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Energy Saving at Work: Exploring the Role of Social Norms, Perceived Control and Ascribed Responsibility in Different Office Layouts

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Reducing energy consumption in office buildings is critical for improving energy efficiency and decarbonization at the large scale. This study (N = 854) investigated the influence of social-psychological factors on energy-saving intention and behaviors in single-person versus shared offices based on the extend model of Theory of Planned Behavior (TPB). We found that ascription of responsibility, a variable added to the TPB, is the strongest predictor of energy-saving intentions for both single-person and shared offices. Interestingly, while injunctive norms are an important predictor of behavioral intention for single-person offices, descriptive norms are an important one for shared offices. Energy-saving intention mediates the influences of the aforementioned variables on energy-saving behaviors. Contrary to our hypotheses, perceived control over energy-saving and perceived ease of access to building control features have no direct impacts on energy-saving behaviors in single-person offices, while they have impacts on energy-saving behaviors in shared offices. This study provides useful insights for building designers and occupant behavior and energy modeling researchers.

Keywords: energy saving, Theory of Planned Behavior, ascription of responsibility, social norms, occupancy types, building energy management

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INTRODUCTION

Buildings and appliances are responsible for 36% of primary energy use in the world, which leads to nearly 40% of energy-related carbon dioxide (CO_2) emissions (Abergel et al., 2018; John, 2019). In the United States, the building sector consumes more energy than the industry or transportation sector, and office buildings, as one of the most important components of the building sector, account for 14% of total energy consumption in the nation (Stern, 2014). Reducing energy use in office buildings is, therefore, a critical strategy for improving economic efficiency and decarbonization. Human behaviors have proven to be an important factor influencing building performance and energy consumption (Carrico and Riemer, 2011; Hong and Lin, 2013; Stern, 2014). Reducing energy consumption in office buildings, however, is particularly challenging because of the lack of direct financial motivation and the diffusion of responsibility (Chen and Knight, 2014; O'Brien and Gunay, 2014). In addition, with the increased automation of

building energy control systems and the popularity of open-plan workspaces, many office occupants lack control over windows, blinds, ceiling lights, AC thermostats, and other related environmental controls (Devlin, 2018). This situation leads to occupants' low satisfaction with the work environment (Lee and Brand, 2005; Wagner et al., 2017), low tolerance for fluctuation of indoor conditions (Langevin et al., 2012), and few opportunities to save energy (Emery and Kippenhan, 2006; Meier, 2006).

A growing body of research has now started to investigate factors, especially the social-psychological factors, that contribute to office energy efficiency in a holistic way (Zhang et al., 2013; Li et al., 2017, 2019; Xu et al., 2017). This study explored the important factors that are likely to drive or impede workplace energy saving, using an extended Theory of Planned Behavior (TPB) model (Ajzen, 1991). More importantly, we examined the energy-saving intention and behaviors of office workers, while keeping in consideration the building's physical design, and we treated single-person offices and shared offices separately, which was rarely executed in previous research. Due to the fact that the social norms, interpersonal dynamics, and access to energy control features are very different between the two office types, their impacts on energy-saving behaviors could be fundamentally different.

LITERATURE REVIEW

Theory of Planned Behavior for Explaining Energy Saving

This study adopted and extended one of the widely applied social-psychological theories, the TPB. The TPB, a rational decision-making framework, has achieved great success in explaining the social-psychological factors that connect behavioral intention and its antecedents with actual behaviors (Ajzen, 1991; Chen and Knight, 2014; Chen, 2016). The main assumption of the TPB is that behavioral intention leads to actual behavior; thus, the more substantial the intention is, the more likely it is that the behavior will follow. Meanwhile, attitudes toward behavior (positive or negative evaluation of a behavior), subjective norms (including injunctive norms – expected approval from significant others, and descriptive norms – beliefs about what behaviors others are actually doing), and perceived behavioral control (PBC) (i.e., ease or difficulty in performing a behavior) exert their influences on behavior through intentions (Ghany et al., 2009; Wolske et al., 2017). Additionally, PBC has a direct influence on behavior: when the intention is held constant, individuals will be more likely to perform a behavior as their PBC increases (Conner and Armitage, 1998). Attitudes, subjective norms, and PBC are three commonly studied factors in determining pro-environmental behaviors and behavioral intentions (e.g., Abrahamse and Steg, 2011; Li et al., 2019).

