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# *REDUCTION OF RESIDENTIAL CONSUMPTION OF ELECTRICITY THROUGH SIMPLE MONTHLY FEEDBACK*

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Feedback has been widely used in efforts to control the consumption of electricity. Previous efforts, however, have used forms of feedback that seem economically impractical. The present study examined the effects of a feasible program of monthly feedback. Forty matched nonvolunteer participants were randomly divided into two groups: a no-contact control group and a monthly feedback group. In an A-B-A design, the data showed a clear decrease in electricity consumption for the feedback group during the feedback phase. The effect was maintained during a 4-mo intervention period. Withdrawal of the feedback was associated with a return to higher levels of electricity consumption.

DESCRIPTORS: electrical energy, conservation, feedback, environmental problems, behavioral community psychology, consumer behavior

Behavior analysts have recently focused on ways to reduce energy consumption. Although a few studies have examined reductions of nonelectrical types of energy (e.g., fuel oil, Seaver & Patterson, 1976; natural gas, Winett & Nietzel, 1975), most of the effort has thus far been directed at electricity use (e.g., Hayes & Cone, 1977; Heberlein, 1975; Kohlenberg, Phillips, & Proctor, 1976; Palmer, Lloyd, & Lloyd, 1977; Winett, Kaiser, & Haberkorn, 1977; Winett & Nietzel, 1975).

The independent variables that have been manipulated in these studies have included both antecedent events, such as information about ways to conserve, repeated prompts, and governmental appeals, as well as consequent events such as monetary payments for reduction, letters of commendation, decals, and feedback about consumption levels.

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Although monetary payments for reduction have been the most consistently effective consequence (see Cone & Hayes, 1980 for a detailed review), they tend to be relatively expensive and thus not likely to be permanently or widely adopted. Feedback procedures, although somewhat less effective (Hayes & Cone, 1977), need not be expensive and thus have a greater likelihood of being used on a large scale.

Feedback is a somewhat imprecise term, being neither purely functionally defined nor purely descriptive. Nevertheless, it has been widely used to refer to any procedure in which subjects are taught to discern their own behavior through contingent stimulation. In the energy area, subjects have been taught to discern the amount, cost, or trends in energy consumed. There are major differences among the feedback procedures that have been developed.

Feedback programs have differed in their content. Some have reported changes to subjects in terms of kilowatt-hours (kWhs), percent change, and monetary value. Others have included predictions of the amount of electricity that will be consumed at current levels of usage over a longer period of time and have stated these predictions in terms of kWhs, percentage change, and dollars and cents. Some programs have given feedback on the behavior of an entire group; most programs have concentrated on the individual.

Feedback programs have been used in the presence or absence of clear monetary contingencies. In a normal residential situation, the energy bill provides both verbal feedback and direct financial consequences. For example, reductions in consumption produce both a positive verbal consequence and a lower bill to be paid. Little work has been done to date systematically comparing the effect of feedback with and without natural monetary consequences. This is an important applied issue for situations in which natural monetary contingencies are absent or at least concealed (e.g., dormitories, some apartment complexes). In one situation, Hayes and Cone (1977) compared feedback with and without experimental payments for reduction and showed that: (a) daily feedback had at least some effect on the energy consumption of apartment residents who normally received no electricity bill, (b) adding monetary payments for reduction to daily feedback further reduced consumption, (c) a combination of daily feedback plus monetary payments for reduction worked no better than payments alone when these payments were high, but may have when they were low. Further research on these issues is needed.

Although all these types of feedback seem to influence energy consumption (see Cone & Hayes, 1980), little experimental work has been done to determine the most effective forms of feedback. A preliminary effort was made by Palmer, Lloyd, and Lloyd (1977). They tested the effects of daily feedback expressed in either monetary of kWh form. Although both seemed effective, the data received and design used precluded any definitive statement as to their comparative effectiveness.

A final dimension of the feedback procedures studied to date is the frequency of feedback given. Effects have been obtained with feedback given continuously (Kohlenberg, Phillips, & Proctor, 1976); daily (e.g., Hayes & Cone, 1977; Palmer et al., 1977); four times each week (Seligman & Darley, 1977) and, in the case of fuel oil, as infrequently as only once in several months (Seaver & Patterson, 1976).

