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Encouraging energy conservation at work: A field study testing social norm feedback and awareness of monitoring

Gabrielle Wong-Parodi[b,a,*], Tamar Krishnamurti[a,c], Joshua Gluck[d], Yuvraj Agarwal[d]

[a] Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213, USA
[b] Department of Earth System Science, Stanford University, Stanford, CA 94305, USA
[c] Department of Medicine, University of Pittsburgh, Pittsburgh, PA 15213, USA
[d] School of Computer Science, Carnegie Mellon University, Pittsburgh, PA 15213, USA

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ABSTRACT

The financial cost of personal energy consumption is substantial at the organizational level. Rarely do incentives for saving energy for the individual employee and organization align, making conservation a challenge. Here we perform a 12-week field experiment piloting two behavioral strategies: (1) social norms feedback and (2) awareness of energy monitoring, to encourage savings among 46 administrative staff at a university who were given the impression of participating in an energy quality study to reduce self-selection bias. Those in the social norms feedback condition used significantly less energy during the intervention (10% less energy) and follow up monitoring (11% less energy) phases compared to their baseline consumption. Moreover, these participants demonstrated that they learned more about their energy use than did those in the awareness monitoring condition. For policy makers and building mangers interested in the effectiveness of behavioral nudges in inducing energy savings, social norms feedback appears to be an effective energy savings nudge in an organizational setting where there are neither financial savings at-stake nor intrinsic motivation to conserve.

1. Introduction

The financial cost of personal energy consumption is substantial at the organizational level. Office equipment consumes roughly 13% of energy used in office buildings (Pérez-Lombard et al., 2008), of which computers comprise 40–60% of that energy consumed (Bray, 2006). Indeed, more recent work has shown that in newer mixed-use buildings, computers and peripherals can constitute up to 25% of total building energy use during work hours and up to 40% during nights and weekends (Agarwal et al., 2009). With reductions in use during non-work hours, it could be possible for the average computer to save more than 75% of electricity (Berard, 2019). In many organizational contexts, personal computers, unlike lighting or indoor climate control, are controlled by the individual rather than the group or building manager. Incentives for saving energy from the perspective of the individual employee may not align with those of the organization for whom they work. For example, financial incentives that accrue to the organization through energy conservation, such as lower energy bills or rebates, are not experienced by the individual within an organization (Ries et al., 2006). This may make it particularly challenging to encourage individuals in the workplace to conserve energy.

The research into energy conservation at the level of the individual consumer has been predominantly focused on energy savings in the residential sector (Lesic et al., 2018). In this context, increased awareness of energy use is associated with energy conservation behaviors and in-home displays showing people how much energy they consume over time has met with some success in motivating savings (Davis et al., 2013). Other research suggests that alerting people to social norms, such as comparing an individuals' household energy use to the average household energy use of their neighbors can have a positive effect on conservation (Allcott, 2011; Allcott and Rogers, 2014), however this may only be the case when individual use is higher than average use (Schultz et al., 2007). Increased awareness of energy use and social norm comparisons are promising strategies for inducing energy conservation in the residential sector among high-energy consumers, but their applicability to individual decision making in organizational settings is unknown.

Some research in organizational settings is suggestive of the efficacy of employing social norms feedback, in the absence of financial incentives for the individual. For example, Siero et al. (1996) found that employees in a metallurgical company who were given comparative feedback about their energy consumption in conjunction with

* Corresponding author.
E-mail address: gwongpar@stanford.edu (G. Wong-Parodi).

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education about conservation behaviors, saved more energy than those who received only education (Siero et al., 1996). The effects of the social norm intervention persisted 6 months later. These savings were achieved without any changes in attitudes or intentions with respect towards energy conservation. A more recent study by Dixon et al. (2015) of a year-long university energy conservation comparative feedback campaign found that participating buildings reduced their energy consumption by 6.5% whereas non-participating buildings increased their consumption by 2.4% during the same period of time (Dixon et al., 2015). The authors attribute the decrease in consumption among the participating buildings due to self-reported energy conservation behavior among residents since those in the non-participating buildings reported no difference in conservation behaviors from baseline. Other studies using energy dashboards showing individual level energy consumption compared to other employees also show similar trends (Chen et al., 2014; Delmas et al., 2013; Dixon et al., 2015; Siero et al., 1996). These findings underscore the promise of social norm comparisons on influencing energy conservation in organizational settings.

While social norm comparisons are effective in organizational settings, they place the burden of data collection, synthesis, and reporting on the organization, which can be costly in terms of time and expense. Recent research suggests that the mere awareness of being monitored or watched can influence energy conservation. To evaluate the potential "Hawthorne Effect," Schwartz et al. (2013) conducted a field experiment with a randomly selected sample of 5598 participants, half of whom received five postcards notifying them of their participation in a study of household electricity use (Schwartz et al., 2013). The researchers found a 2.7% additional reduction in the energy use of those receiving the postcards during the month of the study absent additional information or instruction. Moreover, energy savings were not maintained once the month-long study period ended. Whether the awareness effects of merely being observed are transferrable to the context of an organizational setting without direct financial incentives is an empirical question, and one that we seek to investigate here.

