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Relative power: Material and contextual elements of efficacy in social dilemmas

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ABSTRACT

In Step-Level Public Good (SPG) situations, groups of individuals can produce a public good if a sufficient number of them contribute. In SPG situations it is thus only rational for any group member to contribute if according to the beliefs of that group member her contribution is essential to the production of the public good. An individual's estimate of the impact of their contribution on the likelihood of public good production is known as their *efficacy*. The classic *efficacy – cooperation hypothesis* holds that individuals will be more likely to contribute if they estimate their contributions to be more necessary. Based on a *game theoretical analysis* of the SPG game, we contribute to the literature by identifying two distinct components of efficacy, viz. *material efficacy* and *contextual efficacy*. The former is based on objective characteristics of group members (such as resources, power, or skill) and the latter on beliefs about the material efficacy of other group members and expectations concerning their behavior. We present evidence from three experimental studies, showing how information on the distribution of material efficacy in the group can break the monotone material efficacy – cooperation relation. In addition, contrary to what one would expect based on both the efficacy – cooperation hypothesis and game theory, our results show that the effects of material efficacy are not mediated by contextual efficacy, both forms of efficacy having significant effects on behavior.

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1. Introduction

A surprising trait of human societies is the prevalence of cooperation between unrelated individuals. Studies of cooperation have a long tradition at the forefront of social science. Cooperation problems are frequently conceptualized as social dilemmas (Kollock, 1998): situations in which individually rational behavior can lead to collectively suboptimal outcomes (Messick and Brewer, 1983). Social dilemmas are characterized by the existence of *deficient equilibria* (Kollock, 1998). These equilibria are such that (i) there is at least one alternative outcome in which everyone is better off (deficient), but (ii) no one has an incentive to unilaterally change their behavior (equilibrium). One reason why cooperation has received so much scholarly attention is that its prevalence appears fundamentally unlikely (e.g. Kollock, 1998; Olson, 1965). Despite grim predictions, experimental and observational research has shown significant levels of cooperation (Ostrom, 1990; Sally, 1995; Balliet et al., 2009). Prominent explanations of this phenomenon suggest that humans have *social preferences* (e.g., Fehr and Gintis, 2007), expressed variously as for example fairness (Rabin, 1993; Charness and Rabin, 2002) or inequality avoidance

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(e.g. Engelmann and Strobel, 2004; Falk et al., 2008; Fehr et al., 2006), or may be motivated to cooperate by *incentives* or *disincentives* (e.g. Fehr and Gächter, 2000, 2002; Fehr et al., 2002; Olson, 1965). Sociologists and social-psychologists have specifically identified social incentives such as *status rewards* (Willer, 2009) and *moral judgments* (Simpson et al., 2013). While these are all examples of *proximate mechanisms* explaining why individuals cooperate, *evolutionary game theory* advances *ultimate mechanisms* explaining how the proximate mechanisms can be evolutionarily adaptive (Rand and Nowak, 2013).

Prominent models to test proximate explanations include the *Prisoners' Dilemma* (Axelrod, 1984), the *Ultimatum Game* (Thaler, 1988), the *Trust Game* (Snijders and Keren, 2001) and the *Public Good Game* (e.g. Fehr and Gächter, 2000). Most of these share the important property that free riding (i.e. not contributing) is a dominant strategy. That is, regardless of the decisions of others, not contributing is the most rewarding strategy.

However, cooperation is not always irrational for selfish individuals. An important model for which this is true is the *Volunteer's Dilemma*, studied by Diekmann (1985). A generalization of the Volunteer's Dilemma is the so-called *Step-Level Public Good games* (SPGs) in which a minimal level of cooperation is required to produce a collectively beneficial outcome (e.g. Van de Kragt et al., 1983; Marwell and Oliver, 1993). In SPGs payoffs from defection are not always greater than payoffs from cooperation. In particular, when one's contribution completes the minimum requirement for the collective good to be produced, one is better off contributing than defecting. Hence, cooperating is rational for individuals whose contributions are likely to be both *necessary* and *sufficient* for the collective good to be produced. Assuming that no actor can produce the SPG alone, this implies strategic uncertainty: whether cooperation is rational or irrational depends on the behavior of others. These traits describe a variety of real-life situations.

Consider an urban community situated in the approach path of an airport, such that landing aircraft cause much noise pollution. Households in this community would all benefit from a reduction in flight activity or a retracing of the approach path, yielding a reduction of noise pollution. Such a reduction would constitute a public good, as any decrease in noise pollution would benefit all community members regardless of whether they contributed to its production. In fact, the production of this public good frequently has the key characteristics of the SPG. Typically, community members have to set up some kind of community association that will negotiate with the airport authorities and (local) politics about reducing noise pollution. The cooperation problem then is *who* among the many community members is to become active in the community association, contributing time and effort to the production of the public good. Almost never can any single community member alone sway all necessary politicians, nor can any single person successfully negotiate with the airport authorities without the explicit backing by a large section of the community. Thus, multiple people have to combine their efforts for successful public good production. However, not every community member's efforts are needed, and once a sufficiently large portion of the community is active, additional contributions have little perceptible effects.

Previous research suggests that individuals deal with this strategic uncertainty by estimating their impact on the likelihood of collective good production (Kerr, 1989, 1992, 1996). An individual's estimated impact on the probability of collective good production is referred to as her *efficacy* (Kerr, 1992). Efficacy is a *subjective* construct, which can be based on but is not fully captured by a person's objective characteristics. The more likely it is in an individual's perception that her contribution is the deciding factor in whether or not the collective good is produced, the higher her efficacy, and thus the more likely that cooperating will be worth her while. As a result, the *efficacy-cooperation hypothesis* holds that individuals with high efficacy contribute more frequently than individuals with low efficacy (Kerr, 1992). Experimental research (e.g. Kerr, 1992, 1996) has corroborated this hypothesis.

Within a group individuals will differ in their power, wealth or skill, and an individual's estimation of her efficacy will be influenced by this intra-group heterogeneity. Much like how small political parties may be the deciding factor in the formation of coalition governments, individuals with low power, wealth or skill may be highly efficacious when complementing more powerful group members in the production of a collective good. Efficacy is thus not only subjective but also *context-dependent*, consisting of both *material* and *contextual* components. We propose to label *material efficacy* objective characteristics of a person relevant to the production of the collective good. In the context of our community example, the material efficacy of a community member would consist of her skill in letter writing, her knowledge of the physics of sound, her organizational abilities, the contacts she has in local politics, and the time she has available to devote to the community association, among other things. We propose to term *contextual efficacy* the individual's estimate of what her material efficacy is worth given her social environment. It is determined, first, by the individual's perception of material efficacies of other group members and, second, by the individual's expectations about the behavior of other group members as a function of these material efficacies. Thus, in our example any community member will assess the levels of relevant knowledge, skills, time, and social contacts possessed by fellow community members, and compare them to her own to decide about joining the association.

Social-psychological research on the efficacy-cooperation hypothesis (e.g. Kerr and Kaufman-Gilliland, 1994; Kerr, 1992, 1996) has commonly presented experimental subjects with information about their own material efficacy, giving only a general description of how material efficacy is distributed among their peers. Subjects are thus forced to form private beliefs about the distribution of material efficacy. Analyzing a game-theoretical model, Dijkstra and Oude Mulders (2014) show how different beliefs about the material efficacy distribution may result in vastly different behaviors of persons with the same material efficacy. This strongly suggests that anything that affects individuals' beliefs about the material efficacy distribution in the group (such as more detailed information on it) affects contribution behavior. *The purpose of this paper is therefore to investigate how contributions to SPGs depend on the degree of information about the distribution of material efficacy.*

This is an important topic for two reasons. First, we test hypotheses derived from prominent models of choice in interdependent contexts, thus providing insights into the tenability of these models. Second, SPG games are omnipresent in social life and the information individuals have about the material efficacy distribution varies greatly across domains. For instance, an individual member of a political party seeking to redirect that party's political course will generally have scanty knowledge about the power and skills of potential supporters. In a socially well-integrated community, however, people likely have much more accurate assessments of what other community members are capable of contributing when it comes to negotiating with the local airport or putting pressure on politics.

