ELSEVIER

Journal of Environmental Psychology 27 (2007) 265–276

Journal of ENVIRONMENTAL PSYCHOLOGY

www.elsevier.com/locate/jep

The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents

Wokje Abrahamse*, Linda Steg, Charles Vlek, Talib Rothengatter

Department of Psychology, University of Groningen, The Netherlands

Available online 12 August 2007

Abstract

In this multidisciplinary study, an Internet-based tool was used to encourage households ($N = 189$) to reduce their direct (gas, electricity and fuel) and indirect energy use (embedded in the production, transportation and disposal of consumer goods). A combination of tailored information, goal setting (5%), and tailored feedback was used. The purpose of this study was to examine whether this combination of interventions would result in (i) changes in direct and indirect energy use, (ii) changes in energy-related behaviors, and (iii) changes in behavioral antecedents (i.e. knowledge). After 5 months, households exposed to the combination of interventions saved 5.1%, while households in the control group used 0.7% more energy. Households exposed to the interventions saved significantly more direct energy than households in the control group did. No difference in indirect energy savings emerged. Households exposed to the interventions adopted a number of energy-saving behaviors during the course of the study, whereas households in the control group did so to a lesser extent. Households exposed to the interventions had significantly higher knowledge levels of energy conservation than the control group had. It is argued that if the aim is to effectively encourage household energy conservation, it is necessary to examine changes in energy use, energy-related behaviors and behavioral antecedents.

Keywords: Tailoring; Household energy conservation; Behavioral change

1. Introduction

The last decades have witnessed a steady increase in emissions of greenhouse gases, contributing to the phenomenon referred to as global warming. Human-induced climate change through increased greenhouse gas emissions is considered to be one of the most pressing problems of our time (OECD, 2002). Households partly contribute to these emissions through day-to-day energy-related behaviors, such as gas and electricity use, and the use of energy-intensive products and services. To illustrate, US households account for 21% of greenhouse gas emissions in their country (US Department of Energy, 2005), households in the UK for 15% (UK Department of Trade and Industry, 2005), and households in the Netherlands for 17% (RIVM, 2005). In view of this, households can be considered an important target group for energy conservation. By targeting energy-related behaviors at home, household energy use may be reduced, resulting in a reduction of households' impact on the environment.

Household energy use can be divided into two categories (Vringer & Blok, 1995). Direct energy use is related to the use of gas, electricity and fuel, e.g. for heating and the use of electric appliances. Indirect energy use is related to the production, transportation and disposal of a variety of consumer goods and services. For instance, the availability of meat or cheese requires energy, because of the transportation involved in the production and distribution processes (also referred to as food miles). For an average Dutch household, approximately half of the amount of energy annually used is composed of indirect energy use (Reinders, Vringer, & Blok, 2003). Households may not always be aware of this type of energy use, that is, they may not realize that the goods they purchase are

*Corresponding author. Centre for Environmental Strategy, University of Surrey, UK. Tel.: +44 1483 686669.

E-mail address: W.Abrahamse@surrey.ac.uk (W. Abrahamse).

0272-4944/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jenvp.2007.08.002

associated with CO_2 emissions. It is therefore important to educate households on this relatively inconspicuous type of energy use, as households can make an important contribution to energy conservation by consuming products that have lower energy intensities (viz., requiring less energy per product).

If the aim is to encourage households to reduce their energy use, it is important to examine an intervention's effectiveness in relation to (i) changes in direct and indirect energy use, (ii) changes in energy-related behaviors and (iii) changes in behavioral antecedents. This way, insight is provided into the reasons why an intervention was effective or not, and based on this, interventions can be further improved. To illustrate, the provision of information may not have encouraged households to reduce their energy use because their knowledge levels did not increase. Intervention studies, however, rarely incorporate these three measures simultaneously (see Abrahamse, Steg, Vlek, & Rothengatter, 2005). This multidisciplinary study aimed to fill this gap, and examined whether a combination of interventions (tailored information, individual goal setting, and tailored feedback) was successful in bringing about changes in direct and indirect energy use, energy-related behaviors and knowledge. Further, this study examined the additional effect of the use of a group goal and group feedback.

2. Strategies for behavioral change

Over the years, many interventions have been used to encourage households to reduce their energy use on a voluntary basis, with varying degrees of success. Reviews indicate that tailored information, goal setting and feedback have been successful in reducing household energy consumption (Abrahamse et al., 2005; Dwyer, Leeming, Cobern, Porter, & Jackson, 1993; Stern, 1992). Interventions work better when used in combination, because different households are prevented from action by different barriers (Gardner & Stern, 2002). This section gives a brief overview of relevant studies that have made use of (tailored) information, goal setting and feedback, with a specific focus on the interventions' effects on energy use, energy-related behaviors and knowledge.

Information is widely used to encourage energy conservation (Stern, 1992). Different kinds of information may be provided. First, information about energy-related problems can help increase knowledge about issues such as global warming, Second, by providing information about behavioral options for reducing energy use, households can acquire more knowledge about how they themselves can save energy. Geller (1981) found that a workshop about energy conservation resulted in higher knowledge levels about conservation, but not in behavioral changes. Staats, Wit, and Midden (1996) evaluated a mass media campaign on global warming and observed an increase in knowledge about this issue. They did not measure behavioral changes or changes in energy use. Overall, the provision of information appears to lead to changes in knowledge about the issue at hand, but not necessarily to behavioral changes, or energy savings.

Tailored information is potentially a more effective way to encourage behavioral changes. Tailoring is an approach frequently used in health psychology as part of interventions aimed to change unhealthy practices into healthy ones (e.g. smoking cessation). Essentially, tailoring is an approach which makes use of data from or about a specific individual and related to a given (health) outcome to determine the most appropriate information that meets the unique needs of this individual (Kreuter, Farrell, Olevitch, & Brennan, 1999). It has been shown to have beneficial effects for a wide range of health-related behaviors (see Rimer & Kreuter, 2006), and has also been applied to energy conservation in the workplace (Daamen, Staats, Wilke, & Engelen, 2001). In the field of household energy conservation, well-known examples of tailoring are home audits, in which energy experts give households information about energy-saving measures based on their current situation. Various studies have found these audits to result in significant energy savings through behavioral changes (e.g. Gonzales, Aronson, & Costanzo, 1988; Winett, Love, & Kidd, 1982–1983) and increased knowledge about energy conservation (e.g. Winett, Leckliter, Chinn, Stahl, & Love, 1985).