In this study we perform a 12-week field experiment where we pilot two behavioral strategies to encourage energy conservation at the organizational level. The first strategy ('feedback on social norms') is informed by social norms research suggesting that people may be influenced to reduce their energy use by virtue of knowing what others are doing in contrast to their own behavior. The second strategy ('monitoring awareness') is informed by research suggesting that people may be influenced by the awareness that their energy behaviors are being observed. Our first aim is to investigate which, if either, of the two strategies yields the greatest energy savings. Given Schwartz's et al.'s (2013) findings, we hypothesize that those randomly assigned to the 'monitoring awareness' condition will use the same or less energy as those in the 'feedback on social norms' condition.

Other research in psychology, consumer behavior, and education suggests that engagement, understanding, perceptions, and behaviors may affect energy savings. Indeed, individuals who *engage* more frequently or longer with information are better able to process messages and retain important or relevant details (Kollmuss and Agyeman, 2002; Wang, 2006). Another factor that may play an important role is the extent to which people *understand* how to save energy (e.g. Does powering off my computer over the weekend save more energy than sleep mode?) (Gill and Lang, 2018; Gillingham et al., 2017; Wen et al., 2018). Yet another factor are people's *perceptions* of their own energy consumption (e.g., Do I consume more or less energy than my coworkers?), with people who perceive themselves to consume more energy being more likely to reduce use (Lacroix and Gifford, 2018; Mcdonald et al., 2015). Finally, the *behaviors* that people perform in response to the nudge may influence the extent of energy savings (Lacroix and Gifford, 2018; Mcdonald et al., 2015). Therefore, our second aim is to explore whether engagement, understanding, perceptions, and behaviors contributes to energy savings. We hypothesize that greater engagement, better understanding of energy information, perceptions of greater energy consumption, and more reported energy saving behaviors will be associated with greater energy savings.

2. Methods

2.1. Recruitment and participants

Participants were administrative staff at Carnegie Mellon University from the School of Computer Science (SCS) and the Department of Engineering and Public Policy (EPP) and were identified through university mailing lists. Given the importance of reference group in the social norms literature, choosing a group of administrative staff is a more concrete and identifiable group that our participants belong to than more abstract group memberships (e.g., men, women, citizen) that people can belong to (Goldstein et al., 2008). Hence, it is likely that when presented with any social comparison information referring to administrative staff in SCS and CIT, that they will see themselves as part of that group. Recruitment emails (Appendix A) were sent to staff in May 2015 asking them to participate in a research study monitoring network connectivity and power quality, explained as both the quality WiFi and the rate of power spikes and failures in their office. This deception was used for two reasons: (1) to ensure that participants were unaware that their energy use was being monitored during the baseline phase of the study, so it could stand as a control for the Monitoring condition; (2) to prevent the sample from being biased towards those who would naturally participate in a study relating to energy conservation. They were also informed that the study would involve plugging a small energy meter the size of a phone adapter inline with office computers, and that the meters would not interfere with the performance of their computer and installation technicians would be available to answer any questions. As an incentive to participate, all participants were entered into a lottery to win one of two $200 Amazon gift cards. Follow-up in-person staff recruitment by recruiters affiliated with the Synergy Lab at Carnegie Mellon University occurred in the weeks after the initial recruitment email. Participants signed-up online or in-person, and made an appointment with a Synergy Lab installation technician to install an energy meter during the last week of June 2015. After completion of the study, each participant was sent a debriefing email (Appendix B) explaining the true purpose of the study, the reason for the deception, and contact information for the Institutional Review Board (IRB) and members of the research team.

We enrolled 50 administrative staff. Over the course of our study four participants were removed for reasons unrelated to our study protocol (e.g. leaving their employment at the university), leaving us with a total sample size of 46. As a result, our sample consisted of 24 participants in the Monitoring Awareness (or "Monitoring") condition and 22 participants in the Feedback on Social Norms (or "Feedback") condition.[1] Of our participants, 67.4% reported being female with a mean age of 42.1 (SD = 13.1). Participants' reported mean employment at Carnegie Mellon University was 8.7 years (SD = 8.7). Most participants (58.7%) used a laptop at work, while the rest used a desktop. Finally, participants reported working on their computer an average of 7.2 h per day (SD = 1.7). The IRB of Carnegie Mellon University approved our study procedures.

2.2. Energy consumption sensor deployment

We collected energy data using Belkin Wemo Insight power meters

[1] Post hoc analyses calculating the Minimum Detectable Effect given the variance observed during the intervention and follow-up phase for energy savings between the monitoring and feedback condition find a sample size of 46 to be adequately powered during the intervention phase (~70%) and well powered during the follow-up phase (~95%).