1.1. Social Value Orientation

Both the efficacy-cooperation hypothesis and the analysis performed by Dijkstra and Oude Mulders (2014) depend on the assumption of fully rational, selfish agents. In practice individuals differ in the degree to which they are selfish (Falk et al., 2008). We use the concept of *Social Value Orientation* (SVO) to determine the extent of an individual's selfishness. SVO is determined by assessing how individuals weight their outcomes relative to others' outcomes in a situation of interdependence (Messick and McClintock, 1968), and has been shown to be a strong predictor of behavior in social dilemmas (Au and Kwong, 2004; Balliet et al., 2009; Bogaert et al., 2008; Van Lange, 1999).

Based on their SVO, individuals can be divided into three preference types: *prosocials*, *individualists* and *competitors* (Van Lange, 1999; Messick and McClintock, 1968), the latter two together forming the *proselfs* category. According to SVO theory, prosocials are natural cooperators striving for maximal joint outcomes and equality (Van Lange, 1999), and showing a higher willingness to cooperate than proselfs do (Bogaert et al., 2008; Van Lange et al., 1990). Moreover, prosocials and proselfs differ in how they frame social situations (Liebrand et al., 1986). Prosocials typically view a social dilemma as a 'community game', while proselfs typically view the dilemma as an 'economic game' (Balliet et al., 2009).

Since the theoretical models we investigate assume selfishness, we expect the hypotheses to hold particularly for proself players. This expectation is reinforced by the fact that different SVO types not only indicate different preferences, but also different *beliefs* held by players. Aksoy and Weesie (2014) for instance show that prosocials expect others to be prosocial, and proselfs expect other to be proselfs. Thus, both preferences and beliefs of proselfs are more in accord with the theoretical assumptions we employ. In particular when it comes to strategic reasoning, expecting others to play (selfish) equilibrium strategies is crucial for choosing one's own strategy.

1.2. Overview

We present the results of three experimental studies to investigate how contributions depend on information about the material efficacy distribution. The results of Study 1 are suggestive but inconclusive with respect to one of the hypotheses due to lack of power. Study 2 is therefore conducted, consisting of a larger scale replication of Study 1. To investigate the extent to which the information-behavior link is actually mediated by subjective estimates of contextual efficacy, we conducted Study 3. The next section describes the basic SPG used in all studies. After that we present Study 1, starting with hypotheses and continuing with the experimental design, results and partial conclusions. The two subsequent sections are devoted to Study 2 and Study 3, again describing hypotheses, design, results and partial conclusions. The paper closes with an overall conclusion and discussion.

2. The basic SPG game

In the SPG game individuals (henceforth called *players*) in a group of size N independently decide whether or not to contribute to the production of a collective good. If a sufficiently large proportion of players decide to contribute,¹ the good is produced and all players receive the corresponding benefits. If the cooperation threshold is not reached, the good is not produced: there are no benefits, and any investors incur a net loss. The specific SPG game used in this paper is adapted from Kerr and Kaufman-Gilliland (1994). This implementation has 5 players, each with an initial endowment of 10 points. Each player decides (anonymously and in isolation) whether to *invest* all her points or *keep* all her points. If a player decides to invest, she loses her 10 points. In the event that the SPG is produced all players, regardless of their investment, receive 15 points. Thus, investors end up with 15 points while non-investors end up with 25 points. If the SPG is not produced no points are awarded, with investors ending up with 0 points and non-investors with 10. The rules determining SPG production are as follows. In addition to the endowment of 10 points, which is identical for all players, each player is assigned a *share* between 1 and 50. Different players may have different shares. It is common knowledge that the shares of all 5 players sum to 100 and that no single player has a share greater than 50. The SPG is produced if the *shares* of the investors sum to at least 51.

¹ We will use *contribute* and *invest* interchangeably, and similarly for *contributors* and *investors*, and *contribution* and *investment*.

Table 1a

Decision and payoffs faced by any player in game with incomplete information.

		Behavior of others		
		Sum of shares of other investors < (51 – Own share)	Sum of shares of other investors = (51 – Own share)	Sum of shares of other investors > (51 – Own share)
Own behavior	Contribute	0	15	15
	Not Contribute	10	10	25

3. Study 1

3.1. Theoretical model

From the rules of the SPG it follows that a player's material efficacy equals her share. The players' contextual efficacies in addition depend on their beliefs about the distribution of material efficacy, which in turn depends on the information they have about this distribution. The core of Study 1 is a comparison between behavior under complete information and incomplete information concerning the material efficacy distribution. The share distribution used is one in which there is one player with a share of 50, one player with a share of 2, and three players with a share of 16. Under *incomplete* information players know only their own share and the fact that the shares sum to 100. Under *complete* information players know the distribution of shares in their group. This implies that the decision situation for any player in the incomplete information condition looks as in Table 1a, regardless of their share. The decision situation for players in the complete information condition does depend on their share, as shown in Table 1b.

To make a decision in the incomplete information game of Table 1a, a player must assess the likelihood of being in each of the three columns. Depending on her share, these likelihoods are different. In general, given the behavior of others, the larger a player's share, the less likely it is that this player faces the second or third column compared to the first. In particular, for the share 50 player the probability of being in the third (right-most) column is 0. For the complete information case of Table 1b we review the Nash equilibrium analysis from Dijkstra and Oude Mulders (2014).²

Nash equilibria are sets of strategy profiles (i.e. a list of strategies, one for each player) such that no rational player has an incentive to individually change her strategy. In SPGs this must mean that either *no one* contributes or that *just enough* players contribute to produce the SPG. In the SPG of Table 1b 9 such equilibria exist: one in which no one contributes, four in which two players contribute with certainty and four in which two players contribute with high probability.³ In the equilibria where two players contribute, successful cooperation requires the share 50 player and any one other player to contribute. The fact that all combinations of the share 50 player and *any other* player are sufficient for successful cooperation immediately shows the context-dependent nature of efficacy. Although the share 2 player and the share 16 players differ in *material* efficacy, their power to affect the outcome of the game given the efficacy distribution (i.e., their *contextual* efficacy) is equal. This is also exemplified by the fact that they face the same decision problem in Table 1b.

The fact that there are 9 equilibria confronts the group with an *equilibrium selection problem*: which of the nine equilibria will they settle on? Schelling's *focal point principle* (Schelling, 1960) provides an answer to this question. A focal point is a strategy profile that players will tend to use when they are unable to coordinate prior to making their decisions, because it has characteristics that make players focus their attention on them and *expect others to do the same*. In our SPG, players all knowingly face the same decision problem and have the same information. Players are therefore indistinguishable, *but for their shares*. Hence, from the perspective of any player, differential expectations concerning the behavior of distinct others can logically only be rooted in differences between the shares of these others. Since focal points revolve around expectations of the behavior of others, the only points of application for a focal point are the differences in shares between players. This leads to the selection of *symmetric equilibria*, in which players with the same share behave the same. Note that this does not imply that players who behave the same have the same share. The only symmetric equilibria are those in which a) nobody invests or b) only the player with a share of 2 and the player with a share of 50 invest with high probability or certainty. The focal point principle thus provides very clear predictions for behavior under complete information: if there is any cooperation at all, it must be between the share 2 player and the share 50 player. Players with a share of 16 never invest. Note how equilibria in which a share 16 player would have a nonzero probability of cooperating could not be a focal point, since expectations as to whom of the three available share 16 players would have to invest are not clearly specified by any focal point, share being the only characteristic differentiating players.

