RESOLVING SOCIAL DILEMMAS: DYNAMIC, STRUCTURAL, AND INTERGROUP ASPECTS

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Chapter 9

The Volunteer's Dilemma: Theoretical Models and Empirical Evidence

Axel Franzen

INTRODUCTION

Many interesting situations of public good provisions can be modeled as a volunteer's dilemma (VOD, Diekmann 1985). The most prominent example of a VOD game is helping behavior. Imagine a group of individuals watching an accident or a crime. Assuming the bystanders feel compassion for the victim, they obtain a benefit if the victim receives help. Since volunteering (that is helping the victim) is costly, even if it only means to call the police, every bystander might abstain from providing help, hoping for someone else to interfere. The phenomenon that bystanders of a crime or accident hesitate to help in the presence of others has inspired much research in social psychology. Darley and Latane (1968) labeled the reluctance of individuals in groups to help as "diffusion of responsibility."

Another example, discussed and analyzed by Brennan and Lomasky (1984), is voting behavior. Assume that a group of voters (e.g., members of a committee) has to make a decision on some proposal under unanimity rule. Acceptance of the proposal may increase the utility of outsiders but decrease the utility of the committee members. Every member prefers that someone use his or her right to veto the proposal. However, vetoing is costly

I am indebted to Norman Braun for helpful comments and discussions on this paper.

(e.g., the party that vetoes receives a bad reputation in the eyes of outsiders). Hence, the group needs a volunteer who is willing to veto in order to avoid a bad for the group.

A third example is the sanctioning dilemma. Assume a group of people whose utility is decreased because one member violates a norm (e.g., the norm not to smoke in a nonsmoking restaurant or the norm to line up in a queue). In such a situation one member's expression of discomfort with the norm violation often suffices to restore the public good of clean air (or social order). However, providing the sanction is usually costly and so every member prefers someone else to do it.

These and other examples of volunteering behavior have been analyzed with game theoretical concepts. VOD is a special case of a public good, in which a single contribution of a player suffices to provide the good (or avoid a public bad). Public goods, once provided, are by definition open to usage by all players, even to noncontributors. Therefore, rational actors usually have an incentive not to contribute to the production of the good and to free-ride on the contribution of others. Because of this incentive problem rational actors might produce an inefficient outcome of collective goods.[1] Game theoretical analysis shows that rational actors have an incentive problem in the VOD. The game is therefore a special case of a social dilemma that is defined as a situation in which individual rational action leads to an inefficient collective outcome.[2]

Game theory is a normative theory. It tells us how individuals should behave if they are utility maximizers. But this does not necessarily exclude altruistic motives. Thus, the example of helping behavior demonstrates that altruism is included into the utility function which is subject to maximization. Actors can only derive utility from the fact that a victim receives help if they care for the well being of others. Therefore, they must be to some extent altruistic. Hence, whether altruistic motives are involved does not depend on the game theoretical model but rather on the nature of the public good.

The original formalization of the volunteer's dilemma is due to Diekmann (1985). Since then the game has received four major refinements which derive from the relaxation of major assumptions of the original game. This chapter is organized according to those refinements of the VOD. It describes the original model of the VOD. This game assumes that players have symmetric preferences concerning the outcome of the game, players have complete information about others' preferences, decisions are non-observable, and the production costs are indivisible. Thus, one extension of the game is achieved by relaxing the symmetry assumption. The chapter also discusses the consequences of introducing asymmetric preferences and then deals with the concept of time in the VOD. In the original model players have no opportunity to observe other players' decisions. However, the possibility to observe others' decisions makes time a crucial factor. Following this, the consequences of actors having only incomplete information about others' preferences are discussed. The penultimate section is concerned with cost sharing—that is, it examines the consequences of divisible production costs. Finally the theoretical and empirical research findings for the volunteer's dilemma are summarized.

THE VOLUNTEER'S DILEMMA

In its original version (Diekmann, 1985) a group of n individuals have equal interests in a public good. The good can be provided by the contribution of a single member. All individuals receive the same benefit (b) if the good is provided. Provision is costly (c) to the potential volunteer. Thus, the volunteer receives $b - c$ where $b > c$ and all noncontributors receive b. However, if no group member decides to volunteer all players will receive a

payoff of 0. Thus, the game describes a symmetric binary choice situation in which all players have the option to provide the good or to free-ride on the provision of another player. The decision situation is depicted in Figure 9.1, where C denotes the decision to volunteer and D the option not to volunteer.[3]