Within residential and organizational settings, scholars have applied the TPB to explain a variety of pro-environmental (Steg et al., 2015), energy-conserving (Scherbaum et al., 2008; Abrahamse and Steg, 2011; Li et al., 2019) and carbon-reducing behaviors (Chen, 2016; Chen et al., 2016; Wolske et al., 2017). For example, Kaiser and Gutscher (2003) found that the TPB variables explained 81% of the variance in conservation behavioral intention. Furthermore, Greaves et al. (2013) study of workplace pro-environmental behavioral intentions showed that the TPB explained 61% of variance in employees' intentions to turn off their computers when not in use, 46% of variance in intentions to use video-conferencing rather than travel to meetings, and 53% of variance in intentions to recycle at work. Similarly, strong support was found for the TPB's power in explaining residential solar panel adoption (Rai and Beck, 2015), opinions toward wind farm development (Read et al., 2013), and support for renewable energy policy (Vermillion and Peart, 2010; Chen et al., 2016). Finally, in a study on Dutch households, TPB and other psychological variables were found to associate with energy-saving intentions, but not with energy use (Abrahamse and Steg, 2011).

We chose to adopt and build upon the TPB framework for two reasons. First, the TPB and associated variables are well supported by studies of the above-mentioned behaviors similar to or related to office energy saving (Greaves et al., 2013; Chen, 2016). Second, the TPB variables (especially PBC and subjective norms) capture the situational constraints and social influences that are suitable for studies in workplace settings (Bamberg and Möser, 2007; Chen and Knight, 2014). Although the evidence for the TPB is strong, researchers have suggested that an extended TPB model has better explanatory power in accounting for certain pro-environmental behaviors (Bamberg, 2003; Chen et al., 2016). In this study, the two variables added to the model are ascription of responsibility (AR) and perceived ease of access to building environmental controls, which are described in detail in section "Differences in Energy Saving in Single-Person Versus Shared Offices". **Figure 1** shows the extended TPB framework. This study also explicitly distinguished between injunctive norms and descriptive norms because they do not always go hand in hand (Rivis and Sheeran, 2003). For example, a workplace can have positive injunctive norms (e.g., slogans for saving energy being displayed in the building) and negative descriptive norms (e.g., most workers leaving work with their desktop computers on) at the same time. Therefore, these two types of norms could have independent effects on behavioral intention and the inclusion of them could increase the explanatory power of the model (Ghany et al., 2009; Schultz et al., 2018). More interestingly, research found that descriptive norms play a particularly important role in influencing the behaviors of low-PBC individuals (Rai and Beck, 2015), which could be resulted from office layouts and lacking access to building controls. Therefore, investigating how injunctive norms and descriptive norms affect behavioral intention and behaviors in single-person and shared offices is pertinent.

Extended TPB Model

Ascription of Responsibility

Ascription of responsibility (AR) is the feeling of being responsible to take action (De Groot and Steg, 2009), and is an important component in the Norm Activation Model proposed by Schwartz (1977), which explains altruistic behaviors such as recycling (Park and Ha, 2014), volunteering

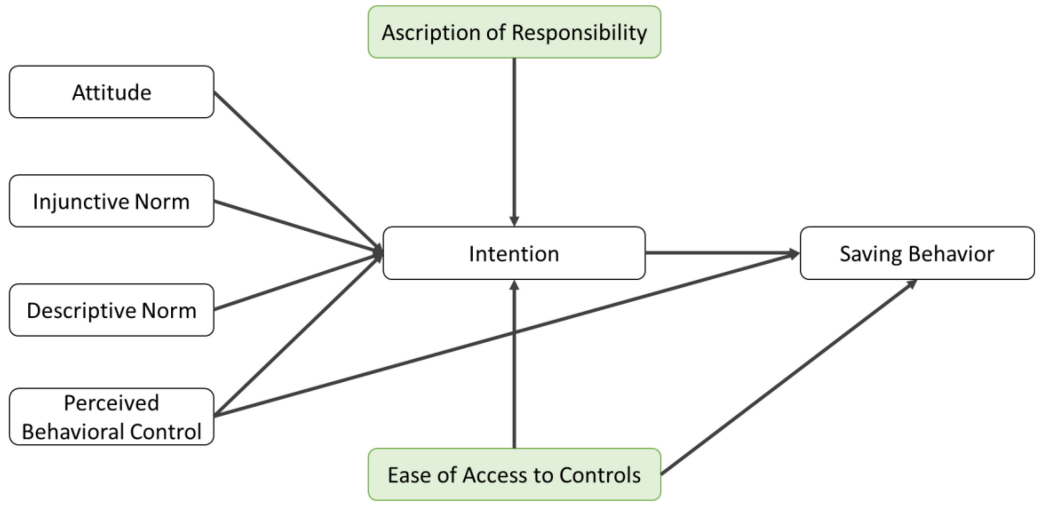

FIGURE 1 | The extended TPB model proposed in this study.