Goal setting is frequently used to promote energy conservation and entails giving households an energy-saving goal to strive for, e.g. to save 5%, or 10%. Goal setting has been shown to be effective when combined with a commitment (promise) to save energy (e.g. Katzev & Johnson, 1983), or with feedback (e.g. McCalley & Midden, 2002). A relatively difficult goal combined with feedback appeared to be more effective in reducing energy use than a relatively easy goal combined with feedback (Becker, 1978). A goal can be set by households themselves, or by some external entity; but research suggests that there is no difference in energy savings between the two (e.g. McCalley & Midden, 2002). Another distinction can be made between an individual goal or a group goal. Group goals combined with rewards were found to be effective in reducing energy use (e.g. Slavin, Wodarski, & Blackburn, 1981).

Feedback has emerged as another effective strategy for encouraging energy conservation. It is especially effective when it is given frequently, as is for instance the case with continuous electronic feedback (e.g. Hutton, Mauser, Filiatrault, & Ahtola, 1986; Van Houwelingen & Van Raaij, 1989). In general, feedback is given about own energy savings. This way, households can observe the effectiveness of their efforts to conserve energy. Feedback can also be given about energy savings of other people, which is referred to as comparative or group feedback. It has been found to be effective in promoting energy conservation at work (Siero, Bakker, Dekker, & Van den Burg, 1996). Group feedback may be effective because it makes salient a social norm in favor of energy conservation, that is, it becomes clear that others are actively engaged in energy conservation as well. Also, this way it becomes clear that one can make an important contribution to energy conservation and help reduce energy-related problems. A study with EcoTeams (small groups of households exchanging information about energy conservation) who received a combination of information and group feedback found significant changes in energy-related behaviors and energy use (Staats, Harland, & Wilke, 2004).

In brief, the present study examined the extent to which a combination of tailored information about possibilities to reduce energy use, goal setting, and tailored feedback about energy savings would result in changes in direct and indirect energy use, changes in energy-related behaviors, and changes in knowledge of energy conservation. Moreover, it was examined whether a group goal and group feedback would have an additional effect. Based on the existing body of literature, it was hypothesized that households exposed to the combination of interventions would save more direct and indirect energy (Hypothesis 1A), would adopt more energy-saving behaviors (Hypothesis 1B), and would have higher levels of knowledge (Hypothesis 1C) than households in a control group. Further, it was expected that households who received a group goal and group feedback would save more direct and indirect energy (Hypothesis 2A) and would adopt more energy-related behaviors (Hypothesis 2B) than households who only received an individual goal and individual feedback.

3. Method

3.1. Participants

The study took place in Groningen, a city of approximately 180,000 inhabitants in the northern part of the Netherlands. A request letter including a free response card was distributed in August 2002 to some 6000 customers of a Dutch utility company. Prior to this, households had been randomly selected for the experimental groups or the control group. Households selected for the experimental groups received a letter asking them to participate in a study aimed to test a newly developed website, which would provide them with custom-made information about energy conservation at home as well as custom-made feedback about their energy savings. Households could register online, or by returning the free response card. Upon registration for the study, households were then randomly assigned to either one of the two experimental groups. Potential households for the control group received a different letter: they were asked to participate in a study aimed to gather information about household energy use, for the purpose of the development of a website about this topic. Households in the experimental groups and the control group filled out the same online questionnaires. This was done to be able to compare the groups with respect to their energy use, energy-related behaviors and behavioral antecedents. Each time, the questionnaires were filled out by the same household member.

Households had to meet several criteria to be eligible for participation. Access to the Internet was obviously a first requirement. Further, households who had moved residence in the year preceding the study or had plans to do so during the course of the study were excluded, because previous year's energy use was used for calculating energy savings. Households who did not have own gas and/or electricity meters were also excluded, because meter readings were used to calculate energy savings. A total of 874 response cards were returned. Some 200 households indicated a willingness to participate. The most important reasons for refraining from participation were: no access to the Internet (30.4%), no time or interest (21.6%), moved residence or plans to do so (6.5%), or other reasons, such as illness or old age (6.2%). Households could also register online and 114 households did so. This altogether resulted in an initial sample of 314 households.

The study took place over a period of 5 months. Households in the experimental groups filled out the online questionnaires at three fixed times. The first measurement took place before implementation of the interventions, the second and third measurements took place 2 and 5 months after implementation of the interventions, respectively. Households in the control group were asked to fill out the online questionnaires at two fixed points in time. These coincided with the first (before the intervention) and third measurement (5 months after the intervention) of the experimental groups.

A total of 314 households took part in the first measurement, before implementation of the intervention (October 2002). The sample was not entirely representative of the Dutch population. Men were overrepresented (64.1%), and average age of respondents was 42.3 years ($SD = 11.96$), which is slightly higher than the Dutch average. A large majority (81.9%) was employed, and 18.1% was otherwise engaged (e.g. retired, unemployed). Average household size was 2.5, which is in accordance with the Dutch average of 2.3. Of these households, 23.3% were single-person households (compared to approximately 35% single-person households in the Dutch population), 35.6% were two-person households, and 41.1% consisted of three persons or more. Higher income levels were overrepresented, with 17.5% having a net monthly income of less than 1500 Euros, 40.8% having an income between 1500 and 2500 Euros, and 41.7% of more than 2500 Euros (in 2002, 1 Euro = $0.95). Homeowners were also overrepresented (73%). Average gas use of participating households in 2001 (the year preceding the study) was 1636 m^3 ($SD = 735.96$), which is lower than the Dutch average of 1965 m^3. Average electricity use in 2001 of 3048 kWh ($SD = 1557.28$) was somewhat lower than the Dutch average of 3230 kWh.

