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Multiple motives of pro-social behavior: evidence from the solidarity game

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Abstract The article analyses experimental "solidarity games" with two benefactors and one beneficiary. Depending on their motive for giving—e.g., warm glow, altruism, or guilt—the benefactors' response functions are either constant, decreasing, or increasing. If motives interact, or if envy is a concern, then more complex (unimodal) shapes may emerge. Controlling for random utility perturbations, we determine which and how many motives affect individual decision making. The main findings are that the motives of about 75% of the subjects can be identified fairly sharply, that all of the motives discussed in the literature co-exist in the population, and that for any given individual no more than two motives (out of six motives considered overall) are identified. We conclude that a unifying motive for solidarity cannot be derived even when we allow for individually heterogeneous parameterization: different subjects give for different reasons and all existing social preference theories are partially correct.

Keywords Social values · Individual differences · Solidarity game

JEL Classification D64 · C72 · C92

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1 Introduction

Contributions to charitable organizations amount to 1.8% of the GDP in the United States and to about 0.7% in countries such as Canada and Great Britain. The contributions are of obvious relevance for the recipients, and for this reason, many studies investigate why people contribute. Furthering our knowledge about the reasons of "solidarity" may then allow charitable organizations to design improved contribution mechanisms. Early studies (e.g., Kingma 1989, and the studies cited therein) argued that contributing people are altruistic in the sense that they view the aggregate contributions as a public good. Donators that are altruistic in this sense reduce their contributions if third parties (most notably, the government) increase their contributions.[1] An alternative point of view is that people contribute due to warm glow (Andreoni 1995; Andreoni and Scholz 1998), and then individual contributions are independent of those of third parties. Finally, we can often observe that seed money attracts private contributions, i.e., that individual contributions are increasing in those of third parties. This may be a consequence of "guilt" or "conditional co-operation" (Fischbacher et al. 2001), or of initially increasing returns to scale (Andreoni 1998; Brooks 2000) and incomplete information (Andreoni 2006).

Clearly, the contribution mechanism optimally chosen by a fund raiser and the behavior of the government depend on whether individual contributions are decreasing, constant, or increasing in those of third parties, and more generally they depend on the individual motives for giving. In this article, we introduce an econometric framework to identify individual motives and then use experimental data to investigate whether individual motives are sharp indeed and whether the alternative motives discussed in the literature co-exist. If this turns out to be the case, i.e., if the individual motives for giving are sharp and heterogeneous, then sequences of funding campaigns targeted at specific motives may be optimal.

In order to identify the individual motives underlying charitable contributions, we therefore conducted a controlled experiment on solidarity in three-person "societies." To be precise, we investigate a subgame of the original "Solidarity Game" (Selten and Ockenfels 1998) that can be summarized as follows: two players (the benefactors) receive €10, one player (the beneficiary) receives nothing. The benefactors may donate an amount of their choice to the beneficiary, and we ask all subjects: assuming your co-benefactor donates x_k, how much would you donate? We do so for a variety of x_k and thus elicit the very response functions $x_i(x_k)$ that are the topic of debate in the studies mentioned above.

If the subject is egoistic, then the response is $x_i = 0$ for all x_k. The response is a positive *constant* $x_i = c$ for all x_k if she gives due to warm glow. Further, x_i is *decreasing* in x_k if she is altruistic (slope $= -1$) or feels guilt (slope $= -1/2$) toward the beneficiary (as explained below), and x_i is *increasing* in x_k if she donates due to guilt toward her co-benefactor. (Envy toward either beneficiary or co-benefactor

[1] Much of the literature (Khanna and Sandler 2000; Okten and Weisbrod 2000) refer to "crowding out" if government spendings induce a decline of individual contributions and to "crowding in" if government spendings attract individual contributions. "Crowding out" can also be observed by purely selfish players in *non-linear* public goods games, see e.g., Bergstrom et al. (1986) and Bernheim (1986).

would cap her donations, in turn.) Based on response functions in solidarity games, we may thus separate differently motivated subjects rather sharply.

In contrast, this is not possible based on standard dictator games. If the dictator's only motive is self-interest, she would keep everything. Any positive donation, in turn, can be explained by a variety of motives after simple parametric adaptations of the utility function. A modest separation of motives can be achieved by varying the transfer rates in dictator games (see e.g., Andreoni and Miller 2002; Tan and Bolle 2006 and Cox et al. 2007), but primarily, this allows us to identify elasticities of substitution (between individual incomes) rather than the underlying motive. However, this distinction is central to the understanding of solidarity. Elasticities of substitution can be identified if the set of utility relevant commodities is known, but the existing literature disagrees on which "commodities" are utility relevant in laboratory giving. Is it the amount being transferred in theories of warm glow giving (Arrow 1972; Andreoni 1995), the pecuniary payoff of the recipient in altruism, or a payoff difference with respect to co-players in theories of inequity aversion (Fehr and Schmidt 1999)? As indicated, response functions in the two-benefactor solidarity game allow the identification of the relevant "commodities," and thus a distinction of the respective motives.

Due to our focus on identifying the utility relevant commodities, we will be unable to relate explicitly to all of the utility functions defined in the literature. As it turns out, however, many proposed utility functions are included nonetheless. "Beckerian" altruism (Becker 1974) is behaviorally equivalent to standard altruism in the solidarity game, Bolton and Ockenfels (2000) inequity aversion is behaviorally equivalent to warm glow giving here, and reciprocal altruism (Levine 1998) is behaviorally equivalent to normal altruism (as benefactors have no information about others' altruism). Preferences for efficiency are a special case of altruism, too, and as such they are irrelevant here, as the aggregate payoff is fixed. Maximin/Rawlsian preferences (Charness and Rabin 2002; Engelmann and Strobel 2004) can be regarded as a special variant of inequity aversion in our context, and conditional co-operation (Bolle and Ockenfels 1990; Keser and Van Winden 2000; Fischbacher et al. 2001; Frey and Torgler 2004; Croson et al. 2005) is implied by the guilt motive of inequity aversion in the solidarity game.

This wealth of cross-references highlights the need to break down the existing concepts into their defining "commodities" and to re-express them in elementary utility relevant terms. This will allow us to understand the cross-references, i.e., parallelism of behavior across games, as well as the sources of behavioral heterogeneity between subjects and across games.

