Managing Natural Resource Dilemmas through Structural Change: The Psychological Effects of Water Metering

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Running Head: STRUCTURAL CHANGE IN RESOURCE DILEMMAS

Key Words: SOCIAL DILEMMAS, STRUCTURAL CHANGE, RESOURCE MANAGEMENT, WATER CONSERVATION, TECHNOLOGY

Abstract

This chapter examines the behavioral and psychological effects of a structural intervention in a natural resource dilemma — the implementation of water meters. Based upon social-psychological research into social dilemmas, it is proposed that metering helps to promote efficient resource management, first, because it gives households a direct financial incentive to conserve. In addition, there are numerous psychological side-benefits associated with this structural change. For example, metering increases the personal efficacy to conserve as well as enhances concerns with responsible resource use. Moreover, metering is likely to raise expectations about others' conservation efforts and is considered to be socially more fair. We will present evidence from different studies, showing the beneficial effects of metering in promoting conservation, particularly during a resource crisis. Our analysis has important implications for the development of theories and programs to promote resource management.

Managing Natural Resource Dilemmas through Structural Change:

The Psychological Effects of Water Metering

A major challenge of modern society is to find solutions for dilemmas involving the distribution of limited natural resources, such as water and energy. These problems are the result of an ever-growing mismatch between resource supplies and demands. Whether due to a real shortage or to excessive usage, it is increasingly clear that long-term strategies are needed to cope with these problems, and these should focus on changing resource consumption patterns (Stern, 1992). Among the various solutions available, the implementation of technological devices, such as meters for the use of water, gas or electricity, seems a quite promising strategy to promote individual conservation (Crabb, 1992). Little is understood, however, about the longer term and psychological effects of such interventions. So far, conservation programs have been designed primarily in response to an immediate resource crisis (see e.g., Berk et al., 1980).

For example, in 1995 the United Kingdom was hit by one of the worst droughts in recent history, which culminated in a severe water shortage during the summer months. Around the UK a variety of activities were organised at once to bring down the consumption levels. Throughout the country, education campaigns v/ere implemented to inform the public of the seriousness of the situation and to stress the need for domestic water conservation. In some areas, people were given practical information how and when they should conserve water. In other parts of the country, actual bans were imposed on the use of sprinklers and hose pipes, and fines were given when people failed to comply. Finally, in some areas problems were considered to be so severe that domestic water supplies had to be disconnected for certain periods of the day.

It is important to realize that these strategies were adopted in response to an acute resource crisis and that they were not intended to have any long-lasting effects. Also, because of the time pressures involved there were no opportunities to systematically evaluate them. As a result, there still is great uncertainty among policy makers — representatives of government and water industry — what needs to be done to promote efficient resource management. What seems evident though is that intervention programs should focus more on the prevention and less on the management of a shortage (OFWAT, 1996).

The current chapter examines the impact of a particular structural strategy to tackle resource problems, the instalment of domestic water meters. We will present evidence that metering leads to a substantial reduction in water consumption rates. Moreover, we will show that this intervention yields numerous psychological effects that facilitate the management of an acute resource crisis. The behavioral and psychological effects of metering can be understood by insights provided by social-psychological theories of social dilemmas.

Resource Conservation as Social Dilemma: Theory and Findings

The reward structure underlying many natural resource problems shows similarities to an N-person Prisoner's Dilemma Game (Dawes, 1980; Messick & Brewer, 1983). According to this dilemma game, it is highly attractive for people to maximize their resource consumption as this is personally most convenient. For example, most individuals want to be able to take a shower or water their garden whenever they like. However, if all or most individuals act accordingly, the resource is not likely to be sustained for long. Eventually, this could result in a situation whereby everyone is worse off than if all would have exercised some restraint. The conflict between the individual interest not to conserve and the collective interest to conserve is particularly eminent during a resource crisis, such as a water shortage, because the situation requires the need for conservation, but at the same time motivates people to consume as much as they can before the resource collapses (Kramer, McClintock, & Messick, 1986).

Insert Figure 1 about here.

The reward structure portrayed here is much the same as the one described in the well-known story of the "Tragedy of the Commons" (Hardin, 1968) in which a group of herdsmen were together managing a common pasturage, but eventually destroyed it because each individual increased the size of his herd. This parable inspired much experimental research into these kind of problems, which led to the development of the replenishable resource dilemma paradigm (Messick et al., 1983; Samuelson et al., 1984). In this computer controlled task, a group of six individuals are instructed to manage a common resource pool which consists of points representing a certain monetary value. Per trial each of the participants harvests a number of points from the pool. Subsequently, the computer calculates the new pool size by subtracting the requested sum from the total number of points in the pool. The remaining points are then multiplied by a certain replenishment rate to establish the resource for the next trial — this process is analogue to a natural resource pool that also has a natural capability to restore itself to a certain degree (e.g, a water reservoir). Feedback about the pool size is usually preprogrammed in these tasks so as to determine how people might, for example, respond to information about the resource state and harvest decisions of other people.

This line of research has identified three key motives that underlie people's consumption decisions (Messick et al., 1983; Samuelson & Messick, 1995; Samuelson et al., 1984; Wilke, 1991). First, people are motivated to consume as much as they can of a particular resource. This motive is inherent to the reward structure of the resource dilemma as it is, by definition, more attractive to overconsume than to exercise restraint. However, the desire to be greedy is somewhat restricted by two other motives which depart from people's immediate self-interest. They are also motivated to use the resource responsibly —

so that it remains intact for an extended time period — as well as concerned with the distribution of resources among the group members, which should be in line with their fairness expectations. Although all three motives — greed, responsibility, and fairness — influence harvest decisions to some extent, the dominant concern presumably is greed (Wilke, 1991). It is therefore fairly likely that a resource will be overused if there are no attempts to influence people's consumption decisions.

Behavioral Strategies to Promote Conservation

Strategies to influence decisions in resource dilemmas can be conveniently grouped according to what motive they primarily focus on. Following the greed-motive, interventions to decrease consumption rates aim to bring a change in the reward structure of the dilemma. The results of numerous laboratory studies show that this structural approach can be quite effective in solving dilemmas provided that the rewards for conservation and punishments for nonconservation are sufficiently high (Komorita & Parks, 1994). In real-world dilemmas this strategy usually comes about via a modification in the price-setting of the resource units. For example, the standard price of water can be raised or the price of a unit above a certain level of use (i.e., a so-called step-level charging system).

