Effectiveness of a Competition-Based Intervention in Promoting Pro-Environmental Behavior in a University Residential Setting

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ABSTRACT

A large number of university-based energy reduction efforts have been implemented in recent years, but few have been subjected to empirical evaluation. The aim of the present study was to evaluate the effectiveness of a web-based intervention in reducing energy consumption in a university residential setting. The study used a prospective experimental design with a control group. To engage participants, the project was implemented using a building-versus-building competition framework. Participants completed baseline and follow-up self-report surveys regarding energy use behaviors and key constructs derived from the Theory of Planned Behavior and the Norm Activation Model. A web-based application was developed with buildings assigned access to different intervention content. A total of 298 students participated in the first survey and 225 in the second, yielding a follow-up rate of 76%. Combined, the target buildings reduced their daily average electricity consumption by 8% during the 8-week competition compared to the baseline use levels, indicating that a competition-based intervention was viable in this setting. Only 6 students registered to use the web-based intervention application, however, which suggests that the requirement for registration was a barrier to use. Different methods of intervention content delivery may be better suited to an undergraduate population. Additional analyses using the self-report data will investigate individual-level changes in pro-environmental attitudes and behavior.

Background

Modifying human behavior is important for mitigating human contributions to global climate change. Residential and commercial building energy use represents a key target for intervention work. For example, in the US, 71% of all electricity used is consumed in residential and commercial buildings (United States Energy Information Administration 2010). Many interventions targeted at reducing residential energy consumption have been successful (for review see Abrahamse et al. 2005). In addition, several theories have been applied to understand behavior pertaining to pro-environmental behavior (PEB), which is defined here as any behavior that supports the sustainability of natural ecosystems, environmental health, and "contribute[s] towards environmental preservation and/or conservation" (Axelrod & Lehman 1993, p. 153). Below we briefly review three of these theories. Following is a review of energy reduction interventions implemented in residential and university settings.

Theoretical Models of Behavior

Research supports the application of several theoretical models to PEB, including the Norm Activation Model (NAM; Schwartz 1994), Theory of Planned Behavior (TPB; Ajzen & Fishbein 1980), and Cognitive Dissonance Theory (Aronson, 1969; Festinger, 1957).

The Norm Activation Model (NAM) posits that PEB is a type of altruistic behavior predicted directly by personal norms and indirectly by social norms. The relationship between personal norms and behavior is proposed to be moderated by awareness of consequences and ascribed responsibility, such that personal norms are activated only when a person is both aware of the consequences (AC) of performing or not performing a particular behavior, and ascribes responsibility (AR) for these consequences to the self. When these conditions are met, NAM predicts that a person will act in accordance with personal norms. Several studies support the application of pieces of the NAM to PEB (Guagnano et al. 1995; Hopper & Nielsen, 1991; Stern et al. 1995; Van Liere & Dunlap 1978). For instance, Van Liere and Dunlap (1978) found a significant interaction between AC and AR in predicting yard-burning behavior. Among 307 US residents surveyed by telephone, those reporting both high AR and high AC were less likely to burn yard waste than others.

The Theory of Planned Behavior (TPB) postulates that behavior is directly determined by intention to perform the behavior, which is predicted by three factors: attitudes, social norms, and perceived control (Ajzen & Fishbein 1980). There is considerable empirical support for the application of pieces of TPB to PEB (Cheung et al. 1999; Kaiser et al. 1999; Stern et al. 1995; Stutzman & Green 1982), although full tests of the model are few. Bamberg (2003) fit a TPB model to data from a study of 380 university students. The model explained 60% of the variance in PEB and supported the TPB: PEB was predicted proximally by a behavioral intention factor, which was predicted by environmental attitudes, social norms, and perceived control.