With electricity consumption, the longest feedback period yet tested is weekly (Winett, Kagel, Battalio, & Winkler, 1978; Bittle, Thaler, & Valesano, Note 1; Kohlenberg, Note 2). Yet even if this low frequency of feedback is effective, it seems impractical. Electricity bills are usually based on monthly meter readings, and increases in the frequency of these readings would be quite expensive. Two immediate alternatives seem available: (a) teach consumers to generate frequent feedback themselves (perhaps with the help of special meters, see Fitch, 1977) or (b) give feedback monthly. Hayes (1977) and Winett, Neale, and Grier (1979) have generated preliminary data supportive of the first alternative; the present study is designed to investigate the second.

Low frequency feedback seems to be the next logical variable to investigate because any information gained about other feedback related variables will only be practically useful if infrequent (e.g., monthly) feedback is still effective, or if data collection and feedback delivery systems independent of the normal utility practices can be developed (e.g., Hayes, 1977). The typical monthly utility bill can serve a feedback function, of course. Unfortunately, the information is generally of limited usefulness. Consumers seem to remember and respond to the cost of the bill, not to the kWhs consumed. But cost is influenced by rate changes, fuel surcharges, and taxes as well as actual changes in consumption. Thus, the feedback provided by cost per month figures is not always directly related to the consumer's behavior. Further, consumers typically compare their performance month by month to the preceding bills. But seasonal and temperature changes are well known to influence energy consumption in many ways, depending upon the individual consumer's means of heating, cooling, and other such factors. Thus, most consumers do not use a correct baseline in responding to the feedback inherent in a regular electricity bill.

The present study was designed to evaluate one solution to these difficulties; computing each consumer's monthly consumption as a percent change from the same month in previous years and expressing this change in both dollars and cents, and kWh form. Thus, consumers would know how much more or less they were spending and consuming for electricity compared with a similar time period in previous years. These figures are available in monthly bills, but require some record keeping and computation by the consumer. Providing the calculations directly may significantly increase the feedback function of the typical bill. In the present study, the form, but not the frequency of feedback, was altered from that received in monthly bills.

## METHOD

### *Subject and Setting*

In another study conducted at the same time (Hayes, 1977), 20 volunteer families, from among the residents of Pawtucket, Rhode Island, were solicited by fliers and newspaper ads to participate in a project designed to help them reduce electrical energy consumption. Families for the present study were matched to volunteers and were selected in the following manner: Two single digit numbers ($N$ and $N'$) were drawn from a table of random numbers for each of the 20 volunteer families. Using the account lists of Blackstone Valley Electric Company (BVE), the privately owned electrical utility serving the area, the next $N$ and ($N$ plus $N'$) customers after the volunteer customers were chosen as nonvolunteer participants. Because BVE arranged account numbers by area, this method produced two participants, geographically matched to each volunteer.

To produce the confidentiality of these 40 nonvolunteers, only their account numbers were given to the experimenters by the utility. All data collection and communication were done by account number through BVE. The study was conducted in the winter and spring of 1976.

### *Procedure*

Two groups of nonvolunteer consumers were formed by randomly assigning one of each $N$ and ($N$ plus $N'$) pair to a baseline-only control condition and the other to a monthly feedback condition. In this manner, two geographically matched groups were formed.

*Baseline-only control.* These 20 consumers were never contacted in any way. Their consumption information was simply given to the experimenters by BVE.

*Monthly feedback.* These 20 consumers were sent an official-looking form letter each month from BVE. The letter reported the percent change in consumption over the same month during the baseline period and showed the number of kWhs and actual dollar amounts involved. Letters were sent one week following the monthly meter reading (the day of the month varied according to meter reading area), and the mean number of days between letters was 30. Letters were sent in an envelope separate from the actual electric bill, and were timed to arrive a few days after the bill. The form of the letter is shown in Figure 1.

### *Design*

The study was conducted in such a way as to permit both within- and between-group comparisons. There were two initial baseline periods: one over the years 1973 and 1974, and a second during the immediate preintervention period from January 1975 through January 1976. The monthly feedback condition was implemented in the experimental group in February 1976 and withdrawn in June 1976. A final withdrawal phase was conducted from July 1976 through August 1976. The control group remained in the baseline phase throughout the study.

Two dependent measures were used: (a) raw kWh and (b) percent change scores. Raw scores were calculated by BVE in the usual way, sub-

THIS IS NOT A BILL

Dear Consumer:

With all the concern over energy conservation, we thought you might like to know whether you are consuming more or less electricity now than in previous years. Based on our records for this address over the last three years, your consumption of electricity this last month was:

_____% below previous years. Congratulations! You are saving energy.

_____ % above previous years.

(For those of you who would like more detail, this last month you consumed _____ kWh of electricity, compared to the previous average of _____ kWh. At today's prices, this means you saved/spent about an extra $ _____ .)