Some longitudinal studies have been conducted to determine the effects of different pricing systems on water demand, but on the whole these effects are not too impressive (e.g., Stewart Agras et al., 1980; Berk et al., 1980). This may be explained, in part, by the fact that water is traditionally offered at a cheap rate. Hence, the incentive for water conservation is perhaps not as big as for other resources, such as gas and electricity, whereby monetary strategies do seem to have some effect (Stern, 1992). Moreover, tariff changes usually become noticeable when customers receive a bill, which may be months later, and that makes it hard for households to adjust their consumption patterns. Thus, the effects of monetary strategies may be importantly shaped by social-psychological factors, such as the amount of feedback people receive (Kempton et al., 1992).

A different set of strategies to promote conservation focus primarily on promoting concerns with responsible resource management. This is usually achieved by social-psychological interventions which attempt to change the perceptions and motivations of people in dealing with resources. Experimental research suggests at least four social-psychological factors that may be relevant in encouraging conservation in resource dilemmas: (1) awareness of a shortage, (2) a responsibility to do something for the collective welfare, (3) a belief in the efficacy of an individual contribution, (4) a belief that other people in the community will also contribute (Komorita & Parks, 1994; Van Lange et al., 1992).

In the context of natural resource management, the social-psychological approach generally culminates in the implementation of public education campaigns, whereby people receive messages with details about the shortage and moral appeals to use the resource wisely (Gardner & Stern, 1996). These campaigns might also contain practical suggestions how to conserve. There is some indication that these campaigns persuade people to conserve water, butonly in the face of an acute shortage (Berk et al., 1980; Maki, Hoffman, & Berk, 1978). Under normal resource conditions such campaigns were found to have no effects at all (e.g., Geller, Erickson, & Buttram, 1983; Thompson & Stoutemeyer, 1991).

What conclusions can we draw from these approaches to promote water conservation? A first methodological conclusion is that it is very difficult to generalize the results from experimental dilemma tasks to resource management problems in the real-world. Interventions that work in the laboratory often fail to produce the desired effects when implemented in practice (Van Vugt, Van Lange, Meertens, & Joireman, 1996). Whenever possible, resource management strategies should therefore be studied directly in the field (see Ostrom, 1990). Secondly, interventions tend to be focused on either the greed or responsibility to conserve but they seldomly focus on both motives simultaneously. Yet there is good evidence from applied behavioral research that a combination of interventions may prove to be far more successful (Geller, Winett, & Everett, 1982). For example, analyses of the 1976/1977 California drought revealed that due to the specific combination of penalties and moral appeals conservation efforts were quite substantial (Berk et al., 1980).

The present chapter contributes to the existing literature by examining the effects of a structural intervention with psychological implications, the instalment of domestic water meters. We will first summarize briefly the results of two large-scale metering projects that have been carried out in the US and UK over the past decades. Then we will discuss the various social-psychological implications of metering and present findings of two recent studies. These studies were carried out in the United Kingdom, one of the countries with the lowest proportion of domestic water meters in Western society (i.e., about 90 percent of properties in the UK are not equipped with a meter; OFWAT, 1996).

The Effect of Meters on Water Demands

During the 1950s and 1960s large-scale water metering projects were carried out in the United States, and they have shown some dramatic changes in consumption patterns. Probably the best documented research was carried in Boulder, Colorado, where water meters were universally installed in 1962 (Hankie & Boland, 1971). From '62 onwards customers were charged according to use level ($0.35 per 1000 gallons) instead of paying a standard charge. The water consumption data in Boulder had been gathered since 1955 and so a detailed time-series analysis could be performed on the development of domestic water consumption patterns. The researchers examined the average consumption data in the period between 1955 and 1968 and their findings showed that water demands decreased by an average of 36 percent after the instalment of meters. This result is depicted in Figure 2. The figure also indicates that the effects of metering remained fairly stable over the years. A behavior analysis of the data further revealed that the drop in water use could be attributed largely to a reduction in the use of sprinklers for such actions as lawn sprinkling, car washing, and filling swimming pools.

Insert Figure 2 about here.

Similar metering programs were carried out on different locations in the UK in the early 1990s. These trials showed a more modest decrease in water demand of about 11 percent on average (Department of Environment, 1993). However, the effects varied substantially between regions which could be accounted for by the use of different tariff systems associated with meters. The best results were obtained in East-Worcester, which introduced a so-called seasonal tariff whereby the price of water (above a certain level) increased during the summer months. This area showed an average drop of 17.2 percent over a 3-year period. In areas where meters were introduced without a change in tariff system, the results varied from a reduction of 1.6 percent (Bristol) to 7.3 percent (Mid Southern region). Similar to the Boulder-study, the drop in use levels remained fairly stable across the three year period after the intervention.

The Psychological Implications of Metering

The above results reveal that the introduction of meters can lead to a fairly substantial reduction in domestic water consumption. Although these findings are quite impressive by itself, they do not tell us a great deal about the mediating psychological processes of metering. Also, based upon these findings it is impossible to identify conditions under which the effects of metering will be more or less pronounced. For example, are the effects of metering different from one situation to another? Without the knowledge about possible mediating and moderating factors (cf. Baron & Kenney, 1986), it will be difficult to make a good prediction about its effects. Below, we will examine some psychological processes that are likely to mediate the effects of metering. Moreover, we will argue that the effects of metering will be moderated by the perceived state of the resources.

Greed. A first motive that may account for the positive effects of metering is greed. When water consumption is not individually metered households can use as much of the resource as they want without incurring additional costs. Charges are made according to a standard tariff, which is usually based upon the value of the property (i.e., a so-called flat rate tariff). This tariff system provides no direct incentive for conservation. The introduction of meters — and the associated change in tariff system — alters the reward structure of the dilemma dramatically. Suddenly, it becomes financially attractive for households to use as little water as possible. It follows logically from prior theorizing about social dilemmas (Dawes, 1980; Luce & Raifa, 1957; Wilke, 1991) that under these circumstances people will start to make conservation efforts as it is in their best interest.

Moreover, the greed motive will be particularly salient when people are facing a shortage. A crisis situation will highlight the conflict between people's self-interest and the interest of the community as a whole. From a collective view point, individuals should increase their conservation efforts to contribute to the solution of the problem. Yet many people might decide to increase their consumption rates while there is still an opportunity to do so (Kramer et al., 1986). This effect is likely to be attenuated, however, by the presence of a meter as metered households are penalized if they increase their water demands. Accordingly, the availability of a meter serves as a buffer against overconsumption during a shortage.