If the players can communicate in the VOD they can agree on a mechanism (e.g., a lottery) to determine the volunteer. In such a case $N - 1$ players choose not to provide the good and one volunteers. Thus, there exist N asymmetric equilibria in pure strategies and all associated outcomes are Pareto-efficient.[4] Similarly, there is no obstacle to a Pareto-efficient solution if the game is iterated, since players could simply agree to take turns as a volunteer. However, if players have no opportunity to communicate in a one-shot VOD, there is no straightforward answer to the question of how rational actors should behave in the VOD. There exists a unique equilibrium solution in mixed strategies (Diekmann, 1985).[5] This equilibrium is found by calculating the expected payoff for a mixed strategy and determining that probability for which the payoff reaches a maximum. If q_i denotes the probability with which player i chooses not to volunteer then the expected payoff is given by:

$$E_i = q_i b\left(1-\prod_{j}^{N} q_j\right) + (1-q_i)(b-c) \quad \text{with } i \neq j \tag{1}$$

Taking the derivative with respect to q_i yields:

$$\frac{dE_i}{dq_i} = c - b\prod_{j}^{N} q_j \quad \text{with } i \neq j \tag{2}$$

Setting $dE_i/dq_i = 0$ ($i = 1, 2 \ldots N$) results in a system of simultaneous equations that yields the equilibrium strategy with the symmetric solution:

$$q_{VOD} = \sqrt[N-1]{\frac{c}{b}}\,. \tag{3}$$

Thus, the probability that utility maximizers will defect in the volunteer's dilemma is a function of group size (N) and the cost-benefit (c/b) ratio. The probability of defecting increases with group size and costs, but decreases with the benefit. Put differently, the probability that an individual volunteers decreases in larger groups and with larger costs,

	C choices of other players				
	0	1	2	...	N - 1
C	b - c	b - c	b - c	b - c	b - c
D	0	b	b	b	b

Figure 9.1 Volunteer's dilemma payoff matrix where C denotes volunteering and D not volunteering

and increases with larger benefits. Substituting Equation 3 into Equation 1 shows that the expected payoff of the equilibrium strategy is b – c. Hence, the expected payoff of the equilibrium strategy is not any larger than the payoff of the maximin strategy to volunteer. As a consequence a player may deviate from the equilibrium strategy towards a higher probability to volunteer without decreasing his expected payoff. Hence, the mixed equilibrium in the VOD may be called a weak equilibrium.

The probability that a public good will be provided by a group, which is not to be confused with the individual probability to volunteer, is given by:

$$P_{VOD} = 1 - q_{vod}^{N} \tag{4}$$

Substituting Equation 4 into Equation 3 yields:

$$P_{VOD} = 1 - \left[\frac{c}{b}\right]^{N/(N-1)} \tag{5}$$

From Equation 5 it is evident that a group of rational actors will always have a positive probability that no player volunteers and hence that the good will not be provided. Because of this characteristic, the volunteer's dilemma is a special case of a social dilemma, which by definition is a situation in which individual actions of rational players produce an inefficient collective outcome. The probability that a group has at least one volunteer decreases with the costs (*c*) and increases with the benefits (*b*). Furthermore, the derivative of P_{VOD} with respect to N is negative. Thus, the probability of public good provision decreases with larger group size.

The result that lower costs and higher benefits increase the individual as well as the macro probability of public good provision in the VOD conforms to intuition. It is also evident that larger groups have by definition a larger number of potential volunteers so that the individual probability to volunteer should decrease with *N*. However, the finding that larger groups have a lower likelihood of public good provision is rather counterintuitive. Thus, the effect that larger groups have more potential volunteers does not override the decreasing individual probability to volunteer. Therefore, according to game theoretic analysis, the chances that a victim receives help, that a norm violator will be sanctioned, or that an unfavorable proposition will be vetoed are larger in small groups than in large groups. On theoretical grounds the analysis of the volunteer's dilemma confirms, therefore, Olson's (1965) hypothesis that larger groups are less likely to obtain public goods.

The counterintuitive nature of the group size effect has inspired empirical research. One way to study the effect of group size is to construct field experiments. Examples include situations in which a confederate fakes an accident or constructs a helping situation and observes whether the presence of different numbers of bystanders influences the probability of public good provision (Darley & Latane, 1968; Latane & Nida, 1981). Another way is to conduct experiments in laboratories by describing the decision situation and by presenting payoff matrices similar to the one that is shown in Figure 9.1. Field experiments have the advantage of higher external validity, but the drawback is that not all factors are adequately controlled. Thus, in a field experiment a bystander's decision becomes immediately visible to all others. This actually changes the decision structure and calls for a refinement of the VOD model. Furthermore, in field experiments it is usually more difficult to control benefits and costs. Since costs and benefits are not observable in field experiments, the symmetry assumption of the original VOD might not be fulfilled. This calls for a further refinement of the game in order to submit game theoretic predictions to an empirical test in real life settings. Despite those differences most field experiments as well as laboratory studies on group size in the VOD find that individuals are less likely to volunteer with increasing group size but that the macro likelihood of public good provision increases contrary to game theoretic expectation.

