surpass the production threshold, rendering overproduction less harmful. This may change the efficiency narrative. Namely, the payoff (for player *i*) associated with a successfully produced collective good would look like:

$\pi_i = y - C_i + [(\Sigma^n_{j=1} C_j) - T]*K$

Where y is the endowment received by each player, C_i is player i's contribution, $\Sigma^n_{j=1} C_j$ denotes the sum of contributions, T denotes the production threshold, and K is a constant of $0 < K \leq 1$ that reflects the increase in quality of the SPG due to post-threshold contributions. This means that $\partial \Sigma^n_{j=1} \pi_i / \partial C_i = -1 + nK$, which will be greater than zero only if $nK > 1$. Accordingly, given that $nK > 1$, the efficiency of cooperation will be maximised when everyone contributes everything. Although this does not exclude spillover effects to the production of other collective goods, it renders the post-threshold efficiency structure of SPGs equivalent to linear public good games: the more the merrier. However, in this thesis, I assumed that thresholds in SPGs are set such that they ascertain high-quality production of the collective good. This means that only little improvements can be attained by post-threshold contributing (i.e. $K << 1 \rightarrow \partial \Sigma^n_{j=1} \pi_i / \partial C_i < 0$). Ergo, allowing for variance in the quality of the public good would yield the same efficiency maximisation as when homogeneity of quality is assumed. Therefore, I opted to make this assumption. Nevertheless, note that the results in this paper apply only to step-level situations in which $-1 + nK < 0$ for the post-threshold section of cooperation.

Secondly, the studies in this paper all deployed the same distribution of shares (i.e. 2, 16, 16, 16, 50). Dijkstra and Oude Mulders (2014) show that beliefs as to equilibrium strategies change with different distributions of shares across players in step-level games. Hence, players' contribution decisions will likely be different for other share distributions than the one employed in this thesis. And seeing as the efficiency of cooperation in SPGs rests on these individual contribution decisions, this may also change the effect of coordination-enhancing information on efficiency. To get a complete picture of the effect of information, further studies should, therefore, utilise different distributions of material efficacies across players.

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