(Schwartz and Fleishman, 1982), environmental protection (Van Riper and Kyle, 2014), and other energy-saving behaviors (Black et al., 1985; Zhang et al., 2013). The Norm Activation Model argues that altruistic intention and behaviors are largely driven by one's moral considerations, i.e., "expectations, obligations, and sanctions anchored in the self," termed "personal norms" (Schwartz, 1977). Later, Stern et al. (1999) proposed the Value-Belief-Norm framework as an extension of Norm Activation Model, and AR and personal norms remain important predictors of environmental citizenship, energy policy acceptance (Steg et al., 2005), and home energy saving (Jansson et al., 2011). Value-Belief-Norm and TPB often complement each other in the explanation of pro-environmental behaviors (Abrahamse and Steg, 2011; Han, 2015; Shi et al., 2017).

AR is particularly important to energy saving in office settings for two reasons. First, office occupants receive no direct financial benefits for saving energy, unless the organization provides some kind of reward. As a result, occupants tend to view energy saving as the responsibility of their organization rather than their own (Li et al., 2019). In fact, when the goal or practice of energy saving is not mentioned by the employers, saving energy can be viewed as irrelevant to their job duties and sometimes even counter-productive (Xu et al., 2017). Second, the sense of responsibility may diffuse even more with the number of occupants in the shared space (De Young, 1989). Lack of responsibility is a serious matter because denying one's responsibility usually means the inability to perceive any need to change behaviors (Van Raaij and Verhallen, 1983). Based on the reasoning, we examined the level and the impact of AR on energy-saving intention in single-person and shared offices.

Perceived Ease of Access to Building Control Features

Besides PBC, which measures an individual's perceived ease or difficulty in performing a behavior or achieving an outcome, we define the perceived ease of access to building control features as an overarching concept based on evaluations of both physical and social facilitating factors or barriers to accessing environmental control features, such as windows, shades, artificial lighting, and thermostats, which are typical in office buildings. PBC and perceived ease of access to building controls are different in the focal subject being considered: one is "energy-saving behavior" and the other is "building environmental control features." Physical factors include proximity to the control features, difficulty in operating the features (Urban and Gomez, 2012; Peffer et al., 2013), system responsiveness (Hellwig, 2015; Al-Atrash et al., 2018), etc. Social factors include shyness, potential resistance from other occupants in the same space, etc. (Day and O'Brien, 2017). Consequently, perceived control over the environment often decreases with the number of occupants in shared offices (Hedge et al., 1989; O'Brien and Gunay, 2014; Schweiker and Wagner, 2016).

Research has demonstrated that the perception of control (most often based on actual control) has a positive effect on occupant health (Boerstra et al., 2013), satisfaction (Lee and Brand, 2005; Boerstra et al., 2015), tolerance for fluctuation of indoor condition (Baker and Standeven, 1997; Schweiker and Wagner, 2016), performance (Leaman and Bordass, 1999; Boerstra et al., 2015), turnover, and commitment to the organization (Veitch et al., 2007). More relevant to our interest, studies have shown that improved occupant control over building energy systems has enhanced energy-saving attempts in both residential and commercial buildings (Emery and Kippenhan, 2006). Reduced energy consumption can be achieved by adjusting HVAC systems better (Yun, 2018; Papadopoulos et al., 2019), relying on natural ventilation and daylighting (Breesch, 2006; Menassa et al., 2013), and turning off appliances when not needed (Ehrhardt-Martinez et al., 2015). Therefore, our study examined the impact of perceived ease of access to building control features as an addition to the original TPB framework, and we hypothesized it to have a direct effect on energy-saving intention and a direct effect on energy-saving behavior.

Differences in Energy Saving in Single-Person Versus Shared Offices

There is little research directly examining the distinct factors contributing to energy saving in single-person offices versus shared offices. However, a few uncovered differences between single-person and shared offices suggest unique challenges and opportunities for each of the office types. First, research demonstrated that the number of occupants influences the ways in which occupants restore thermal comfort (Jung and Jazizadeh, 2019). One experimental study found that the opening/closing windows and putting on/taking off clothes increases with the number of occupants, while turning on ceiling fans occurs most often in single-person offices (Schweiker and Wagner, 2016). Another study found that occupants in shared offices operate blinds less often than occupants in private offices and are more tolerant of intensive daylight (Haldi and Robinson, 2010). O'Brien and Gunay (2014) summarized several studies and concluded that the number of adaptive actions decreases significantly in shared spaces compared to in private offices, indicating that people might be shyer about adjusting workplace conditions and/or are afraid they will annoy co-workers (Hunt, 1979; Foster and Oreszczyn, 2001). A different survey study later confirmed that the fear of bothering others is very pronounced among office workers, and many of the surveyed workers believe that personalized control systems (e.g., task lighting, desk fans) have greater potential to empower occupants to improve their comfort in energy efficient ways (Day and O'Brien, 2017). We believe the lack of control or perceived control poses a more serious challenge in shared offices than in single-person offices.