Table 1
Experimental design over time.

Step	Baseline	Intervention	Follow-up	Questionnaire
Week	1–4	5–8	9–12	12
Procedure	No intervention, monitoring of energy use	Weekly message: feedback or monitoring	No intervention, monitoring of energy use	Questionnaire administered

(Wemo® Insight Smart Plug). These meters were installed over a one-week period in participants' offices at the end of June 2015. We installed these meters unobtrusively, where possible, in the same outlet participants already use for their computers. We provided power splitters for participants with desktops or multiple monitors.

2.3. Experimental design

Table 1 outlines the experimental design, with the following providing more detail (see Table 2).

2.3.1. Phase 1 (baseline)

During weeks 1–4 of the study, all participants' energy consumption was passively monitored. This provided a baseline to help understand participants' consumption without our intervention.

2.3.2. Phase 2 (intervention)

Participants were then randomly assigned to one of two conditions: Monitoring Awareness or Feedback on Social Norms.

- *Monitoring Awareness*: During weeks 5–8, participants in the Monitoring condition received an email every Friday at 1 p.m. simply making them aware that their energy consumption was being monitored (Fig. 1). In the body of the email, participants were alerted that researchers from the Synergy Lab and Department of Engineering and Public Policy at Carnegie Mellon University were running a study to monitor energy consumption. Emails were sent from Energy-study@lists.andrew.cmu.edu with the subject line, "Your energy usage." No additional explanation for the notification was provided to the participants.
- *Feedback on Social Norms*: During weeks 5–8, participants in the Feedback condition received similar emails to those in the Monitoring condition and at the same time, but with their energy consumption compared to that of their average co-workers and most energy efficient co-workers (co-workers in the top 10% of least energy consumption) (Fig. 2) and with the subject line, "Your energy usage details." The information displayed in these emails were generated using energy data from all 46 participants. We sent users with laptops notifications comparing their consumption to other laptop users, and users with desktops to other users with desktops. This was to ensure that the baseline energy consumption of the computers used by participants being compared were roughly equivalent. No additional explanation for the notification was provided to the participants.

2.3.3. Phase 3 (follow-up)

We continued to passively monitor without notification participants during weeks 9–12, in order to study any lasting effects of our notifications on energy consumption.

Table 2
Descriptive statistics of variables.

Variables	Awareness Monitoring			Social Norm Feedback		
	n	M	SD	n	M	SD
(a) Electricity knowledge (% correct)	24	33.33	28.23	22	38.64	37.58
(b) Environmental behaviors (1 = not at all, 5 = frequently)	24	3.15	0.94	22	2.94	0.84
(c) Energy savings behaviors (1 = not at all, 5 = frequently)	24	2.79	1.03	22	2.95	1.47
(d) Daily computer use (hours)	24	8.98	7.56	22	9.14	6.61
(e) Participant recruitment						
In person	16			13		
Online	8			9		
(f) Computer type						
laptop	5			14		
desktop	19			8		
(g) Energy consumption (MWH)						
Baseline	24	18.5	21	22	41	30.5
Intervention	24	19.8	24	22	36.9	28.8
Passive monitoring	24	18	19.5	22	36.5	28.9
(h) Engagement						
Email recall (number)	23	2.22	1.83	21	2.86	1.96
Open and read (number)	23	1.74	1.63	21	2.71	1.95
(i) Engagement (overall) (5-point scale, e.g., boring/interesting)	22	3.32	0.7	19	3.78	0.76
Understanding (% correct)						
(j) Electricity feedback	23	69.57	29.15	20	61.25	30.86
(k) Energy saving strategies	24	69.79	28.53	21	63.1	26.95
Perceptions						
(l) Comparative energy use						
increase	3			10		
no difference	14			2		
less	5			9		
(m) Overall energy use						
increase	0			3		
no difference	17			14		
less	4			4		
Behaviors						
(n) Settings						
yes	1			1		
no	23			20		
(o) Frequency (1 = not at all, 5 = frequently)	24	3	1.69	21	2.57	1.72

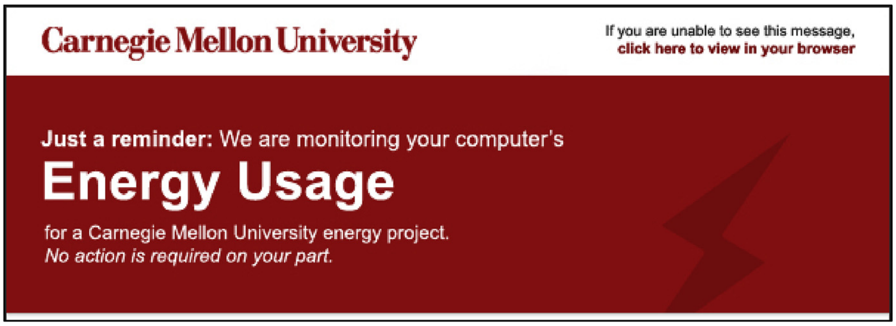

Fig. 1. Screen shot of the Monitoring condition email notification. Participants were notified that their energy use was being monitored, and that no action was required on their part.