² For the incomplete information case a Bayes-Nash equilibrium analysis can be performed. In this analysis a sample space of share distributions must be specified with a probability measure over the elements. Intuitively, equilibria are then computed by finding a strategy for each player that is a best reply against the expected strategies of the others. For details see Dijkstra and Oude Mulders (2014).

³ With $\{p_2, p_{16}, p_{16}, p_{50}\}$ representing the probabilities of investment of each player, the 9 equilibria are the following: $\{0, 0, 0, 0, 0\}$, $\{1, 0, 0, 0, 1\}$, $\{0, 1, 0, 0, 1\}$, $\{0, 0, 1, 0, 1\}$, $\{0, 0, 0, 1, 1\}$, $\{2/3, 0, 0, 0, 2/3\}$, $\{0, 2/3, 0, 0, 2/3\}$, $\{0, 0, 2/3, 0, 2/3\}$, $\{0, 0, 0, 2/3, 2/3\}$. For more detail and the mathematical rationale behind these equilibria see Author (2014).

Table 1b

Decision and payoffs faced by players in game with complete information, depending on share.

		Behavior of others		
		Share 50 player does not contribute	Only share 50 player contributes	Share 50 players and at least one other player contribute
Own behavior Share 2 and Share 16 players	Contribute	0	15	15
	Not contribute	10	10	25
Own behavior Share 50 player	Contribute	No other player contributes	At least one other player contributes	
	Not contribute	0	15	
		10	15	

Applied to our community association example the focal point principle would imply that in forming their expectations about the efforts of others and in deciding what they themselves will contribute, community members focus on a limited number of personal characteristics, such as the free time people can devote to the association and their level of education (indicative of their general skills). The symmetric equilibrium solution then implies people expect community members similar in skills and available time to behave similarly.

3.2. Hypotheses

The results from the game-theoretical analysis form a solid basis for expectations regarding the differences in behavior between SPGs with *incomplete* information and *complete* information. Under incomplete information we expect that material efficacy will form the basis of behavior. According to the efficacy-cooperation hypothesis the investment probabilities of players should increase in their share. It should be noted here that, despite having no knowledge of the distribution of material efficacy, players with a share of 50 can immediately infer they are essential to the production of the SPG. Knowing that the shares sum to 100, players with a share of 50 can deduce that the shares of all other players together can never reach the threshold of 51 (cf. Table 1a). This does *not* mean that contributing is risk-free for share 50 players, since it is quite possible that none of the other players contribute.

Hypothesis 1. (incomplete information efficacy-cooperation): Under incomplete information, there is a monotonic positive relationship between a player's share and her investment probability.

The game-theoretical analysis suggests that under complete information share 2 players and share 16 players are equally efficacious. This is reflected by the facts that for each of these four players there exist two Nash equilibria under which they invest with positive probability, and that they face the same decision problem in Table 1b. Thus, the complete information version of the efficacy-cooperation hypothesis predicts that there will be no difference in the probability of investment between share 2 and share 16 players.

Hypothesis 2. (complete information efficacy-cooperation): Players with a share of 2 and players with a share of 16 are equally likely to contribute under complete information.

The symmetric equilibrium focal point analysis predicts that share 2 players will be more likely to contribute under complete information than under incomplete information, while the reverse is expected from share 16 players.

Hypothesis 3. (symmetric equilibrium focal point): (a) Players with a share of 16 are less likely to contribute under complete information than under incomplete information; (b) Players with a share of 2 are more likely to contribute under complete information than under incomplete information.

Finally, using SVO to divide individuals into *prosocials* and *proselfs*, we expect prosocials to be more likely to invest in the SPG than proselfs. As mentioned before, Hypothesis 1 through 3 are based on assumptions of selfishness. They are therefore expected to hold particularly for proselfs, and we will test them for both preference categories separately.

3.3. Methods

3.3.1. Design

The experiment of Study 1 consists of three parts: the SVO questionnaire, a one-shot SPG as described previously and a repeated version of this SPG. The repeated SPG is not part of this paper and is only included in one of the control variables describing the order in which the three parts were played. Participants assigned to the incomplete information condition played with incomplete information in both the one-shot and repeated SPGs, and similarly for participants assigned to the complete information condition. This resulted in a $2 \times 2 \times 2 \times 2$ design in which 'information' (complete/incomplete), 'SVO first' (SVO questionnaire first/SPG games first) and 'repeated first' (repeated game first/one-shot game first) were between-subject factors and 'iteration' (repeated/one-shot) was a within-subject factor. This meant a total of 8 between-subject treatments, each of which was played in one experimental session. A session consisted of three groups of 5 participants.

Overall there were 72 participants with a share of 16, 24 participants with a share of 2 and 24 participants with a share of 50, in a total of 24 groups. Twelve groups (60 participants) played the incomplete information condition. The other 12 groups (60 participants) played the complete information condition. Table 2 below shows the number of participants of each of our three studies, broken down by information condition and share.

3.3.2. Participants

Recruitment was organized through the Sociological Laboratory at the University of Groningen, The Netherlands (see <http://www.gmw.rug.nl/~orsee/public/>), consisting of approximately 1300 participants. Participants were male and female undergraduates from a variety of disciplines. Each received a monetary reward for participating and was guaranteed that the experiment was free of deception.

3.3.3. Payment

Points earned in the one-shot SPG and one randomly selected round of the repeated SPG were converted to money at the rate of 10 eurocents per point, and participants received this amount at the end of the experiment in a closed envelope. The payment procedure was made public before the SPGs were played. Pay ranged between 5 and 10 euros for a 40 min experiment.

3.3.4. Procedure

The experiment was computer-mediated and programmed using the Z-tree software (Fischbacher, 2007). Participants were randomly assigned to a group before playing the first SPG game (either one-shot or repeated depending on the treatment) and were randomly reassigned to new groups before the start of the second SPG game. This procedure was common knowledge.

Each part of the experiment (SVO, one-shot SPG, repeated SPG) was preceded by instructions. For both information conditions these instructions included the information that the sum of shares in the groups was 100 and that no one had a share of more than 50. In the SPG games participants were informed of their shares after reading the instructions. Players had the same shares throughout the entire experiment. In the complete information condition they were additionally informed of the distribution of shares across the other group members. Participants then decided, anonymously and without knowing the decisions of others, whether to invest or keep their 10 points. After all group members had made their decisions, participants were told whether the SPG was produced. Participants were not told which of their fellow group members had invested.

3.3.5. The SVO questionnaire

For measuring SVO the nine-item decomposed game measure (e.g. Van Lange et al., 2007) was used. This measure involves asking participants to imagine they have been randomly paired with another person, whom they do not know and will never knowingly meet. Participants are then presented with nine separate decisions, each involving a choice between three different distributions of points across the participant and the imagined other. The three distributions in each decision are associated with each of the Social Value Orientations (pro-social, individualists and competitive). For example:

	A	B	C
You get:	480	540	480
Other gets:	80	280	480

Competitive answers are distinguished by the biggest difference between the payoffs for self and other (option A), individualistic answers are those with the highest payoff for self (option B) and pro-social answers are those with the most equal distribution (option C). The decomposed game measure of SVO is not incentivized and participants' earnings therefore did not depend on their choices in the SVO questionnaire.

Table 2

Number of participants in each study, broken down by information condition and shares.