Festinger's well-known theory of Cognitive Dissonance (Festinger, 1957) has also been applied to PEB. Under this theory, when individuals recognize that they hold attitudes, beliefs, or behaviors that are in conflict with one another, psychological discomfort arises. A strong motivation then arises to alleviate this distress by making consistent the conflicting attitudes, beliefs, or behaviors. Strategies to alleviate dissonance include changing attitudes, adding consonant cognitions, and reducing the perceived choice regarding a behavior. Several studies have employed the hypocrisy paradigm, an experimental manipulation that attempts to highlight discrepancy between past behavior and present attitudes, to understand PEB. For instance, as part of one experiment, university students wrote and delivered a pro-recycling speech (Fried & Aronson, 1995). Prior to writing the speech, half of the students were asked to provide examples of recent occasions that they had failed to recycle. When queried after giving the speech, these students reported that they would volunteer for a local recycling organization significantly more frequently and for longer periods of time compared to those who had not provided examples of their own recycling behavior. These results suggest that when an individual is made aware of a conflict between personal behavior and stated goals, s/he may be motivated to resolve the conflict by changing behavior.

Synthesizing, PEB is multiply determined, and the empirical evidence does not support one of the working theories as superior relative to the others. An important limitation of this literature is that theoretical studies of PEB have largely used cross-sectional designs, limiting their ability to address causal processes and provide information about mechanisms of behavior change.

Household Interventions

For more than 30 years, empirical studies on the effectiveness of interventions aimed at reducing energy (e.g., electricity, gas, water) consumption in residential settings have yielded results that generally support their effectiveness (Abrahamse et al. 2005). Two overarching intervention approaches have primarily been used: behavioral antecedent strategies and behavioral consequence strategies.

Antecedent interventions aim to influence a given behavior prior to its performance (Abrahamse et al. 2005). The provision of information is a commonly used method in household energy reduction interventions. Information ranges from conceptual, for instance, facts about global warming, to specific, such as recommended behaviors based on audits. Information may increase awareness of problems and knowledge about possible solutions. Related to the TPB, Ajzen (2009) suggests that information can influence attitudes and perceived control by modifying existing beliefs related to those constructs. Information interventions have been found to be more effective than control conditions in increasing PEB. Based on the results of 8 studies, a meta-analysis by Hines et al. (1987) identified a corrected correlation coefficient of .47 (SD=.29) between information approaches and increased PEB. Information appears to be more effective when tailored (Hirst & Grady 1982-1983) or combined with other intervention strategies (Seligman & Darley 1977).

Another common antecedent intervention strategy is goal-setting, which entails presenting participants with a reference point, for instance to save 5% or 10% electricity relative to use in some prior time period (Abrahamse et al. 2005). Goal setting is most often combined with information or feedback strategies to highlight conflicts between actual behavior and stated goals. This has the potential to evoke cognitive dissonance. For example, goal setting combined with feedback has been found to be more effective than feedback alone (McCalley & Midden 2002) or goal setting alone (Becker 1978). In a study that provided immediate feedback about washing machine electricity use on a display on the machine (McCalley & Midden 2002), participants who set a reduction goal showed a 20% water savings, significantly more than a group that received washing machine feedback but did not set a goal (11%).

Whereas information and goal setting operate through influencing behavioral antecedents, behavioral consequence strategies are implemented after behaviors are performed, with the goal of impacting future engagement in the same behaviors. More specifically, feedback entails providing individuals with information about their energy consumption after some baseline period (Abrahamse et al. 2005). Feedback enables people to associate their behaviors with outcomes and therefore has the potential to influence awareness of consequences, ascribed responsibility, and perceived control. Also, comparative feedback on other’s behavior may influence perceived social norms.

Feedback is generally an effective strategy for reducing household energy use (Abrahamse et al. 2005). Various forms of feedback interventions have been shown to be effective in prior work, including personalized feedback on past energy use and comparative feedback (e.g., Donaldson et al. 1994). The effectiveness of feedback increases with increased frequency of provision (van Houwelingen & Van Raaij 1989). The Hines (1987) meta-analysis found a corrected correlation coefficient of .28 (SD=0.11) between feedback strategies and increased PEB, supporting this strategy.