This result was also observed in an experimental study by the author (Franzen, 1995).[6] The experimental results (see Figure 9.2) confirm the qualitative predictions derived from game theory. The proportion of participants who cooperate in the VOD decreases with increasing group size.[7] However, the prediction is not very accurate. The observed cooperation rates in all groups, particularly in the larger ones, are much higher than expected according to equilibrium behavior. That does not come as a great surprise since the mixed equilibrium is weak and deviations are not punished by smaller expected payoffs. As a consequence of the higher individual rates of volunteering, the macro probability of public good provision is much higher than hypothesized. If the observed rates are substituted into Equation 4 then 2-person groups would have provided the good with a probability of .88, 3-person groups with a probability of .93, 5-person groups with .94, 7-person groups with .87 and 9-person groups with a probability of .98. Thereafter the probability of public good provision is very close to 1. Thus, on the macro level the data contradict the game theoretical hypothesis. According to the mixed equilibrium the macro level probability should be .75 for the 2-person group and fall thereafter to .50 in the largest group. Instead, the data show that the probabilities of public good provision are increasing with group size. Hence, the experimental evidence actually suggests some doubts about Olson's (1965) analysis. Similar findings concerning the effect of group size are reported by Darley and Latane (1968), Diekmann (1986) and Murnighan, Kim and Metzger (1993).[8]

ASYMMETRIC PREFERENCES IN THE VOLUNTEER'S DILEMMA

The assumption of symmetric preferences is rather unrealistic in real life settings of public good provisions. Most likely, there is variance in costs of provision or utility derived from the good for different actors. Diekmann (1993) generalized the original game by introducing asymmetric costs and benefits. As in the symmetric case there are N equilibria in the asymmetric game in which one player volunteers and all others defect. Furthermore, there exists an equilibrium in mixed strategies that is given by allowing for different benefits and costs by substituting b_i and c_i into Equation 1:

$$E_i = q_i b_i (1 - \prod_{j \neq i}^{N} q_j) + (1 - q_i)(b_i - c_i) \tag{6}$$

Taking the derivative of Equation 6 with respect to q_i, setting the resulting N equations to zero, and rearranging yields the following equilibrium solution:

$$q_i^* = \frac{b_i}{c_i}\left(\prod_{j=i}^{N} \frac{c_j}{b_j}\right)^{\left(\frac{1}{N-1}\right)} \tag{7}$$

Analogously to the symmetric VOD, substitution of Equation 7 into Equation 6 gives the maximin payoff of $b_i - c_i$. The mixed equilibrium yields a rather counterintuitive result. If the costs (*c*) of providing a public good decrease for a player *i* or, alternatively, the benefits (*b*) increase then q_i* increases. Thus a strong player with a relatively large interest in the