Study	Information condition	Share 2	Share 16	Share 50	Totals
Study 1	Complete	12	36	12	60
	Incomplete	12	36	12	60
	Totals Study 1	24	72	24	120
Study 2	Complete	31	89	30	150
	Incomplete	31	100	34	165
	Totals Study 2	62	189	64	315
Study 3	Complete	29	27	31	87
	Incomplete	31	27	32	90
	Totals Study 3	60	54	63	177
Grand Totals		146	315	151	612

3.4. Results

3.4.1. Descriptives

There were 12 share 2 players, 12 share 50 players and 36 share 16 players per information condition. Due to low power small and medium effects on the behavior of share 2 players ([Hypothesis 3b](#)) are unlikely to be detected. Of the 120 participants involved, 51 (42.5%) decided to invest their 10 points. There was little difference between the incomplete and complete information conditions in this respect (43.33% and 41.67%, respectively).

[Table 3](#) below presents investment behavior broken down by information condition and share. The pattern predicted by H1 (investment increasing in share under incomplete information) seems present in the data (two-tailed Fisher exact test, $p = 0.018$). Also, the investment probabilities of share 2 and share 16 players under complete information seem quite close, as predicted by H2 (two-tailed Fisher exact test, $p = 1$). Finally, as predicted by H3, share 16 players indeed seem to have higher investment probabilities under incomplete information than under complete information (although the difference in the raw data is not significant; two-tailed Fisher exact test, $p = 0.46$), and share 2 players appear to have a slightly higher investment probabilities under complete information than under incomplete information (although the difference in the raw data is not significant; two-tailed Fisher exact test, $p = 1$).

The SVO questionnaire was used to classify all 120 participants as Prosocial, Competitive or Individualist if they chose the payoff distribution corresponding to that type in at least 6 out of the 9 questionnaire items ([Messick and McClintock, 1968](#); [Van Lange, 1999](#)). Sixty-two participants were classified as Prosocial, 39 as Individualist and 2 as Competitive. The remaining 17 participants did not choose at least six times the same type of payoff distribution. Thus, 85.8% of the participants could be classified.

3.4.2. Testing hypotheses

We have formulated *directed* hypotheses, which we test with one-tailed tests presented in the text. Table footnotes present two-tailed p -values. [Fig. 1](#) (below) shows distributions of predicted investment probabilities based on the parameter estimates of Model 1 in [Table 1](#) (see below), plotted against participants' share. [Fig. 1a](#) shows predicted probabilities for the incomplete information condition, while [Fig. 1b](#) shows the same information for the complete information condition. In accordance with the raw data from [Table 3](#), the impression from [Fig. 1](#) is that, in line with [Hypothesis 1](#), contributions in the incomplete information condition are monotonically positively related to participants' share. In line with [Hypothesis 2](#), under complete information share 2 participants are about equally likely to invest as share 16 participants. Participants with a share of 16 are less likely to contribute in the complete information condition than in the incomplete information condition, as predicted by [Hypothesis 3a](#). Finally, share 2 participants have a somewhat higher investment probability in the complete information condition than in the incomplete information condition, in line with [Hypothesis 3b](#).

To formally test the hypotheses we inspect the parameter estimates of Model 1 in [Table 4](#), presenting the results of a logistic regression of investment behavior (invest = 1; not invest = 0) on the set of predictor variables. Listed first are several control variables describing the order of the various parts of the experiment (SVO questionnaire first or SPGs first, and One-shot Game first or Repeated Game first), and a variable 'Selfish' describing how many times participants chose one of the selfish options (individualist or competitive) in the SVO questionnaire. The substantive variables are 'Share 2' and 'Share 50' (dummy variables for participants' share, with share 16 as the reference category) and 'Info' (complete information = 1, incomplete information = 0). The parameters for Share 2 and Share 50 show that in the incomplete information condition share 2 participants are not quite significantly less likely to contribute than those with a share of 16 ($p < 0.1$, one-tailed). Share 50 participants are significantly more likely to contribute than participants with a share of 16. These results partly corroborate [Hypothesis 1](#). [Hypothesis 3a](#) and [3b](#) predict how the investment probabilities for share 2 and share 16 participants change with the introduction of information about the distribution of material efficacy. The parameter 'Info' demonstrates this effect for share 16 participants. This change almost reaches statistical significance ($p = 0.08$, one-tailed). The difference between the incomplete and complete information condition for share 2 participants is given by the sum of the parameters for 'Info' and the interaction 'InfoShare2', and equals zero. This result contradicts [hypothesis 3b](#). Model 2, using only data from the complete information condition, shows that the investment probabilities do not differ significantly between share 2 and share 16 participants in the complete information condition, in line with [Hypothesis 2](#). [Hypothesis 2](#) being a null hypothesis, the lack of effect found in our analysis could be due to a lack of statistical power due to the low number of share 2 ($N = 12$) participants in the complete information condition. The pattern that emerges is as follows. In the absence of information on

Table 3

Investment behavior Study 1 by share in Complete and Incomplete Information conditions; column percentages in brackets.

		Share 2	Share 16	Share 50	Totals
Incomplete information	Not invest	10 (83.3%)	21 (58.3%)	3 (25%)	34 (56.7%)
	Invest	2 (16.7%)	15 (41.7%)	9 (75%)	26 (43.3%)
	Totals	12	36	12	60
Complete information	Not invest	9 (75%)	25 (69.4%)	1 (8.3%)	35 (58.3%)
	Invest	3 (25%)	11 (30.6%)	11 (91.7%)	25 (41.7%)
	Totals	12	36	12	60

Fig. 1. Predicted probabilities by shares in Study 1; (a) Incomplete Information (b) Complete Information.

Table 4

Logistic regression models Study 1; dependent variable decision to invest (1 = 'yes'; 0 = 'no').

	Model 1 all participants (N = 120)		Model 2 complete information only (N = 60)	
	B	S.E.	B	S.E.
SVO first	−0.75	0.44	−0.94	0.68
One-shot first	0.38	0.44	−0.26	0.67
Selfish	−0.20*	0.08	−0.30*	0.14
Share 2	−1.14	0.88	−0.39	0.82
Share 50	1.92*	0.82	4.42**	1.38
Info	−0.75	0.54		
Info × Share 2	0.75	1.19		
Info × Share 50	1.96	1.39		
Constant	0.56	0.52	0.39	0.64

*p < 0.05, **p < 0.01, two-tailed.

the distribution of material efficacy in the group there is a positive association between material efficacy and investment probability. The introduction of information about the material efficacy distribution reduces the probability of investment for share 16 participants, but does not affect the investment probabilities of participants with shares of 2 or 50. However, the patterns found are weak and do not reach standard significance levels.

Our hypotheses assume selfishness. We therefore explore the impact participants' SVO had on their behavior. The linear effect of participants' SVO on their probability of investment is investigated in the logistic regression models of Table 4,

Table 5

Contingency table of behavior of prosocial and proself share 16 participants across conditions in Study 1.

		Invest	Not invest	Total
Incomplete information	Proself	7	13	20
	Prosocial	8	8	16
Complete information	Proself	0	10	10
	Prosocial	11	15	26

through the parameter ‘Selfish’. In both models more selfish participants showed a significantly lower probability of investment.

Second, we expect our hypotheses to hold particularly for selfish participants. Table 5 shows the behavior of prosocial and prosself share 16 participants in both information conditions. In the incomplete information condition approximately one third of the twenty proselves invested, compared to one half of the sixteen prosocials. In the complete information condition none of the ten proselves chose to invest, compared to eleven of the twenty-six prosocials. Proselfs’ behavior differed significantly between the incomplete and complete information treatments (one-tailed Fisher exact test, $p = 0.037$), while prosocials’ behavior showed no significant difference ($p = 0.433$, one-tailed). Thus, prosself share 16 participants show a significantly lower probability of investment when presented with complete information, corroborating Hypothesis 3a.