The bulk of the literature indicates that rewards also enhance energy savings, perhaps by operating as an extrinsic motivation to conserve energy. Several studies indicate significantly greater energy savings among households that receive rewards versus those that do not (e.g., Winett et al. 1978). However, energy savings associated with rewards have been shown to decline towards the end of interventions (McClelland & Cook 1980b) or after (Pitts & Wittenbach 1981). Rewards are typically combined with other intervention components, making it difficult to isolate their effect on behavior.

University Interventions

Two studies aimed at reducing energy consumption among college students living in dormitories were identified. Over the course of an academic year, McClelland and Cook (1980a) implemented a campus-wide intervention study at a public university in the US targeting residential, office, and mixed-use buildings. Buildings were randomly assigned to a control condition or one of two experimental conditions. Electricity consumption dropped significantly among all buildings, and significantly more so among experimental buildings. No differences between experimental groups were observed, which was attributed to student enthusiasm and initiatives that resulted in user participation-based interventions in all buildings. During the academic year following the intervention, average residential housing electricity consumption levels remained at the 15% reduced level that had been achieved during the intervention.

In the only identified study that evaluated a dormitory vs. dormitory electricity reduction competition, Petersen et al. (2007) evaluated the effects of a web-based intervention implemented among undergraduate dormitory residents at Oberlin University in Ohio. Feedback and rewards were used to promote behavior change. On-campus advertising provided information about the importance of energy conservation to all participants, but did not provide specific reduction strategies. Dormitory buildings were randomized to receive either continuous feedback or feedback on two occasions. Using an automated data system that provided feedback on electricity use, participants in the continuous feedback group could log in to a website that provided electricity feedback. During the 2-week intervention, electricity use was reduced by an average of 32% across all buildings compared to the preceding 3-week baseline period. This amounted to 68,300 kWh of electricity savings.

Currently, the literatures on energy reduction interventions and environmentally relevant behavior change are not well integrated. The intervention studies have not examined theoretical determinants of behavior change, and the theoretical literature has largely relied on cross-sectional designs. Consequently, further research and elaboration is required to better understand the mechanisms of environmentally-relevant behavior change and strategies to target these. In addition, recent years have witnessed dozens of dorm vs. dorm sustainability competitions at universities, but as of yet the results of only the Oberlin project (Petersen et al. 2007) have been published in a peer-reviewed academic journal. Exactly which PEBs are modified by the interventions, the duration of these effects, and the mechanisms that contribute to change merit further investigation.

Study Aims

The primary aim of the proposed study was to evaluate the effectiveness of a pro-environmental behavior intervention that was implemented among undergraduate residence halls at the University of Southern California (USC) in Fall 2009. A secondary objective of the project was to provide for the assessment of the mechanisms of behavior change.

Method

Using a prospective experimental design, this study randomly assigned groups of participants to different levels of exposure to intervention content, including a partial control group exposed to limited levels of the intervention and an assessment-only control group not exposed to any part of the intervention. Participants completed baseline and follow-up self-report surveys regarding energy use behaviors and key constructs derived from the Theory of Planned Behavior and the Norm Activation Model. See Figure 1 for the study timeline.

Procedures

Survey 1. Beginning in September 2009, survey 1 was publicly accessible online for approximately eight weeks. The survey assessed inclusion criteria and ended automatically if participants returned responses that indicated ineligibility (see Participants section below for eligibility criteria). Recruitment for the survey began in September 2009 and continued through November 2009. Emails, poster advertising inside of target buildings and on the USC campus, the Department of Psychology research participant pool, and contact with residential advisors in the target residence halls were used as recruitment strategies. Experimenters also set up tables to distribute information in a high-traffic area on campus. All participants were entered into raffle drawings to receive a variety of prizes, ranging in value from $10-$300. Participants who were enrolled in the Psychology Department research participant pool also received credit for taking the surveys, which could be applied as extra credit in psychology courses.