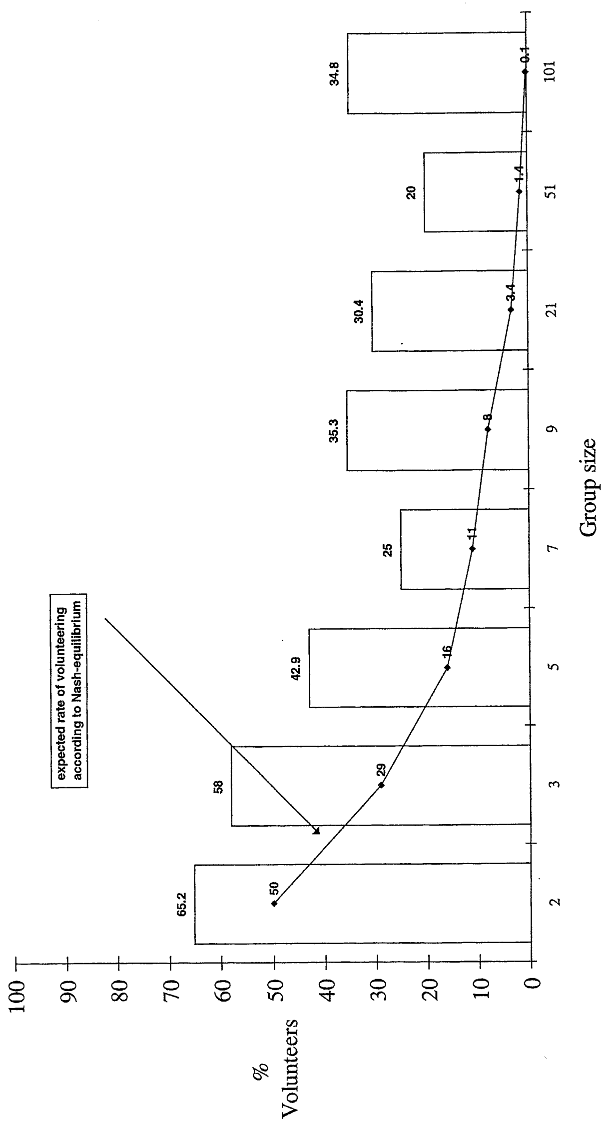


Figure 9.2 Group size effects in the volunteer's dilemma

good or relatively low production costs will be less likely to volunteer.[9] However, Schelling's (1960) concept of *focal equilibrium* in situations of conflict suggests that players will choose the asymmetric equilibrium in pure strategies. Particularly, if a single player is clearly the strongest actor, the prominent or focal solution would be that he or she volunteers. A similar conclusion can be derived from Harsanyi and Selten's (1988) theory of equilibrium selection. As in the symmetric VOD the individual probability to volunteer decreases for the mixed equilibrium with group size as well as the probability that the public good will be provided.[10]

Since the analysis of the asymmetric VOD produces rather counterintuitive results, experimental research is of particular interest. Diekmann (1993) tested the effect of strength and weakness on the probability of volunteering for 2- and 5-person groups.[11] The experimental results confirm the common sense expectation. Strong (weak) players have a higher (lower) probability to volunteer. Thus, in experiments participants tend to realize the asymmetric equilibrium in pure strategies, but do not adhere to the counterintuitive mixed equilibrium. Group size effects were found in two out of three test situations. Individuals in larger groups did defect more often than players in smaller groups.

TIMING IN THE VOD

Another extension of the volunteer's dilemma is the volunteer's timing dilemma (VTD) from Weesie (1993). Its starting point is that in reality (and in contrast to the volunteer's dilemma) individuals can very often observe others' choices. The decision is no longer to contribute or not contribute, but rather whether an actor should volunteer immediately or wait whether another actor volunteers. Assume further that the value (benefit) of the public good decreases with increasing time delay (e.g., the chance that a victim is rescued diminishes with the time delay). Though players' costs (c) for volunteering remain constant, the benefits decrease with increasing waiting time. Denote the probability of a successful public good provision by $\varphi(t)$. Then an actor receives a utility of $b_i\varphi(t) - c_i$ if he volunteers and $b_i\varphi(t)$ otherwise.

In the symmetric VTD all players have the same costs of providing the good and the same interest in receiving the good. There are N equilibrium sets in pure strategies in which one player volunteers immediately (at time delay 0) and all others free-ride on the provision of the volunteer. There is also an equilibrium in mixed strategies (Weesie, 1993):

$$q_{VTD} = \exp\left(\frac{c - b}{(N - 1)c}\right) \quad (8)$$

where q_{VTD} denotes the probability that a player does not volunteer at any time. This probability is positive and increases with group size (N), rises with increasing costs (c), and decreases with increasing benefits (b).[12] Thus, q_{VTD} and q_{VOD} are analogous with respect to the effects of group size and the cost benefit ratio. Also, the expected payoff in both games is b-c. However, the probability of defection is lower in the VTD than in the VOD.
The macro probability that the public good will be provided is (Weesie, 1993):

$$P_{VTD} = 1 - \exp\left(\frac{N}{N-1} \bullet \frac{c-b}{c}\right) \quad (9)$$

It follows from Equation 9 that there is still a positive probability that the public good will not be provided. Because of this positive probability, the mixed equilibrium solution of

VTD is Pareto-inefficient as in VOD. However, the probability that no good will be provided is smaller in the VTD than in the VOD. But in the VTD volunteering might happen after a time delay, which by definition, decreases the value of the public good. It can be shown (Weesie, 1993) that the expected value of the public good is smaller in the symmetric VTD than in the VOD. Thus, applied to a rescue situation a victim is more likely to receive help when bystanders can observe each other's behavior. But the possibility of observation introduces a time delay that decreases the chance that the victim receives the help in time and thus makes helping less valuable.

Weesie (1993) analyzes the volunteer's timing dilemma with asymmetric preferences. It can be shown that if one player in the VTD has lower costs to provide the good or has higher benefits from it, and thus is a strong player, he or she will volunteer without any time delay. Hence, if players are able to observe each other's behavior in an asymmetric VTD then the equilibrium solution will be in line with common sense expectations. So far neither the volunteer's timing dilemma nor the VTD with asymmetric preferences have been empirically investigated.