We can use our results to estimate the probability p of SPG production in a randomly composed group conditional on the information condition. Letting p_k denote the fraction of share k participants that invest, the estimated probability of SPG production in a randomly composed group equals $p = p_{50}(1 - (1 - p_{16})^3(1 - p_2))$. In the incomplete information condition $p_2 = 2/12$, $p_{16} = 15/36$, and $p_{50} = 9/12$, yielding $p = 0.63$. In the complete information condition $p_2 = 3/12$, $p_{16} = 11/36$, and $p_{50} = 11/12$, yielding $p = 0.69$. Thus, information slightly improves the chances of successful SPG production (Odds Ratio = 1.31).

3.5. Conclusions study 1

Study 1 suggests that in one-shot SPGs information about the distribution of material efficacy across group members affects contribution decisions of prosself players. Whereas under incomplete information a positive relationship between share and probability of investment is observed (in accord with Hypothesis 1), the complete information condition shows no difference between players with a share of 2 and players with a share of 16 (in line with Hypothesis 2). It was shown that this is caused by selfish share 16 participants being significantly less likely to invest when they know the shares of their fellow group members (in line with Hypothesis 3a). This suggests that participants took both their material and contextual efficacy into account when making their investment decision.

Having said that, we also observed that share 2 participants were not more likely to contribute under complete information than under incomplete information (contrary to Hypothesis 3b). An intuitive explanation for this observation is that (selfish) participants are more sensitive to new information that tells them to contribute *less* often than to information that tells them to contribute *more* often. However, we note that Study 1 contained only 24 share 2 participants, resulting in low statistical power.

4. Study 2

4.1. Motivation for study 2

The low number of share 2 participants in Study 1 rendered it difficult to make accurate inferences about their behavior, also in relation to (the corroborated) Hypothesis 2. For these reasons a larger-scale replication (Study 2) was conducted.

4.2. Methods

4.2.1. Design

Study 2 was conducted as an online experiment using the Qualtrics online survey software. Participants played a one-shot SPG with the use of the same numeric shares as in Study 1 and a different one-shot SPG using letter labels. Data from the SPG with numeric shares are used to retest our hypotheses. All participants played one of each type of SPG. The experiment included the SVO questionnaire. In total the experiment thus consisted of three parts. Each participant takes the SVO questionnaire, plays one condition with the use of numeric shares (either the incomplete information condition or the complete information condition) and plays one condition with the use of letter labels (not used in this paper).

The order in which the three parts were played was varied. The SVO questionnaire was always taken as either the first or the last part of the experiment. We further varied whether the participant played the SPG with numeric shares before the SPG with letter labels, or vice versa. This resulted in a $2 \times 2 \times 2 \times 2$ design where ‘information condition’ (complete or incomplete information), ‘label condition’ (there were two different conditions in the label SPG), ‘SVO first’ (SVO questionnaire first/SVO questionnaire last) and ‘shares first’ (SPG with shares first/SPG with labels first) were between-subject factors. This results in a total of 16 between-subject treatments.

4.2.2. Participants

Subjects for Study 2 were again recruited from the subject pool of the Sociological Laboratory. Those who had participated in Study 1 were excluded from Study 2, leaving over 1100 potential participants. All 1100 individuals were invited by email to take part in the online experiment. In the invitation, potential participants were informed of the rules for payment (see Payment below) and the expected duration of the experiment (10 min). This information was repeated in the introduction screen of the experiment. The experiment was open for participation from the 22nd of April through the 25th of May 2014. At the end of this period 315 people had participated.

Table 6

Investment behavior Study 2 by share in Complete and Incomplete Information conditions; column percentages in brackets.

		Share 2	Share 16	Share 50	Totals
Incomplete information	Not invest	24 (77.4%)	52 (52%)	4 (11.8%)	80 (48.5%)
	Invest	7 (22.6%)	48 (48%)	30 (88.2%)	85 (51.5%)
	Totals	31	100	34	165
Complete information	Not invest	22 (71%)	43 (48.3%)	11 (36.7%)	76 (50.7%)
	Invest	9 (29%)	46 (51.7%)	19 (63.3%)	74 (49.3%)
	Totals	31	89	30	150

4.2.3. Procedure

Participants were randomly assigned to one of the 16 treatments upon starting the online experiment. Additionally, participants were randomly assigned a share. At the start of the experiment a general introduction was given in which participants were informed of the structure of the experiment, the potential for a monetary reward for their actions and the approximate duration of the experiment. The estimated ten minutes were sufficient time to complete the experiment for the large majority of participants.

Before each part of the experiment participants were informed whether it would potentially result in a monetary reward. This was the case for both SPG games and not for the SVO questionnaire (similar to Study 1). In each part participants then read instructions, after which they learned their share and decided to invest or not (in the SPG conditions) or were presented with their first item (in the SVO questionnaire). Participants were informed that they could return to the instructions for the current part of the experiment at any time during this part. Participants could not return to a previous part of the experiment. As before, all decisions were made anonymously without knowing the decisions of any other participant. In contrast to Study 1, participants did not learn whether the SPG was produced or not.

4.2.4. Payment

The potentially very large number of participants in this online experiment made paying all participants unfeasible. In addition, the convenience and short duration of an online experiment means that paying all participants a guaranteed fee is less necessary than in laboratory experiments. For these reasons we decided participants would be paid with a given probability per contribution decision. Those participants selected for payment would be rewarded based on their performance in the experiment. Since performance in an SPG depends on the actions of other group members, this method of payment meant that subjects would have to be assigned to groups. Players were assigned to a group for each SPG they played. This was done at random, separately for each SPG, making sure that all groups had the appropriate shares distribution. Out of all groups created across the variants of the SPG game, 10% were selected for payment.⁴ Through this process, 54 players were eventually awarded payment for one decision while another 4 players were awarded payment for both of their decisions. To determine their payment, each point they earned during the experiment was converted to 30 eurocents.

4.3. Results

4.3.1. Descriptives

For the assignment of participants to information conditions and shares see Table 2. In the SPG 159 out of 315 participants (50.5%) decided to invest in the group project. This ratio appears to be similar in both information conditions, with 51.5% investing in the incomplete information condition and 49.3% investing in the complete information condition.

Table 6 below presents investment behavior broken down by information condition and share. The pattern predicted by H1 (investment increasing in share under incomplete information) seems present in the data (two-tailed Fisher exact test, $p < 0.001$). However, contrary to the prediction of H2, the investment probabilities of share 2 and share 16 players under complete information are very different (two-tailed Fisher exact test, $p = 0.037$). Similarly, the predictions of H3, are not borne out by the raw data (two-tailed Fisher exact test, $p = 0.66$ for share 16 players; two-tailed Fisher exact test, $p = 0.77$ for share 2 players).

Based on the SVO questionnaire 182 participants were classified as Prosocial, 84 as Individualist and 10 as Competitive. The remaining 39 participants were unclassified. Thus, 87.6% of participants were classified according to one of the SVO types.

4.3.2. Hypothesis testing

Table 7 presents the parameter estimates of the logistic regression models for the two treatments replicated from Study 1. The variables 'SVO First' and 'Shares First' represent the order in which the treatments were played. All other variables have meanings identical to those in Study 1. Fig. 2 (below) shows predicted investment probabilities for all participants based on the parameter estimates of Model 1 in Table 7, plotted against their share. Fig. 2a shows predicted probabilities for the incomplete information condition, while Fig. 2b shows the same information for the complete information condition. The

⁴ Since each participant was a part of two groups, one group for each of the SPG games they played (numeric shares and labels), each participant had a 19% chance of being paid for at least one of their decisions.

Table 7

Logistic regression models Study 2; dependent variable decision to invest (1 = 'yes'; 0 = 'no').