Intervention. Following the close of survey 1, eligible participants were contacted via email and invited to participate in the intervention component of the project. Participant eligibility was determined based on responses to the psychology subject pool screening measure administered prior to survey 1, available to students in psychology classes as an extra credit option, as well as responses to survey 1. To engage participants, the intervention was advertised as a dormitory-versus-dormitory competition called the “Energy Reduction Challenge”. Buildings earned points based on building-level survey completion rates and reductions in building-level electricity use during the Fall 2009 semester. A pizza party served as the reward for the winning building. Residents of target buildings were informed of this incentive and told that the goal was to save energy. New posters were placed in target buildings weekly. Each poster explained the competition and pizza party, and contained graphics, images, and messages that encouraged energy reduction (e.g., “Which is the greenest dorm on campus?”). Eligible participants were prompted by email on several occasions to remind them of the competition. Email content was similar to poster content and included a URL to the intervention website. Resident advisors of target buildings were also contacted via email and asked to distribute information about the project verbally and electronically to their residents. No advertising or recruitment efforts were made in the buildings not included in the competition.

The intervention lasted for eight weeks and all intervention content was delivered via a study website. Seven target buildings were selected to participate in the intervention, on the basis of being similar in the types of appliances that were under the control of residents and in other characteristics such as type of construction, layout, and population. These buildings were randomized to receive different combinations of intervention components. As part of the registration process required to access the website, users reported their building of residence.

Based on this information, the website granted access to the assigned condition. Residents of the partial control building served as a limited control group; although they could not access any intervention content on the website, they were still included in the competition and exposed to the same advertising and prompts as the other buildings. Residents of a second building were granted access to informational modules only. Three buildings shared one electricity meter and were treated as a single group; residents of these buildings were assigned access to informational modules and real-time electricity feedback of all participating buildings. Residents of the sixth building had access to informational modules and were required to set an individual and building-level electricity reduction goal. Residents of the seventh building could access the information, feedback, and goal-setting modules. See materials section below for additional information on intervention content.

Participants who completed either survey but were not residents of one of the seven target buildings comprised the assessment-only control group. These participants were not included in the competition and not recruited for the intervention. They were not given access to website modules. They completed the study measures to earn course credit or raffle prizes.

Survey 2. Survey 2 was available for three weeks beginning the day after the intervention ended.

Figure 1. Study Timeline

<table>
<tr><th>Study Group</th><th></th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Partial Control</td><td rowspan="5">Residents of the seven target buildings

Included in competition</td><td colspan="2" rowspan="5">Electricity Baseline Period: August 24-Sept 29

Survey 1: Sept 9 – Nov 1</td><td colspan="2">Competition/intervention: Sept 30-Nov 25. No website modules available to partial control building</td><td rowspan="5">Interven-tion ended: Nov 25

Survey 2: Nov 26-Dec 17</td></tr>
<tr><td>Info</td><td colspan="2">Information module available</td></tr>
<tr><td>Info, goal setting</td><td colspan="2">Set reduction goal during initial log-in, then information and goal modules available</td></tr>
<tr><td>Info, feedback</td><td colspan="2">Information & feedback modules available</td></tr>
<tr><td>Info, goal setting, Feedback</td><td colspan="2">Set reduction goal during initial log-in, then information, goal, & feedback modules available</td></tr>
<tr><td>Assessment only control</td><td>Not included in competition</td><td colspan="3">Survey 1: Sept 9 – Nov 1</td><td></td><td>Survey 2: Nov 26-Dec 17</td></tr>
</table>

Participants

To be eligible to participate in the surveys, participants had to be at least 18 years of age, a current USC undergraduate student, and a resident of USC-owned or USC-managed housing. To be eligible to participate in the intervention, participants also had to be residents in one of the seven selected target buildings. A total of 298 students participated in the first survey and 225 in the second, yielding a follow-up rate of 76%.