Personal efficacy. The beneficial effects of metering may also be due to social-psychological factors. Metering introduces a feedback mechanism that allows people to regularly monitor their consumption pattern. Feedback about use levels is provided standard on the bills customers receive, but they also may inspect the meter themselves - provided it is located at a convenient place. There is considerable evidence that feedback works, both in the context of water (Aitken et al., 1994; Geller et al., 1983) and energy conservation (Samuelson, 1990; Seligman & Darley, 1977). But, precisely how it works remains unclear.

The most likely explanation is that it enhances people's sense of personal efficacy as it allows them to determine if their conservation efforts have a noticeable effect on the size of their bills (Bandura, 1977).

An increased efficacy will help people cope better during a shortage for various reasons. First, they are presumably better able to adjust their behavior in case of a crisis as they know better how to reduce their consumption level. Also, unlike unmetered households they might think that their conservation efforts make a real difference in tackling the collective problem (Kerr, 1996). Finally, the occurrence of a shortage may be interpreted as negative feedback for the efforts they are already making and they may therefore work harder on the task ("goal-relevant information;" Locke, 1968).

Concern with responsible resource use. Thirdly, metering may be effective because it promotes the concern for a responsible use of water resources. That is, charging water according to a standard rate conveys to people that water resources are abundant and that they can engage in unrestrained consumption without any collective consequences. In contrast, via the introduction of meters and the associated pay-per-unit system it is communicated to customers that water is a valuable commodity and that it is each individual's responsibility to conserve. Such considerations will make it likely that individuals make conservation efforts, particulary when there is a collective threat like a shortage (cf. Samuelson & Messick, 1995).

Trust and attributions. A fourth factor that may account for the success of metering programs is that metering increases expectations about the conservation efforts of other people in the community. Individual households may have perfectly good intentions to conserve water during a shortage, but it is clear that their efforts are futile unless sufficient other people in the community make an effort as well. Hence, to engage in conservation it is important that individuals develop reciprocal trust (Liebrand et al., 1986; Yamagishi, 1986). Metering programs promote trust because in universally metered areas each community member realizes that others will be punished (i.e., by receiving a higher bill) if they do not restrain. This argument follows nicely from the structural goal/expectation theory (Yamagishi, 1986), which suggests that particularly in large-scale social dilemmas structural changes (e.g., in the form of a sanctioning system) are necessary to assure people that their well-intended behavior cannot be exploited by others.

In case of a resource crisis, these expectations also influence the attributions people make regarding the causes of the shortage. In areas where households are not charged according to use the occurrence of a water shortage may well be attributed to some greedy individuals consuming too much. Yet, when a whole community is charged according to use, a shortage is perhaps more likely to be attributed to external factors, such as leakages or unusual weather. Such attributions might determine how willing individuals are to restrain themselves during a shortage (Rutte & Wilke, 1987; Samuelson, 1991)

Fairness. Fifth, it may be considered fair that everyone pays according to what they use instead of paying a standard charge for water (cf. equity vs. equality rule; Deutsch, 1975). For example, people may regard it as unfair that they pay the same as their neighbors who are washing their car everyday. Because a metered system may be more in line with people's fairness expectations, it might encourage them to make conservation efforts, particularly when it is collectively most desirable (e.g., in case of a shortage; Tyler & Degoey, 1995).

Accountability. Finally, people with meters may feel more accountable for their behavior as their consumption patterns can, in theory, be monitored by the water authorities. Rather than in unmetered households, people in metered households may therefore feel more pressure to restrain themselves in case of a shortage (cf. Kerr, 1983).

Empirical Evidence for the Psychological Implications of Meters

In a first attempt to unravel the psychological mechanisms underlying the impact of metering we conducted two studies. In the first study we presented unmetered participants with scenarios to investigate how the idea of having of a water meter would affect their decisions in a hypothetical resource shortage. The second is a questionnaire study that was carried out during the 1995 water shortage in the UK among residents living in a universally metered or largely unmetered community.

Introduction to Study 1

In this study we presented a sample of one hundred UK citizens with fairly realistic scenarios describing their domestic situation and the state of the water resources in the community they were living.

Method

Participants and procedure. One hundred questionnaires were distributed to residents in Southampton, a middle-sized city in Hampshire, southern England. They were approached by research assistants either at the entrance of a large shopping mall or at a car park near the city center on two consecutive weekday mornings. If people agreed to participate they received a letter with instructions, a freepost return envelope, and a questionnaire to fill out at their leisure. Sixty-four questionnaires were returned (39 women, 24 men and one gender-anonymous, with an average age of 45 years), most of which (96 percent) were returned by residents living in properties without water meters.

Scenarios. The first part of the questionnaire consisted of various scenarios with information regarding the water resource situation in the place the participants were supposedly living. The scenarios were introduced as follows:

"Life on earth would be impossible without water. It is essential for mankind to have sufficient water supplies year round. Under normal circumstances there is enough water available in the UK to meet demands of all citizens. Currently, however, some parts of the UK are confronting a water shortage. Shortages now and then occur as a result of a sudden drought, massive leakages, or excessive demands."

Subsequent information was provided regarding the state of the water resources. Approximately half of the participants received information that they were living in an area where the water supplies were sufficient to meet the demands of all customers (abundance-condition). Conversely, the other half of the participants read that there were distribution problems in the region and that the water supplies were regularly insufficient to meet the demands of the people (scarcity-condition).

Thereafter information was provided about the charging system in the area they were living. In the metered scenario it was stated that all properties in the area were equipped with a meter and that residents had to pay according to use. In the unmetered scenario participants were informed that none of the properties in the area were equipped with a meter and that they were charged a standard fee regardless of their use level. All participants received both scenarios but they were presented in a random order.

After each scenario participants indicated their intention to conserve water by answering the following questions: "Under these circumstances are you willing to conserve water in your household?" "...are you willing to take fewer baths and/or showers?" (1 = not at all, 5 = very much so). Out of these questions, a single conservation index was construed ($r = 0.58$). Also, participants rated the two charging systems in terms of fairness and they expressed their willingness to invest money in improving the water supply system.

Results and Discussion.

