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The effectiveness of light switch reminders in reducing light usage

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Summary A carefully controlled field study has shown that reminder stickers attached to light switch plates reduce lighting energy consumption in private offices. The magnitude of the energy savings is large enough for the switch stickers to be cost effective in 10 weeks or less. A questionnaire administered at the end of the study showed that people were generally receptive to the switch stickers as reminders for saving energy.

Résumé Une étude *in situ* étroitement contrôlée a montré que les autocollants de rappel posés sur les plaques d'interrupteurs d'éclairage permettent de réduire la consommation d'énergie dans les bureaux particuliers. Les économies ainsi réalisées sont telles que le coût des autocollants est amorti en 10 semaines ou moins. À la fin de l'étude, on a fait remplir aux occupants des locaux un questionnaire qui a révélé qu'ils étaient généralement réceptifs face aux autocollants leur rappelant d'économiser l'énergie.

1 Introduction

Use of labels or notices to remind occupants to turn off lights when they leave a room has been a common technique in trying to conserve energy. Government agencies, schools and private corporations often supply such reminders, usually in the form of a label that can be attached to the light switch (Figure 1). The assumption that such reminders will actually conserve energy by helping occupants to remember to turn off lights has never been adequately tested. A controlled field study was therefore undertaken to test the effectiveness of switch stickers in reducing light usage in commercial offices.

2 Method

2.1 Sample

Single-occupant offices (304) in four commercial office buildings were evaluated for inclusion in the study. Unoccupied offices, offices without light switches, offices with existing labels, and offices not accessible at the weekend were not used in the final study. The remaining 155 offices were divided into two approximately equal groups in each of the four buildings. In addition, an attempt was made to balance the number of offices in the two groups that had (a) task lighting, (b) windows and (c) glass partitions. For example, if there were six of offices in one group with windows and task lighting but no partitions, an attempt was made to have an equal number of offices in the other group with the same specifications. Within these constraints the assignment of offices to groups was random. (It should be noted that adjacent offices may have been in different groups.) The final sample of 155 offices consisted of 10 in building A, 91 in building B, 19 in building C, and 35 in building D (Table 1).

2.2 Experimental design

The experimental manipulation involved attaching a switch sticker reminder to turn lights off (Figure 1) to each wall switch plate. These reminder stickers were placed in or removed from offices at predetermined times during the course of the study. A light auditor (described in the next section) was installed in every office to record the accumulated hours of light usage. Weekly hours of usage of fluorescent ceiling fixtures were recorded for 15 consecutive weeks starting in February 1983. Records were collected on Sundays when most offices were closed and lights were turned off. Thus, recordings could be made without influencing occupants or affecting light usage. During the first three weeks baseline amounts of light usage were obtained before any switch stickers were attached. At the start of week 4 labels were attached to switch plates in the Group 2 offices, but not in Group 1

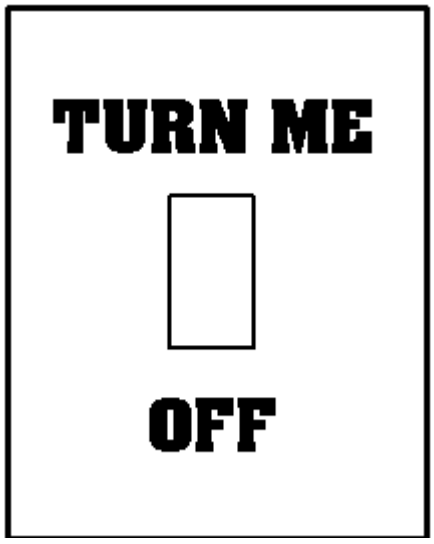

Figure 1 Reminder sticker attached to switch plate during experiment (blue background with white letters)

offices. At the start of week 13 labels were removed from the offices in Group 2 and placed in offices in Group 1. This experimental design is a variation on the interrupted time series with changing replications design [1].

Table 1 Distribution of offices by group and building.