A total of 11 participants provided responses that indicated random responding (see Validity Items below). Responses from these participants were dropped from the analyses, yielding a total sample size of 291. Please see table 1 for descriptive characteristics of Survey 1 participants.

Approximately 1500 students resided in the target buildings and were eligible to participate in the intervention component of the study. However, only six students registered to use the website. Data on the number of students who participated in the energy reduction competition without registering for the website are unavailable.

Table 1. Survey 1 Participant Characteristics

Characteristic	
Mean age in years (SD)	19.0 (1.2)
Sex (% female)	75
Mean high school grade point average	>4.0
Mean number of semesters residing in current residence hall	1.6
Class status	(%)
Freshman	53.3
Sophomore	28.8
Junior	11.6
Senior	5.6
Urbanicity of place of origin	(%)
Rural	3.5
Suburban	74.9
Urban	21.6
Behavioral data	*Mean (SD, range)*
Schultz PEB	49.3 (8.5, 17-85)
Consumer Behavior	11.6 (2.9, 5-20)

Materials

- **Surveys.** Each survey was administered online and required approximately 25 minutes to complete. Surveys were publicly accessible 24 hours per day. The two surveys were identical except that the second included a set of follow-up questions regarding behavioral changes and perceptions of the intervention.
- **Demographic data.** Demographic variables assessed included age, gender, year of university parental educational attainment, and urbanicity of region of origin (urban, suburban, or rural).
- **Behavior.** Behavior was assessed using two self-report scales, including a 17-item modified version of the Schultz Proenvironmental Behavior Scale (Schultz et al. 2005). Responses were provided on a 5-point Likert scale. Cronbach's alpha was calculated to assess internal consistency and was .73 for survey 1 and .75 for survey 2. The Consumer Behavior Subscale from Stern's Indices of Pro-Environmental Behavior was used to assess consumer behavior (Stern et al. 1999). Responses were given on a 5-point Likert scale. Internal consistency alphas for time 1 and 2 were .74 and .67, respectively
- **Validity items.** One true/false question was included in each survey to detect random responding. It stated "George W. Bush is the current president of the United States." The Impression Management scale from the Balanced Inventory of Desirable Responding was also included in both surveys to assess patterns of socially desirable responding (Paulhus 2002).
- **Additional items.** The surveys assessed a number of additional constructs, including perceived control, attitudes, knowledge, personal and social norms, and behavioral

intentions. For brevity, the measurement and results related to many of the survey items will not be discussed here, but will be investigated in future work.

- **Intervention Website.** A web-based application was developed to administer all intervention content. The website included informational modules on environmental problems and strategies to reduce energy consumption; a goal-setting component; and a module that provided real-time electricity feedback for included buildings (www.EcolympicsUSC.com). If assigned to receive the goal-setting component, participants were asked to set both individual-level and building-level goals. The feedback component was an interactive graph that displayed real-time electricity consumption for all target buildings, and provided for time-frame and building-vs-building comparisons.
- **Electricity.** Electricity data, measured in kilowatt-hours (kWh), were gathered on a continuous basis, with data points summarized every 15 minutes for all on-campus buildings. Baseline data included electricity data from August 24-September 29. Competition data were September 30-November 25. To clarify the effects of the intervention, we also obtained data from the target buildings from Fall 2007, as well as the 5-year average from 2003-2007. Only monthly data were available for these time periods. Data from Fall 2008 and other (non-target) buildings during Fall 2009 were under preparation when these analyses were conducted.

Results

Electricity Consumption

Mean daily electricity consumption during the baseline and intervention time periods were compared to evaluate change in consumption during the intervention period. Intervention daily use was subtracted from baseline daily use, and the resulting figure was divided by baseline daily use. Combined, the target buildings reduced their daily average electricity consumption by approximately 8% during the 8-week competition compared to their combined baseline use level. This represents an estimated savings of 75,000 kWh electricity based on projected electricity use from baseline levels. Please see Figure 2 for a visual representation.