A repeated measures ANOVA on conservation intention revealed first of all a main effect of charging system, $F(1,62) = 15.70$, $p < .001$ indicating a greater willingness to conserve when water use was metered ($M = 3.97$) rather than unmetered ($M = 3.36$). Also, a main effect of shortage was observed, $F(1,62) = 15.86$, $p < .001$, revealing that the willingness to conserve was much greater in case of a shortage ($M = 4.41$) rather than an abundance of water ($M = 2.91$). Finally and most interestingly, these variables were found to interact, $F(1,62) = 3.66$, $p < .05$. There was a significant difference in conservation between the metered ($M = 4.84$) and unmetered scenario ($M = 3.98$) in case of a shortage ($p < .05$), but this difference disappeared in case of an abundance of water (M's = 3.09 vs. 2.73, $p < .10$).

A similar effect was obtained for the willingness to invest money in improving the water supplies. There was a significant interaction between charging system and shortage, $F(1,62) = 3.53$, $p < .05$, in that people showed a greater willingness to give money in case of a shortage rather than an abundance, but only when they were metered (respective means M's = 3.36 vs. 1.59; $p < .05$) rather than unmetered (respective means: M's = 1.80 vs. 1.69, n.s.).

Finally, a repeated measures ANOVA on the fairness judgment revealed that the two charging systems were not seen as equally fair. Indeed the metered system was perceived as more socially fair ($M = 4.25$) than the unmetered system ($M = 3.71$), $F(1,62) = 3.27$, $p < .05$. This judgment was not influenced by the presence of a shortage, $F(1,62) < 1$.

To summarize, these experimental findings reveal a positive effect of metering, particularly when people are facing an immediate water shortage. Moreover, a metered system is considered to be more fair than an unmetered system in distributing water resources. These findings are generally in line with predictions derived from our social dilemma approach to metering. Next, we will examine the behavioral and psychological effects of meters during a naturally occurring resource crisis.

Introduction to Study 2

This study was conducted during the summer of 1995, in which the UK experienced one of its driest summers of the century. As indicated previously, all kinds of activities were initiated to promote conservation from the public, including media messages, leaflets, and hose pipe bans. Our research was conducted in Hampshire, an area in Southern England that was not subjected to any formal water use restrictions. This region was particularly suitable for our research purposes as it contained, within a largely unmetered area, a community in which all households had been (involuntarily) equipped with a water meter as part of the national metering trials in the early 1990s. By comparing responses in this community with those made in a similar but unmetered community we were able to examine the impact of metering ceteris paribus.[1] Although the immediate resource crisis had been allayed at the time of our survey, it was still having a major impact on radio, television, and in the newspapers.

Participants and procedure. Sixty questionnaires were distributed among residents in an area of Hampshire that was fully metered (i.e., Isle of Wight), whereas another sixty were distributed in a largely (but not fully) unmetered area (i.e., Southampton). We approached these people in local supermarkets on two consecutive Saturday mornings in September. If they agreed to participate they received an envelope containing an introduction letter, a questionnaire, and a freepost return envelope.

Of the total number of distributed questionnaires, thirty-six were returned by people in the metered community (60 percent) and 40 by people in the unmetered community (66.7 percent). The final sample consisted of 32 men and 44 women with an average age of 43 years.

Survey. The questionnaire was subdivided into various sections. The first section contained a number of questions regarding household (e.g., size of household) and demographic characteristics (e.g., age, gender etc). The second section consisted of a series of statements (1 = strongly agree, 5 = strongly disagree) measuring the perceptions and motives of people during the shortage. For example, there were items related to greed, the severity of the shortage (e.g., "The water shortage had an important impact on me and the other members of my community"), concern with responsible use, trust in others (e.g., The shortage was due to gardeners using too much water"), and the efficacy to do something about the problem (e.g., "I found it difficult to change my behaviour and adapt to the dramatic situation"). The third and final section contained a series of ten statements about how people adapted their behavior to the shortage (e.g., "I only used the dishwasher when I had a full load" "I washed my car less than usual" etc.). All constructs were measured reliably with Cronbach's alpha's between 0.72 and 0.75 (i.e., greed was measured by a single item).

Results and Discussion

Conservation decisions A hierarchical regressional analysis was performed to examine the behavioral effects of metering. In a preliminary analysis we included various demographic variables in the equation (e.g., age, gender, household size) but these were dropped because they did not affect the conservation decisions.[2] The main analysis included the dummy coded metering variable (0 •= not metered, 1 = metered) as well the estimated severity of the shortage as factors in the design, because we argued that the effects of metering would be particularly pronounced when people were indeed aware of the resource crisis.

This analysis revealed no main effect for metering (beta = 0.08, n.s), but we did find evidence for a main effect of severity (beta = 0.47, p <.001) and an interaction between severity and metering (beta = 0.44, p <-001). This interaction is graphically displayed in Figure 3 (see Aiken & West, 1991, for the treatment of interactions with continuous variables). It shows that when the shortage was perceived as severe the metered residents exhibited greater conservation than the unmetered residents, whereas these differences were less pronounced when the shortage was not perceived to be severe. The totally explained variance by the three factors amounted to almost 30 percent (adjusted R^2 = .2967).

Insert Figure 3 about here.

Psychological effects of metering. Although the analysis failed to obtain a straightforward effect of metering on conservation, we did find that metering had a beneficial impact when people were aware of the resource crisis. We will now look at some of the psychological mechanisms that may account for the positive effects of metering, greed, personal efficacy, responsibility, and trust.

We argued previously that the beneficial effects of metering may be due to the fact that people will be "punished" if they do not restrain themselves during a shortage as they will receive a higher bill. An ANOVA on the greed-question ("I remained reluctant to splash out for fear of large bills") revealed that people in the metered sample (M = 1.93) were indeed more concerned with their personal costs than people in the unmetered sample (M = 3.33), F(1,75) = 19.46, rj <.001. This difference was particularly pronounced when the shortage was perceived as severe as indicated by a significant interaction effect between metering and severity (i.e., the latter variable was dichotomized through a median split), F(1,75) = 4.53, rj <.05. In the high severity condition the difference between metered (M = 1.64) and unmetered residents (M = 3.47) was much larger (p <.05) than in the low severity-condition (M's = 2.29 vs. 2.62; n.s.).

