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THE EFFECT OF FEEDBACK AND SOCIAL REINFORCEMENT ON RESIDENTIAL ELECTRICITY CONSUMPTION

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ABSTRACT

This experiment explored the effect of informational feedback in reducing electrical energy consumption with eleven matched quads of all-electric apartments in Portland, Oregon. Feedback about KWH usage was provided from electrical meter readings during baseline, treatment and follow-up phases during the summer of 1977. Following a two week baseline period, apartments were exposed to one of the following conditions: (1) No treatment Control; (2) Daily Contingent Feedback, where informational feedback about KWH usage was provided on a daily basis; (3) Three Day Contingent Feedback Plus Decal, where feedback was provided every third day and commendation in the form of a decal was presented for reduced consumption; (4) Three Day Noncontingent Feedback Plus Decal, where feedback plus commendation were provided every third day, regardless of whether or not electricity consumption had decreased. Each of these feedback conditions had very little impact on electrical energy consumption during the two week treatment or the two week follow-up periods. These findings were viewed as consistent with other research which has also documented the limited impact of feedback on energy consumption. An analysis of the boundary conditions for the effectiveness of informational feedback stimuli was presented.

Recent articles in this journal [1-3] and elsewhere [see 4-6 for reviews of this work] have documented the results of recent psychological research on the nation's energy crisis. This research is based on the assumption that a significant amount of energy consumption stems from needless and excessive waste. Thus,

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while many current proposals to solve this problem focus on technological innovations, such as developing alternative energy sources, psychologists have stressed the equally important task of promoting widespread behavioral changes in the way individuals use energy. This research has focused on teaching individuals to weaken behaviors which involve excessive and wasteful energy consumption and to strengthen behaviors which involve greater energy conservation. At the same time, it has explored a variety of techniques for implementing these behavioral changes across a large population of individuals.

Providing individuals with feedback about their consumption of energy has been one of the most widely employed psychological techniques in this research program. This technique is derived from the well established principle [7-9] that giving individuals informative feedback about the consequences of their behavior is one of the essential conditions for behavioral change. Unfortunately, individuals are rarely provided with immediate or explicit feedback about their consumption of energy. For example, feedback about residential electricity or natural gas consumption is only tenuously related to the actual consumption of these resources. Information in the form of monthly billing arrives long after they are consumed. The information on such bills makes it impossible to monitor daily usage. Indeed, this form of feedback fails to provide individuals with unambiguous information about the effects of specific energy conserving behaviors, such as turning down the hot water heater or lowering the thermostat.

In order to improve these conditions, a variety of new feedback procedures has been developed to provide homeowners with information about residential energy consumption. For example, feedback has been presented on written notes delivered to the residence [10, 11], by light signals activated by current sensitive relays [12] and more recently with energy monitors which provide digital displays of momentary energy usage [3]. Further, such feedback has been presented to homeowners on a daily [2], weekly [11] or even monthly basis [13]. Moreover, this information has been formulated in several ways, such as absolute KWH usage [14], percentage change from baseline level [15], and actual KWH usage compared with weather corrected estimates of such usage [16] or the consumption of other individuals [17, Experiments 3 & 4]. It has also been combined with other consequences including information about monetary costs or savings [10], as well as various positive reinforcers such as rebates [11] and social commendation [18].

Regardless of such methodological differences, the majority of these studies indicate that providing individuals with such feedback can reduce residential electrical consumption from 10 per cent to 20 per cent. At the present time however, the parameters governing this effect are far from certain. For example, while there is some evidence [2] that frequent (e.g. daily) feedback is most effective, other evidence indicates that comparable reductions occur even when feedback is given on a monthly basis [13]. Further, almost all of the research indicates that these decrements do not last long and once the feedback stimuli

are removed, homeowners very quickly revert to their former patterns of energy consumption. Most importantly, there are an increasing number of studies (11, 12, 17-21) which report conditions under which feedback has very little, if any, effect on overall residential energy consumption. Accordingly, the following study was designed to investigate in a rigorous fashion the role of feedback on residential energy consumption in order to determine more clearly the boundary conditions under which this technique will instigate a significant change in behavior.