In our analysis of solidarity games, we find that individual motives can be identified indeed, and even so sharply (in a sense to be made precise) for 75% of the subjects. All motives discussed in the literature are valid in that each of them influences donations of a share of the subjects. This underlines heterogeneity of subjects on the most basic of levels—their utility functions have heterogeneous domains—and calls attempts to express heterogeneity parametrically (via elasticities and weights) into question.

A number of previous studies have estimated utility functions for laboratory giving, see e.g., Levine (1998); Fehr and Schmidt (1999); Bolton and Ockenfels (2000); Tan and Bolle (2006), and Fisman et al. (2007), but none of them discriminate motives as finely as it is done below. Other studies, e.g., Kritikos and Bolle (2001); Kagel and

Wolfe (2001); McCabe et al. (2003); Güth et al. (2003), and Engelmann and Strobel (2004), provide evidence that single motives (usually inequity aversion) cannot explain social behavior in all contexts. Our experiment strengthens this evidence by specifying the various motives at work and by showing that different subjects have different motives. Also, in contrast to this literature, we control for deviations from utility maximization due to random utility perturbations. Finally, Frohlich et al. (1987), Andreoni and Miller (2002), Cox et al. (2007), Cappelen et al. (2007), Herne and Mard (2008), among others, discuss subject heterogeneity in terms of both elasticities of substitutions and weights between own payoffs and opponent payoffs. Similar to these studies, we control for elasticities and weights, but we additionally allow for the possibility that other "commodities" but the recipients' payoff are utility relevant.

Section 2 defines the experimental game and describes the logistics. Section 3 presents a first look at the results, based on which a family of utility functions is introduced and discussed in Sect. 4. Section 5 describes the identification procedure and Sect. 6 discusses the identification results. Section 7 concludes.

2 The experiment

2.1 The solidarity game

Our experiment covers a subgame of the solidarity game originally defined by Selten and Ockenfels (1998, SO hereafter). In the game SO considered, three players are allocated endowments by i.i.d. random draws (DM 0 with probability 1/3 and DM 10 with 2/3). The players that had been allocated DM 10 are then asked how much they wish to donate to those that had been unlucky (if there are any). The benefactors choose donations contingent on the initial endowments, i.e., how many co-benefactors there are, and they simultaneously choose the amounts they donate.

We focus on the subgame with one beneficiary and two benefactors. The outcome of this game is equivalent to the outcome of the respective subgame in SO's game if subjects act in a manner that is compatible with backward induction, e.g., by playing a sequential equilibrium (Kreps and Wilson 1982) or an agent quantal response equilibrium (McKelvey and Palfrey 1998). Deviations from backward induction may result due to framing effects, for example. Evidence for such deviations have not been found in our experimental data, however, i.e., the transfers in our game are similar to those observed in SO's subgame (see below).

While SO's analysis treats the solidarity game as a collection of independent decisions, our analysis treats it as a three-player interaction, which requires a game theoretic analysis. In specific, since we explicitly allow for non-additive social preferences with respect to the co-benefactor's choice, the optimal choice of the benefactor has to be treated as strategic. This also shows how the two-benefactor solidarity game generalizes the one-benefactor dictator game.

In total, the subjects made four (sets of) decisions throughout the experiment. The first two decisions are used to compare the results of our experiment with the results of the respective subgames in SO and Büchner et al. (2007).

(a1) What do you give without knowing what the other owner of Euro 10 will give?
(a2) What do you expect the other owners of Euro 10 to give on average?
The answers are denoted as x^a and e, respectively, in the following. We then asked the subjects to fill in a table, effectively yielding their response function.
(b) What do you give if you know what the other owner of Euro 10 will give?
The answers are called $x^b(x^{\text{other}})$ in the following where x^{other} denotes the co-benefactor's donation. The strategy method was used, i.e., the subjects were asked for their donation in response to 12 cases of x^{other}. These 12 cases consist of the extreme points 0 and 10 and the 10 intervals $(0, 1), [1, 2), \ldots, [9, 10)$.

Finally, we asked how much the subjects would donate as "Stackelberg leader."

(c) What would you give if the other owner of Euro 10 was informed about your gift in advance?

The answers to this question will not be analyzed in the following,[2] but asking (c) is required as part of the pay out procedure for our main question (b).

2.2 Logistics of the experiment

The experiment was conducted at the Europa Universität Viadrina in Frankfurt (Oder), Germany. In classroom experiments, 150 first-year students were randomly divided into groups of three, one "beneficiary" who got nothing and two "benefactors" who had been endowed with €10 each. They were not called benefactors and beneficiaries in the experiment. The subjects were positioned such that at least one seat to the right and one seat to the left were empty. They were instructed that it was strictly forbidden to communicate with each other. Neither the subjects nor the two experiment monitors knew which subjects belonged to a group.

After short verbal instructions, every subject received a sheet of paper with a code number (already filled in) and a space to fill in a pseudonym to be chosen by the subject. The front pages of the sheets of paper restated the instructions and gave the information "you have received Euro 10 (or 0)."[3] On the back page, the benefactors were asked to make the decisions described above. The subjects were informed that the payoff relevant action was chosen randomly group-by-group, namely as to whether the answers to question (a1) are relevant or the answers to questions (b) and (c).

The English translations of the instructions and decision forms as well as the complete data set are provided as supplementary material. Once all subjects had made their decisions, their forms were collected. Several days later, the subjects received their earnings (after giving their code number and pseudonym) from a secretary who was otherwise not involved in the experiment.

[2] An earlier draft that contains the analysis is available from the authors.

[3] The beneficiaries' front page contained the information that they had received nothing. They were then asked what they expected to get from their co-players. In addition, they were asked how they would have decided if they had received €10. The back page was the same as the benefactors' back page. The beneficiaries' hypothetical decisions are not analyzed.

3 Overview of the results

The average "uninformed" donation x^a of the subjects in our experiment is 23% of the endowment. This is slightly but insignificantly less than the donations observed by SO. Overall, the average results in our experiment are rather close to the weighted average of SO and Büchner et al. (2007), hereafter BCG. In relation to SO, the subjects in our experiment stated significantly higher expectations e, but in this case, the difference between actual donations and expected donations (which is significant at the 5% level) is about as large as in the BCG experiments. These comparison suggest that our observations do not exhibit significant biases in relation to either SO or BCG.