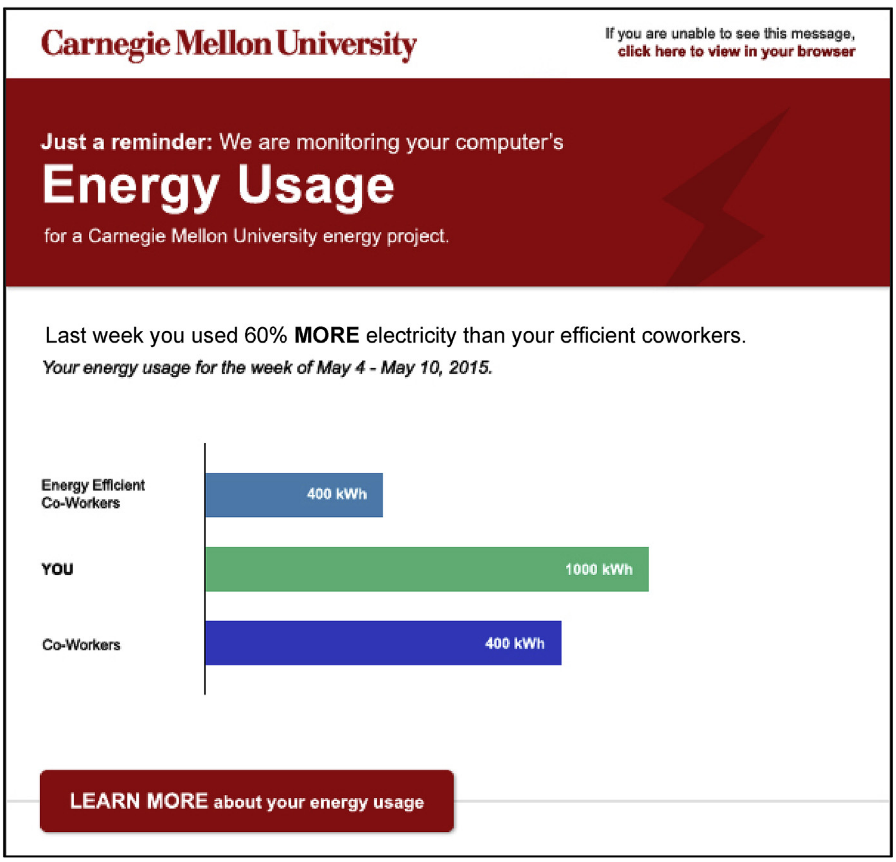

Fig. 2. Screenshot of the Feedback condition email notification. Participants were notified that their energy use was being monitored, and the extent to which they consumed MORE or LESS electricity that their efficient coworkers for the previous week in order to further emphasize the social comparison.

At the end of the study, all participants completed a survey (Appendix C) asking them questions related to their *engagement* with the notifications during the intervention phase, *understanding* of the notifications, *perceptions* of their energy consumption, and *behaviors* related to computer energy consumption.

2.4. Response variables

(a) **Electricity knowledge.** Participants indicated their knowledge of electricity by answering two questions: "What are the units of electrical energy called?" [Correct response: Watt-hours]; and, "Which of the following is equal to the amount of energy consumed by an electrical appliance?" [Correct response: Power rating multiplied by the time it's used]. Correct responses were coded as 1 and all others coded as 0, and then averaged to calculate an overall *electricity knowledge* score.

(b) **Environmental behaviors.** Participants indicated on a typical day how often they did the following, where 1 = not at all and 5 = frequently: "Use public transportation or carpool"; and, "Walk or bike instead of driving." The mean of the responses was taken to assess *environmental behaviors* (Cronbach's $\alpha = 0.47$).

(c) **Energy savings behaviors.** Participants indicated on a typical day how often they did the following, where 1 = not at all and 5 = frequently: "Turn off the lights when they are not needed"; "In the winter, set the thermostat to 68° or cooler"; and, "In the summer, set the thermostat to 76° or warmer." The mean of the responses was taken to assess *energy savings behaviors* (Cronbach's $\alpha = 0.58$).

(d) **Daily computer use (hours).** To assess daily computer use, participants were asked: "During a typical work day, how many hours do you use your computer during the day? (Please enter average number of hours)"

(e) **Participant recruitment.** Participants' mode of recruitment was assessed by their response to the question: “Were you recruited into this study in person or by email?” Responses were verified by matching their self-reported mode to that recorded by the recruiting researcher during the enrollment period of the study.

(f) **Computer type.** Participants' computer type was assessed by their response to the question: “Do you primarily use a laptop or a desktop computer at work?” Responses were verified by matching their self-reported type to that recorded by the recruiting researcher during the enrollment period of the study.