Not uncommon to longitudinal studies, a substantial number of households dropped out during the course of the study. In addition, it appeared that several households had received incorrect feedback, which was mostly due to technical problems with the website. These households were not included in further analyses. Total attrition from pretest to posttest was 39.4% ($N = 123$). To examine the nature of attrition, a comparison was made between households who dropped out and those who remained of average scores on annual gas and electricity use, household size, net monthly household income, age, and gender. This was done for each experimental group and the control group separately. In the first experimental group, household members who dropped out during the course of the study tended to be slightly younger ($M = 40.15$ years) than those who remained ($M = 44.56$ years): $F(1,129) = 4.19$, $p < .05$. No other differences emerged between households who dropped out and those who remained, suggesting that drop-out was not too selective.

3.2. Study design

The final sample consisted of 189 households, i.e. those households who filled out the questionnaires at the three fixed times. Households in the first experimental group ($N = 71$) received a combination of tailored information, individual goal setting (5% reduction), and tailored individual feedback (about own energy savings). Households in the second experimental group ($N = 66$) received the same combination of tailored information, individual goal setting and individual feedback. In addition to this, they received a group goal of 5% as well as group feedback about average and total energy savings of all participants. Households in the control group ($N = 53$) were not exposed to any of the interventions. They did not receive tailored information, no goal was set for them and they did not receive any feedback. For an overview of the interventions per experimental group (see Table 1).

3.3. Procedure and materials

Two websites were developed by a multidisciplinary team of social psychologists, environmental scientists and computer engineers. The first website contained the interventions and was designed for the experimental groups. The second website, designed for the control group, did not contain any of the interventions. The questionnaire aimed to provide insight into the direct and indirect energy use of households, their current possession and use of household appliances, their current energy-related behaviors, and knowledge of energy conservation.

For households in the experimental groups, the intervention was implemented upon completion of the questionnaire. First, information was given about energy-related problems and the need to do something about them. The information contained an explanation of the global warming phenomenon. It also featured information about the increase in energy use over the last decades and the increased costs of energy use, with accompanying graphs depicting these trends.

Second, households in the experimental groups then received a list of tailored energy-saving measures. Each household only received those energy-saving options that were relevant for them. For each energy-saving measure an indication was given of the amount of energy that could

Table 1
Overview of interventions per experimental group for each measurement

		Experimental group 1 ($N = 71$)	Experimental group 2 ($N = 66$)	Control group ($N = 53$)
Time 1	A	Questionnaire	Questionnaire	Questionnaire
	B	Information about energy problem Tailored information Individual 5% goal	Information about energy problem Tailored information Individual 5% goal Group 5% goal	
Time 2 (T1 + 2 months)	A	Questionnaire	Questionnaire	
	B	Tailored information Individual 5% goal Tailored feedback: • total energy savings • energy savings per option • monetary savings	Tailored information Individual 5% goal Tailored feedback: • total energy savings • energy savings per option • monetary savings	
	C		Group 5% goal Group feedback	
Time 3 (T1 + 5 months)	A	Questionnaire	Questionnaire	Questionnaire
	B	Tailored information Tailored feedback: • total energy savings • energy savings per option • monetary savings	Tailored information Tailored feedback: • total energy savings • energy savings per option • monetary savings	

potentially be saved. A tool, developed by the environmental scientists, which was based on the so-called Energy Analysis Program (for a detailed description of this tool and its calculations, see Benders, Kok, Moll, & Wiersma, 2006) was used as a basis for providing the tailored information. This tool calculated for each individual household which energy-saving options were relevant for them, and how much energy could be saved. To illustrate, households who indicated setting the thermostat at 23 °C in the wintertime would receive the advice to lower it. The website displayed how much energy this household could save per °C they would lower the temperature setting. Households who indicated setting the thermostat at 18 °C would not receive this advice, since it was assumed they already used energy modestly in this behavioral domain.

Households in the experimental groups were then asked to try and save 5% energy during the course of the study. Households were free to choose which energy-saving measures they would adopt to attain the goal. The website displayed an overview of relevant (tailored) energy-saving measures and an estimated percentage of the energy savings involved. This enabled households to choose how they could best attain the 5% goal. In addition to this, households in the group feedback condition were told the aim was to save 5% energy as a group of participants. It was emphasized that as a group, households in Groningen could make an important contribution to energy conservation and would help reduce energy-related problems.

Two and 5 months after the first measurement, households in the experimental groups filled out a (tailored) questionnaire on the website. That is, for each household, only those behaviors were monitored for which energy-saving options had been indicated, under the assumption that the other behaviors would remain constant. Upon completion of the questionnaire, tailored individual feedback was given about energy savings. The website displayed the feedback in three different ways. First, as a percentage change in total energy use, compared to the first measurement (viz., before the intervention). This was also related to the 5% goal, e.g. "You have (not) attained the 5% goal (yet)". Second, tailored feedback was given about the extent to which each energy-saving behavior had contributed to total changes in energy use. A bar chart was displayed, with a green bar indicating a reduction in energy use for a given option, and a red bar indicating an increase in energy use (e.g. 'lowering thermostat setting': +4%; 'meat consumption': −3%). Third, the amount of money (in Euros) each household had saved on their gas and electricity bills was displayed on the website.[1] In addition, households in the group feedback condition received feedback about average as well as total energy savings of the entire group of participants, in relation to the group goal of 5%. Because average and total group savings could be calculated only after all households had filled out the questionnaire, participants received group feedback 1 month after the second measurement, via a newsletter sent by regular mail (to ensure every participant received and read it).

Households in the control group took part in the first and third measurement only. They filled out the same online questionnaires as the experimental groups. They did not receive any intervention upon completion of the questionnaire. Instead, they were told they would be contacted again after 5 months to obtain additional information from them in order to further improve the website about household energy conservation. They were not contacted after 2 months, because it meant they would have to fill out a long questionnaire again—without receiving any energy-saving advice in return. This could potentially encourage them to drop out. During the course of the study, households in the control group did not receive any information about energy problems, they were not given any tailored information, nor were they asked to reduce their energy use by 5%. They did not receive any feedback either.