The rank correlation coefficient between gifts and expectations of what others give is 0.58 in SO, while we find only 0.25. However, these correlation coefficients are rather sensitive to outliers. Our data feature three cases of zero gifts accompanied by "frivolous" expectations of a gift of €10 by the other benefactor.[4] Without these three cases, the correlation coefficient rises to 0.52, about the level observed by SO. Aside from this, our data confirm SO's observation that many subjects give €5 and expect that the other benefactor gives €5. This seemed surprising to SO, as the consequence is that the benefactors end up with €5 each, while the beneficiary gets €10. SO's explanation is that these subjects use the strategy "fixed gift per loser" in both of their subgames, i.e., in the one-benefactor case (where giving 5 seemed more reasonable to SO) and in the two-benefactor case. After replicating their result in the pure two-benefactor case, we can infer that confusion over subgames is probably not the reason.

Figure 1 provides a detailed look at the stated response functions. Figure 2a is a bar plot of the donations in response to the various levels of the co-benefactor's donation. It shows that in response to co-benefactor's donations x_k in the range $0 < x_k < 7$, donations between 0.01 and 3.3 are most common, while zero donation is most common otherwise (i.e., in response to 7 and in response to donations greater than 7). Figure 2b classifies the individual responses into constant, increasing, decreasing, quasi-concave, quasi-convex, and other functions. This shows that the subjects are distributed fairly uniform over these categories. The exceptions are that "quasi-convex" has just two instances and "decreasing" is doubly populated.

The following section will investigate the shapes of response functions implied by specific motives. The main finding will be that the four basic shapes—constant, increasing, decreasing, and quasi-concave—cannot be obtained as special cases of a single motive. Differently shaped response functions are reported by differently motivated subjects, and thus Fig. 2b provides a first look at the separation of motives induced in the two-benefactor solidarity game.

4 Best response functions implied by social preferences

4.1 The family of utility functions

The utility of benefactor i is a function $u_i : \mathbb{R}^3 \to \mathbb{R}$ that maps the payoff profiles into the reals. The payoff profiles are denoted as $\pi = (\pi_i, \pi_j, \pi_k)$ with the following

[4] These three subjects do not give anything in all parts of the experiment.

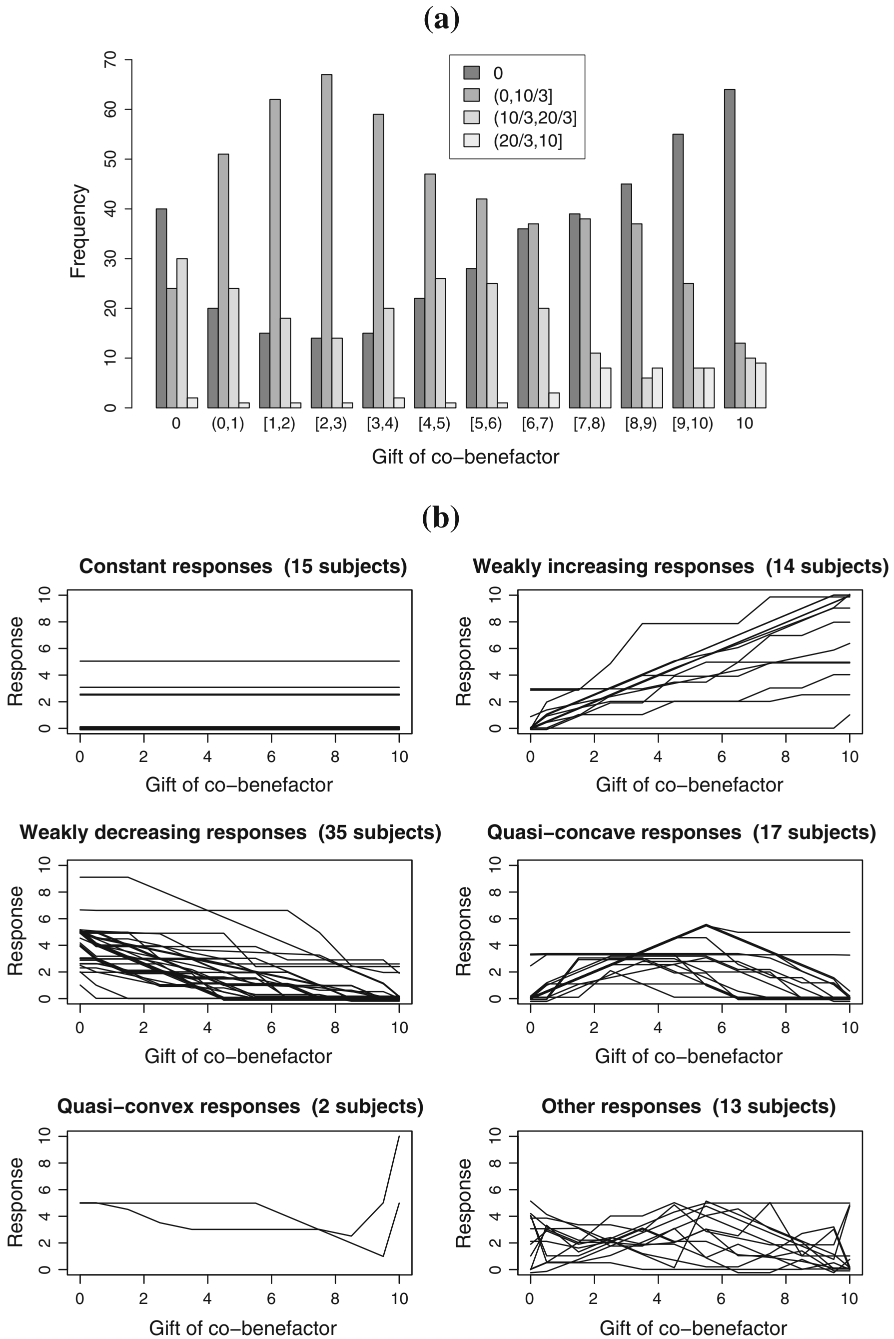

Fig. 1 Stated responses in the two-benefacor: An overview. *Note* The response functions had been individually shifted (by an i.i.d. constant with $\sigma = 0.08$) to facilitate their distinction. A response function is classified as weakly increasing/decreasing only if the response is not constant, and as quasi-concave/-convex only if it is not weakly monotonic