The effects of metering might also be due to a greater personal efficacy to make conservation efforts. We analyzed the results of two questions ("I found it difficult to change my behaviour and adapt to the dramatic situation" "Looking back I could not have restrained myself more than I did") and found that metering influenced only the responses to the second question. Relative to the unmetered sample (M = 2.93), people in the metered sample thought they could have restrained themselves more during the shortage (M = 3.90), F(1,75) = 4.11, 2 <.05, which reveals a greater sense of efficacy to conserve. This was not further influenced by perceptions of the severity of the shortage.

A third advantage of metering might be that people become more concerned with responsible resource use. The analysis on a combined score of these items (e.g., "I felt that if I limit my water use this might have collective consequences") revealed no overall difference between the metered and unmetered sample, F(1,75) <1. However, metered residents showed a greater concern when the shortage was perceived as severe (M = 1.61) rather than insignificant (M = 2.72; 2 <.05), whereas this difference was less pronounced for unmetered residents (M's = 2.04 vs. 2.50; n.s.).

A final factor associated with metering might be that it enhances trust in the cooperation of others and prevents from attributing the shortage to "selfish" others. We analyzed the results on a combined score of three questions related to trust (e.g., "The shortage was due to gardeners using too much water"). This analysis revealed that as expected residents in the metered sample (M = 2.86) were more trusting than residents in the unmetered sample (M = 2.51), F(1,75) = 4.27, 2 <.05. This was not further influenced by perceptions about the severity of the shortage, F(1,75) = 1.34, n.s.

The above findings show that metering yields numerous psychological effects that may help to increase conservation. The availability of a meter appears to be associated with a greater concern about the personal costs and collective costs of water use, and it enhances feelings of efficacy, responsibility, and trust in others.

Mediators of the impact of metering during a shortage. Which of these factors are most likely to account for the beneficial effects of metering during the experienced shortage? We performed several additional mediational analyses to examine which factors best account for the obtained behavioral effects. To establish mediation it has to be shown that these psychological mechanisms not only directly predict conservation decisions, but also that the effect of metering on conservation disappears or weakens when these factors are added as covariates (Baron & Kenney, 1986).

These additional analyses revealed that the most likely mediator of the impact of metering during the shortage is a concern with responsible water use. First, the previously reported analysis revealed already that metered residents who perceived the shortage as severe were much more concerned with responsible resource use than the unmetered residents. Furthermore, these concerns were positively and strongly related to people's conservation decisions (beta = 0.57, 2 <-001). Finally, when these concerns were accounted for the interaction effect of metering and severity on conservation lost its strength (a four percent decrease in explained variance; beta = 0.36 vs. 0.44 in the equation without the covariate). Hence, there is some evidence to suggest that the restraint shown by metered residents during the shortage was due predominantly to a greater concern with responsible resource management.

General Discussion

In the current chapter we utilized insights derived from social dilemma research to understand the effects of domestic water metering. Having conceptualized metering as a techno-structural intervention in a natural resource dilemma, we evaluated the psychological implications of this change. Our theoretical and empirical analysis yields a number of interesting conclusions.

Based upon a review of two large-scale metering programs a first conclusion is that the instalment of domestic water meters can have a quite dramatic impact on the use levels. Reductions in average demand of 11 to 36 percent per year were measured in studies conducted in the UK and US, respectively. Interestingly, the results revealed that these reductions remained fairly stable over the years. This suggests that with the introduction of meters households develop new consumption patterns which become habitual after some time. In this regard, it is interesting to note that there is a widespread idea in the research literature that the instalment of conserving technological devices may lead to a "compensation" strategy (Geller et al., 1983), whereby use levels increase after a while to compensate for any financial savings (e.g., taking longer and frequent showers). The current findings reveal no support for this theory as the use levels remained low over the years.

What behavioral adjustments may account for the obtained reduction in water demand? It is quite difficult to answer this without an extensive behavioral analysis. However, there is some preliminary evidence from the US study to suggest that water savings may have been largely due to one kind of behavioral change, a more restrained use of sprinklers. If this is true, we would expect the effects of metering to be most pronounced under a tariff system that makes excessive water use particularly unattractive during the summer months. A comparison between different tariff systems used in the UK metering trials indeed revealed that the greatest reduction in water demand was obtained in regions where metering was accompanied by a seasonal tariff (Department of Environment, 1993). Under this tariff households are charged extra for any water use in the summer exceeding their use level in the winter. Accordingly, it is made less attractive for people to engage in activities during the summer that require much water such as gardening or the use of swimming pools. Our second conclusion is therefore that metering is beneficial in promoting conservation but that the size of the effect depends, at least to some extent, on the nature of the tariff system that accompanies the meter.

Third, the present analysis indicates that the behavioral impact of water meters is moderated by the perceived state of the resources. Our survey findings revealed that the effects of metering were particularly pronounced when people were facing a resource crisis. In the face of a water shortage (i.e., either real or simulated), households with meters appeared to be more willing to make conservation efforts than households without meters, and this difference was much smaller in case of a resource abundance. These results were quite consistent with the aggregated consumption data in the two communities during the shortage in the hot and dry summer of 1995. Relative to the summer of 1994, there was an eight percent growth in water consumption in the metered community compared to a growth in the unmetered community of more than L7 percent.

This result is very important because it gives a strong justification for the widespread implementation of metering programs - recall that, for example, in the UK less than ten percent of the properties are currently equipped with a meter. Following recent droughts, policy makers are increasingly concerned with developing strategies to cope with a future shortage (OFWAT, 1996). Our findings suggest that the introduction of water meters may help to tackle future problems in two different ways. First, by decreasing water demands structurally, meters are instrumental in preventing a future shortage. Second, meters promote a better resource management during a shortage when there is an urgent need for conservation. To understand why let us examine the various psychological processes underlying the effects of metering.

Following prior theorizing about resource dilemmas (Messick et al., 1983; Samuelson et al., 1984), we proposed that metering works because it yields a personal incentive to conserve as well as promotes concerns with responsible resource management and is in line with people's fairness expectations. These motives are most salient during a water shortage (cf. Kramer et al., 1986). The analysis of our survey data revealed that the behavioral effects of metering during the shortage could be accounted for by concerns with the collective wellbeing. That is, rather than in the unmetered community, residents in the metered community were more concerned with responsible resource management, at least to the extent that they perceived the shortage as more severe. As the resource problems in both communities were essentially the same, it is tempting to conclude that the availability of a meter evokes these prosocial concerns.