3.4. Measures

3.4.1. Total energy savings

Changes in total energy use were calculated by means of the aforementioned tool, developed by the environmental scientists. Households were first asked to indicate which household appliances they owned (e.g. clothes dryer, washing machine) and how often they used these appliances. This was done on a household level, i.e. for all household members combined. Then, the energy 'contents' of these behaviors were assessed by the environmental scientists. This way, not only direct energy use was estimated (that is, the use of electricity, fuels and natural gas), but also indirect energy use (i.e. associated with the production, distribution and disposal of goods). Next, the energy contents of possession and use of appliances, and various energy-related behaviors were summed, yielding the total energy use related to a given behavior pattern of a specific household. Based on changes in possession and use of household appliances and self-reported energy-related behaviors, the tool calculated the associated changes in energy use. This kind of impact-related behavior measure provides an indication of the environmental impact of household behavior patterns, for the measure refers to (direct and indirect) energy use. Moreover, information is available on which behaviors particularly contribute to the (changes in) energy use of households.

Energy savings were calculated on the basis of changes in self-reported behavior. This methodological choice was guided by several considerations. First, changes in indirect energy use could only be calculated on the basis of (self-reported) behavioral changes, because indirect energy use is not visible on a meter. In order to be consistent in the methodology used to calculate energy savings, we decided

[1] It was not possible to calculate financial savings for indirect energy use, since these savings are not visible on a meter.

to compute savings in direct and indirect energy use in the same way, that is, based on self-reported (changes in) behavior. Second, we aimed to provide households with detailed feedback on the effects of their changes in behavior on total household energy use. This is not possible when energy savings are calculated on the basis of meter readings. Detailed feedback provides households with more insight into the relative impact of various energy-related behaviors on total energy use, which is important from an educational point of view (Gatersleben, Steg, & Vlek, 2002). To minimize the influence of social desirability, questions about energy-related behaviors referred to occurrence of behaviors. For instance, instead of asking: "Did you lower thermostat settings since the start of the experiment?", the question was: "At what temperature did you set the thermostat since the start of the experiment?" Also, the answers households had provided in the first measurement were not displayed.

In this study, two categories of energy use were distinguished, namely direct (gas, electricity and fuel use), and indirect energy use (e.g. food preparation, holidays). The percentage of energy savings referred to the change in energy use (in MJ) since the start of the project, i.e. (energy use after 5 months−energy use before intervention)/energy use before intervention)*100.

3.4.2. *Changes in energy-related behaviors*

A total of 27 energy-related behaviors were measured by self-report. Behavioral changes were examined by comparing respondents' answers before and after the intervention. Fifteen behaviors were measured using interval scales. For instance, daytime thermostat setting was measured in °C, showering time was measured in minutes, and rinsing dishes with warm water was measured on a scale from 1 'always' to 5 'never'. Eight behaviors were measured on dichotomous scales, for instance, whether or not households had 'green' (renewable) electricity (1 'yes', 0 'no'). Four behaviors were measured after the invention only, such as the number of traditional light bulbs that had been replaced by energy-saving light bulbs.

3.4.3. *Knowledge*

Knowledge of energy conservation was measured after the intervention only, by means of an 'energy quiz', including five multiple-choice questions. The questions were: 'Which statement best describes the greenhouse effect?', 'What is the main cause of the greenhouse effect?', 'Which appliance uses more energy, a washing machine or a video recorder (VCR)?', 'What uses more energy, cooking on an electric or a gas stove?' and lastly 'What uses more energy, with a family of four, driving 16,000 km a year or flying to the West Coast of the US (from the Netherlands)?'.[2] Per respondent, the total number of correct answers was calculated as an indicator of knowledge of energy conservation.

[2]The answers to the energy questions are: global warming, the use of fossil fuels, a washing machine, an electric stove, and flying to the US West Coast.

4. Results

First, the effectiveness of the interventions in changing total, direct, and indirect energy use is discussed. Second, changes in energy-related behaviors are reported. Third, changes in knowledge about energy conservation are considered. In the data analyses, only those households that had completed all questionnaires at the three fixed times (see Table 1) were included ($N = 189$). The focus is on energy savings after 5 months, since savings after 2 months could not be compared to a control group.

4.1. *Changes in total energy use*

After 5 months, households in the experimental groups combined had reduced their energy use by 11,951 MJ (5.1%). On average, households who received the combination of interventions reduced their energy use by 11,411 MJ (5.0%), and households who, in addition to this combination, received a group goal and group feedback reduced their energy use by 12,550 MJ (5.3%). In contrast, households in the control group had used 1730 MJ (0.7%) more energy since the start of the study. Average total energy savings and standard deviations are listed in Table 2.

A repeated measures analysis of variance was conducted with energy use before and after the intervention as the within-subjects variable and experimental group as the between-subjects variable. The main effect for time was marginally significant, indicating that after 5 months, all participating households (the experimental groups and the control group combined) had marginally significantly reduced their energy use (F (1187) = 3.19, $p = .08$). The time*group interaction effect was however not significant, indicating that, after 5 months, there was no significant difference in energy savings between the experimental groups and the control group (F (2186) = .86, *ns*). In other words, households who had been exposed to the interventions had not saved significantly more energy than households in the control group had.

4.2. *Changes in direct and indirect energy use*

Separate repeated measures analyses of variance were performed, with direct and indirect energy use before and 5 months after the intervention as the within-subjects variable, and experimental condition as a between-subjects variable. Means and standard deviations are listed in Table 2. After 5 months, households exposed to the interventions saved significantly more direct energy (i.e. gas, electricity and fuel) than households in the control group did: $F(2,186) = 9.02, p < .001$. Households in the two experimental groups combined reduced their direct energy use by 9143 MJ (8.3%), whereas households in the control

Table 2
Means and standard deviations for total, direct and indirect energy savings (in MJ) after 5 months, for the two experimental groups and the control group

	Experimental group 1 ($N = 71$)		Experimental group 2 ($N = 66$)		Control ($N = 52$)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Direct energy savings	7466_a	9641	$10{,}802_a$	19,842	-973_b	10,193
Indirect energy savings	3945_a	70,344	1748_a	48,002	-757_a	42,627
Total savings	$11{,}411_a$	73,274	$12{,}550_a$	52,383	-1730_a	43,688

Note: For each row, unequal subscripts indicate a significant difference between means at $p<.001$.

group used 973 MJ (−0.4%) more direct energy. Pairwise comparisons revealed no significant difference between direct energy savings of both experimental groups ($t(186) = -1.38$, *ns*).