Although several investigations have shown that feedback alone is relatively ineffective in reducing energy consumption, some of these studies have, at the same time, demonstrated that when feedback is combined with various positive reinforcers residential energy consumption is reduced. For example, Seaver and Patterson found that feedback plus social commendation (a "We Are Saving Oil" decal) led to significantly lower fuel-oil consumption than informational feedback alone [18]. Similarly, Kohlenberg, Phillips and Proctor report that a combination of feedback plus attractive monetary incentives was far more effective in reducing peaking (use of electrical energy during high use periods) than feedback alone [20]. Lastly, Winett, Kagel, Battalio and Winkler report that homeowners were much more likely to curtail their use of electricity when they were given large monetary rebates in combination with weekly feedback, than they were when they were given such feedback alone [11]. Thus, the second objective of the following study was to explore the generality of these findings by investigating the effect of informational feedback when it was combined with social commendation.

In all of the foregoing studies the presentation of feed-back plus reinforcement has been *contingent* upon actual reductions or energy consumption. Thus, it is impossible to know from this research whether comparable effects would occur if these conditions had been administered in a *non-contingent* fashion, i.e. independent of whether or not individuals actually used less electricity. For example, feedback might reduce electricity consumption because it provides individuals with information about their performance of specific energy conserving behaviors. Or it might produce such changes because it motivates them in a variety of ways to conserve energy. Such a possibility is, for example, implied by Bem's self-perception theory which suggests that if an individual is given information indicating he is saving energy, he may develop a positive attitude toward doing so and, thereby, actually become an energy conserver [22]. Thus, while the outcome might be the same, the basic process underlying such changes in consumption might be entirely different. Accordingly, the following study was also designed to distinguish between these alternative interpretations by including a condition in which subjects were given feedback combined with social commendation, regardless of whether or not they actually decreased their consumption of electricity.

In short, this experiment attempted to answer three questions:

1. Would regular feedback about electricity consumption reduce residential usage of this resource?
2. Would a combined feedback plus social reinforcement condition be more effective than feedback alone?
3. Would comparable effects be obtained when these conditions were delivered in a noncontingent fashion?

METHOD

Subjects

The subjects were tenants of a large apartment complex in Milwaukie, Oregon, a suburb of Portland. The complex was composed of 106 one, two and three bedroom apartments, ninety of which were available for electrical meter readings. These apartments were all-electric units, including electrical air-conditioning, which represents a major source of summer electricity consumption. Electric meters were located on the back side of each apartment block in view of most of the tenants for that block. The subjects inhabiting the apartments were of all age levels and generally appeared to be in the middle class income bracket. Although ninety electrical meters were read during the initial baseline period, only forty-four apartments could be included for the duration of the study. The others were excluded if the experimenters could not contact the tenants to gain their permission to continue meter readings, if the tenants had recently moved in or planned to move out within the period of the study, if their electrical consumption was low enough to suggest a floor effect (where further reductions in consumption were not likely) if the tenants would not grant permission to continue meter readings, if the apartment's baseline average consumption could not be matched with an appropriate quadruple, or if the tenants planned an extended vacation (more than three days) during the period of the study.

Procedure

The study followed an ABA design which spanned a seven week period in the summer of 1977. This period was divided into three two-week phases and a one-week information phase as follows: Baseline, Information, Treatment and Follow-Up. During the Baseline period the experimenters read all ninety electric meters at 10 a.m. every morning. At this time only the managers were aware that the study was in progress. If the tenants asked about the meter readings the experimenters explained that they were conducting research and would talk to them within a couple of weeks. Following the Baseline phase, during a contact period of one week, the experimenters visited each of the ninety apartments to obtain information about the tenants, to secure their

permission to continue meter readings, and to distribute a copy of Portland General Electric's "Watt Watcher's Guide." The interview was conducted in the following manner:

> Hello, my name is _____ with the Environmental Studies Organization, and we are currently involved in some research on electrical consumption, and would like to ask you a few questions. It will only take a few minutes.

If the tenant agreed, the experimenter read the questions from a questionnaire which was utilized mainly to gain access to the unit, to determine whether the tenant had lived and intended to live there for the entire seven weeks, and whether a vacation was planned during that period. Following the questions the experimenter continued as follows:

> As I mentioned, we are conducting research on electrical consumption, and you may have noticed us reading your meter for the last couple of weeks. We would like to continue reading your meter, with your permission, for another four weeks. Also, we may or may not be dropping off some information on your consumption; if we do, we'll just tape it to your door.

The interviewer concluded by thanking the tenant and leaving the Watt-Watcher's Guide. During these interviews the experimenters were blind to the tenant's future condition, as well as to the apartment's average KWH usage.