Fig. 1. An example of the form letter sent by BVE to nonvolunteer consumer households in the monthly feedback condition. (Depending upon whether the consumer was using more or less electricity than previously, various parts of the letter relevant to consumers in the opposite circumstances were crossed out).

tracting the previous month's meter reading from the present one. Percent change scores, designed to remove some of the seasonal variation found in monthly scores, were calculated in the following manner: [kWh consumed in month "x" − (kWhs consumed in month "x" during 1973 + kWhs consumed in month "x" during 1974)/2)]/[(kWhs consumed in month "x" during 1973 + kWhs consumed in month "x" during 1974)/2] × 100. In other words, the current consumption figure for a given month was calculated as a percent change from the average consumption for that month in 1973 and 1974.

*Reliability*

The primary data for analysis were the BVE consumption figures, as determined by the regular monthly readings. BVE maintains several procedures to ensure reading reliability. The residential kWh meters themselves are extremely rugged and are routinely tested and replaced. Meter readers are extensively trained. They participate in a multi-week course on meter reading, are supervised in the field by an experienced meter reader, and are only then allowed to read meters on their own. Readers are taught to check the identification number of the meter and its location, to read the meter, and to check the reading against the last month's reading to see if it is in the expected range of consumption.

Meter reading errors are minimized by this check-recheck system, but they still occur occasionally. Errors are located primarily by the computer or by customer complaints. The BVE computer compares the obtained reading against known consumption patterns for that household. Any significant deviation from the predicted value results in a recheck of the meter. In a four or five digit meter, misreading the ten thousands or thousands place will typically result in computer rejection. Misreading the hundreds, tens, or units place will typically not result in a rereading unless the average consumption is quite small, or if the obtained reading is less than the previous reading (an error by definition because the meter cannot reverse itself). Thus, the computer can be expected to locate at least one-fourth of all meter reading errors, given equal probability of error for each digit.

Based upon computer- and customer-located errors for the 3 mo prior to the onset of the study, BVE meter readers made less than one error for every thousand meters read, or a 99.9% reliability figure. Even if this figure is low by a factor of four, the reliability is approximately 99.6%.

## RESULTS

*Monthly Feedback*

The effects of monthly feedback were analyzed in terms of change in use over the 1973-1974 baseline period with percent change scores determined by the previously mentioned formula. These data are presented in the upper half