Households in both experimental groups combined reduced their indirect energy requirements (e.g. food consumption, holidays) by 2809 MJ (3.8%), whereas households in the control group increased their indirect energy use by 757 MJ (−0.3%). Despite the fact that changes in indirect energy use were in the expected direction, after 5 months, the difference in indirect energy savings between the experimental groups and the control group was not significant, $F(2,186) = .09$, *ns*. Pairwise comparisons revealed no significant difference between direct energy savings of both experimental groups, $t(186) = .23$, *ns*.

A possible explanation for the absence of significant differences in indirect energy savings may be the large variability in energy use, in particular related to holidays. Several households had been on various trips using air travel in the year preceding the study, but did not undertake any such trips during the course of the intervention (or the other way around); this resulted in a large within-group variability. In fact, when energy use related to holidays was not considered, after 5 months, households in the experimental groups combined saved more total (direct and indirect) energy than households in the control group did: $F(2,186) = 7.94$, $p<.001$. Households in the group feedback condition saved 12,840 MJ, households in the individual feedback condition saved 9442 MJ, and households in the control group saved 1260 MJ.

4.3. Changes in energy-related behaviors

Table 3 lists average scores of participants in the (combined) experimental groups and the control group on various energy-related behaviors belonging to direct and indirect energy use. For the 15 behaviors measured on interval scales, occurrence of behaviors before and 5 months after implementation of the intervention were examined using repeated measures analysis of variance, with time as a within-subjects factor and experimental condition as a between-subjects factor. Since the group goal and group feedback did not appear to have any significant additional effect on energy savings, the two experimental groups were combined. It was not possible to conduct a multivariate analysis of variance including all behaviors simultaneously, due to the number of missing values (recall that participants filled out different—tailored-questionnaires). Therefore, to reduce capitalization on chance, a Bonferroni correction was used, resulting in a significance level for the 15 overall *F*-tests of $p<.003$.

For nine of the 15 behaviors, a significant change in behavior over time could be observed. This indicates that after 5 months, households had started adopting these energy-saving options. However, for none of the behaviors, the time * group interaction was significant, indicating that households in the experimental group and households in the control group did not differ significantly from each other with respect to these behavioral changes. To further explore the nature of the behavioral changes after 5 months, we examined the extent to which households changed their behavior, and this was done for the experimental and control group separately. This was only done for behaviors that had significantly changed after 5 months (i.e. for which the main effect for time was significant at $p<.003$), by comparing average scores on the behaviors before the intervention with average scores after the intervention by means of *t*-tests ($p<.05$).[3] For behaviors for which only post-intervention measurements were available, ANOVA's were conducted to examine differences between the experimental groups combined and the control group.[4]

Five months after implementation of the intervention, households in the experimental groups had significantly lowered daytime thermostat setting, $t(122) = 6.69$, $p<.001$, whereas thermostat setting did not change among households in the control group, $t(45) = 1.00$, *ns*. Both households in the experimental groups, $t(136) = -6.02$, $p<.001$ and in the control group used warm water less often when

[3]The non-parametric Wilcoxon Signed-Rank Test was also performed because the assumption of homogeneity of variance was violated. For all behaviors, results of the non-parametric tests and the *t*-tests coincided, and, for reasons of clarity, the latter are reported.

[4]Since assumptions were violated, the non-parametric Mann–Whitney test was conducted. As these results coincided with the ANOVA results, the latter are reported.

Table 3
Energy-related behaviors before and 5 months after implementation of the intervention for households in the experimental groups (E) and the control group (C)

Direct energy use		Time 1		Time 3 (T1 + 5 months)		*N*
Lower daytime thermostat setting (°C)	E	20.0	$(1.08)_a$	19.5	$(1.23)_b$	123
	C	20.0	$(1.44)_a$	19.9	$(1.49)_a$	46
Lower nighttime thermostat setting* (°C)	E	14.6	(2.15)	13.9	(2.28)	123
	C	14.6	(1.80)	14.5	(2.00)	46
Turn off thermostat when absent (% yes)	E	95.9		97.6		123
	C	95.6		97.8		45
Lower thermostat before leaving (% yes)	E	69.9		90.2		123
	C	57.8		73.3		45
Leave thermostat on in empty rooms (% yes)	E	33.6		19.8		131
	C	38.8		32.7		49
Leave heat on while air co. is on (% yes)	E	19.7		8.8		118
	C	25.0		13.5		43
Close doors between rooms (% yes)	E	75.9		92.0		137
	C	78.8		84.6		52
Rinsing dishes with warm water	E	3.2	$(1.64)_a$	3.7	$(1.36)_b$	137
	C	3.2	$(1.45)_a$	3.4	$(1.41)_b$	53
Using dishwasher while not full (times per week)	E	.7	$(1.09)_a$	.2	$(.50)_b$	64
	C	.9	$(1.51)_a$	.3	$(.62)_b$	32
Defrosting of refrigerator (% yes)	E	75.2		83.5		121
	C	79.5		79.5		44
Number of showers per week (per household)	E	10.7	$(6.80)_a$	9.2	$(6.67)_b$	137
	C	10.9	$(6.55)_a$	10.1	$(6.41)_a$	53
Showering time (minutes per shower)	E	9.5	$(4.53)_a$	8.2	$(3.72)_b$	133
	C	9.0	$(4.33)_a$	9.4	$(4.82)_a$	53
Bathing* (no. of times per week)	E	2.5	(2.48)	1.8	(2.52)	37
	C	2.0	(1.51)	2.1	(1.67)	15
Doing laundry at 90 and 60 °C* (times per week)	E	1.5	(1.35)	1.2	(1.21)	135
	C	1.6	(1.82)	1.4	(1.78)	53
Doing laundry at 40 °C* (times per week)	E	2.4	(1.90)	2.5	(1.97)	135
	C	2.5	(1.71)	2.6	(1.52)	53
Using washing machine when not fully loaded when not fully loaded (times per week)	E	1.5	$(.65)_a$	0.9	$(.41)_b$	38
	C	1.8	$(1.52)_a$	1.4	$(.93)_a$	17
Using dryer while not full (no of times per week)	E	1.6	$(.93)_a$	0.6	$(.74)_b$	14
	C	1.7	$(1.33)_a$	1.1	$(.77)_a$	13
Use of green electricity (% yes)	E	48.2		57.7		137
	C	53.8		59.6		52
Use of energy-saving light bulbs (no. of replacements)	E	N/A		1.2	$(2.00)_a$	137
	C	N/A		0.5	$(0.52)_b$	52
Lights on in unoccupied rooms (no. of rooms)	E	.80	$(.91)_a$	.42	$(.70)_b$	132
	C	.98	$(1.04)_a$	.75	$(.97)_a$	52
Less appliances on stand-by 1 ‘no’, 2 ‘somewhat less’, 3 ‘a lot less’	E	N/A		1.53	$(.59)_a$	107
	C	N/A		1.28	$(.45)_b$	47
Indirect energy use						
Car use for trips shorter than 5 km[a] (per week)	E	2.7	(3.50)	2.5	(3.51)	113
	C	3.5	(3.98)	3.4	(4.00)	43
Car trips between 5 and 10 km[a] (per week)	E	2.6	(3.30)	2.5	(3.32)	111
	C	2.8	(3.97)	2.7	(3.97)	44