Following the contact period, the experimenters distributed the apartments among the four treatment blocks according to the following method: First, an average daily Baseline KWH usage for each apartment was established. Apartments were then matched in groups of four based on the similarity of such usage. The experimenters sought as close a match as possible, rather than a large sample size. Therefore, a few apartments were eliminated because their tenant's average daily consumption did not readily match another three apartments. The criterion for this match was that the differences in average daily usage not exceed 1.6 KWH between the four apartments in one matched quad. The final sample consisted of eleven matched quads. The four apartments in each quad were randomly assigned to the four treatment conditions.

Conditions

During the two week treatment phase, the experimenters continued to read meters daily. The four conditions were distinguished in the following way.

Control–Subjects in this condition had their meters read daily, but received no other intervention.

Daily Contingent Feedback–Subjects in this condition had their meters read daily. Following each such reading they received a feedback sheet taped

to their door. As shown in Figure 1, this sheet indicated how many KWH they had used during the previous day. This figure was compared with their reading of the day before, to the Control group's average for the preceding day and was translated into monetary costs. The subjects in this condition received a total of fourteen such feedback slips.

Three Day Contingent Feedback Plus Decal—Subjects in this condition also had their meters read each day. Every third day they received a feedback sheet similar to the one distributed in the Daily Contingent Feedback condition. As shown in Figure 1, the information on this sheet covered their total usage for the preceding three days. When their consumption for that three day period was less than the amount used in the previous period they also received a stick-on decal. As shown in Figure 2, this decal contained the research group's logo (Environmental Studies Organization) and the statement "We are conserving energy." Subjects were initially informed that they would receive up to a maximum of five different decals along with their feedback sheets during the two week treatment period.

Three Day Noncontingent Feedback Plus Decal—Subjects in this condition had their meters read daily. Every third day they received a feedback slip indicating that they had been successful in saving electricity for that time period. A sample of this sheet is shown in Figure 1. These sheets were presented regardless of whether or not the subjects' electricity consumption had actually decreased. Along with the feedback sheets the subjects also received a total of five "We are conserving energy" decals during the two week period.

During the Follow-Up period all intervention procedures were removed and the meters continued to be read daily. Throughout each phase of this study verbal contact was kept to a minimum. At the conclusion of the Follow-Up phase all the subjects received a thank you note. Those who had never received a decal were also sent one at this time.

RESULTS

Table 1 lists the range and mean daily KWH usage for each group during the three phases of the study. While there was some initial variation between apartments, the matching process insured a high degree of pretreatment comparability between the groups, with each averaging approximately 21 KWH of electricity consumption per day. Thus, there were no differences between the groups on this measure during the two week baseline period.

Table 1 also provides information about electricity consumption during each week of the treatment and follow-up periods. It is clear from this evidence that the level of consumption in each group continued to be about the same as it had been during the baseline period. Indeed, the average KWH change was

1. *Sample Feedback Slip for Daily Contingent Feedback Subjects*

You used _____kilowatts of electricity yesterday ( ) which amounts to $_____. This is up/down _____kilowatts from the previous day's ( ) usage and up/down _____kilowatts from yesterday's ( ) average usage by Spring Creek residents.

2. *Sample Feedback Slip for Three Day Contingent Feedback Plus Decal Subjects*

You have used _____kilowatts of electricity in the last three days ( ) which amounts to $_____. This is up/down _____kilowatts from the previous three-day period ( ) and up/down _____kilowatts from the average Spring Creek resident's same three-day usage.

3. *Sample Feedback Slip for Three Day Noncontingent Feedback Plus Decal Subjects*

Our records of the number of kilowatt hours of electricity that you have used the last three days ( ) indicate that you have been successful/unsuccessful in saving electricity (this measure takes into account the variations due to weather conditions). We appreciate your participation.

Figure 1. A sample of feedback slips presented to each of the experimental groups.

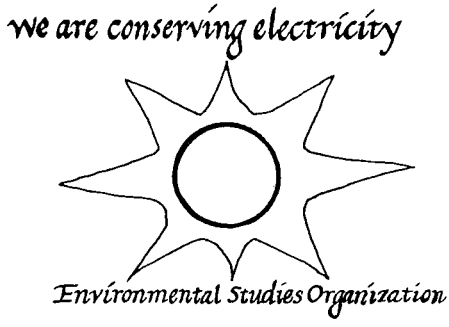

Figure 2. A sample decal presented to subjects in the Three Day Contingent Feedback + Decal and the Three Day Noncontingent Feedback + Decal conditions