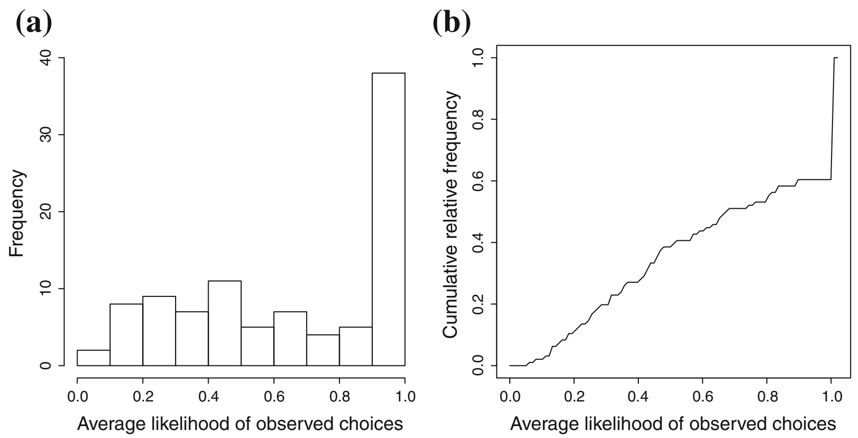

Fig. 2 Precision of the fitted utility models. **a** Histogram of fit accuracies; **b** Cumulative distribution of fit accuracies

notational convention: π_i is the payoff of the benefactor in question, π_j is the beneficiary's payoff, and π_k is the co-benefactor's payoff. In general, the utility may depend on the following "commodities:" i's own payoff π_i, the beneficiary's payoff π_j (altruism), the amount being transferred $10 - \pi_i$ (warm glow, see Arrow 1972; Andreoni 1995), the non-positive differences $\min\{0, \pi_i - \pi_j\}$ and $\min\{0, \pi_i - \pi_k\}$ (envy toward j or k), and the non-negative differences $\max\{0, \pi_i - \pi_j\}$ and $\max\{0, \pi_i - \pi_k\}$ (guilt toward j or k). We do not include the co-benefactor's payoff π_k as a commodity, as its quantity would not affect i's decision in our case (as it is independent of i's decision). Our task will be to determine which of these commodities are utility relevant for the individual subjects.

The social commodities, i.e., all but i's own payoff π_i, are bundled using a CES aggregator similar to the one used by Cox et al. (2007).[5] The elasticity of substitution between i's own payoff and the social commodity bundle is normalized to 1. This could be generalized by using a nested CES aggregator, from which we abstain. Finally, we invert the guilt components by subtracting their value from 10 to obtain "goods" in the traditional sense (rather than "bads"), which allows us to bundle them conventionally. To avoid numerical instability, we add 1 to all quantities. This yields the following family of utility functions[6]:

$$
\begin{aligned}
u_i(\pi) = (1+\pi_i) + \big[&\alpha \cdot (1+\pi_j)^\rho + \beta \cdot (11-\pi_i)^\rho \\
&+ \gamma_1 \cdot (11 + \min\{0, \max\{-10, \pi_i - \pi_j\}\})^\rho + \gamma_2 \cdot (11 + \min\{0, \pi_i - \pi_k\})^\rho \\
&+ \gamma_3 \cdot (11 - \max\{0, \pi_i - \pi_j\})^\rho + \gamma_4 \cdot (11 - \max\{0, \pi_i - \pi_k\})^\rho\big] / \rho
\end{aligned}
$$

[5] Cox et al. (2007) did include i's payoff π_i into the CES aggregator, since they aimed to estimate the elasticity of substitution between the players' payoffs. We, on the contrary, seek to estimate the elasticity of substitution between the social commodities (the motives), and hence do not include π_i.

[6] The envy toward j, i.e., $\min\{0, \pi_i - \pi_j\}$, is capped at -10, so as to ensure that the "quantities" of all social commodities range from 0 to 10 (i.e., from 1 to 11 after adding 1).

In this utility function, γ_1 and γ_2 are coefficients on envy terms, and γ_3 and γ_4 are coefficients on guilt terms, as explained below. Within the social commodity bundle, the aggregation may be linear ($\rho = 1$), Cobb–Douglas ($\rho = 0$, see Cox et al. 2007), Leontief ($\rho \to -\infty$), and anywhere in-between these special cases. Note that the Cox et al. (2007) CES aggregator adopted here normalizes by multiplication with $1/\rho$, rather than by exponentiation. In our case, where i's own payoff π_i is not included in the aggregation, normalization by multiplication allows for non-linear influence of social commodities even if subjects are concerned with only one of them.

The interplay of the basic commodities gives rise to the more complex forms of behavior discussed in the literature. For example, $\gamma_1 = \gamma_2 > 0$ and $\gamma_3 = \gamma_4 > 0$ enacts inequity aversion as defined by Fehr and Schmidt (1999). Guilt toward the co-benefactor ($\gamma_4 > 0$) induces "imitating" donations (i.e., that one would not want to be the one who has more left), and in combination with warm glow it induces the more general form of conditional co-operation. Efficiency concerns (Kritikos and Bolle 2001; Güth et al. 2003) follow from $\alpha = \rho = 1$. Inequity aversion as defined by Bolton and Ockenfels (2000), in turn, is a special case of warm glow in the solidarity game. To see this, recall that their definition relies on the quotient (own income)/(aggregate income) and that the aggregate income is constant in the solidarity game. Maximin preferences (Charness and Rabin 2002; Engelmann and Strobel 2004) over all payoff profiles are not included in the above specification, but for $\rho \to -\infty$ we obtain maximin preferences over the social commodities.

Finally, let us note that alternative functional forms could be used and that other motives (i.e., meta-motives such as inequity aversion and norm driven giving, where the co-benefactor's donation establishes the "norm") could be introduced. However, as far as the distinction of elementary social commodities is concerned, the list of items introduced above is fairly exhaustive in solidarity games. That is, most (meta-) motives discussed elsewhere can be represented as convex combinations of altruism, warm glow, envy, and guilt in solidarity games, and as we see next, these basic motives can explain all relevant types of response functions.