Table 3 (*continued*)

Direct energy use		Time 1		Time 3 (T1 + 5 months)		N
Eating meat (grams per meal)	E	101.0	$(25.07)_a$	92.0	$(27.14)_b$	103
	C	104.0	$(23.65)_a$	97.0	$(28.24)_a$	45
Throwing away food 1 'no', 2 'somewhat less', 3 'a lot less'	E	N/A		1.6	$(.64)_a$	137
	C	N/A		1.4	$(.60)_b$	52
Sticker on mailbox against unwanted advertisements (% yes)	E	37.2		38.0		137
	C	46.2		48.1		52
Sharing daily newspaper (no. of newspapers)	E	N/A		.09	$(.27)_a$	89
	C	N/A		.03	$(.16)_a$	37

Notes: (1) Means, standard deviations (between brackets) and number of participants are listed for behaviors measured on interval scales. For dichotomous variables, the percentage of households that indicate engaging in the behavior is listed. For some behaviors, only a measurement after the intervention was available. (2) Unequal subscripts indicate a significant difference over time between means at $p < .05$.

[a]For these behaviors, the overall *F*-test for time was not significant.

rinsing dishes, $t(52) = -2.09$, $p < .05$. The number of times the dishwasher was used without being fully loaded was significantly reduced over time by the experimental, $t(23) = 4.63$, $p < .001$ as well as the control group, $t(11) = 3.66$, $p < .01$. Households in the experimental groups significantly reduced the number of weekly showers, $t(136) = 5.07$, $p < .001$, whereas the control group did not: $t(52) = 1.69$, *ns*. Households in the experimental groups also significantly reduced the length of their showers, $t(132) = 4.45$, $p < .001$, while showering time among households in the control group increased slightly, but non-significantly: $t(52) = -.88$, *ns*. Households in the experimental groups used the washing machine less often when it was not fully loaded, $t(37) = 4.01$, $p < .001$, whereas the control group did not change this behavior, $t(16) = 1.33$, ns. Households in the experimental groups used the clothes dryer less often when it was not fully loaded, $t(13) = 4.27$, $p < .001$, whereas the control group did not change this behavior, $t(12) = 1.67$, ns. The experimental groups had replaced significantly more traditional light bulbs with energy-saving light bulbs than the control group had, $F(1,187) = 5.65$, $p < .05$. After the intervention, households in the experimental groups significantly reduced the number of lights left on in unoccupied rooms, $t(110) = 7.24$, $p < .001$, as did the control group, $t(51) = 2.13$, $p < .05$. Households in the experimental groups left fewer appliances on stand-by than the control group, $F(1,152) = 7.07$, $p < .01$. Households in the experimental groups significantly reduced meat consumption per meal, $t(102) = 5.09$, $p < .001$, whereas the control group did not, $t(44) = 1.70$, *ns*. Five months after the intervention, households in the experimental groups threw away less food unnecessarily, compared to the control group, $F(1,187) = 4.92$, $p < .05$.

4.4. *Changes in knowledge of energy conservation*

As one of the targets of the intervention, knowledge levels after the intervention were expected to be higher among participants in the experimental groups compared to the control group. This appeared to be the case, as the overall difference between groups in the number of correct answers was significant: $F(1,186) = 6.38$, $p < .05$. On average, respondents in the experimental groups gave more correct answers ($M = 4.0$; $SD = 1.13$), than respondents in the control group did ($M = 3.5$; $SD = 1.03$).

5. Discussion

The present study examined the extent to which a combination of interventions (tailored information, goal setting and tailored feedback) resulted in changes in direct and indirect energy use, energy-related behaviors and knowledge of energy conservation. It was also examined whether a group goal and group feedback would have an additional effect.

Households exposed to the intervention saved significantly more direct energy (gas, electricity and fuel) than households in the control group did. Households in the two experimental groups combined reduced their indirect energy use, whereas households in the control group increased indirect energy use. This difference was not statistically significant. In terms of total energy consumption, households in both experimental groups reduced their energy use, and attained the goal of 5% energy savings, while households in the control group tended to use more energy. This difference in energy savings between the experimental groups combined and the control group was not significant, probably due to a large within-group variance in energy savings. This large variability could be attributed to energy savings related to holidays. When the latter were excluded from the analysis, households exposed to the interventions saved significantly more on their total (direct and indirect) energy use than households in the control group did. When within-group variances are large, a large sample size is needed to increase statistical power. This issue is not uncommon in energy conservation research and has been reported elsewhere (e.g. Brandon & Lewis, 1999).

Taken together, the results suggest that the combination of interventions mainly encouraged households to reduce gas, electricity and fuel use.