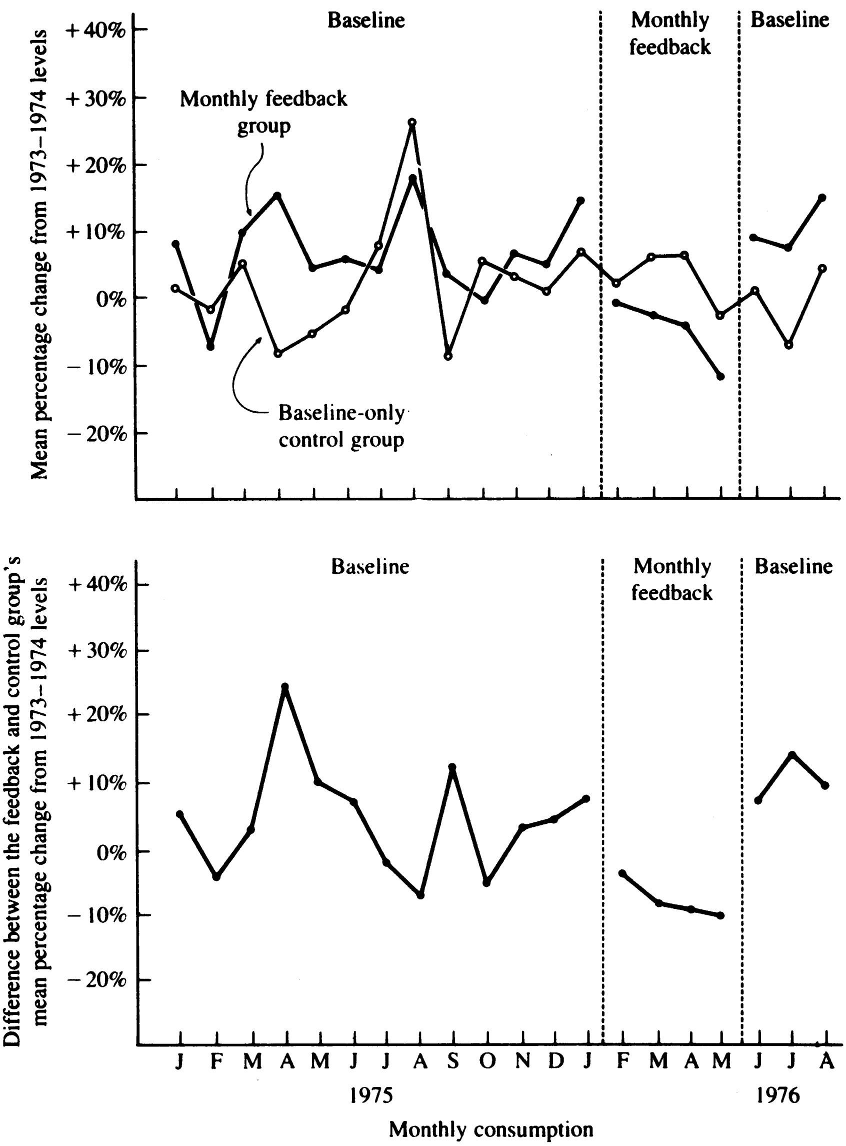


Fig. 2. The upper half shows the mean percent change scores of the monthly feedback and the control groups in baseline, monthly feedback, and return to baseline phases. The lower half shows the difference between the percent change scores of the monthly feedback group and the control group, in baseline, monthly feedback, and baseline conditions.

of Figure 2 for both control and monthly feedback groups. The data are presented for the January 1975 through January 1976 preintervention period and for the implementation and withdrawal phases that followed.

During the preintervention period, the feedback group had a greater increase in consumption than the controls when compared with their 1973-1974 baseline levels, though both groups had increased somewhat (2.2% and 6.5% for control and feedback groups, respectively). Thus, there was a tendency toward increased consumption over earlier years for both groups before feedback was introduced.

With the introduction of monthly feedback, this pattern was reversed. Those consumers receiving feedback actually consumed 4.7% *less* electricity than during the comparable periods in 1973 and 1974, while control consumers continued exceeding their 1973-1974 consumption levels by 2.3%. When monthly feedback was withdrawn, those consumers who had received it reversed their consumption patterns again, using 11.3% *more* electricity than during the comparable period in 1973-1974. Consumers in the control group actually reduced their use slightly (−.3%) during this period when compared with their 1973-1974 levels.

In order to assess the statistical significance of these effects, a 2 (Groups) by 3 (phases: baseline, treatment, baseline) ANOVA with three repeated measures was conducted on the mean percent change scores for the relevant phases. Results showed no significant effects for groups, $F(1, 38) = .13$, $p > .10$, or phases, $F(2, 76) = 1.05$, $p > .10$, but there was a significant group by phase interaction, $F(2, 76) = 3.19$, $p < .05$. The nature of this interaction can be seen by examining Figure 2; the treatment group had lower consumption in the treatment phase, but not in the baseline phases.

Although the percent change scores remove much of the seasonal variation in consumption patterns, they do not provide complete protection against unexpected changes. An unusually warm or cold month could have a major effect on consumption. Even corrections based on regressions between temperature-related statistics (e.g., degree days) and consumption (e.g., see Seligman & Darley, 1977) do not ensure elimination of these potential contaminations because consumption may be influenced by a number of climatological variables other than temperature (e.g., wind, sun, snow cover, vegetation).

One possible solution to some of these problems is to use the data from randomly selected control consumers as a correction factor. Such an analysis was performed in the present study in the following manner: mean percent change scores for the control group were subtracted from those of the experimental group, yielding a value that should reflect little contamination due to climate-related variables. The rationale here is that because both groups are exposed to the same weather conditions, subtracting one group's mean from the other's in effect removes any weather-related variance. Thus, any systematic changes in the remainder cannot be attributed to climatological changes. The data shown in the upper half of Figure 2 were transformed in this manner and are presented in the lower half of Figure 2.

Once again, there seems to be a clear effect (most impressive in this format due to the minimal overlap between the data in the pre- and postintervention phases and those in the experimental phase). Thus, any experimental effect apparent in Figure 2 cannot easily be explained on the bases of climate related variables.

Although the transformed scores in lower half of Figure 2 and the percent change scores in the upper half of Figure 2 appear to support the effect of monthly feedback, it is worthwhile to return to the more familiar kWh metric for a final analysis. It will be recalled that the feedback group was using approximately 6.5% more electricity during the preintervention phase than during the earlier 1973-1974 baseline period. Assuming a comparable use rate would have occurred if feedback had not been introduced, the feedback consumers would have used approximately 371 kWh per month for the 4 mo of the intervention phase. However, they actually used 4.7% less, which is 353 kWh per month. Thus, an average of 64 ($4 \times 18$) kWh was saved in the study per consumer. At prevailing cost of 6¢/kWh, this amounts to a monetary savings to the consumers of about $4. Although it is not a large amount for any given consumer, if multiplied by the millions of electrical energy users in the country, the savings would be quite sizable indeed.