4.2 The best response functions

Table 1 summarizes the response functions of players with pure motives.[7] If the players are altruistic ($\alpha > 0$), then the solidarity game exhibits strategic substitutes. In fact, the response functions are decreasing with slope -1. For, if the beneficiary's income counts, then the more the co-benefactor k gives, the less i has to give to bring the beneficiary to the level where the MRS equals -1. In our case, $\pi_j = \alpha - 1$ obtains, and implicitly altruistic benefactors ensure that the beneficiary reaches a certain minimum income. If the players experience warm glow from giving ($\beta > 0$), then the co-benefactor's contribution is irrelevant. In this case, the response functions are constant.

The envy motive (γ_1 and γ_2) does not induce giving on its own, but it caps donations made for other reasons. This is discussed in more detail below. Guilt toward the

[7] The supplementary material contains the (straightforward) formal derivation.

Table 1 Response functions of players with pure motives ($\rho \to 0$ without loss)

Motive (besides egoism)	Parameters > 0	Response function $x_i(x_k)$	Classification
None		$x_i = 0$	
A: altruism	α	$x_i = \alpha - 1 - x_k$	Decreasing response
W: warm glow	β	$x_i = \beta - 1$	Constant response
EB: envy toward beneficiary	γ_1	$x_i = 0$	
EC: envy toward co-benefactor	γ_2	$x_i = 0$	
GB: guilt toward beneficiary	γ_3	$x_i = \min\{5, \gamma_3 - .5\} - x_k/2$	Flatly decreasing response
GC: guilt toward co-benefactor	γ_4	$x_i = x_k - \max\{0, 11 - \gamma_4\}$	Increasing response

In addition to above, all donations are bounded below by zero and above by ten. Notation: x_i = own donation, x_k = co-benefactor's donation. Thus, $\pi_i = 10 - x_i, \pi_j = x_i + x_k, \pi_k = 10 - x_k$

beneficiary ($\gamma_3 > 0$) is rather similar to altruism, in the sense that the co-benefactor's donations x_k alleviate one's guilt and act as a substitute for own giving x_i, but in the case of guilt, x_k is not a perfect substitute for the own donation x_i. The slope of the response function of players giving due to guilt is $-1/2$ rather than -1. To see why, note that increasing the own donation by Δx_i decreases the difference $\pi_i - \pi_j$ by $2 \cdot \Delta x_i$, whereas $\Delta x_k > 0$ decreases $\pi_i - \pi_j$ by $1 \cdot \Delta x_k$. The experience of guilt toward the co-benefactor ($\gamma_4 > 0$), finally, induces a solidarity game that exhibits strategic complements—increasing response functions with slope $+1$. A player in this case would not want to appear cheap, or for intermediate values of γ_4, she would not want to appear too cheap. Given γ_4, i would donate such that the difference of payoffs after donations, $\pi_i - \pi_k$, equates with $11 - \gamma_4$.

The six basic motives thus yield three of the basic shapes of response functions, namely constant, decreasing, and increasing responses.[8] Interestingly, decreasing response functions are induced by either of two distinctive motives, altruism and guilt toward the beneficiary, whereas the other shapes are induced by just one motive each. This nicely corresponds with the observation (recall Fig. 2b) that there are twice as many subjects with decreasing response functions as there are for either constant or increasing responses. Needless to say that this may just be a coincidence and requires further analysis.

Finally, let us show how the combination of basic motives may yield quasi-concave response, which is the fourth basic shape identified in Fig. 2b. Consider a player with $\gamma_1, \gamma_4 > 0$. She does not want to appear cheap (guilt toward k) but does not

[8] In many fields, additional labels are attached to increasing and decreasing responses. For example, in industrial economics, a game exhibits strategic substitutes or strategic complements if the response functions are decreasing or increasing, respectively, contributions to public goods may exhibit "crowding out" and "crowding in" in these cases, and the latter has also been called conditional co-operation. Such binomial labeling is insufficient in our case, since at least constant and quasi-concave responses would have to be named, too, to cover all systematically behaving types. For this reason, we stick to the widely established labels of decreasing, increasing, constant, and quasi-concave responses.

want to see j getting too much either (envy toward j). She matches k's contribution until $\pi_i = \pi_j = \pi_k$, but then the envy sets in and she reduces her contribution again—balancing envy and guilt according to the ratio of their weights. The result is a quasi-concave response with peak at $x_k = 10/3$ and slope $+1$ initially and about $-1/2$ eventually. Alternatively, consider a player with $\alpha, \gamma_2 > 0$. She is altruistic toward j but does not want to see her co-benefactor k being much better off than herself (envy toward k). She would like to give j quite a lot, but due to her envy toward k, she merely matches k's donation—until her altruistic target $\pi_j = \alpha - 1$ (see above) is reached, beyond which donations of k are perfect substitutes for her donation. Now, the result is a quasi-concave response with peak at $(\alpha - 1)/2$ and slopes $+1$ initially and -1 eventually.

It will be clear that further combinations are possible, but the previous two examples are the most relevant cases for quasi-concave responses in light of our data. Further cases will be discussed as need arises in the type specification following below. In any case, the basic theme is that quasi-concavity is indicative of envy being a limitation for a positive motive of giving (e.g., guilt or altruism). This may either be envy toward the beneficiary j (which takes effect in response to high x_k) or envy toward the co-benefactor (which takes effect in response to low x_k). Peak as well as slopes of the response function allow us to infer which kind of envy shapes a subject's behavior, but in general a unique identification of a mixture of motives may be impossible. Our identification strategy is described next.

5 Identification procedure

Several issues are to be specified in addition to the utility function. Let us begin with how we handle noise. Clearly, a fair share of subjects do not choose donations in a way that is rationalizable by any utility function, i.e., some subjects do not always pick best responses. There are several points at which noise might enter their choice procedure, but the most common approaches of modeling noisy choice are known as "random behavior" and "random utility." Models of random behavior tend to be used when the choice set is continuous, while models of random utility tend to be used when the choice sets are finite and of low cardinality or qualitative. Well-known examples are linear regression models and logit/probit regression models, respectively. Choices in dictator and solidarity games seem to be between these two regimes. On the one hand, we did not restrict the choice sets to full Euros, and expressed in Cents subjects had 1,001 choices, which makes the choice set practically continuous. On the other hand, the subjects did not exploit this high cardinality. Most responses are either in full 1-Euro steps or in 50-Cent steps, which reduces the number of relevant choices to either 11 or 21. Such cardinality, in turn, seems sufficiently low to use a random utility model rather than a random behavior model.