(g) **Energy consumption.** We reverse engineered the Belkin energy meter's SOAP API to query each meter for the power use approximately every 5 s. Energy data was stored using BuildingDepot (Building Depot v3.2.7), an open source platform for managing sensor data within buildings. We calculated energy use in a Python script by taking the integral of these power readings over various periods of the day.

(h) **Engagement (email recall, open and read).** One way we assessed engagement was through *recall* and whether or not they *opened and read* the email notifications. This was done by showing the participants a picture of an example Monitoring or Feedback notification, viewing the example notification that matched their assigned condition, and then asking them: “How many emails like this do you recall receiving? (Please enter number); and, “About how many emails did you open and read? (Please enter number).”

(i) **Engagement.** We more directly assessed *engagement* by asking participants to indicate the extent to which they found the email notifications on a 5-point scale: Boring/Interesting, Useless/Useful, Discouraging/Motivating, Untrustworthy/Trustworthy, and Annoying/Welcoming. We then took the mean of the ratings to create a measure of engagement, where Cronbach's $\alpha = 0.76$.

(j) **Understanding (electricity feedback).** We assessed participants' ability to understand the electricity feedback information shown in the Feedback notifications by showing them an example and asking them four questions: “According to this email, how much energy did you use last week compared to your efficient coworkers?” [Correct response: less]; “According to this email, how much energy did you use last week compared to your coworkers?” [Correct response: less]; “Which of the following best describes an Energy Efficient Coworker?” [Correct response: Energy efficient coworkers are those who use less than the average amount of energy over the past week]; and, “Energy efficient coworkers are always more efficient than the average coworker” [Correct response: true]. Correct responses were coded as 1 and all other responses coded as 0, and the average of the two responses were taken to calculate an overall *electricity feedback knowledge* score.

(k) **Understanding (energy savings strategies).** We assessed participants understanding of ways to reduce their computer's energy consumption by asking them four questions: “Keeping multiple applications open on a laptop computer consumes battery life, increasing energy use.” [Correct response: true]; “Turning a computer on and off uses more energy than just leaving it on.” [Correct response: false]; “A computer monitor uses almost the same amount of energy while it is on compared to on standby” [Correct response: false]; and, “Screensavers drain battery life on a laptop computer” [Correct response: true]. Correct responses were coded as 1 and all other responses coded as 0, and the average of the two responses were taken to calculate an overall *energy savings strategies understanding* score.

(l) **Perceptions (comparative energy use).** Participants indicated their perceptions of comparative energy use by answering, “Over the **last 8 weeks**, was the energy used by your computer more or less than the average among computer users in the study?” where 1 = more, 2 = no difference, and 3 = less.

(m) **Perceptions (overall energy use).** Participants indicated their perceptions of their overall energy use by answering, “Overall, did your computer's energy use increase or decrease over the last eight weeks?” where 1 = increase, 2 = stay the same, and 3 = decrease.

(n) **Behaviors (settings).** Participants were asked: “During the study, did you change your computer's settings so it would go to sleep more quickly?” where 1 = yes and 0 = no.

(o) **Behaviors (frequency).** Participants were asked: “During the study, how frequently did you put your computer to sleep when leaving your office?” where 1 = not at all and 5 = frequently.

2.5. Vacation

To account for missing data, we asked participants to detail their vacation times that occurred during the period of the study. None of our participants went on vacation for longer than 2 weeks, so we had some data for each phase of the study for each participant. We removed participant data collected while a participant was on vacation, interpolating the overall energy consumption based only on time when the participants were not on vacation to have comparable energy consumption across all phases.

2.6. Data analytic plan

We assessed the effect of our randomization by first conducting a series of one-way analyses of variance (ANOVA) with electricity knowledge, environmental behaviors, energy savings behaviors, and daily computer use (hours) as the dependent variable and condition as the independent variable. We then investigated any differences in computer type by condition by performing Fisher's exact test, and performed additional analyses to assess whether any differences in computer type by condition influences energy consumption at baseline.

We first assessed the effect of condition on energy consumption by aggregating energy use over each phase (baseline, intervention, and follow-up), and then performed a repeated-measures mixed model with total energy consumption as the dependent variable and condition and phase as the independent variables controlling for computer type and hours used per day.

We then we assessed the effects of the conditions on engagement, understanding, and perceptions through a series of one-way ANOVAs and Chi-Square tests where and when appropriate. Finally we assessed the effect of on reported behaviors through Fischer's exact tests.

3. Results

3.1. Randomization check

A series of one-way ANOVAs found no significant difference in knowledge about electricity, F (1, 44) = 0.3, p = .59, environmental behaviors, F (1, 44) = 0.19, p = .66, energy savings behaviors, F (1,44) = 0.00, p = .99, or number of hours that the computer is used per day, F (1,44) = 0.01, p = .94, between those in the Feedback versus Monitoring groups, suggesting successful randomization (Table 1). Additionally, Fisher's exact test found no difference between the groups in terms of how they were recruited, either in person or by email ($p > .05$), again suggesting successful randomization.