	Model 1 full model (N = 315)		Model 2 complete information (N=)		Model 3 share 16 players (N =)		Model 4 share 2 players (N =)	
	B	S.E.	B	S.E.	B	S.E.	B	S.E.
SVO first	−0.01	0.24	0.26	0.34	0.09	0.29	−1.32*	0.67
Shares first	−0.10	0.24	−0.23	0.34	−0.13	0.30	−0.96	0.66
Selfish	−0.04	0.03	−0.05	0.05	−0.04	0.04	−0.11	0.09
Share 2	−1.20*	0.48	−0.99*	0.45				
Share 50	2.00**	0.57	0.46	0.44				
Info	0.12	0.29			0.13	0.29	0.28	0.62
Info × Share 2	0.23	0.66						
Info × Share 50	−1.55*	0.72						
Constant	0.16	0.31	0.24	0.37	0.12	0.35	0.11	0.69

*p < 0.05, **p < 0.01, two-tailed.

Fig. 2. Predicted probabilities by shares in Study 2; (a) Incomplete Information (b) Complete Information.

pattern in both figures suggests a positive relationship between participants' share and their probability to invest. For the incomplete information condition this pattern is predicted by [Hypothesis 1](#). However, for the complete information condition a different pattern was expected. [Hypothesis 2](#) predicts equal levels of contributions from share 2 and share 16 participants, but [Fig. 2b](#) shows that share 2 participants still contribute less than share 16 participants. [Hypothesis 3b](#) predicts an increase in contributions from share 2 participants, while [Hypothesis 3a](#) predicts a decrease in contributions from share 16 participants. Neither of these is observed.

Statistical tests of the parameter estimates of Model 1 in [Table 3](#) reveal that in the incomplete information condition the share 2 participants are significantly less likely to invest than share 16 participants ($p = 0.014$, one-tailed). In the same condition share 50 participants are significantly more likely to invest than share 16 participants ($p < 0.001$, one-tailed). This pattern is predicted by [Hypothesis 1](#) (incomplete information efficacy-cooperation). The parameter 'Info' indicates the change in investments by share 16 participants between the incomplete and complete information conditions. Model 3 shows that share 16 participants are no more or less likely to invest in the complete information condition than in the incomplete information condition, contradicting [Hypothesis 3a](#). The share 2 participants (Model 4) also do not show any significant change in behavior between the two conditions, contradicting [Hypothesis 3b](#). Model 2 shows that in the complete information condition, share 2 participants contribute *significantly less* than share 16 participants, contradicting [Hypothesis 2](#).

Table 8

Contingency table of prosocial and prosself behavior of share 16 participants across conditions in Study 2.

		Not invest	Invest	Total
Incomplete information	Proself	24	23	47
	Prosocial	28	25	53
Complete information	Proself	21	19	40
	Prosocial	22	27	49

Interestingly, in a logistic regression model estimated only on share 50 participants (not shown), these are significantly less likely to contribute in the complete information condition than in the incomplete information condition ($b = -1.56$, $p = 0.022$, two-tailed). This result is unexpected given the predictions made by both the efficacy-cooperation hypothesis and the symmetric equilibrium focal point analysis. Share 50 participants are essential to the production of the SPG in both conditions (if anything this can be seen more easily in the complete information condition) and are part of the symmetric equilibrium focal point combination of contributors.

The linear effect of participants' SVO on their probability of investment is investigated in the logistic regression models of Table 7, through the parameter 'Selfish'. None of the models in Table 7 indicate any significant effect of selfishness. As discussed previously, our hypotheses assume selfishness on the part of our participants. We therefore expect that if any participants are to show the effects our hypotheses predict, these should be the prosself participants. Table 8 shows that prosself share 16 participants were equally likely to contribute under complete information as under incomplete information, while prosocial share 16 participants contributed slightly more often under complete information than under incomplete information. The same result holds for share 2 participants (results not shown). The fact that the behavior of prosself participants is the same in both conditions contradicts the predictions of Hypothesis 2 and 3.

Finally, estimating the probability of SPG production in a randomly composed group yields $p = 0.79$ ($p_2 = 7/31$, $p_{16} = 48/100$, and $p_{50} = 30/34$) and $p = 0.58$ ($p_2 = 9/31$, $p_{16} = 46/89$, and $p_{50} = 19/30$) in the incomplete and complete information conditions, respectively. Thus, information considerably decreased the chances of SPG production (Odds Ratio = 0.37).

4.4. Conclusions study 2

The results of Study 2 suggest that the incomplete information efficacy-cooperation hypothesis, predicting probabilities of investment to increase in share, holds regardless of whether participants have information on the material efficacy distribution. This contradicts Hypothesis 2 and Hypothesis 3. The refutation of Hypothesis 2 could be due to increased statistical power, which was an important reason to conduct Study 2. However, the results of Study 2 and their partly contradicting the results of Study 1 do pose an important question: how exactly does contextual efficacy mediate the information-behavior link? Therefore, we conducted Study 3, which is a replication of Study 2 with one important addition. After presenting participants with the instructions and informing them about their share, we measured their perception of contextual efficacy.

5. Study 3

5.1. Motivation for study 3

Hypothesis 1 through 3 are all based on the assumption that an individual's investment decision depends entirely on her (contextual) efficacy. Since the information regime (complete or incomplete information) of the SPG theoretically impacts contextual efficacy, it is predicted to affect behavior accordingly. The results of the first two studies cast doubt on this reasoning, however. The facts that hypothesis 2 and 3 were (partly) corroborated in Study 1 but had to be rejected in Study 2 raise the question of whether the link between information and investment is indeed mediated by contextual efficacy.

5.2. Methods

In Study 3 we test the same hypotheses with respect to investment behavior as in the previous two studies. In addition, we measure perceived contextual efficacy and test the equivalents of hypothesis 1 through 3 with respect to the response variable 'contextual efficacy'. We can then analyze the extent to which the effect of information on investment decisions is mediated by contextual efficacy.

The design and methods of Study 3 were identical to those employed in Study 2, but for one difference. After participants had read the instructions (and had learned their share and the share of the others, depending on the information condition), but before they had made their contribution decision, we measured their perceived contextual efficacy with the following three questions: (1) 'To what extent is your investment necessary to produce the group project?', (2) 'To what extent is your investment sufficient to produce the group project?', and (3) 'To what extent does your investment determine whether or not the group project is produced?' Answers were phrased such that participants had to complete the sentences 'It is [ANSWER] that my investment (is necessary for/is sufficient for/determines) the production of the group project', where the answer could range from 1 (impossible), through 2 (very unlikely), 3 (unlikely), 4 (a 50/50 chance), 5 (likely), 6 (very likely), to 7

Table 9

Investment behavior Study 3 by share in Complete and Incomplete Information conditions; column percentages in brackets.

		Share 2	Share 16	Share 50	Totals
Incomplete information	Not invest	19 (61.3%)	8 (29.6%)	6 (18.8%)	33 (36.7%)
	Invest	12 (38.7%)	19 (70.4%)	26 (81.3%)	57 (63.3%)
	Totals	31	27	32	90
Complete information	Not invest	18 (62.1%)	15 (55.6%)	7 (22.6%)	40 (46%)
	Invest	11 (37.9%)	12 (44.4%)	24 (77.4%)	47 (54%)
	Totals	29	27	31	87

(certain). The three questions as a scale had high reliability (Cronbach's $\alpha = 0.833$) and the answers are therefore summed to form the single variable 'contextual efficacy'. Apart from being reliable, we also argue that this is a valid measurement of contextual efficacy. We defined contextual efficacy as an individual's estimate of what her material efficacy is worth given her social environment. This is what we measure when asking participants to assess the degree to which their contributions are necessary, sufficient, and determinant for SPG production, *after they have or have not learned* the entire share distribution. Recruitment and payment⁵ of participants in Study 3 was identical to Study 2. 177 individuals participated and among them there was no one who had participated in either Study 1 or Study 2.