This argument in favor of random utility modeling has been made similarly by Cappelen et al. (2007), for example, but other scholars disagree and propose models of random behavior (e.g., Fisman et al. 2007 and Conte and Moffatt 2009). Arguably, the main advantage of random utility modeling is the implication that costly deviations from the best response are less likely than cheap deviations, whereas random behavior implies that more distant deviations are less likely than less distant deviations. These two aspects of deviations from the best response (costs and distance) are not entirely uncorrelated, but it will be clear that they are not identical, and experimental evidence suggests that the cost aspects dominate (see e.g., the optimization premium reported by Battalio et al. 2001). For these reasons, we follow the proponents of random utility modeling. For an early survey of random utility models, see e.g., McFadden (1984), and for an early application to game theory, see McKelvey and Palfrey (1995). Note that random utility models, usually multinomial logit models, have been applied successfully even to games with continuous action sets (e.g., Anderson et al. 1998 and Crawford and Iriberri 2007).

To define the basic model, let $X_i \subset \mathbb{R}$ denote the (finite) choice set of i and let $\pi(x_i|x_k) \in \mathbb{R}^3$ denote the payoff profile that results if i chooses x_i in response to x_k. Thus, i's utility is

$$v_i(x_i|x_k) = u_i\big(\pi(x_i|x_k)\big) + \varepsilon/\lambda, \tag{1}$$

with λ as a scale (or precision) parameter and ε as the random utility component. If ε is normally distributed, the probit model of choice results (for a recent application, see e.g., Conte et al. 2011), but in case more than two choices are available, the (convenient) standard assumption is that ε is extreme-value distributed. This assumption implies multinomial logit responses with the following choice probabilities.

$$\sigma_i(x_i|x_k) = \mathrm{e}^{\lambda \cdot u_i\left(\pi(x_i|x_k)\right)} \Big/ \sum_{x_i' \in X_i} \mathrm{e}^{\lambda \cdot u_i\left(\pi(x_i'|x_k)\right)} \tag{2}$$

This choice function is a special case of the "quantal response" model (McKelvey and Palfrey 1995), a parametric relaxation of the best response assumption, and will be the basis of our analysis.

Next, we specify the choice sets. Almost all of the choices made by the subjects are well approximated as having been made on either a €.33 grid, a €.50 grid, or a €1 grid. There are exceptions, but there does not seem to be a point in modeling that a subject chose 2.51 instead of 2.50, for example. Similarly, there is no gain in modeling the grid choice of a subject, and for this reason, we will assume that a given subject operated on the simplest grid (out of the three mentioned above) that is closest to the actual choices under the maximum norm.

It remains to specify how we estimate the model dimension, i.e., how the individually relevant motives are identified. The family of models defined above has eight parameters, λ, ρ and α, β, $\gamma_1, \ldots, \gamma_4$, and we seek to determine which are significant. Our analysis adopts the "general-to-simple" approach toward model selection. For each subject, we first estimate the full-dimensional model and determine whether a parameter may be eliminated without inducing a significant drop of the likelihood (in a likelihood ratio test at the .01 level). We consider the parameters for elimination in the order of their (absolute) t-statistics, starting with the lowest $|t|$ and using standard deviations derived from the information matrix. We eliminate the first parameter that does not induce a significant drop of the likelihood. The procedure ends if no such parameter exists, and otherwise a new round follows using the lower dimensional, re-estimated model.

In general, the general-to-simple approach is more robust than the simple-to-general approach (Greene, 2003, p. 148ff), at the cost of being more time consuming. In every case, the parameters are estimated by maximizing the full likelihood jointly over all parameters using the Nelder–Mead algorithm (which again is robust at the cost of being time consuming), which is restarted repeatedly to ensure convergence.

6 Results and discussion

Figure 2 depicts the histogram and the cumulative distribution of the goodness-of-fits attained in the estimated models. The goodness-of-fit of logit models is given by their log-likelihood, but to be able to interpret the numerical results, we normalize the log-likelihood as follows. Let $\widehat{LL}_i$ denote the maximized log-likelihood of the model for subject i. Thus, $\hat{L}_i = \exp\left(\widehat{LL}_i\right)$ is the likelihood and $\hat{l}_i = \left(\hat{L}_i\right)^{1/12}$ is the average likelihood over the 12 choices (i.e., the geometric mean over the 12 fitted choice probabilities). If $\hat{l}_i = 1$, then the estimated model attains a perfect fit (i.e., the subject plays *best* responses according to the fitted utility function). If $\hat{l}_i < 0.1$, then the observed choices are not related systematically to the six social commodities considered in this study. Such cases are comparably rare and generally related to response functions that are neither monotonic nor quasi-concave. Primarily, these are the 15 quasi-convex or "other" responses in Fig. 2b.

As can be seen in Fig. 2, about 40% of the subjects play best responses according to some utility function. The accuracies of the remaining 60% are distributed largely uniformly on (0, 1) in terms of their average likelihood. This can be seen best in the histogram, but also in the largely constant slope of the cumulative distribution, and constitutes an interesting piece of information for researchers aiming to model subject heterogeneity in choice precisions: there is a sense in which choice precision may be uniform, namely if measured in terms of the average likelihood rather than the precision parameter λ. Representing precision heterogeneity solely in terms of λ is inappropriate in our case, as different subjects may have different ρ and hence differently scaled utility functions, while the logit response precisions are not scale invariant.[9]

In the following, we say that the estimated model fits a subjects' choices "reasonably well" if the average likelihood satisfies $\hat{l}_i \geq 1/3$. Loosely speaking, if this threshold is met, then the model achieves to reduce the initial range of (at least) 11 choices to a subset of three choices from which a given donation is picked. This threshold is natural, as it allows for average deviations of ± 1 on the subjects' grid. If the fitted model repeatedly fails to stay within this bandwidth, then the choices will be considered "irregular" in relation to our model family.

Figure 3, finally, classifies the subjects' response functions according to the estimated motives. It focuses on subjects with at least one significant motive whose

[9] Parametric distributions of λ have been shown, however, to work in a number of other contexts, e.g., a Gamma distribution in Kübler and Weizsäcker (2004).