INCOMPLETE INFORMATION IN THE VOLUNTEER'S DILEMMA

So far all variations of the VOD assumed that players have complete information on the costs and benefits of all other coplayers. But this assumption is not very realistic. Most likely players in real life situations of public good provision will not know each other's production costs or benefits. Thus, Weesie's (1994) introduction of incomplete information is a useful extension of the VOD. Incomplete information means that players only know their own cost-benefit ratio (*c*/*b*) but not that of others. Weesie (1994) assumes that players only know the distribution of others' cost-benefit ratios which in their simplest form is uniform with $U[(c/b) - \sigma, (c/b) + \sigma)]$. Thus, the larger σ, the larger the uncertainty about others' cost-benefit ratios in the volunteer's dilemma with incomplete information. For the VOD with uncertainty Weesie (1994) proves that the individual probability to defect (α_{vdi}) increases in σ if and only if $(1/2)^{N-1} < c/b$.

Unfortunately, Weesie (1994) misinterpreted the theorem. The effect of uncertainty in the VOD depends on the condition $(1/2)^{N-1} < c/b$. This condition is more likely to be fulfilled in large groups. Thus in large groups uncertainty increases the probability to defect. But in smaller groups the individual probability to defect (α_{vdi}) *decreases* with uncertainty. Hence, in small groups uncertainty may foster volunteering behavior.

The effects of uncertainty are completely reversed for the volunteer's timing dilemma. Weesie (1994) shows that the individual probability for unconditional defection (α_{vdi}) increases in σ if and only if $c/b < (c/b)^{\tilde{}}_N$. The threshold $(db)^{\tilde{}}_N$ decreases in *N* and satisfies $1/2(N\text{-}1) < (db)^{\tilde{}}_N < 1/2$. Therefore, the probability of defection increases with uncertainty if groups are small. In larger groups uncertainty decreases the probability that a player will defect. Thus, in the volunteer's timing dilemma uncertainty fosters cooperation only in large groups. So far research on incomplete information in the VOD and VTD has been conducted analytically. But the hypotheses that are derived from game theoretical analysis have not been empirically tested.

COST SHARING IN THE VOLUNTEER'S DILEMMA

There is a fourth extension of the volunteer's dilemma, namely the introduction of cost sharing (Weesie & Franzen, 1998). In many settings the cost of public good provision is divided among players. For example, if a victim is in distress several bystanders could intervene and share each other's costs by coordinating their help. Another example is the maintenance of a community center. The latter depends on many voluntary contributions such as time spent on cleaning, renovating, or the organization of social activities. Clearly, most activities are divisible so that the provision costs for each actor decreases with the number of volunteers. Cost sharing may also take place in voting behavior under the unanimity rule. Suppose that a committee member who vetoes a proposal that is unfavorable to the committee members but favorable to outsiders receives a bad reputation if outsiders get to know his choice. The costs of receiving a bad reputation can be shared and thus decreased if others veto as well.

Assuming that all volunteers share costs, player *i*'s utility function may be written as:

$$u_i(s;b,c) = \begin{cases} b - \dfrac{c}{k} & \text{if} \quad s_i = C_i \\ b & \text{if} \quad s_i = D_i \quad \text{and} \quad k \geq 1; \quad \text{and} \\ 0 & \text{if} \quad k = 0. \end{cases}$$

where *k* denotes the number of volunteers. Thus, the utility function that is given here assumes symmetry in the sense that all players have the same costs and benefits as well as that costs are shared equally among the volunteers. There exists a symmetric equilibrium in the VCS that is given by:

$$\alpha_{VCS} = \frac{\omega(b/c)}{N} + O(N^{-2}). \tag{10}$$

where α_{VCS} denotes the probability to volunteer, ω(.) is a Riemann function, and $O(N^{-2})$ represents a residual term which can be neglected for large N. The probability to volunteer increases with benefits (*b*) and decreases with costs (*c*) and group size (*N*).[13] Moreover, the macro level probability that the public good will be provided is given by:

$$P_{VCS} = 1 - (1 - \alpha_{VCS})^N. \tag{11}$$

Substituting Equation 10 into Equation 11 yields:

$$P_{VCS} = 1 - e^{-\omega(b/c)} + O(N^{-2}). \tag{12}$$

Therefore, the probability that the good will be produced increases with *b* and decreases with *c* and group size *N*.