We were unable to obtain consumption data for the exact calendar dates of the intervention in prior years because only monthly electricity data were available for prior years. However, September roughly corresponds to the baseline period in our study, and October and November roughly correspond to the intervention period. See Figure 1 for the study timeline. Therefore, for the purposes of this set of analyses, we compared aggregate monthly electricity consumption summed across all target buildings in September to aggregate consumption in October and November. Results from 2007 showed that October and November electricity consumption increased above September levels by 3% and 6%, respectively. Across the 2003-2007 time frame, October and November electricity use increased above September levels by 10% and 5%, respectively. Conversely, during the intervention in 2009, October and November consumption decreased below September levels by 3% and 11%, respectively. Data from a residence hall built in 2008 were excluded from these analyses.

Figure 2. Daily Average Electricity Consumption among the Seven Target Buildings During the Fall 2009 Intervention and Baseline Periods

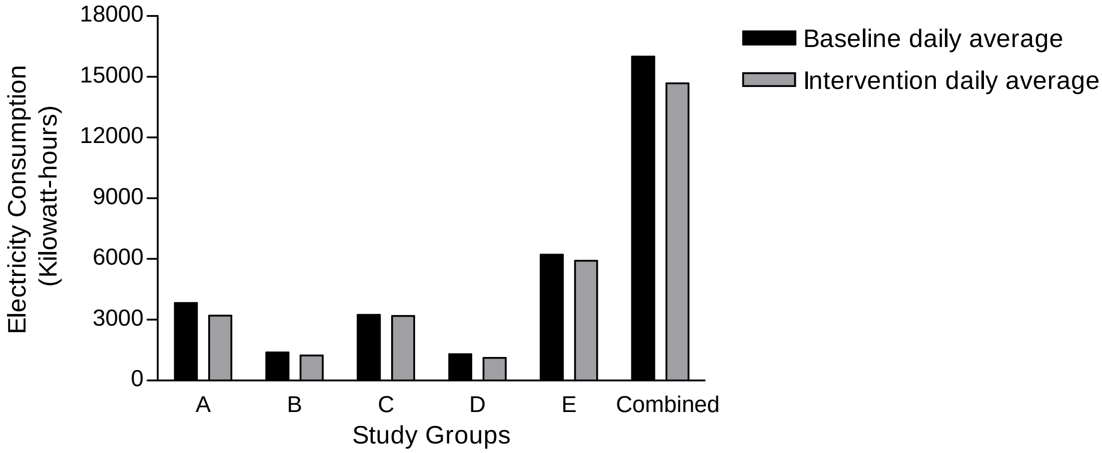

Figure note. Study Group B represents the partial control building included in the intervention and competition. The "Combined" columns represent electricity consumption summed over all target buildings.

Self-Reported Behavior

Because only six participants accessed the intervention content on the study website, we were unable to conduct planned analyses to evaluate the effects of the different intervention components on PEB. Instead, we combined the data from all respondents who resided in target (competition) buildings at time 1 into a single group. Responses from participants who resided in buildings that were not included in the competition were combined in an assessment-only control group. All competition buildings were treated equally with respect to advertising, recruitment (i.e., posters, emails, contact with resident advisors), and incentives/rewards. Likewise, advertising was absent in assessment-only control buildings. Prior work has used similar strategies. As part their university-based intervention, Petersen and colleagues (2007) used advertising that explained the importance of saving energy without providing additional information about saving energy. Another study found that advertising and prompts induced self-monitoring and the performance of behaviors already familiar to people in the domain of physical activity (Kahn et al. 2002).