Finally, the use of geographically matched nonvolunteer consumers enables a comparison of the baseline consumption patterns of volunteers versus nonvolunteers drawn from the same area (presumably with similar socioeconomic status). This comparison was performed on the monthly kWhs consumed during the 1974-1974 baseline period. The two groups used virtually identical amounts of electricity during this period ($\overline{X}$ kWh per month = 376.3 and 380.3 for volunteers and nonvolunteers, respectively). The comparability of volunteer and nonvolunteer consumers is gratifying in view of the frequent reliance on volunteers in studies of this type.

## DISCUSSION

The relatively clear effects of the feedback procedure are somewhat surprising for several reasons. First, the intervention is rathen innocuous, consisting merely of the reformulation of the information already available in a regular electricity bill. Feedback was not presented more frequently (although, because the letter was separate from the bill, one could argue that the frequency of feedback was doubled), nor were smaller units of time analyzed. The only major difference between the bill and monthly feedback seems to be in the form of the feedback, i.e., expressing consumption as a percent change relative to a baseline and in monetary terms, in addition to the usual kWhs used.

A second reason for surprise is that Winett et al. (1978), Bittle, Thaler, and Valesano (Note 1), and Kohlenberg (Note 2) have reported contradictory data on the effects of weekly feedback, contrary to the rather stable effects of the more frequent feedback used in other studies (e.g., Hayes & Cone, 1977; Seligman & Darley, 1977; Winett et al., 1977). However, Kohlenberg (Note 2) used rather complicated computer readout sheets for feedback in contrast to the simple form letter used here. Further, all three studies used volunteers. Finally, the consumption patterns in Pawtucket are extraordinary. It is an old, established community, relying heavily on oil and gas for heating. Because electric space or water heating is rare, the average consumption of electricity by a household is less than half that reported in other studies. Because heating and cooling patterns seem to be less influenced by feedback (Winett et al., 1977), differences between the feedback studies may be due to differences in the type of consumption consequated. The conflicting results require further investigation, and replications of the studies involved are needed.

Few studies have examined the mechanisms that account for the effectiveness of feedback. Becker (1978) has shown that consumption feedback is effective only when there is a standard against which to evaluate the consequences, and vice versa. Perhaps the form of the present feedback simplified that task. Other explanations for feedback have been advanced (e.g., it reduces the delay between behavior and significant consequences), but at present the procedures are primarily technical packages with no clear theoretical base to guide their development.

The present results are encouraging for two reasons. First, the procedure is extremely practical. At an estimated cost of 20¢ per feedback letter (including paper, envelopes, postage, and BVE estimates on the labor cost of stuffing and data calculation), approximately $16 was spent on the project. Subtracted from the approximately $80 saved by the 20 consumers in the feedback group, the net savings comes to $64. An even greater net savings could be realized by including the form letter in the same envelope with the monthly bill, and by modifying the computer billing program to print out percent change and dollar amounts represented by the change. Second, these participants were not volunteers; they were never even aware that they were participants in a study. Thus, these procedures may work with the general population.

Before such programs are likely to be implemented on a large scale, however, it may be necessary to arrange different types of consequences for power companies than are presently available. Money saved consumers in studies such as this is proportional to reduced revenues received by the utility. Why should the companies sponsor large-scale efforts at conservation when these consequences prevail? Their capital expenditures are relatively unaffected by small changes in use, so there is no comparable savings to them. One possibility would be for the federal government to arrange tax refunds to utilities based on the demonstrated effectiveness of their individual campaigns to encourage conservation. Such a program would undoubtedly spur active efforts at developing more effective conservation tactics, and could be paid for out of taxes levied on excess use by corporate or residential consumers.

The present study showed the value of providing monthly feedback in kWhs and dollars and cents form as a change from a comparable calendar period. The study did not investigate the nature of the optimal feedback content or frequency. Although it is probably not profitable to study the comparative effectiveness of kWh feedback versus monetary feedback forms (because both can so easily be provided) the frequency issue may be important. In this regard, perhaps the most relevant data needed presently would be those comparing savings produced by the low-cost monthly feedback provided herein and by continuous feedback possible with one of the various "in-house" meters currently being marketed (Fitch, 1977) or through consumer-generated feedback (Hayes, 1977; Winett et al., 1979). If any of these relatively inexpensive interventions produce consistent reductions in energy consumed, the potential savings for our society could be enormous.

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