Building	Final sample			Complete data		
	Group 1	Group 2	Total	Group 1	Group 2	Total
A	5	5	10	5	5	10
B	46	45	91	19	18	37
C	9	10	19	8	10	18
D	17	18	35	5	7	12
	77	78		37	40	

2.3 Measurement of light usage

The light auditor accumulates the amount of time, to within one tenth of an hour, that a particular electric light is on by counting the number of light oscillations produced by lamps operated on alternating current [2]. The light auditor is insensitive to daylight and to lights powered by a DC supply. Usually it can be 'tuned' to record light usage from a single light fixture or circuit within a room. A 9 V alkaline battery powers the light auditor for about one year. The light auditor must be removed from its wall-mounted holder before the light usage data can be read; a plug-in reader (Figure 2) displays the accumulated hours of light usage. Weekly readings of the light auditor provide the total number of hours of light usage during the week but do not provide information on the patterns of light usage.

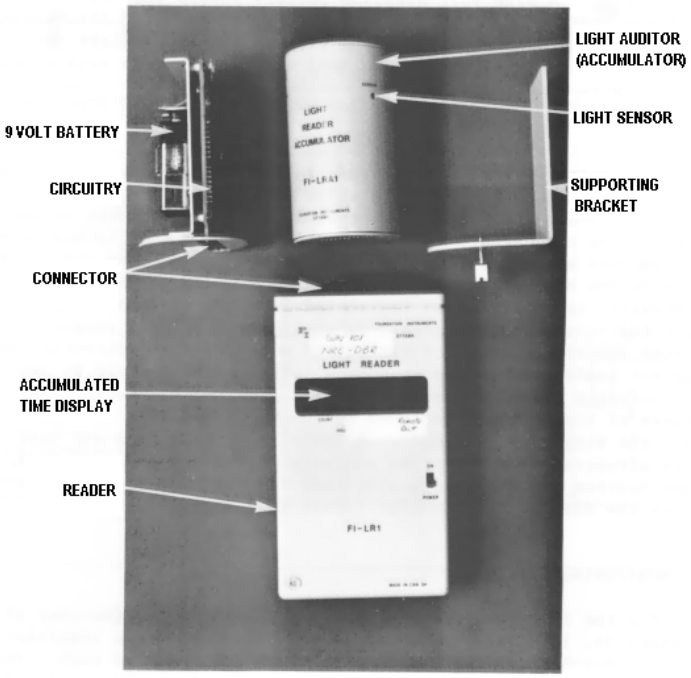

Figure 2 Light audior, supporting bracket and reader.

2.4 Occupancy

As the light auditor does not monitor occupancy, it is not known for certain whether occupancy patterns varied systematically during the test period. Periodic visits to the offices, however, and discussions with the office management (who were aware of the tests) gave no indication that occupancy patterns differed systematically during the test period or that any other factors were confounded with implementation of the switch stickers.

2 Method

3.1 Missing data

In a long-term field study it is inevitable that some data will be missing. The primary cause in this study was battery failure in light auditors, although adhesive failure, abuse by occupants, and covering of sensors, etc., also occurred. Furthermore, data were judged to be invalid if a reading from the light auditor *(a)* was lower than the week before, *(b)* gave incremental values larger than the number of hours in a week, (c) gave absolute values of zero for two consecutive weeks. (Note that zero hours of light usage in a week, e.g. a 500 hr reading one week and a 500 hr reading the next week, was valid.) Two offices were also removed from the study because all weeks except the first two showed no light usage at all, suggesting either light auditor failure or a vacant office.

In all, 78 offices with incomplete data were rejected from the analysis [(3)]. Because analyses based on a reduced data set are preferable to analyses based on a questionable data set, the analyses are based on 77 offices with complete data. The distribution of offices with complete data is also shown in Table 1 by group and by building.

3.2 Data analysis

A series of statistical tests were performed on the light usage data; details may be found in Reference 3. Essentially, the results may be summarised as follows. First, there was no significant difference between the two test groups. There was, however, a significant reduction in light usage during the test weeks. The interaction between test groups and weeks was not significant. Thus, *both* groups reduced the hours of light usage during the test period even though only one group at a time had labels.

Figure 3 shows the mean hours of light usage for the two groups measured at each of the 15 test weeks for the final sample of offices. (Mean and median data were similar.) The first three weeks, i.e., before implementing the switch stickers, had the highest hours of light usage in both groups, averaging about 51 h per five-day work-week (Figure 4). After installation of the switch labels in the Group 2 offices, there was an initial rapid decline in light usage in both groups followed by a more gentle decline until light usage reached about 40 h per five-day work-week (Figure 4).