Table 1. Daily Kilowatt (KWH) Usage

	Baseline	*Treatment*		*Follow-Up*	
	(Weeks 1 & 2)	*Week 4*	*Week 5*	*Week 6*	*Week 7*
Control					
Mean	21.2	21.2	22.6	21.3	22.3
Range	13.2-36.0	14.3-38.5	13.9-43.3	14.0-45.7	14.5-38.
Daily Contingent Feedback					
Mean	21.2	20.6	18.7	20.7	21.9
Range	12.9-34.7	12.8-27.8	7.0-31.1	8.2-32.3	5.7-32.9
Three Day Contingent Feedback + Decal					
Mean	21.2	19.3	19.7	19.8	21.8
Range	12.7-34.0	9.7-30.5	13.7-30.6	12.5-26.0	12.1-35.
Three Day Non-Contingent Feedback + Decal					
Mean	21.3	21.9	21.9	19.5	22.6
Range	12.6-33.9	17.2-30.8	13.9-35.9	9.3-32.7	12.9-30.

Table 2. Number of Apartments That Decreased KWH Usage From Baseline (N=11)

	Treatment		*Follow-up*	
	Week 4	*Week 5*	*Week 6*	*Week 7*
Control	6	5	6	4
Daily Contingent Feedback	6	9	5	4
Three Day Contingent Feedback + Decal	9	7	6	6
Three Day Non-Contingent Feedback + Decal	5	3	4	2

negligible in all groups during each subsequent week of the study. In only one case (week 5 for the Daily Contingent Feedback group) was this change greater than 10 per cent. A Friedman two way analysis of variance failed to detect any significant overall difference between the groups in mean KWH usage during either the treatment or follow-up periods [23]. The same was true for the analysis of percentage change in KWH usage between baseline treatment, as well as for the percentage change in such usage between the baseline and follow-up period.

Because this quantitative analysis was not significant, an additional, somewhat simpler measure of electricity consumption was analyzed. This measure categorized apartments in terms of those that either increased or decreased KWH usage relative to the baseline period, regardless of the magnitude of this change. Table 2 lists the number of apartments in each group that displayed decreasing levels of consumption when this comparison was made for each week of the treatment and follow-up periods.

This evidence indicates that the majority of residences used less electricity during the treatment period than they did during the baseline phase. However, the magnitude of this effect was not large. Thus, a Cochran Q test for related samples revealed there were no overall differences between the groups during the first week of treatment [23]. However, during the second week there was a significant ($Q = 6.66$, $df = 3$, $p < .05$) overall difference between the groups on this measure. Although none of the experimental groups differed from the Control, the Binomial Test [23] revealed that significantly ($X = 1$, $p < .035$) more residences in the Daily Contingent Feedback group used less electricity during week 5 than was the case in the Three Day Noncontingent Feedback + Decal group. Further, a Chi Square test of an *ad hoc* combination of the two contingent groups revealed that in the Daily Contingent Feedback and Three Day Contingent Feedback + Decal groups the total number of residences that used less electricity during the second week of treatment differed significantly from the Three-Day Noncontingent Feedback + Decal group ($X = 3.58$, $df = 1$, $p < .05$). This difference did not persist however, and these groups did not differ on this measure during either of the two follow-up weeks. There were no other significant differences between the groups during any phase of the study.

DISCUSSION

Taken together these results indicate that the feedback conditions employed in the present study had very little impact on electrical energy consumption. This was true when apartment dwellers were provided with daily feedback about their consumption of electricity. It was also true when they were given such feedback every three days and also commended if they reduced their consumption. Moreover, the contingency requirement did not seem to matter, since the same outcome occurred when feedback every third day was combined with commendation, regardless of whether or not subjects actually used less electricity. Finally, although there was some evidence of decreasing levels of consumption during the second week of treatment, this was an extremely modest effect which was confined to only one of the group comparisons. Moreover, it was not maintained during the follow-up period, after the feedback conditions had been removed. In short, the role of informational feedback was explored under a variety of conditions and in none of them was it found to be very effective.

These findings are consistent with several other studies which have also reported conditions under which feedback by itself does little to promote energy conservation. For example, Seaver and Patterson found that feedback about fuel oil consumpiton was not effective in reducing its subsequent usage [18]. Seligman, Darley and Becker also report that three different types of feedback (comparisons based on the subject's, others or objective usage patterns) had little or no effect on homeowners consumption of natural gas during the winter (Experiment 3) or on the consumption of electricity during the summer (Experiment 4) [17]. Further, in two separate studies Becker has reported that feedback about electrical energy consumption was not effective in reducing usage when it was provided every third day [12] or when it was delivered to subjects who were asked to set a relatively easy performance goal of reducing their consumption by 2 per cent [19]. Kohlenberg and his colleagues have also reported [20] that feedback had relatively little impact on peaking in three residences or on overall KWH usage in a much larger sample [21]. Finally, Winett, Kagel, Battalio and Winkler [11] report that weekly feedback about electricity consumption was actually associated with an increasing rate of consumption in electrically air conditioned homes during the summer.