Results further indicate that households exposed to the combination of interventions adopted various specific energy-saving behaviors, whereas households in the control group did so to a lesser extent. Behavior changes were particularly marked for relatively low-cost behaviors (i.e. in terms of time, effort, convenience), such as thermostat setting, and the efficient use of appliances. Households were less likely to adopt behaviors associated with relatively high costs, such as reducing the number of car trips. The interventions appear to have particularly encouraged households to adopt behaviors that are relatively easy to change.

After 5 months, households that had been exposed to the interventions had higher knowledge levels of energy conservation than households in the control group. This corroborates previous findings (see Geller, 1981; Staats et al., 1996). There is initial evidence to suggest that the provision of information about indirect energy use resulted in energy savings in this domain. Households in the control group in fact increased their indirect energy use, which may be explained by the fact that these households had not been provided with information about indirect energy use. This is an important finding from a policy perspective. Energy policies tend to focus mainly on reducing direct energy use, but it would be advisable to also provide households with information about indirect energy use, especially in view of its environmental impact.

Several explanations may be given for the fact that a group goal and group feedback did not have any additional effect on energy savings. First, group feedback could be given only after all participants had filled out the questionnaire, thereby reducing the period of time during which participants could translate this feedback into behavioral changes. Generally, the effectiveness of feedback is enhanced when it is given immediately following the behavior in question (e.g. Van Houwelingen & Van Raaij, 1989). Second, the manipulation may have been too subtle, i.e. the reference group may not have been relevant for participants. The present results corroborate findings by Midden, Meter, Weenig, and Zieverink (1983), who did not find any additional effect of comparative feedback over individual feedback either. Other studies did find a combination of individual and comparative feedback to be beneficial (e.g. Siero, Bakker, Dekker, & Van den Burg, 1996; Staats et al., 2004). A possible explanation is that in these latter studies, members of the groups communicated with each other, and social norms in favor of energy conservation may have been more salient. More research is needed to help clarify why social influences seem to work in some cases, but not in others.

A limitation of the present study is that self-reported behaviors were used to calculate (changes in) energy use, which yield only an estimated measure of energy use. Also, self-report measures can be prone to socially desirable answers (e.g. Luyben, 1982), however, there are studies that suggest otherwise (Warriner, McDougall, & Claxton, 1984). An important reason for the inclusion of self-reported behaviors was that this study aimed to encourage behavioral changes by means of tailoring. To be able to provide households with tailored information about energy-saving options, information was needed about their current behaviors. By giving households detailed feedback about the effects of their behavioral changes on total household energy use, they were given insight into which behaviors had been responsible for changes in energy use. Meter readings cannot provide this kind of information. This is especially true for behaviors related to indirect energy use, as they are embedded in consumer goods, and thus not visible on a meter.

In the present study, the principle of tailoring was employed. It may be worthwhile to further explore the possibilities of tailoring by examining the barriers to change for specific target groups and to tailor interventions to these barriers (see also McKenzie-Mohr, 2000). By customizing interventions to specific characteristics of target groups, the effectiveness of interventions in promoting energy conservation may be further enhanced. The Internet is a potentially effective medium for tailored interventions, because it offers the possibility of reaching a relatively large number of households, while at the same time providing custom-made information and electronic feedback to individual users. This is especially true as the Internet is gradually making its way into an increasing number of households (Dutch Ministry of Economic Affairs, 2003).

The present study highlights the added value a multi-disciplinary study may have over a mono-disciplinary approach. The Internet-based tool was the result of an ongoing collaboration between environmental scientists, social scientists, and computer engineers, i.e., the output of one discipline served as input for the other discipline. The social psychologists selected and implemented the interventions, and focused on behaviors that would be feasible and acceptable for households to adopt. The environmental scientists developed a tool used for calculating the energy use and savings associated with a wide range of energy-related behaviors, covering both direct and indirect energy use. The computer engineers were responsible for the design and implementation of a user-friendly website. Participants were of the opinion that the information and feedback provided via the website were clear, and they found the website to be user-friendly (for a more detailed evaluation of the website, see Abrahamse, 2003).

Taken together, the results indicate that after a period of 5 months, a combination of tailored information, goal setting and feedback was especially successful in reducing gas, electricity and fuel use (i.e. direct energy use). Households attained the energy-saving goal of 5%.

Further, the combination of interventions encouraged households to start adopting various energy-saving options, and it led to higher knowledge of energy conservation. In terms of reduced environmental impact, the households exposed to the interventions were able to save 1.6 million MJ of energy, which is equivalent to the annual gas use of 27 Dutch households. The multidisciplinary approach of the current study allowed households to get a more comprehensive insight into the possible ways to reduce their energy use, and into the relative impact of these changes. In future research, which should include larger sample sizes, the possibilities of encouraging households to reduce direct and indirect energy use via the Internet may be further explored.

Acknowledgements

The authors would like to thank the following people for their invaluable help in this project: Gerwin Wiersma and Klaas Jan Noorman (KNN Milieu B.V.), Rixt Kok, René Benders and Henk Moll (Centre for Energy and Environmental Studies, University of Groningen), Peter Smeets and Sofie Graas (website designers, Smeets & Graas B.V.), and Peter van Kampen (computer engineer, Science Plus B.V.).

The project was made possible through funding from the Dutch Ministry of Economic Affairs through NOVEM (Dutch Institute for Energy and Environment), Grant no. 0144-01-03-00-0008.

References

Abrahamse, W. (2003). The effect of tailored information, goal setting and feedback on household energy use. In L. Hendrickx, W. Jager, & L. Steg (Eds.), *Human decision making and environmental perception. Understanding and assisting human decision making in real-life settings* (pp. 183–201). Groningen: Department of Psychology, University of Groningen.

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, *25*, 273–291.

Becker, L. J. (1978). Joint effect of feedback and goal setting on performance: A field study of residential energy conservation. *Journal of Applied Psychology*, *63*, 428–433.

Benders, R. M. J., Kok, R., Moll, H. C., & Wiersma, G. (2006). New approaches for household energy conservation—In search for personal household energy budgets and energy reduction options. *Energy Policy*, *34*, 3612–3622.