There were very sharp declines in light usage associated with the three four-day work-weeks (week 7, Good Friday; week 8, Easter Monday; week 15, Monday, public holiday). Correcting the data from these three weeks by a factor of 5/4 placed them in close accord with the five-day workweek data (Figure 4). Statistical tests revealed that there was a significant difference between the first three weeks and the remainder of the test period, even after correcting the four-day work-week data.

Additional analyses were performed to determine whether these conclusions depended upon certain office characteristics, identified before the experiment, that might be important to light usage. These characteristics were: (a) the presence or absence of task lighting, (b) the presence or absence of windows, and (c) the presence or absence of glass partitions. Full details concerning the statistical tests may be found in Reference 3, but the various analyses provided no evidence to suggest that windows, glass partitions or task lighting influenced the amount of overhead light usage.

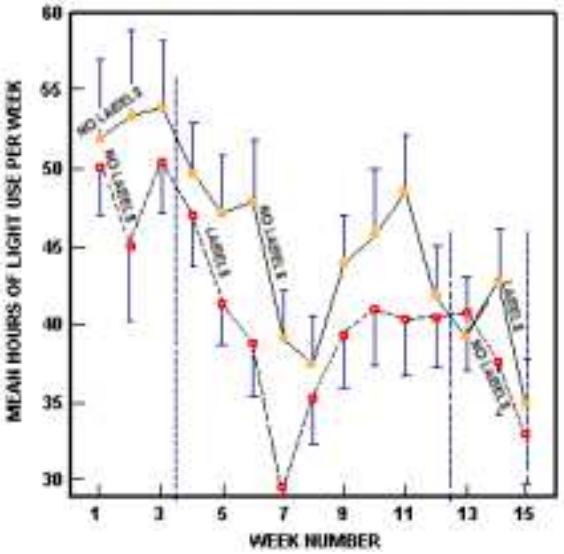

Figure 3 Mean hours of light usage per week for two groups (Group 1, solid circles; Group 2, open circles) over 15 weeks. Standard errors of means are indicated by vertical lines.

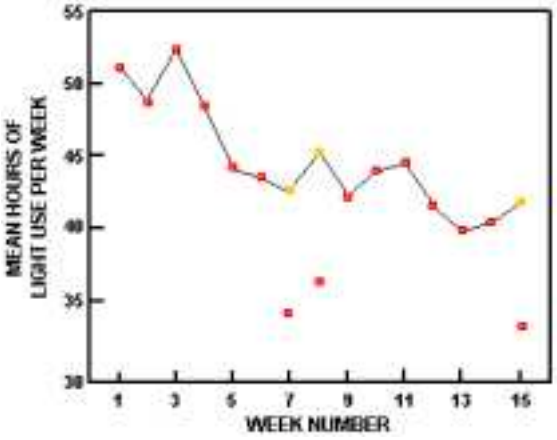

Figure 4 Mean hours of light usage per-week for 15 weeks (open circles) with corrected values for the four-day work-weeks (closed circles

4 Questionnaire

A one-page questionnaire was left in each office when the last reading was taken and the light auditor removed. A covering letter explained the purpose of the study and asked for cooperation in completing the questionnaire; a total of 132 of the 155 questionnaires (85%) were returned. This was considered a very high rate of return.

Table 2 gives a slightly reformatted version of the questionnaire; immediately below or adjacent to each response category are the percentages of respondents who checked that category. The total percentage for each question is occasionally less than 100% because some respondents did not answer all of the questions.

4.1 Attitudes regarding switch labels

As shown in Table 2, a large percentage (62%) of the respondents liked the idea of having a switch sticker, and the majority (56%) of the respondents felt the stickers helped to remind them to turn the lights off 'occasionally', frequently or 'always'. Of the 128 people who responded to both of the first two questions, 85% of those who did not

like the idea of a reminder felt that the reminder 'never' or 'seldom' had an effect. In contrast, 83% of those who liked the idea of a reminder felt that the reminder had an effect 'occasionally', 'frequently' or 'always'.