5.3. Results

5.3.1. Descriptives

For the assignment of participants to information conditions and shares, see Table 2. In the SPG 104 out of 177 participants (58.8%) decided to invest in the group project. This ratio appears to differ depending on information: 63.3% invest in the incomplete information condition and 54% invest in the complete information condition.

Table 9 below presents investment behavior broken down by information condition and share. The data look very similar to those of Study 1, the only difference being that share 2 participants seem not to increase their investment under complete information compared to incomplete information (an effect that was also non-significant in Study 1). Thus, the pattern predicted by H1 (investment increasing in share under incomplete information) seems present in the data (two-tailed Fisher exact test, $p = 0.002$), and the investment probabilities of share 2 and share 16 players under complete information also seem quite close (two-tailed Fisher exact test, $p = 0.79$), as predicted by H2. As predicted by H3, share 16 players indeed seem to have higher investment probabilities under incomplete information than under complete information (two-tailed Fisher exact test, $p = 0.098$), while the behavior of share 2 players does not differ under these two conditions (two-tailed Fisher exact test, $p = 1$).

Using the same SVO classification as before 102 participants were classified as Prosocial, 51 participants were classified as Individualist and 6 participants were classified as Competitive. The remaining 18 participants were unclassified. Thus, 89.8% were classified in one of the SVO types. The contextual efficacy variable is a scale theoretically running from 3 to 21. The empirical range was 5 through 21, with a mean of 13.20 and a standard deviation of 3.68.

5.3.2. Hypothesis testing

We first replicate the analyses of Study 1 and Study 2. Table 10 presents the parameter estimates of the logistic regression models. Model 1a shows the results when contextual efficacy is not included, Model 1b shows the results when it is. Fig. 3 (below) shows predicted investment probabilities for all participants based on the parameter estimates of Model 1a in Table 10, plotted against share. Fig. 3a shows predicted probabilities for the incomplete information condition, while Fig. 3b shows the same information for the complete information condition. The pattern present in these figures replicates the pattern found in Study 1. For the incomplete information condition we find the pattern predicted by Hypothesis 1. For the complete information condition Hypothesis 2 predicted equal levels of contributions from share 2 and share 16 participants, which is indeed suggested by Fig. 3b. Hypothesis 3b predicted an increase in investments from share 2 participants going from incomplete to complete information, of which we again find no evidence. The predicted decrease in contributions from share 16 participants (Hypothesis 3a) again seems present in the data.

To test the hypotheses formally we look at Model 1a in Table 10. In the incomplete information condition the share 2 participants are significantly less likely to invest than share 16 participants ($p = 0.02$, one-tailed). In the same condition share 50 participants are not significantly more likely to invest than share 16 participants ($p = 0.09$, one-tailed). The first part (share 2 – share 16) of this pattern is predicted by Hypothesis 1 (incomplete information efficacy-cooperation). The second part of this pattern (share 16 – share 50), though not significant, is in the direction predicted by Hypothesis 1. The parameter 'Info' in Model 1a indicates the change in investments from share 16 participants between the incomplete and complete information

⁵ In the payment procedure of Study 3 we matched Study 3 participant decisions with decisions made by participants from both Study 2 and Study 3. This allowed us to assign shares 2, 16, and 50 with equal probability without worrying about having a sufficient number of share 16 participants to complete groups for the payment. We only paid Study 3 participants, however, and made sure that for them the probability of getting paid was identical to that probability in Study 2.

Table 10

Logistic regression models (Models 1a through 4) and OLS regression model (Model 5) Study 3; in Models 1a through 4, dependent variable is decision to invest (1 = 'yes'; 0 = 'no'); in Model 5 dependent variable is contextual efficacy.

	Model 1a (N = 177)		Model 1b (N = 177)		Model 2 complete information (N = 87)		Model 3 share 16 players (N = 54)		Model 4 share 2 players (N = 60)		Model 5 response Variable: Contextual efficacy (N = 177)	
	B	S.E.	B	S.E.	B	S.E.	B	S.E.	B	S.E.	B	S.E.
SVO first	0.30	0.34	0.27	0.35	0.42	0.48	0.39	0.59	0.14	0.53	0.33	0.45
Shares first	−0.30	0.34	−0.48	0.36	−0.20	0.47	−0.71	0.62	−0.04	0.55	0.59	0.45
Selfish	−0.11*	0.05	−0.10*	0.05	−0.10	0.07	−0.07	0.09	−0.04	0.07	−0.05	0.06
Share 2	−1.19*	0.57	−1.10	0.59	−0.27	0.56					−0.89	0.79
Share 50	0.85	0.64	0.46	0.67	1.43*	0.59					2.38*	0.79
Info	−1.01	0.59	−1.11	0.60			−1.08	0.60	−0.05	0.54	0.28	0.81
Info × Share 2	0.92	0.80	1.50	0.86							−2.71*	1.12
Info × Share 50	0.58	0.87	0.48	0.90							0.70	1.12
Contextual efficacy			0.20*	0.06								
Constant	1.14*	0.52	−1.25	0.91	−0.004	0.54	1.20	0.65	−0.342	0.63	12.53	0.69

* $p < 0.05$, ** $p < 0.01$, two-tailed; $R^2 = 0.38$ in Model 5.

Fig. 3. Predicted probabilities by shares in Study 3; (a) Incomplete Information (b) Complete Information.

conditions. Model 1a shows that share 16 participants are indeed less likely to invest in the complete information condition than in the incomplete information condition ($p = 0.04$, one-tailed), corroborating [Hypothesis 3a](#). This result is confirmed in Model 3, which is confined to share 16 participants ($p = 0.04$, one-tailed). Although the positive parameter for the interaction

Table 11

Contingency table of prosocial and prosself behavior of share 16 participants across conditions in Study 3.

		Not invest	Invest	Total
Incomplete information	Proself	3	6	9
	Prosocial	5	13	18
Complete information	Proself	7	5	12
	Prosocial	8	7	15

between share 2 and info in Model 1a was predicted by [Hypothesis 3b](#), it is insignificant. Model 4, estimated for share 2 participants only, confirms this result: share 2 participants are not significantly more likely to invest under complete information, contradicting [Hypothesis 3b](#). [Hypothesis 2](#), predicting investment probabilities for share 2 and share 16 participants to be equal under complete information is corroborated, as shown in Model 2. Finally, Model 1a shows that the number of proself answers out of 9 items of the SVO measurement instrument indeed are negatively associated with investment probability ($p = 0.01$, one-tailed).

The hypotheses assuming selfishness on the part of our participants, we again scrutinize whether proself and prosocial share 16 participants differed in their behavior under complete and incomplete information. [Table 11](#) shows the results. Both proself and prosocial share 16 participants are responsible for the drop in investment going from incomplete to complete information. Using Fisher's exact test, the change is insignificant for either group separately ($p = 0.245$ for proselfs, $p = 0.128$ for prosocials, one-tailed), but significant for their combination ($p = 0.049$, one-tailed), confirming the significantly negative parameter for 'Info' in Model 1a of [Table 10](#). The equivalent cross-table for share 2 participants (not shown) reveals no difference in behavior for either prosocials or proselfs across information conditions.

Model 1b in [Table 10](#) adds the contextual efficacy variable. All our hypotheses assume contextual efficacy mediates the effects information and share have on investment behavior. Therefore, we expect the effects of these separate variables to disappear once contextual efficacy is added to the model. Model 1b shows quite the opposite. Although contextual efficacy itself has the predicted positive effect on investment probability ($p = 0.001$, one-tailed), the effect of share on investment probability under complete information is qualitatively the same as in Model 1a. Similarly, the effect of information for share 16 participants is still significantly negative in Model 1b ($p = 0.033$, one-tailed). Moreover, the positive interaction between information and share 2 (estimating the differential effect of complete information for share 2 participants compared to share 16 participants) that was insignificant in Model 1a, is significant in Model 1b ($p = 0.04$, one-tailed). The overall effect of information for share 2 participants is now positive (0.39), but still insignificant (t -score = 0.65). Thus, unexpectedly, we find corroborative evidence for [Hypothesis 1](#) (incomplete information efficacy-cooperation hypothesis) and [Hypothesis 3a](#) (but not 3b), after controlling for contextual efficacy. When adding the contextual efficacy variable to Model 2 of [Table 4](#) (results not shown), share 2 and share 16 participants still do not differ significantly in their investment probabilities, corroborating [Hypothesis 2](#).