Brandon, G., & Lewis, A. (1999). Reducing household energy consumption: A qualitative and quantitative field study. *Journal of Environmental Psychology*, *19*, 75–85.

Daamen, D. D. L., Staats, H., Wilke, H. A. M., & Engelen, M. (2001). Improving environmental behavior in companies. The effectiveness of tailored versus non-tailored interventions. *Environment and Behavior*, *33*, 229–248.

Dutch Ministry of Economic Affairs. (2003). *The International ICT-test*. 〈http://apps.ez.nl/publicaties/pdfs/Nieuw%20ICT-toets2002,herziene%20versie%20voor%20EZ-web.pdf〉. Consulted July 27, 2004.

Dwyer, W. O., Leeming, F. C., Cobern, M. K., Porter, B. E., & Jackson, J. M. (1993). Critical review of behavioral interventions to preserve the environment. Research since 1980. *Environment and Behavior*, *25*, 275–321.

Gardner, G. T., & Stern, P. C. (2002). *Environmental problems and human behavior* (2nd ed.). Boston: Pearson Custom Publishing.

Gatersleben, B., Steg, L., & Vlek, C. (2002). Measurement and determinants of environmentally significant consumer behavior. *Environment and Behavior*, *34*, 335–362.

Geller, E. S. (1981). Evaluating energy conservation programs: Is verbal report enough? *Journal of Consumer Research*, *8*, 331–335.

Gonzales, M. H., Aronson, E., & Costanzo, M. A. (1988). Using social cognition and persuasion to promote energy conservation: A quasi-experiment. *Journal of Applied Social Psychology*, *18*, 1049–1066.

Hutton, R. B., Mauser, G. A., Filiatrault, P., & Ahtola, O. T. (1986). Effects of cost-related feedback on consumer knowledge and consumption behavior: A field experimental approach. *Journal of Consumer Research*, *13*, 327–336.

Katzev, R. D., & Johnson, T. R. (1983). A social–psychological analysis of residential electricity consumption: The impact of minimal justification techniques. *Journal of Economic Psychology*, *3*, 267–284.

Kreuter, M. W., Farrell, D., Olevitch, L., & Brennan, L. (1999). *Tailored health messages: Customizing communication with computer technology*. Mahwah, NJ: Lawrence Erlbaum.

Luyben, P. D. (1982). Prompting thermostat setting behavior: Public response to a presidential appeal for conservation. *Environment and Behavior*, *14*, 113–128.

McCalley, L. T., & Midden, C. J. H. (2002). Energy conservation through product-integrated feedback: The roles of goal-setting and social-orientation. *Journal of Economic Psychology*, *23*, 589–603.

McKenzie-Mohr, D. (2000). Promoting sustainable behavior: An introduction to community-based social marketing. *Journal of Social Issues*, *56*, 543–554.

Midden, C. J., Meter, J. E., Weenig, M. H., & Zieverink, H. J. (1983). Using feedback, reinforcement and information to reduce energy consumption in households: A field-experiment. *Journal of Economic Psychology*, *3*, 65–86.

Organisation for Economic Co-operation and Development (OECD). (2002). *OECD Environmental Outlook 2002*. Available online: 〈http://www.oecd.org/dataoecd/51/6/2088589.pdf〉.

Reinders, A. H. M. E., Vringer, K., & Blok, K. (2003). The direct and indirect energy requirement of households in the European Union. *Energy Policy*, *31*, 139–153.

Rimer, B. K., & Kreuter, M. W. (2006). Advancing tailored health communication: A persuasion and message effects perspective. *Journal of Communication*, *56*, S184–S201.

RIVM. (2005). *Referentieramingen energie en emissies 2005–2020* [*Reference estimates for energy and emissions 2005–2020*]. Consulted March 29, 2005. 〈http://www.rivm.nl/bibliotheek/digitaaldepot/RREE20052020.pdf〉.

Siero, F. W., Bakker, A. B., Dekker, G. B., & Van den Burg, M. T. C. (1996). Changing organizational energy consumption behavior through comparative feedback. *Journal of Environmental Psychology*, *16*, 235–246.

Slavin, R. E., Wodarski, J. S., & Blackburn, B. L. (1981). A group contingency for electricity conservation in master-metered apartments. *Journal of Applied Behavior Analysis*, *14*, 357–363.

Staats, H., Harland, P., & Wilke, H. A. M. (2004). Effecting durable change. A team approach to improve environmental behavior in the household. *Environment and Behavior*, *36*, 341–367.

Staats, H. J., Wit, A. P., & Midden, C. Y. H. (1996). Communicating the greenhouse effect to the public: Evaluation of a mass media campaign from a social dilemma perspective. *Journal of Environmental Management*, *45*, 189–203.

Stern, P. C. (1992). What psychology knows about energy conservation. *American Psychologist*, *47*, 1224–1232.

UK Department of Trade and Industry. (2005). *Energy. Its impact on the environment and society*. 〈http://www.dti.gov.uk/energy/environment/energy_impact/impact_booklet.pdf〉. Consulted March 29, 2005.

US Department of Energy. (2005). *Energy Information Administration: Carbon dioxide emissions.* 〈http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html〉 Consulted January 20, 2005.

Van Houwelingen, J. H., & Van Raaij, F. W. (1989). The effect of goal-setting and daily electronic feedback on in-home energy use. *Journal of Consumer Research*, *16*, 98–105.

Vringer, K., & Blok, K. (1995). The direct and indirect energy requirements of households in the Netherlands. *Energy Policy*, *23*, 893–910.

Warriner, G. K., McDougall, G. H., & Claxton, J. D. (1984). Any data or none at all? Living with inaccuracies in self-reports of residential energy consumption. *Environment and Behavior*, *16*, 503–526.

Winett, R. A., Leckliter, I. N., Chinn, D. E., Stahl, B., & Love, S. Q. (1985). Effects of television modeling on residential energy conservation. *Journal of Applied Behavior Analysis*, *18*, 33–44.

Winett, R. A., Love, S. Q., & Kidd, C. (1982–1983). The effectiveness of an energy specialist and extension agents in promoting summer energy conservation by home visits. *Journal of Environmental Systems*, *12*, 61–70.