Further insights into the characteristics of the game are gained by a comparison between the volunteer's dilemma with and without cost sharing. Note that the qualitative characteristics of the volunteer's dilemma are analogous to the characteristics of the volunteer's dilemma with cost sharing. In both games the micro probability to cooperate as well as the macro probability that the good will be produced increase with benefits (*b*) and decreases with costs (*c*) as well as group size *N*. Thus, cost sharing does not affect the conclusion that larger groups have a lower probability of public good production despite the fact that larger groups have, by definition, more potential volunteers. However, cost sharing implies that the individual costs (c) for producing the good are lower in the VCS than in the VOD. Hence, costs are potentially reduced in the VCS and therefore α_{VCS} and P_{VCS} are strictly larger than α_{VOD} and P_{VOD} if the cost-benefit ratio and group size are held constant.[14] The difference between the micro level probabilities depend on the cost-benefit ratio and on group size. In large groups the probabilities are very small and, consequently, so are the differences.

To test the qualitative hypotheses of the volunteer's dilemma with cost sharing and its differences to the original volunteer's dilemma Weesie and Franzen (1998) conducted an experiment. Group size was varied between 2, 4, and 8 players. The benefits of the public good were set to 100 points ($b = 100$) while the costs of volunteering varied between a high cost ($c = 80$) and a low cost situation ($c = 40$).[15] To compare behavior in the VCS with behavior in the VOD both variations were also conducted for the symmetric volunteer's dilemma. Thus, the experiment is a three way factorial design: dilemma type (2) by group size (3) by cost-benefit ratio (2), with 12 experimental conditions. For each of the 12 conditions separate questionnaires were designed in which the decision task was verbally explained and presented in matrix form. Participants were told that a given number of other players received the same questionnaire and that their payoffs would be determined by the match of their own and others' decisions. Participants indicated their decision to volunteer or not volunteer. In addition they had to give an estimate of how many of their coplayers would choose either alternative. Furthermore, participants were asked to calculate their own payoffs given that their estimate on their coplayers choice as well as the payoffs coplayers would receive would be correct. This information was later used to determine whether participants properly understood the decision situation.

An equal number of copies of the 12 questionnaires were randomly assigned to a random sample of 850 first and third year students of the University of Berne in Switzerland. Four hundred and eighty-nine students returned the questionnaire of which 465 answered all control questions correctly. Since there was no selective influence of the conditions on the response rate there were between 33 and 45 participants in every experimental category. About half of the participants were female. A third of the students were enrolled in economic and law programs, one third in history and language programs and another third in medicine and natural sciences. Figure 9.3 depicts the results of the experiment.

It can be observed from Figure 9.3[16] that the qualitative hypotheses are mainly corroborated. The *individual* probability to cooperate was, as predicted, a decreasing function of group size. This replicates former findings about group size effects in the VOD. The group size effect is clear for all experimental conditions between group sizes 2 and 4. However, for larger groups ($N = 8$) the results are less clear cut. A minor drop of volunteering behavior can be observed for the VOD conditions. In the VCS condition, the effect is undetermined. There is a profound drop in the cooperation rate for the VCS with low cost between group sizes 4 and 8, but an increase for the VCS with high cost. In accordance with theoretical predictions is also that cooperation rates are always higher in the cost sharing condition than in the VOD. Furthermore, an increase in the provision costs (c) decreases the probability to volunteer with one exception in all conditions. These observations are confirmed by a logit-analysis in which all three effects were in the expected direction and are statistically significant.

Figure 9.4 shows that the observed values of the low cost conditions are rather close to the game theoretical predictions, particular for the VCS. However, for the high cost situation the experimental results deviate clearly from the predictions.[17] Overall, it can be concluded that the qualitative predictions, the direction of the main effects, were con-