Table 2 Questionnaire

Do you like the idea of having a reminder to turn off lights attached to your light switch?					Yes 62%	No 36%
Do you think the reminder helped you turn off lights?	Never 25%	Seldom 17%	Occasionally 31%	Frequently 23%		Always 2%
Did you know that the cylinder attached to the wall monitored overhead light use?			Yes 81%			No 19%
If yes, did presence of the light monitoring device affect your use of lights?		Never 46%	Seldom 18%	Occasionally 15%	Frequently 5%	Always 2%
If you turn out lights, what effect will it have on energy conservation?		Will conserve energy:		Will not conserve energy		Don't know:
-When lights can be off for at least 12 h (e.g. overnight)		96%		1%		1%
-When lights can be off for at least 1 h (e.g. lunch time)		71%		8%		20%
-When lights can be off for at least 15 min (e.g. coffee break)		40%		29%		30%
-When lights can be off for at least 1 min (e.g. running an errand down the hall)		11%		61%		25%

4.2 Attitudes regarding light auditor

One concern in a study of this sort is the effect the light monitoring device might have on occupants' behaviour. Most respondents (81%) knew that the device monitored light usage, but most (77%) claimed that the light auditor did not influence their light usage. (46% reported that it 'never' had an effect, 18% reported that it 'seldom' had an effect, and 13% reported that they did not know the purpose of the auditor.) Of those who indicated that they knew the purpose of the light auditor, only 26% felt that it influenced their light use occasionally or more often.

4.3 Knowledge of light usage and energy conservation

The last four questions shown in Table 2 were designed to determine how knowledgeable people were about energy conservation by manual control of overhead lights. Nearly everyone (96%) believed that turning lights off for at least 12 h would conserve energy, but only a few (11%) believed that energy could be conserved by turning lights off for at least 1 min. It can be shown [6] that, in fact, lighting energy (and probably energy consumption in general) can be saved by turning lights out for less than 1 min. Even when fluorescent lamp replacement costs are included in the economic analysis [7] it is still attractive to turn lights off for very short periods (3-5 min).

There were no systematic differences between individuals who liked the idea of having reminder stickers and those who did not in terms of their answers to the last four questions. That is, the percentages in each category for each of questions 5 to 8 were

similar for those who did and did not like the reminder [3]. Beliefs about energy conservation were apparently similar for those who liked the light switch reminder and those who did not.

4.4 Responses to questionnaire and light usage

The questionnaire was included in the study to help determine whether the attitudes of office occupants influenced light usage during the 15 weeks' study. Details of the statistical analyses can be found in Reference 3. Basically, there was no evidence that the attitudes of the respondents, as indicated by their responses to the various questions, influenced light usage.

5 Discussion

5.1 Effectiveness of switch stickers

Light usage was reduced significantly in private offices after reminder stickers were attached to light switch plates (Figure 1), but perhaps surprisingly, the labels did not have to be introduced into all offices to achieve such reductions. Offices with and without switch stickers reduced light usage by approximately 15% in relation to initial test periods without switch stickers*. Since offices with and without labels were intermixed, occupants encountered labels throughout the building and very likely discussed them with their colleagues. It is not known whether saturating all offices with labels would have had a greater (or lesser) effect on light usage. Further, there are no data to ascertain whether this reduction in light usage would have remained indefinitely. Although it is possible that another, unknown variable contributed to the reduction in light usage in this study, it seems most likely that reminder stickers in private offices can lead to reduction in light usage.

The economics associated with installing switch stickers will, of course, depend upon many factors such as lamp wattage, hours of light usage, and electricity rates, as well as the costs of installing the switch stickers. As a conservative example, an energy-efficient office building by today's standards would have a lighting load of 22 W m^{-2} operating for 2500 hr per year. For an office area of 15 m^2 the annual lighting energy cost would be \$33 at an electricity rate of \$0.04 kW h^{-1}. A 15% reduction is worth \$5 annually. Less conservative and more typical examples could easily yield annual savings of \$15 or more. Assuming that the cost of purchasing and installing a switch sticker would average \$1, the payback period would be between 4 and 10 weeks, values well within the length of this study where switch stickers were shown to be effective. Clearly, the effectiveness of switch stickers for reducing lighting energy consumption is worth further investigation and systematic comparison with other, more expensive, schemes.