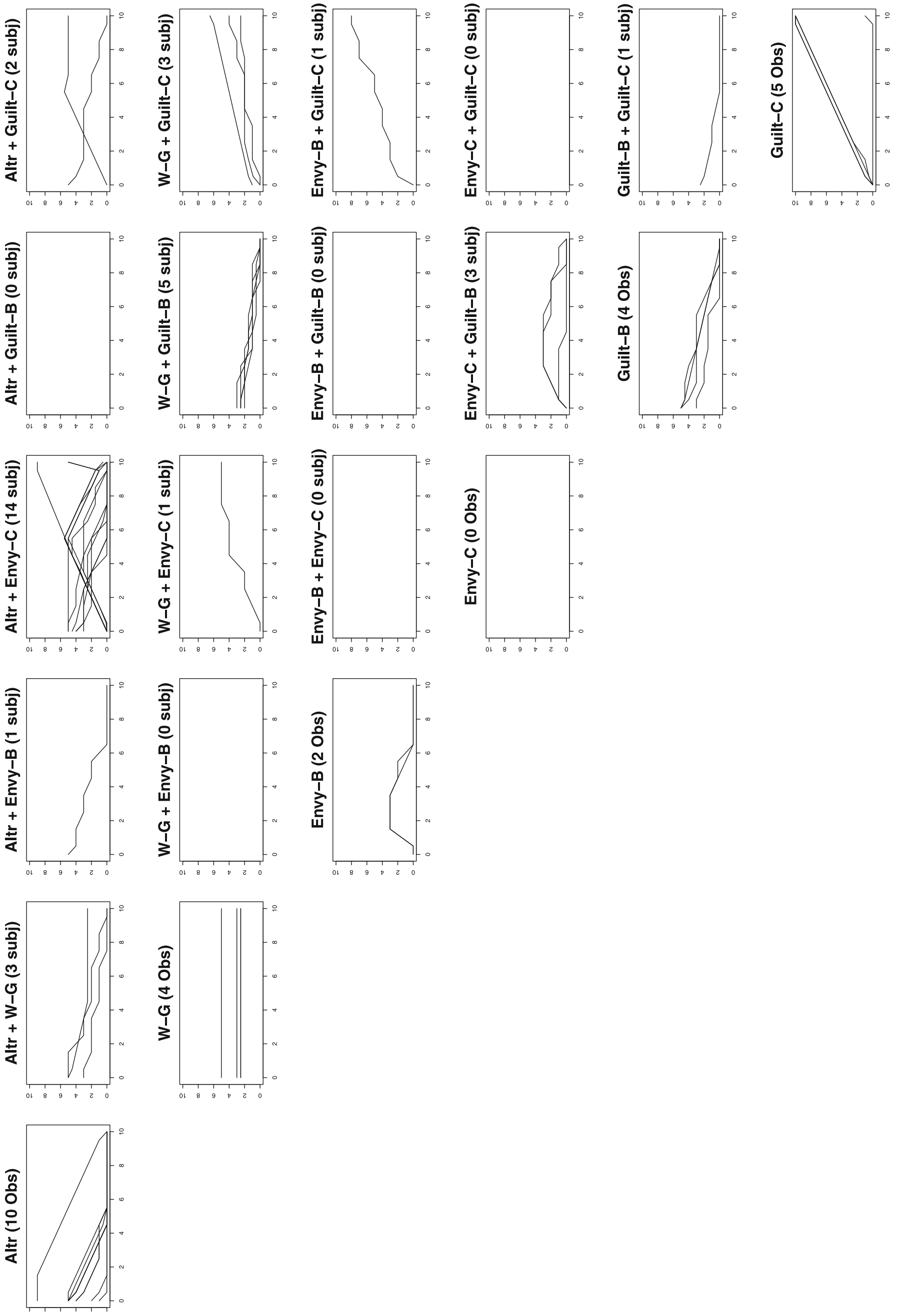

Fig. 3 Classification of response functions with average likelihood of at least 1/3. *Altr* altruism, *W-G* warm glow, *Envy-B* envy toward beneficiary, *Envy-C* envy toward co-benefactor, *Guilt-B* guilt toward beneficiary, *Guilt-C* guilt toward co-benefactor. In addition, there are 13 subjects classified as purely egoistic (no social motive, but $\hat{l}_i \geq 1/3$), two subjects with three motives and $\hat{l}_i \geq 1/3$, and 22 subjects with responses that are unsystematic in the sense $\hat{l}_i < 1/3$.

response functions are fitted "reasonably well" (as described in the previous paragraph).[10]

The main results can be summarized as follows. First, the overall fit can be considered to be good.

Result 6.1 *The estimated response functions of* $74/96$ *subjects fit "reasonably well" (*$\hat{l}_i \geq 1/3$*), the estimated response functions of 48 subjects fit well (*$\hat{l}_i \geq 2/3$*), and 38 play best responses in the sense* $\hat{l}_i \approx 1$.

This shows that the analyzed set of social commodities (i.e., motives) is in general suitable to capture the diversity of behavior displayed by the subjects. Next, look at the number of identified motives of giving for each subject, to which we refer as the "sharpness" of identification.

Result 6.2 *The social motives of 72 of the 74 subjects where the estimates fit "reasonably well" are identified sharply in the sense that only two or fewer motives are significant.*

Hence, the considered motives are sufficiently elementary to represent the variety of individual responses in an efficient manner. This would not be the case if we had estimated weights for meta-motives such as inequity aversion (envy + guilt), conditional co-operation (warm glow + guilt), or symmetric guilt toward beneficiary and co-benefactor. There are few subjects for which such complex motives have been identified, while for the majority of subjects, which have rather elementary motives, fairly complex combinations of such meta-motives would be required to obtain the requisite reduction toward the elementary motives such as guilt toward beneficiary.

Going into the details, altruism is the main motive for giving. This holds true for subjects with pure motives and for subjects with composite motives. There are 10 pure altruists and 20 further subjects with an altruistic submotive, but overall, the range of identified motives is as diverse as the variety of response functions in Fig. 2b.