However, Fischer's exact test found a significant difference between the two conditions in terms of computer type ($p < .001$). Of those in the Monitoring condition, 5 participants reported using laptops while 19 reported using desktops for work, and of those in the Feedback condition, 15 participants reported using laptops while 8 reported using desktops for work. Given differences in energy consumption between desktops and laptops, we would expect to see differences in baseline energy consumption. Indeed, a one-way ANOVA found that those in the Monitoring condition consumed significantly less energy (M = 18.5 MWh, SD = 21.0) than those in the Feedback condition (M = 41.0 MWh, SD = 30.5), F (1,44) = 8.66, $p < .01$. Therefore, in the rest of the analyses where energy consumption is our dependent

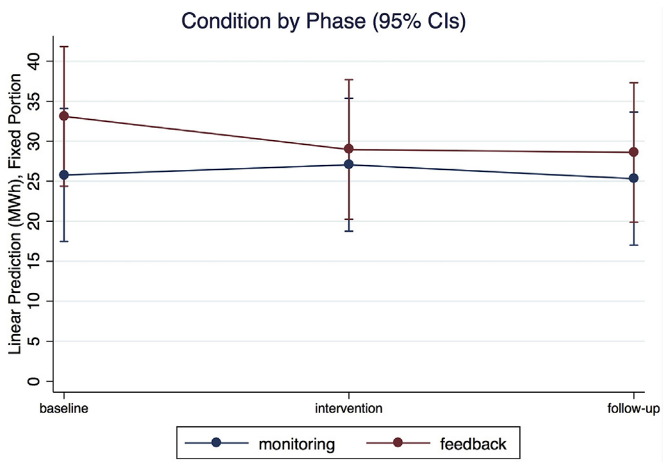

Fig. 3. Interaction between Condition (feedback versus monitoring) and Time (baseline versus intervention versus follow-up) with 95% Confidence Intervals.

variable, we control for computer type.

3.2. Role of condition and phase on energy savings

As shown in Fig. 3 and Table 3, a repeated-measures mixed model controlling for computer type and amount of use per day found a significant interaction between Condition (Monitoring versus Feedback) and Phase (baseline versus intervention versus follow-up) (Model 5: B = −5.42, p = .03 and Model 6: B = −6.41, p = .03). Post hoc analyses suggests a significant average decrease in energy consumption among those in the Feedback condition during the intervention phase (−4.84 MWh, p = .02) and a downward trend during the follow-up passive monitoring phase (−4.06 MWh, p = .06) compared to the baseline phase (see Appendix D for more details). No other significant differences or interactions were observed ($p > .05$).

3.3. Role of engagement, understanding, perceptions, and behaviors on energy savings

A repeated-measures mixed model controlling for type and amount of use per day found individuals who see no difference in their energy use (Model 3: B = −22.53, p < .01; Model 6: B = −25.70, p = .03) or see themselves as consuming less energy than other computer users (Model 3: B = −18.95, p = .02) save significantly less energy over the course of the study than those who see themselves as consuming more energy. Post-hoc, we explored the possibility that this perception may mediate the relationship between the intervention and energy savings by conducting separate mediation analyses for intervention versus baseline and follow-up versus baseline, finding no evidence of mediation ($p > .05$) (see Appendix E for more details).

3.4. Exploring engagement, understanding, perceptions, and behaviors by condition

3.4.1. Engagement

A series of one-way ANOVAs (Table 4) found no difference in ability to recall the number of emails received during the intervention phase of the study, F (1, 43) = 1.25, p = .27, nor in the reported number of emails opened and read, F (1,43) = 3.25, p = .08. However, a one-way ANOVA did find that Feedback participants found the emails significantly more engaging overall (M = 3.77, SD = 0.76) than did the Monitoring participants (M = 3.32, SD = 0.70), F (1,40) = 4.07, p = .05.

3.4.2. Understanding

A series of one-way ANOVAs (Table 4) found no difference in ability to interpret electricity feedback information, F (1, 42) = 0.82, p = .37, nor understanding of strategies for reducing computer energy consumption, F (1, 44) = 0.65, p = .42. One-sample t-tests revealed that participants exhibit a greater than average (50%) ability to interpret electricity feedback information (M = 65.7%, SD = 29.9), t (42) = 3.44, $p < .001$, and understanding of how to reduce computer energy use (M = 66.7%, SD = 27.7), t (44) = 4.04, $p < .001$.