Finally, to complete the mediation analysis we look at Model 5 in [Table 10](#), reporting an OLS regression of contextual efficacy on the predictor variables. Model 5 reveals that under incomplete information contextual efficacies of share 2 and share 16 participants do not differ significantly ($p = 0.13$, one-tailed), while the contextual efficacy of share 50 participants significantly exceeds that of share 16 participants ($p = 0.002$, one-tailed). This provides partial corroboration for [Hypothesis 1](#). The effect of complete information is insignificant for share 16 participants ($p = 0.74$, two-tailed), and in the opposite direction as predicted by [Hypothesis 3](#). For share 2 participants the effect of complete information is also in the direction opposite to what is predicted by [Hypothesis 3](#), this time significantly so ($p = 0.02$, two-tailed). Thus, rather than weakening the positive share-efficacy association, as predicted by [Hypothesis 2](#) and [Hypothesis 3](#), complete information has strengthened it.

Finally, once more estimating the probability of SPG production in a randomly composed group yields $p = 0.80$ ($p_2 = 12/31$, $p_{16} = 19/127$, and $p_{50} = 26/32$) and $p = 0.69$ ($p_2 = 11/29$, $p_{16} = 12/27$, and $p_{50} = 24/31$) in the incomplete and complete information conditions, respectively. Thus, information again considerably *decreased* the chances of SPG production (Odds Ratio = 0.56).

5.4. Conclusions of study 3

Study 3 replicated the results of Study 1: under incomplete information we find a positive association between material efficacy (share) and investment probability, which is broken under complete information by share 16 participants having a significantly lower investment probability. Contrary to the assumption underlying all our hypotheses, we did not find that the relationships between share and information on the one hand and contribution behavior on the other are mediated by contextual efficacy. Instead, we found that material efficacy (share) and contextual efficacy are positively associated, regardless of information condition. Moreover, after controlling for contextual efficacy in our statistical model of contribution behavior, we corroborated all three investment hypotheses except [Hypothesis 3b](#). Thus, after controlling for contextual efficacy we found that (i) under incomplete information share and investment probability are positively associated (incomplete information efficacy-cooperation hypothesis), (ii) under complete information investment probabilities of share 2 and share 16 participants cannot be distinguished (complete information efficacy-cooperation hypothesis), and (iii) comparing incomplete to complete information conditions, share 16 participants have a higher investment probability in the former (symmetric equilibrium focal point hypothesis).

These results are incompatible with the reasoning underlying both the efficacy-cooperation hypotheses and the symmetric equilibrium focal point hypothesis. The first assume players only account for contextual efficacy, disregarding strategic considerations (i.e., expected equilibrium behavior of others). The second hypothesis conceives of strategies as maps from shares to investment decisions. To determine their strategy players assume others play a given equilibrium strategy. Observation of the share distribution consequently implies expectations of the behavior of the other players. Given these expectations, players determine their own contextual efficacy. Hence, contextual efficacy controlled for, shares should not

matter. However, the data show that material efficacy has an unmediated effect after contextual efficacy has been included in the model.

6. Overall conclusions

The results reported in this paper have implications for the efficacy concept and its role in determining cooperative behavior in SPGs. First of all, information about the distribution of material efficacy in the group has a significant impact on cooperative behavior. The effects were not constant across our three studies, though. In particular, the data from Study 1 and Study 3 largely conformed with our expectations, especially in the sense that share 16 players were *less likely* to invest under complete information than under incomplete information. We found no such effect in Study 2, however. We cannot explain this difference between our studies to differences in their respective designs, since Study 2 had the same design as Study 3. We therefore attribute the differences in results to sampling error. In fact, concerns about sampling error induced us to conduct three studies in the first place. In addition, although we predicted the effect of material efficacy to be mediated by contextual efficacy, this was not the case. Both sets of results broadly show that distinguishing material from contextual efficacy is important.

The fact that we did not observe contextual efficacy to play its predicted mediating role could be due to invalid measurement of this concept. The validity of our measurement of contextual efficacy (in Study 3) hinges on our assumption that participants take the information they have about the share distribution into account, when answering the three measurement questions. To the extent that they do not, ours is not a valid measurement of efficacy. Since our manipulation of information itself did affect behavior in two of our three studies (including Study 3), we are confident that participants were aware of the information they had about the share distribution and that they did account for it in assessing their own contextual efficacy. However, the prediction of mediation by contextual efficacy was further predicated on the theoretical assumption that participants take the information about the share distribution into account *according to the complete information version of the efficacy – cooperation hypotheses* (H2). That is, we predicted that upon learning the actual share distribution, share 2 and share 16 participants would realize they were in fact equally efficacious, despite their differing material efficacies. This was evidently not the case, since revealing the share distribution made share 2 participants' contextual efficacy assessments significantly *lower* than share 16 participants' contextual efficacy assessments, and the latter assessments were unaffected by the information condition. Thus, while maintaining that it was in fact contextual efficacy that we measured, we attribute the absence of the predicted mediation to the fact that it is not well understood how players account for information about the share distribution when assessing their contextual efficacy. We readily concede that this is speculation on our part and that we cannot at the moment be entirely sure that our contextual efficacy measurement is in fact valid.

Secondly, building on the previous point, our results reveal that more theorizing and experimental testing are needed to clarify the exact roles played by these distinct efficacy concepts. Our data suggest that contrary to what both the efficacy – cooperation hypothesis and game theory predict, information on the material efficacy distribution enters players' consideration at two distinct points in the decision process. Knowledge of the material efficacy distribution first forms the basis of contextual efficacy assessments. Over and above this influence, however, material efficacy appears to have a 'lingering effect' on decisions, manifested by two patterns on our results: (i) even though complete information about the share distribution reveals to share 2 and share 16 players that their contextual efficacies are identical, share 2 players are still *less likely* to invest in Study 2, and (ii) in Study 3, under complete information share 2 players have a *significantly lower* contextual efficacy than do share 16 players. We speculate that this lingering effect is due to the numeric nature of the material efficacies in our studies. Thus, simply because on a scale from 0 to 50, 2 is 'much lower' than 16, share 2 players feel they are much less efficacious than do share 16 players, even though in the particular context of the current share distribution, their contextual efficacies are equal. We hypothesize that this lingering effect will disappear if material efficacy is presented in non-numeric form, all else being equal. We will test this hypothesis in a second paper, using the data we have on the SPG games that used letter labels. This is an important topic in itself, since in real-life cases, such as the community example of this paper, efficacies can rarely (entirely) be expressed in numeric form.

Third, our studies show that providing information on the material efficacy distribution can affect the probability of SPG production. While the odds increased by 1/3 in Study 1, they were virtually cut in half or even cut in three in Study 3 and Study 2, respectively. Overall, more accurate information on the distribution of material efficacies appears to have made the coordination problem inherent in the SPG more salient for the participants, and therefore harder to solve, at least in Studies 2 and 3. We speculate that the difference between Study 1 on the one hand, and Study 2 and Study 3 on the other might have to do with the online nature of the latter two studies. Contrary to these studies, in Study 1 participants were physically present and although they were prevented from communicating, the actual presence of others may have had the effect of making coordination slightly easier.

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