Validity. The SAS statistical package version 9.1 was used to analyze all self-report data (SAS Institute Inc., 2002). We tested for baseline differences in demographic characteristics and scores on the outcome scales between participants who resided in competition buildings (n=147) versus those who resided in assessment-only buildings (n=144). Two multiple logistic regression models were conducted with different conceptual blocks of variables predicting target building status. In the first block, demographic factors including sex, urbanicity of place of origin (urban vs. suburban or rural), maternal education level, paternal education level, and high school grade point average were entered. Variables related to age and residence status were used in the second model, including age, number of semesters in residence at residence hall, location of residence (on or off campus), and year of university enrollment. Significant differences were found for age (Odds ratio [OR] = 0.49, 95% confidence interval [CI] = 0.33-0.71), and year of enrollment (OR = 1.82, CI = 1.10-3.02). Younger individuals and more recent university enrollees were more likely to reside in target buildings. In examining baseline differences for the outcome scales, we found that time 1 PEB score was significantly higher among residents of target buildings versus assessment-only controls (OR = 0.95, CI = 0.92-0.98).

All analyses below were run excluding respondents who surpassed the cutoff on the Balanced Inventory of Desirable Responding (Paulhus 2002), which indicated a potentially socially desirable response pattern. Results were generally consistent with results from the analyses run on the full sample, and therefore we report the latter here.

Behavior outcomes. We used paired t-tests to evaluate the significance of time 1 to time 2 changes in total scores on the Schultz PEB scale and Consumer Behavior scale. These two behavior outcomes were included to address whether changes from time 1 to time 2 applied only to a specific domain of behavior or were more generalized.

Using two multiple regression models, one for each outcome (general PEB and consumer behavior), we modeled Survey 2 behavior scores based on a set of predictors. A stepwise model building procedure was used. On the first step, survey 1 score was entered as a predictor. On the second step, enrollment year was added as a covariate. On the third step, competition status (resident of competition building vs. control) was added. On the fourth and final step, and an interaction term (survey 1 score x competition status) was added. Age was initially included as a covariate along with enrollment year, but was dropped from all three models because it was highly correlated with enrollment year ($r=-.66$, $p<.0001$) and accounted for less than 1% of the variance in each outcome. Responses with values were excluded from these analyses. Please see table 2 for model parameters.

General PEB. The t-test was significant ($t_{206}=4.26$, $p<.0001$) and indicated a mean increase of 1.7 (SD=5.7) from baseline to follow-up. The overall regression model was also significant ($F=70.93$, $p<.0001$) and accounted for 58.5% of the variance in time 2 PEB. A significant effect was observed for time 1 PEB ($t=12.08$, $p<.0001$), such that higher time 1 PEB scores predicted higher time 2 PEB scores.

Consumer behavior. The t-test was not significant ($t_{201}=-1.05$, $p<.30$), indicating no change in consumer behavior across time. The overall regression model was significant ($F=35.35$, $p<.0001$) and accounted for 41.9% of the variance in time 2 consumer behavior. Significant effects were observed for time 1 consumer behavior ($t=10.30$, $p<.0001$) such that higher time 1 consumer behavior scores predicted higher time 2 scores. A significant effect of competition status ($t=2.09$, $p<.04$) was also observed, such that on average, those in the competition reported higher consumer behavior scores at time 2 than controls. The time 1 consumer behavior x competition interaction term ($t=-2.38$, $p<.02$) was also significant, but accounted for only .02% of the explained variance. These latter two findings are likely due to a ceiling effect, such that individuals with higher scores at time 1, including a large proportion of those in the competition, did not have much room to increase. When the top 25% of scorers on time 1 consumer behavior were excluded, competition status and the interaction term were not significant.

Table 2. Standardized Regression Coefficients and R² Values for General Pro-Environmental Behavior (PEB) and Consumer Behavior Models

	Time 2 outcome			
	General PEB n=206		Consumer Behavior n=201	
	β	R^2	β	R^2
Time 1 score[a]	0.75*	58.1	0.74*	39.9
Year of enrollment	0.04	58.4	-0.02	40.0
Competition status (target=1)	0.04	58.5	0.49*	40.2
Competition status x Time 1 score[a] interaction	0.006	58.5	-0.57*	41.9

[a]Time 1 score corresponds to each time 2 outcome. *p<.05.