3.4.3. Perceptions

A chi-square test (Table 4) revealed significant differences in perceptions about personal computer energy use over the intervention and follow-up phase of the study suggesting learning. Indeed, those in the Feedback condition were more likely to report that they used more energy than the average among computer users in the study (Feedback: n = 10, Monitoring: n = 3), perhaps reflecting what they learned about their own energy use from the intervention, and less likely to report no difference (Feedback: n = 2, Monitoring: n = 14) than those in the Monitoring condition, $p < .001$. No differences were observed with respect to those reporting that they used less energy than average between Feedback participants (n = 9) and Monitoring participants (n = 5). However, when asked to consider whether their overall computer energy use decreased during the intervention and follow-up phase of the study, no differences were observed between the conditions ($p > .05$) and most reported that their energy use stayed the same (Feedback: n = 14, Monitoring: n = 17).

3.4.4. Behaviors

Fisher's exact test (Table 4) found no difference between the Feedback and Monitoring participants in terms of whether or not they changed their computer's settings so that it would go to sleep more quickly ($p > .05$). Indeed, only one participant in each condition elected to change their settings. Moreover, no differences were observed in reported frequency of putting the computer to sleep over the course of the study between the conditions, F (1, 44) = 0.71, p = .41.

4. Discussion

In this paper, we explored the effectiveness of simple awareness and social norm notifications to encourage individuals to conserve energy, in an organizational setting. We specifically examined the effectiveness of these approaches on computer energy use, given the ubiquitous nature of computers and their high energy consumption (Bray, 2006; Pérez-Lombard et al., 2008). Overall we find those exposed to the social norm notices saved energy compared to their baseline consumption during the intervention (10.0% less energy) and follow-up passive monitoring (11.0% less energy) phases. No such difference was observed for those in the awareness monitoring condition during the intervention (7.0% more energy) and follow-up passive monitoring (2.7% less energy) phases. Moreover, those given social norm feedback information felt like they were consuming more energy on average than those who received no such information, possibly suggesting learning and awareness about their energy use. The fact that most participants did not believe that their energy use changed over the 8-week period indicates that those in the feedback condition (whose energy use did in fact decrease), were unaware of this decrease. This suggests that the change in behavior that occurred in this group may have operated through unconscious processes. These findings suggest that changes in energy conservation behaviors were unconscious or the behaviors that people actually performed to reduce energy use were not included in our questionnaire.

Our findings support the relative effectiveness of social norms in inducing individual energy savings in the context of an organizational setting. The deception aspect of our study served to minimize volunteer bias in our sample, suggesting that these effects could be stronger

Table 3
Mixed model regression results with engagement, understanding, perceptions, behaviors, condition, and phase predicting energy savings.

	Engagement				Understanding				Perceptions			
	B	p	95% CI		B	p	95% CI		B	p	95% CI	
(h) Engagement												
Email recall	−0.31	0.83	−8.75	8.14								
Open and read	0.88	0.94	−7.92	9.68								
(i) Engagement	−0.45	0.84	−13.45	4.40								
Understanding												
(j) Electricity feedback					−2.62	0.80	−23.00	17.78				
(k) Energy saving strategies					−4.14	0.72	−26.50	18.16				
Perceptions												
(l) Comparative energy use (ref = increase)												
no difference									−22.53	0.01	−28.38	−6.68
less									−18.95	0.02	−35.26	−2.65
(m) Overall energy use (ref = increase)												
no difference									15.56	0.21	−8.96	40.08
less									10.52	0.46	−17.41	38.45
Behaviors												
(n) Settings (ref = yes)												
(o) Frequency												
Condition (ref = Monitoring)												
Phase (ref = Baseline)												
Intervention												
Passive												
Condition x Phase												
Monitoring x Baseline												
Monitoring x Intervention												
Monitoring x Passive												
Feedback x Baseline												
Feedback x Intervention												
Feedback x Passive												

	Behaviors				Conditions				All			
	B	p	95% CI		B	p	95% CI		B	p	95% CI	
(h) Engagement												
Email recall									0.46	0.93	−9.78	10.70
Open and read									−1.54	0.79	−12.80	9.71
(i) Engagement									−2.62	0.74	−18.00	12.76
Understanding												
(j) Electricity feedback									−8.24	0.56	−36.17	19.70
(k) Energy saving strategies									−4.88	0.75	−35.34	25.58
Perceptions												
(l) Comparative energy use (ref = increase)												
no difference									−25.70	0.03	−49.30	−2.08
less									−18.17	0.14	−42.56	6.22
(m) Overall energy use (ref = increase)												
no difference									12.14	0.46	−20.37	44.65
less									5.31	0.77	−30.59	41.20
Behaviors												
(n) Settings (ref = yes)	4.82	0.76	−25.79	35.42					−1.15	0.96	−41.12	38.83
(o) Frequency	−1.94	0.29	−5.54	1.66					−1.37	0.60	−65.40	37.86
Condition (ref = Monitoring)					7.32	0.26	−5.33	19.98	−3.07	0.79	−25.90	19.75
Phase (ref = Baseline)												
Intervention					1.28	0.46	−2.14	4.70	1.56	0.44	−2.36	5.48
Passive					−0.46	0.79	−3.88	2.97	−0.63	0.76	−4.55	3.30
Condition x Phase												
Monitoring x Baseline					–	–	–	–	–	–	–	–
Monitoring x Intervention					–	–	–	–	–	–	–	–
Monitoring x Passive					–	–	–	–	–	–	–	–
Feedback x Baseline					–	–	–	–	–	–	–	–
Feedback x Intervention					−5.42	0.03	−10.37	−0.48	−6.41	0.03	−12.11	−0.70
Feedback x Passive					−4.04	0.11	−9.00	0.91	−3.44	0.24	−9.14	2.27