How might this work? The presence of a meter perhaps conveys to people that water is a valuable and scarce resource which should not be wasted ("transformation of motivation"; cf. Kelley & Thibaut, 1978). Accordingly, metered households do not have to be told what to do when there is a collective threat. Although our mediational analyses suggest that this is the most likely explanation for the obtained effects, the social dilemma approach suggest alternative interpretations as well. First, as compared to unmetered residents metered residents do not need further instructions as they probably know better how to conserve ("personal efficacy"; Bandura, 1977). Perhaps therefore the metered residents in our survey sample indicated they could have done more to restrain themselves during the shortage.

Second, in universally metered communities there might be greater trust in the conservation efforts of others as people may realize that greedy others will be punished by receiving higher bills (cf. structural goal/expectation theory, Yamagishi, 1986). Preliminary evidence for this interpretation stems from our finding that, relative to the unmetered sample, people in the metered sample attributed the cause of the drought less to gardeners using too much water. Previous experimental research has indeed revealed that such attributions shape the conservation decisions in resource dilemmas (e.g., Samuelson, 1991).

Third, we expected metering to be beneficial because it would be considered a fairer method of distributing a valuable but scarce resource. Indeed we obtained evidence in study 1 that residents (of a largely unmetered sample) thought it was socially more fair if they would be charged according to their use level. That a metered charge is considered to be more fair than a flat rate charge is in line with notions of equity because people pay more to the extent that they use more. The equity principle is commonly used in the transaction of economic or private goods (Deutsch, 1975). The strict application of this distribution rule in the domain of public goods or resources may, however, lead to an undesirable situation as such vital goods or resources could be withheld from individuals who cannot afford to pay. This is a particular problem in countries where resources are regularly insufficient, such as drinking water in some developing countries. In these situations, the introduction of water meters is clearly not a very appropriate strategy to tackle resource problems.

From a more theoretical perspective, our analysis of metering is important because it provides a conceptual framework to understand the nature and role of structural change in social dilemmas. Social dilemma theorists usually distinguish between individual-psychological and structural solutions and assume that the latter produce better results because they provide a direct incentive to cooperate (Messick & Brewer, 1983; Rusbult & Van Lange, 1996). The present analysis suggests, however, that a simple rational-economic model is too limited to explain the effects of structural change. First, the effectiveness of structural solutions is probably moderated by characteristics of the individual actor, the group, or the dilemma situation at hand. As indicated in our studies for example, structural interventions are more effective in the face of a resource shortage rather than abundance. Structural changes probably also work better in low cohesive rather than high cohesive groups as people may not believe in the feasibility of achieving the good by voluntary cooperation alone (i.e., collective efficacy; Kerr, 1996). Finally, the impact of structural change might vary with pre-existing differences in social orientations. For example, the introduction of a sanctioning system (i.e., to punish noncooperators) has a greater impact on people with a low rather than high level of interpersonal trust (cf. structural goal/expectation theory; Yamagishi, 1986). Similarly, people who are high (rather than low) in authoritarianism (Doty, Peterson, & Winter, 1991) may be more willing to cooperate after a structural change (e.g., appointment of leader).

A theoretical model of structural change should also take into account the various psychological processes that mediate the success of structural solutions. Following a rational approach, the primary motive in judging structural change is greed: "How does it affect my personal outcomes?". However, the acceptance of any structural change is also influenced by perceptions regarding its consequences in terms of the collective interest, fairness, and decisional freedom (Samuelson, 1993; Samuelson & Messick, 1995; Van Vugt, in press). The impact of these evaluations are necessary to understand why structural changes might sometimes fail.

For example, in a previous study we examined the impact of a structural solution to a real-world dilemma, the implementation of a carpool lane (Van Vugt et al., 1996). From a purely rational perspective, this lane should have been successful in reducing individual car use because it gave people a clear incentive to share their car (i.e., use of the lane would decrease their travel time with 40 percent). Our longitudinal study revealed, however, that nobody in our sample of about 200 solo drivers switched to carpooling. On the contrary, car drivers developed an even more negative attitude towards carpooling. This reaction can be understood by taking into account the broader psychological effects of this structural change. With the introduction of the carpool lane car drivers felt they were deprived from a benefit they thought they were entitled to — an extra lane to reduce traffic congestion (cf. "relative deprivation;" Cook et al., 1977). Also, they thought this intervention would do very little to solve the collective problems associated with car use (i.e., environmental and congestion problems).

Recommendations for Research and Policy

Based upon the previous discussion we would like to make some recommendations for further research into the effects of structural change in social dilemmas. One of the major goals of future research should be to develop a comprehensive theory of structural change, which takes into account the role of potentially important moderating and mediating psychological processes. Currently, a systematic theory for understanding the effects of structural change is lacking (Ostrom, in press). Future research should evaluate structural interventions both in the real-world as well as in the controlled laboratory environment. For example, to investigate the effects of metering more precisely, we could manipulate this intervention in an experimental resource dilemma task whereby research participants either pay for the resources they use or pay a standard access fee. An important direction for applied research would be to further examine the role of new technological developments, such as metering, because they may be very important in promoting efficient resource management (Kempton et al., 1992). Our findings are indeed consistent with Crabb's (1992; p. 815) general claim that "Technological devices and products .... are in themselves potent sources of behavior control. These devices and products play the key role in regulating energy depletion."

Finally, what lessons can we learn from the above for the development of resource management policies? A first lesson is that in the face of future shortages (in water or energy) it is undesirable to have charging systems in place where resource demand and costs are not or only weakly related. Accordingly, programs of metering should be implemented as soon as possible in places yet unmetered, such as large areas in the UK and Ireland. Before implementing them, however, it is essential that there is sufficient public acceptance of meters as this will greatly facilitate their adoption (Stern, 1992). This could be achieved by public messages stressing the personal and collective advantages as well as fairness of metering. Moreover, once implemented people should be given intensive feedback about their use level, which can be achieved by sending regular bills and/or by locating the meter at a significant place in the house. As for the short-term, the present findings suggest that educational activities during an immediate crisis must target at households without a meter. They should receive messages telling them why and how they should conserve as they may be lacking in motivation and efficacy to conserve.

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Footnotes

[1] If one would compare unmetered properties with properties that have been voluntarily metered it would be difficult to assess the impact of meters independent of existing differences between the households in, for example, family size, property value, and conservation attitudes. According to the UK tariff system metering is indeed relatively less attractive for larger families in cheaper accommodations.