Result 6.3 *The individual motives for giving are diverse. Nine different combinations of motives are identified at least three times. For the 59 subjects with reasonable fit and one or two social motives, altruism is identified 30 times, warm glow 16 times, the two forms of envy 4 and 18 times, and the forms of guilt 13 and 12 times.*

The most populated cell in Fig. 3 is the composite motive of altruism and envy toward the co-benefactor, which had been discussed in Sect. 4 already. The correspondingly classified subjects would like to see the beneficiary doing well, but they do not want to be sole contributors to this "public good." It seems surprising that we hardly identify envy toward the beneficiary, however, i.e., envy is asymmetric in the solidarity game. Clearly, beneficiary and co-benefactor play asymmetric roles in this game, but the beneficiary is often doing quite well. Thus, observed envy would not be asymmetric if envy was solely payoff based. Besides being payoff depend, envy may also depend on the degree of selfishness displayed by the respective player—and the beneficiary does not act selfishly in the solidarity game. In contrast, guilt toward beneficiary and guilt toward co-benefactor are identified similarly frequently (13 times

[10] The whole data set and the parameter estimates are provided in the supplementary material.

and 12 times, respectively), i.e., aggregated over the subject pool, guilt is symmetric whereas envy is not.

The determinants of the direction of envy and guilt may be a topic of further research, but a final result from the classification summarized in Fig. 1 may be helpful in this respect: in the solidarity game, envy and guilt do not operate entirely independently—their occurences are negatively correlated. A subject that gives due to guilt toward either B or C does not feel guilt toward the other player (C or B, respectively, which would induce quasi-convex responses), or envy toward either of them. Similarly, a subject that caps donations due to envy does not feel guilt or envy toward any other player.

Result 6.4 *Of the 59 subjects considered in Result 6.3, 42 subjects experience envy or guilt toward at least one player, but merely five of them have two such comparative motives.*

Rather, envy and guilt are accompanied by the non-comparative motives of altruism and warm glow. This is surprising, as one might have expected (following for example, Fehr and Schmidt 1999) that subjects give due to guilt toward C and cap donations due to envy toward B, or vice versa, and even more so, as these motives on their own are frequent—but not in conjunction. This suggests that subjects that are influenced by relative payoffs do not simply switch the person to which they compare themselves, nor do they simply switch from envy to guilt as the payoff relation inverts. We are unable to conclusively resolve the lack of envy-guilt compositions, but rigidity in one's selection of a peer and in the direction of one's emotion (envy/guilt) toward this peer seems plausible enough to warrant further investigation.

7 Conclusion

This article analyzed response functions in two-benefactor solidarity games, which have been elicited in a controlled experiment. For two reasons, these response functions are particularly suitable to identify subjects' social motives for giving. On the one hand, different motives induce qualitatively different best responses (constant, increasing, decreasing, or quasi-concave). On the other hand, the payoff structure in solidarity games is salient, which allows subjects to play fairly close to theoretical best responses. We set up a structural model that embeds six widely discussed motives (altruism, warm glow, and envy or guilt toward either co-player) in a random utility framework to control for noisy (quantal) responses. The salience of the payoff structure implied that 40% of the subjects strictly played best responses according to some utility function, and overall 75% played sufficiently systematic responses (in a sense made precise above) to allow a reliable identification of motives. The identifiability of motives, which follows from the distinctive shapes of the induced response functions, implied that rarely more than two motives are identified individually. In this sense, the identification is sharp.

In our analysis, all elementary motives for giving that are discussed in the literature have been identified as relevant to at least a share of the subjects. That is, the diversity of experimental analyses in aggregate suitably reflects the diversity of individual motives. This implies, however, that a best model does not exist and that the individual motives for solidarity are more diverse than assumed in any given study. Most analyses assume that subject heterogeneity may be expressed by two-dimensional parametric models (considering that altruism, envy, guilt, and efficiency concerns are special cases of inequity aversion if we allow for negative weights, and that linear, Cobb–Douglas, and Leontief preferences are special cases of two-parametric distributive preferences). We have found that the relevant set of social commodities is finer than just two-dimensional.

According to our approach, all identified utility functions are nested in one general model, but the interdependence of motives and weights seems too complex to model individual heterogeneity parametrically. For example, expressing it by linearly interdependent conditional moments seems impossible, because subjects usually care about two or fewer social commodities (i.e., many motives have zero weight). Thus, in analyses where the data does not allow an individual classification of subjects, a non-parametric model of subject heterogeneity may be called for. In particular, one may think of finite mixture modeling (Peel and MacLahlan 2000) similar to the way it has been applied by Conte et al. (2011) to choice under risk and by Bardsley and Moffatt (2007) to public goods games, but as our results suggest, with a larger variety of composite motives.

We find certain compositions of social motives to be more frequent than other compositions, and in particular envy and guilt rarely occur in conjunction. This observation suggests that both the subject and the direction of one's payoff comparisons are rigid, and thus envy and guilt are not just two sides of one coin. Further research may analyze more games similar to two-benefactor solidarity games to understand the individual interdependence of social motives. As indicated, it seems critical that the relevant game is both discriminating with respect to different motives and salient in terms of its payoff structure. Finding such games may not always be easy, but if the empirical model considers finely disaggregated social commodities, a sharp individual identification may be expected to follow. Our results, at least, suggest that this approach is promising to understand shape, heterogeneity, and interdependence of social motives.

As for fundraising, our results on multiple motives suggest to launch separate campaigns for differently motivated benefactors. A campaign emphasizing the existence of seed money attracts "conditional co-operators" (i.e., subjects with increasing response functions), another campaign emphasizing insufficiency of current contributions attracts altruistic and guilty types (subjects with decreasing responses). For singular events, say to help victims of an earthquake, it may empirically be the case that first altruistic and guilty types step in, which are succeeded by warm glow givers and eventually by conditional co-operators. To our knowledge, existing research on fundraising does not distinguish motives as finely as we do, but its verification as well as consequential adaptations of fundraising strategies may be a topic of future research.

In a more immediate application, further research may apply estimation strategies similar to ours to identify muliplicity of motives in related experimental games. For example, based on response functions to others' contributions in public good experiments (Fischbacher et al. 2001). One would expect that type distributions are not constant across games, as framing effects similar to those described by Andreoni (1995) set in, but it may be possible to understand the basic determinants. Such research will have to control for the fact that different games allow to distinguish different types. Solidarity games, for example, do not allow a distinction of warm glow and Bolton–Ockenfels inequity aversion, while standard public goods games do not allow players to distinguish their opponents (recall that they distinguish beneficiary and co-benefactor in solidarity games). Explaining the distributions of types in different circumstances may therefore be challenging, but such analyses appear possible when they are based on games that allow identifications of motives that are similarly sharp as the identification in our analysis.

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