Discussion

During the 8-week competition, daily average electricity consumption in the seven target buildings included in the competition component of the study was reduced by approximately 8% compared to the baseline period, which translates into approximately 75,000 kWh electricity. This suggests that a competition-based intervention was viable for inducing energy conservation in this setting. This conclusion is supported by the observed increase in electricity consumption during roughly the same time period as the present study in prior years. Results from the self-report data were partially consistent with the 2009 electricity findings: a significant increase in general PEB was observed from time 1 to time 2, but there was no change in consumer behavior across time. The regression results indicated that time 1 behavior was a consistent predictor of time 2 behavior for both self-reported outcomes and accounted for over 97% of the explained variance in each. These findings indicate an overall increase in PEB among the study sample. As well, it appears that consumer behavior may be a distinct type of PEB that is less amenable to change. Alternatively, consumer behavior may require different approaches for modification than were provided by the present competition-based intervention.

Unexpectedly, only six students registered to use the web-based intervention application, which suggests that the requirement of registration was a barrier to use, and that different methods of intervention content delivery may be better suited to undergraduate populations. Regarding individual-level analyses, this precluded planned analyses of the effects of the different intervention components on behavior change. Therefore, we combined the responses of all residents of target buildings, all of whom were exposed to the competition, advertising, and incentivized with a reward, and compared these responses to residents of assessment-only buildings not included in the competition. No significant effects of competition status were identified for the general PEB or consumer behavior outcomes, indicating that residence in a competition building was not significantly associated with these behaviors. Electricity data from other on-campus buildings during the intervention period, as well as 2008 data from all buildings, will be needed to draw conclusions about the effect of the competition on the observed changes in electricity use and self-reported behavior. It is possible that the observed electricity reduction during the Fall 2009 intervention may not have been due to the competition, but rather may represent normal variation in electricity consumption. Given that residents of the target buildings did not access intervention content, this would be somewhat expected. Larger changes would be expected if participants had been exposed to the intervention content.

Our results are partially consistent with prior research conducted on university energy reduction interventions. Although the 8% reduction in electricity use identified in our study was smaller than the 15% and 32% reductions observed in prior work (McClelland & Cook 1980a; Petersen et al. 2007), our study combined baseline and follow-up self-report surveys, which will enable us to investigate mechanisms of behavior change in future work based on our data. This is an important area of inquiry for developing targeted interventions to reduce energy consumption. Similar to McClelland and Cook (1980a), increases in pro-environmental behavior were observed among intervention and control participants, and no differences were observed among experimental groups. This may point to user-based participation as a method of intervention effectiveness.

Limitations

Several limitations to this study should be noted. First, our sample may have been biased such that students interested in environmental issues may have been more likely to participate. Next, the low level of web registration precluded examination of several key hypotheses. Difficulty with outreach combined with limited funding delayed the launch of the intervention and slowed the forging of partnerships with residential hall staff. Residential staff are considered to be key in organizing residential hall activities and encouraging residents to participate in on-campus programs.

Strengths

A key strength of this study was the combination of an energy reduction intervention with the assessment of theoretical determinants of behavior change. Though not described in this paper, this provides for a more comprehensive examination of changes in PEB and its correlates, including enabling identification of the mechanisms of behavior change. Our project also examined the generalizability of household intervention strategies by applying them to a young adult population that has received little attention in the literature. Finally, the 75,000kWh electricity saved during intervention represents a meaningful practical outcome.

Future Directions

In future analyses, we plan to use structural equation modeling to investigate mechanisms of behavior change based on the Theory of Planned Behavior and Norm Activation Model. Additionally, future analyses will investigate moderators of behavior change to determine which intervention strategy or strategies are most effective, and for whom. Finally, we plan to examine the influence of building occupancy and climatic variables on changes in electricity use.

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