among a more motivated or self-aware sample (Davis et al., 2013). In the absence of financial incentives, we find that simply being made aware that ones' energy use was being monitored is not enough to induce energy conservation, as has been observed in the residential sector (Schwartz et al., 2013). Given the ubiquity of computers in organizational settings, and the relative ease with which social norm notices could be generated, these results suggest a method by which significant real world energy savings are possible, providing both financial and environmental benefits. Indeed, it has been found in other studies in the residential sector that people do not find these types of interventions particularly intrusive (Allcott, 2011) and that habits form even after a few exposures (Allcott, 2011; Allcott and Rogers, 2014). In addition, prior work suggests that achieving environmentally conscious behavior (e.g., saving energy) in one domain may spill over into others (Thøgersen and Crompton, 2009), yielding further benefits although we leave exploring those aspects to future work.

Table 4
Analysis showing Condition effects on engagement, understanding, and perceptions.

	Chi-square	F	p
Engagement			
Email recall		1.25	0.27
Open and read		3.25	0.08
Engagement (overall)		4.07	0.05
Understanding			
Electricity feedback		0.82	0.37
Energy saving strategies		0.65	0.42
Perceptions			
Comparative energy use	13.90		0.00
Overall energy use	3.29		0.19
Behaviors			
Settings	1.00		0.92
Frequency		0.71	0.41

Findings have been mixed with respect to the long-term effects of social norms on energy consumption, with some observing that any reductions or changes in behavior fading relatively quickly (Schwartz et al., 2013) whereas others find that savings can persist for up to a few years (Allcott and Rogers, 2014). Most of these findings are from the residential sector and, as of yet, little is known about any long-lasting consequences of social norm or other types of interventions (simple monitoring and awareness) that could result in a change of habit that has long-term benefits. Future studies should continue to passively monitor behavior, in addition to engagement and knowledge, over longer periods of time than one month.

4.1. Limitations

Our work has three main potential limitations. The first limitation relates to the generalizability of our results since our field experiment is based on a relatively small sample of participants (n = 46), all taken from a single organization (one university). However, given the ubiquitous nature of computers and that we recruited administrative staff whose tasks are similar across organizations, we argue that our results may apply across many types of buildings and industries. The small sample size of our study is an important caveat to our results, and was due to the difficulty in recruiting and managing participants for a long-term field study, combined with the need for deception to prevent selection-bias making the study less interesting to those who would normally wish to save energy.

A second potential limitation is in our notification design. Specifically, our goal was not to develop the 'optimal' social norm or awareness monitoring conditions. Thus, it is possible that a better notification may have led to greater conservation. However, our results suggest that our notifications were sufficient to demonstrate the effectiveness of social norm feedback.

A third limitation is that our participants all came from the same institution, and there is a chance that they talked to one another about it, resulting in an additional unmeasured influence on behavior change. This is less problematic for our feedback participants, since we are testing the effect of social comparison on reducing energy consumption. For our monitoring group, there is a chance that participants did note that their energy use was being monitored and may have mentioned this to their colleagues. However, these individuals were not given any information about their energy use nor about the use of their colleagues, and thus no comparison could be made even if they talked about it with others. Therefore, we believe the risk of talking to one another for the monitoring group influencing the results of the study is minimal.

5. Conclusions and policy implications

Objections have been made questioning the ethics of nudges in inducing energy conservation behavior, among other types of behavior, with some arguing that the potential benefits do not outweigh the potential ethical concerns (Kasperbauer, 2017). However, recent work suggests that transparency of nudges appears to have no effect on the efficacy of interventions (Bruns et al., 2018) suggesting that they can be used in a more ethical fashion. Our findings suggest a method for effectively encouraging energy savings in the absence of financial incentives in an organizational setting that is more transparent than "big brother-style" monitoring. Moreover, we observed energy savings among those who are not necessarily intrinsically motivated to save energy, yet did so anyway. Achieving meaningful energy savings and reductions in greenhouse gas emissions will require people to make substantive changes not only in their home lives, but also where they work. This study provides additional evidence for policy makers and building managers that social norm feedback can be a powerful tool for motivating behavior change in an organizational setting.

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Appendix A. Supplementary data

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