* This resulted in about 43 h $week^{-1}$ of overhead light usage, which is comparable to the 45 h $week^{-1}$ found in an open plan office retrofitted with switches at each work station [8].

5.2 Influence of office characteristics

Before starting the experiment three characteristics of offices were identified as potentially important to overhead usage by occupants (task lamps, daylighting, glass partitions) because these characteristics would, in principle, supply more light to task areas than is available from ceiling fixtures alone. Offices were deliberately selected and divided into groups according to the three office characteristics. No evidence was found that any of these features influenced overhead light usage, or further, that the presence of switch stickers interacted in any way with these office characteristics. Apparently the additional sources of illumination had no influence on overhead light usage by occupants. It appears, then, that such features augment rather than supplant illumination from ceiling fixtures.

5.3 Responses to questionnaire

Responses varied among the 132 respondents (85% of the total sample of occupants) to the questionnaire. A majority liked the idea of a switch label and believed the label helped them to remember to turn lights off. If handled well, the use of light switch labels does not seem to irritate occupants and induces them to use light switches.
Although most respondents said they knew the purpose of the light monitoring device, they also claimed that it did not influence their light switching behaviour. Levy and Robertson [(9)] reported that the light auditor did not affect occupant usage of light switches. Together, these findings indicate that the measurement technique described was unobtrusive, and that comparisons of light usage before and after implementation of the switch stickers were valid.

Few occupants were knowledgeable about the economics of switching fluorescent lamps [(7)]. For example, most did not believe or did not know that switching lights off for at least 15 min would conserve energy. Perhaps provision of this information together with use of switch stickers could produce additional savings of lighting energy.

There seems to be no reliable link between the responses to the questionnaire and light switching behaviour. Reductions in light usage were evident in all of the various sub-populations after installation of the switch stickers. This implies that the switch stickers were generally effective, irrespective of occupants' attitudes towards switching, stickers, or the light monitor.

6 Conclusion

Lighting energy usage in private offices can be reduced by implementing reminder stickers on switch plates. People generally like the stickers and find them helpful in remembering to turn ceiling lights off. Many are unaware of the economics of switching fluorescent lamps and perhaps better information could be supplied with switch stickers

to yield still further reductions of light usage. The magnitude of the savings in lighting energy and the cost of stickers clearly justify future experimentation if not immediate implementation in commercial buildings.

Surprisingly, switch stickers need not be applied to switch plates throughout a building to be effective; offices without stickers also reduced hours of lighting usage in this study.

It was also surprising that daylight, glass partitions and task lights had no effect on hours of overhead light usage. Apparently, these sources of illumination serve to enhance rather than replace illumination from ceiling fixtures.

Acknowledgement

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References

1 Cook T D and Campbell D T *Quasi-experimentation, design and analysis issues for field settings* (Chicago: Rand McNally) (1979)

2 Levy A W and Szanto A J A new lighting energy monitor *Lighting Des. And Applic. I0(9)* (September 1980)

3 Engineering Interface Ltd *Final* report *on* lighting *energy conservation* from *labelling switches* Study Contract Report for Division of Building Research, National Research Council Canada, DSS File No. 09SX. 31155-1-4405 (November 1983)

4 Kirk R E *Experimental design: Procedures for the behavioural sciences* (2nd edn), (Belmont, California: Woodworth) (1982)

5 Harris R J A *primer of multivariate statistics* (New York: Academic) (1975)

6 Turn off *the lights!!* Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, California, Tech. data sheet 80-01 (January 1980) (Available in Canada as Turn off *the lights!!* Public Works Canada, Technical Data Sheet EC-210 (February 1981))

7 Carriere L A and Rea M S Economics of switching fluorescent lamps *Proc. IEE-IAS Annual Meeting* (1986)

8 Carriere L A and Rea M S *Lighting energy consumption in an office building having manual switches* National Research Council of Canada, Division of Building Research, Building Research Note 221 (November 1984)

9 Levy A W and Robertson W Monitoring lighting energy consumption: Techniques and results *J. Illum. Eng. Soc.* 10(3) 178-183 (April 1980)