[2] This may seem counterintuitive as these variables have been found to be important predictors of water consumption by other researchers (e.g., Aitken et al., 1994; Thompson & Stoutemeyer, 1991). However, the questions in our survey were primarily focused on how households changed their decisions during the shortage (e.g., "I washed my car less than usual") and there are no good reasons why this should be influenced by demographic characteristics, such as age or family size.

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The preparation of this chapter was supported by a grant from the Annual Grants scheme of the University of Southampton (A95/13).

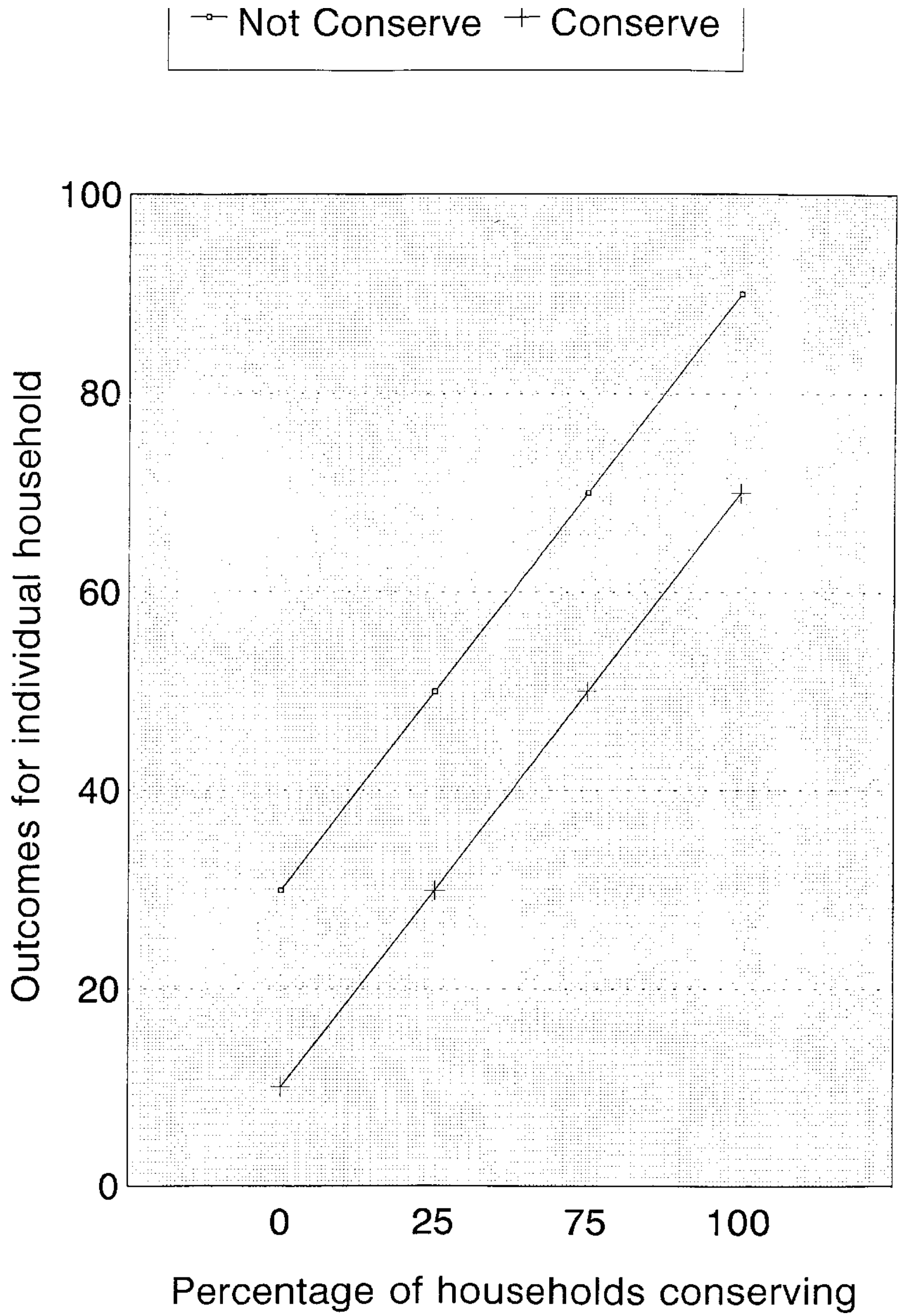
Figure Captions

Figure 1. Reward structure of the conservation problem defined as an N-person Prisoner's Dilemma Game.

Figure 2. Aggregated water use levels in Boulder (Colorado) in the period from 1955 to 1968.