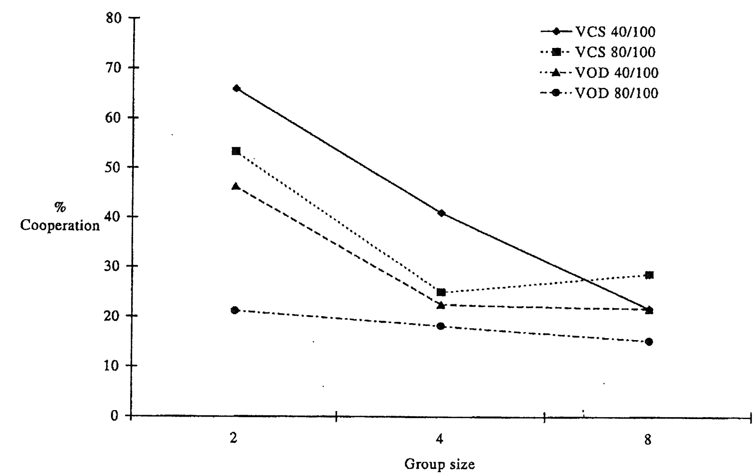


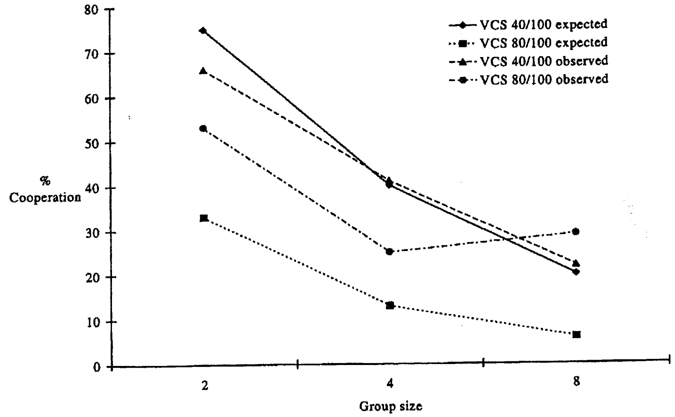
Figure 9.3 Experimental results in the volunteer's dilemma with cost sharing (VCS) and without cost sharing (VOD)

firmed by the experiment. However, the game theoretical model does not describe the observed frequencies very accurately.

CONCLUSIONS

The volunteer's dilemma is a game theoretical model of a class of social situations in which a single volunteer suffices to provide a public good. The game is a special case of a social dilemma, since rational players will produce only an inefficient amount of the good. The model explains a paradoxical phenomenon found in social life: Rational individuals who have sympathy with a victim, and are thus to some extent altruistic, may not help a victim, because they hope that someone else will provide the help. However, the model is more pessimistic than empirical findings suggest. It predicts, although as a *weak equilibrium*, not only that individuals decrease their propensity to help with increasing group size but also that larger groups are less likely to provide the good at all. Experimental evidence confirms the micro level prediction but sheds some doubts on the macro level conclusions. Thus, at least in experiments, participants show a higher probability to volunteer than is expected on the basis of the equilibrium strategy. As a consequence the good is produced more often than is predicted. Particularly, experimental evidence suggests that the (macro level) probability of public good production increases with group size.

The original model assumes symmetry in costs and benefits, complete information on those costs and benefits, and nonobservability of other players' decisions. During the last decade relaxing those assumptions refined the volunteer's dilemma. Asymmetric cost-benefit ratios, incomplete information, observability, and cost sharing were introduced. Analytically, most of these refinements do not alter the basic qualitative predictions—that volunteering is a decreasing function of the cost-benefit ratio and group size. There is, however, one exception. In an asymmetric volunteer's dilemma with complete information a stronger player (e.g., with lower costs or higher benefits) has, according to the mixed



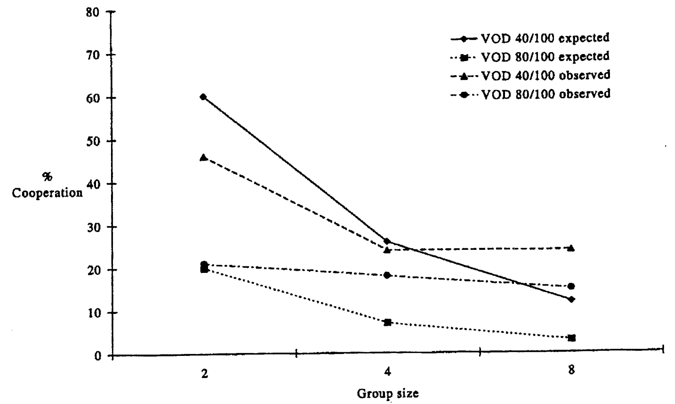


Figure 9.4 Expected and observed rates of cooperation in the VCS and VOD

equilibrium solution, a lower probability to provide the good than a weak player (i.e., someone with higher costs and lower benefits).

The introduction of observability and cost sharing both foster the individual propensity to volunteer as well as the group level chance that the good will be provided. The situation is somewhat more complicated when uncertainty about others' cost-benefit ratio is introduced. In the VOD uncertainty fosters volunteering when groups are small but it inhibits volunteering when groups are large. The effect of uncertainty is completely reversed for the volunteer's timing dilemma. In the VTD uncertainty increases the propensity to volunteer in large groups but decreases it in small groups.