Thus, although previous research has found feedback to be an effective method of reducing energy consumption, the generality of these findings is far from clear. While the technique does appear to work well under some conditions, there appear to be several others where it does not. Thus, it is essential to begin to identify the specific components of these limiting conditions and to determine how they are distinguished from those where positive effects occur. Further, it is also important to attempt to standardize the conditions under which this research is undertaken, so that results will not be obscured by the methodological inconsistencies which have characterized previous studies in this area.

Several factors have been proposed to demarcate these boundary conditions. For example, it has been suggested that feedback must be given several times a week to promote conservation. However, the frequency of feedback presentation does not appear to be crucial, since it has been found to be effective even when it has been presented on a monthly basis [13]. In addition, seasonal factors do not appear to be decisive, since feedback has been reported to reduce consumption in electrically heated homes during the winter [15], as well as in electrically air conditioned homes during the summer [16]. Likewise, commitment to a specific performance goal does not appear to be essential, since feedback appears to be just as effective in the absence of such a goal [16] as it is when homeowners are committed to a difficult one [19]. In short, at the present time the limiting conditions for the effectiveness of feedback have not been spelled out and the crucial parameters which determine if, when and how the technique works are far from clear.

One possibility is, however, suggested by the present study. It is important to note that most of the experiments on energy conservation have employed subjects living in large homes or town houses, while the subjects in this experiment lived in small apartments. Perhaps the limited impact in the present study resulted from the more modest energy needs of these apartment dwellers, which produced a floor effect providing very little opportunity for feedback to exert its influence. This suggests that feedback will be most effective under conditions of high energy requirements and that the magnitude of its impact will diminish as these requirements are reduced.

Evidence in support of this conjecture is provided by a review of prior studies of informational feedback which have performed statistical analyses of baseline rates of KWH consumption. Two such studies with positive outcomes report daily baseline levels of consumption of 68.33 KWH [16] and 161 KWH [15]. In contrast, in two other studies, where feedback was not effective, daily baseline rates were reported to be 36.82 KWH [17] (Experiment 2) and 38.03 KWH [19]. Further, the daily baseline rate of 21.2 KWH in the present study is consistent with the lower values of these latter two studies. Thus, there does appear to be some support for the hypothesis that feedback is likely to be more effective under high, rather than moderate-to-low energy requirements. More conclusive evidence on the role of such initial requirements in determining the effectiveness of informational feedback would, of course, be provided by a direct experimental test of this hypothesis.

Future research designed to promote electrical energy conservation might also benefit by undertaking a similar analysis of the two other variables manipulated in the present study. The role of commendation as well as other incentive conditions in general might be enhanced under conditions of high energy usage. Likewise, the role of the *contingency* between electricity conserving behaviors and positive consequences might be shown to vary as a function of the initial rate of electricity usage. The rationale for introducing the noncontingent procedure in the present study was derived, in part, from recent social psychological formulations of attribution theory. According to this theory (22, 24–25), individuals often infer their attitudes from observing their own behavior or statements other make about their behavior. Thus, commending individuals for saving energy might lead them to believe they were actual energy conservers, even though initially they were not. This belief, in turn, might motivate individuals to engage in a variety of energy conserving behaviors and, in so doing, provide a veridical and credible confirmation of such noncontingent reinforcement. Further, this mechanism of behavioral confirmation might be much more likely to occur under conditions of high energy use, where there are more abundant opportunities for individuals to reduce their consumption, than is possible where energy needs are more limited.

In summary, the present study and the research reviewed herein suggests that the overall effectiveness of feedback in promoting electrical energy

conservation must be viewed with considerable caution. At the same time, it points to a number of possible areas whereby future research might clarify the limiting conditions for the effectiveness of this and related techniques. It is clear that the next stage of psychological research on energy conservation must go well beyond the mere demonstration that a particular technique works well under a specific condition. It is essential now to begin to determine the crucial parameters governing the nature of such influence so that generalizations about the impact of any energy conserving technique can be formulated in a far more exact manner than has hitherto been the case.

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