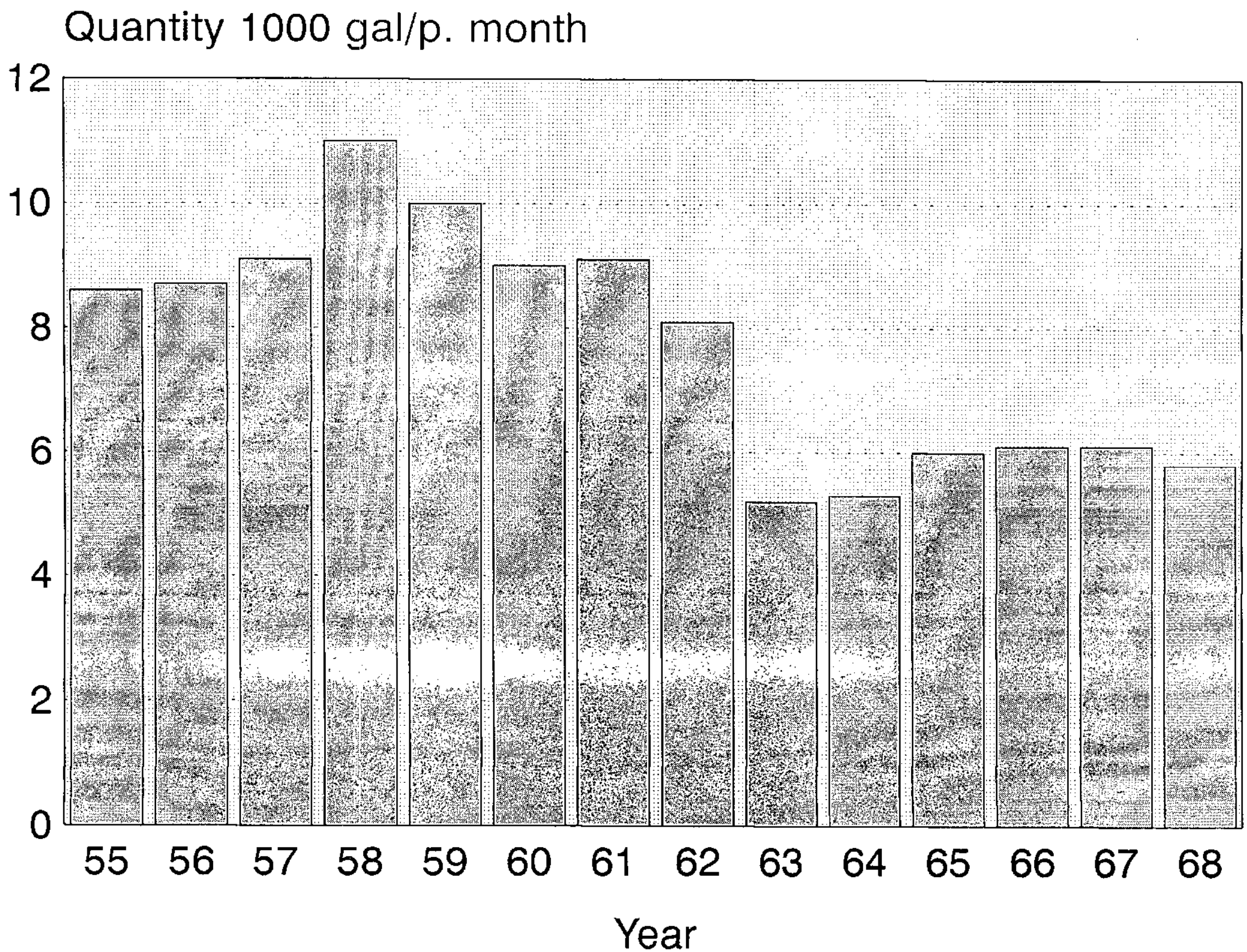
Note Water meters were universally installed during 1962.

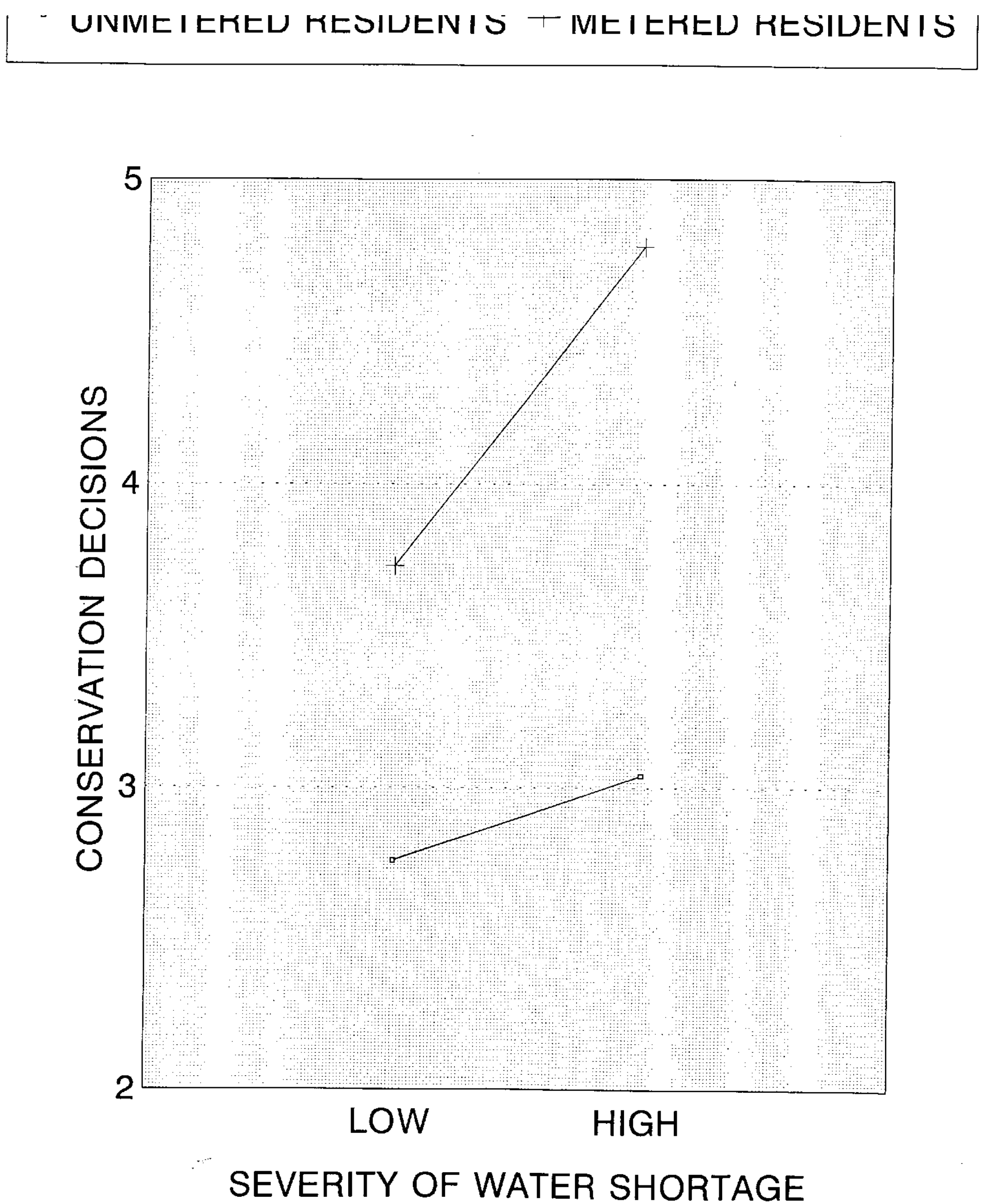
Figure 3. The influence of metering and severity perceptions on conservation decisions during the 1995 UK shortage.



Not Conserve
Conserve
100
80
60
40
20
0
Outcomes for individual household
0
25
75
100
Percentage of households conserving

Domestic Water Use in Boulder, Colorado (adapted from: Hanke & Boland, 1971)




UNMETERED RESIDENTS
METERED RESIDENTS
CONSERVATION DECISIONS
5
4
3
2
LOW
HIGH
SEVERITY OF WATER SHORTAGE