So far experimental evidence is available for the symmetric and the asymmetric volunteer's dilemma as well as for the volunteer's dilemma with cost sharing. Up to now the effects of observability and uncertainty had not been experimentally assessed. Conducting such experimental research could be a fruitful route for further research on public good provisions.

ENDNOTES

[1] See Ledyard (1995) for a review and discussion of literature on public goods.

[2] Note that this definition of a *social dilemma* is broader than the one that was provided by Dawes (1980), who introduced the term. Dawes defined social dilemmas as situations in which every player has (a) a dominant strategy and in which (b) actors' uses of their dominant strategies result in an inefficient outcome. The symmetric equilibrium strategy in VOD is not a dominant strategy, but the symmetric equilibrium solution still results in an inefficient outcome.

[3] At first sight, the volunteer's dilemma seems to be a special case of the minimal contribution set (MCS) described by Van De Kragt, Orbell and Dawes (1983) and formalized by Rapoport (1985). In the MCS it is assumed that a group of k players ($1 < k < N$) suffices to provide a public good. However, the MSC explicitly excludes the possibility that one player (k=1) suffices to provide the good as is assumed in the VOD (Rapoport, 1985). This changes the strategic properties of the game. In the VOD ($k = 1$) volunteering is a maximin strategy whereas in the MCS cooperation is never maximin (see Diekmann, 1994).

[4] If a player i is determined by lottery or any other mechanism to volunteer then none of the N players (including i) has an incentive to deviate from that strategy combination. If there are N players then there are N possible strategy combinations in pure strategies and thus N asymmetric equilibria.

[5] A pure strategy tells a player to either play C or D. A mixed strategy is one that instructs an actor to mix C and D choices. In a one-shot game the term *mixed strategy* refers to a behavior in which an actor chooses C with a certain probability and plays D otherwise.

[6] To conduct the experiment 203 students of the University of Mannheim, Germany were arbitrarily recruited and randomly assigned to the different group size conditions. Thus, there were about 25 participants in every condition. Participants did not form real groups, instead, a separate questionnaire describing the situation and telling participants how many coplayers there were was constructed for every group size condition. Participants had to make their decision privately without communication or any other form of feedback. Cost (c) and benefits (b) were set to 50 and 100 points and were later transferred into money. For further detail see Franzen (1995).

[7] Group size has a statistical significant effect on the cooperation rate ($\chi^2 = 16.24$, $df = 7$, $p < .05$).

[8] These studies have different experimental designs. Darley and Latane (1968) use 2- and 5-person groups in a real life setting. Diekmann (1993) uses a similar design to the one reported. However, all participants (N = 29) had to made the decisions sequentially in all group size condition (2 through 10) so that decisions might not be independent. Murnighan et al. (1993) use hypothetical scenarios and no monetary payoffs with the drawback that participants might not take their decisions very seriously since they have no consequence. Taken together, however, experimental evidence is consistent.

[9] Weesie (1993) presents the same solution for the mixed equilibrium as Diekmann (1993); however, he misinterprets the results. The paradox of the asymmetric VOD exists in the fact that the stronger player would, according to the mixed equilibrium solution free-ride on the provision of the weaker player. Thus, the finding is not a rediscovery of Olson's (1965) assertion that sometimes strong players are exploited by weak players as Weesie suggests. The mixed equilibrium solution predicts quite the contrary.

[10] The probability that the good will be provided is given by

$$P = 1 - \left(\prod_{i=1}^{N} \frac{c_i}{b_i} \right)^{\left(\frac{1}{N-1}\right)}$$

The partial derivative of P with respect to N is negative. Thus, the probability P decreases with increasing N. It is, in contrast to Diekmann's (1993) assertion, a negative function of group size.

[11] The experimental procedure was very similar to the one described in Endnote 7. Participants were randomly assigned to different conditions. They were not part of real groups but received questionnaires which contained payoff matrices and written instructions on how many players would be assigned to the group. Decisions were then taken anonymously.

[12] Note that the implication of Equation 8 with respect to the cost benefit ratio is misinterpreted in Weesie (1993), but correct in Weesie (1994).

[13] Mathematical details and proofs may be found in Weesie and Franzen (1998).

[14] With $\alpha_{VOD}=1-q_{vod}$.

[15] Participants were informed that points would be transferred into monetary payoffs. One hundred points were transferred to 10 Swiss Francs (about $US 9).

[16] Benefits (*b*) were set to 100 points in all experimental conditions while costs (*c*) varied between 40 (low cost) and 80 (high cost) points. (Sample size = 465).

[17] This conclusion is confirmed by a test based on a deviance statistic. Note that the game theoretical predictions assume risk neutrality, thus it is assumed that money equals utility. For details see Weesie and Franzen (1998).