Second, there are different levels of social interactions in single-person and shared offices, and research suggests that group dynamics and social norms significantly affect employees' motivation to save energy (Staddon et al., 2016). Social cognitive theory posits that people can acquire a new behavior by observing a model performing the behavior and by observing the consequences of that behavior (Bandura, 1977). This type of social learning is likely to occur more often in shared offices than in single-person offices. In the same vein, descriptive norms are likely to be more salient and influential in shared offices. Descriptive norms have led to quite a few cases of success in achieving pro-environmental behaviors (Goldstein et al., 2008) and residential energy saving (Mullainathan and Allcott, n.d.). In single-person offices, occupants may have to rely on and internalize injunctive norms to gauge their intention and behaviors. Considering the stated differences between the two office types, our study, which investigates single-person and shared offices separately, is likely to bring some hidden factors to light when it comes to promoting workplace energy saving.

Research Hypotheses

This study tested the extended TPB framework by considering occupants' energy-saving intention and behavior in single-person offices and shared offices, respectively. We hypothesized that attitudes toward energy saving at work, injunctive and descriptive norms, PBC, AR, and perceived ease of access to building controls are all positively associated with the intention to save energy, which then leads to greater engagement in energy-saving behaviors. PBC and perceived ease of access to controls also directly contribute to energy-saving behaviors. We also hypothesized that the influence of each of these factors varies between single-person offices and shared offices.

MATERIALS AND METHODS

Participants

Participants were 1,175 full-time office employees (working 40 h or more per week), recruited from across the United States through Qualtrics Panel Services – an online data collection platform frequently used by researchers. Quotas were set in the data collection process so that we would get equal numbers of females and males, as well as an equal amount of occupants working in single-person and shared offices. Responses from 321 participants were excluded from final analyses because they reported having no control over office lighting or thermostats, making them unable to perform the associated energy-saving behaviors that we were interested in.

Among the remaining 854 participants, 49.3% were males and 50.6% were females. The ages ranged from [18–24 years] to [65 or above], but most were within the ages of [25–34] (21.0%), [35–44] (25.9%), [45–54] (23.1%), and [55–64] (23.9%). The majority of the participants were Caucasian (75.6%), followed by Asian (10.1%) and African American (5.2%). Thirty-eight participants (4.4%) identified themselves with multiple races. About three quarters (75.2%) of the participants indicated that they had a Bachelor's degree (or equivalent) or higher, which is higher than the census data (41.9%) (United States Census Bureau, 2018).

Measurements

Our dependent variables included occupants' intention to save energy and actual energy-saving behaviors at work. Our independent variables included attitude, injunctive and descriptive norms, PBC, AR, and perceived ease of access to building environmental controls. All variables were measured by participants' responses to the survey questions on a five-point Likert scale from "*1 = strongly disagree*" to "*5 = strongly agree*" or from "*1 = never/less than once a week*" to "*5 = More than once a day.*" **Table 1** shows the basic statistics of the variables in the proposed model. In this table, factor loadings, mean, and standard deviation (SD) are presented for single-person offices (on the left) and shared offices (on the right). A complete list of survey questions can be found in Li et al. (2019).

RESULTS

To examine the extended TPB model and to identify the factors influencing energy-saving behavior and intention at work, path modeling was conducted using Mplus 8.1 with the maximum likelihood (ML) estimator. To better assess the model fit, a combination of fit indices was adopted to reflect different facets of the model (Li et al., 2019). The hypothesized model needs to satisfy the criteria of all fit indices before the path coefficients

TABLE 1 | Factor loadings, means, and standard deviations of dependent and independent variables.

Dependent variable	*Loading*	*Mean*	*SD*
Intention *– How much do you agree with the following statements?*			
Spearman-Brown Coefficient: single-person office = 0.84, shared office = 0.84			
1. I am motivated to save energy at work	0.85/0.85	3.59/3.44	1.15/1.14
2. I always think about ways to save energy at work	0.85/0.85	3.23/3.00	1.21/1.22
Behavior *– How often do you. . .at work to save energy?*			
Spearman-Brown Coefficient: single-person office = 0.63, shared office = 0.63			
1. Adjust thermostat settings	0.68/0.68	3.41/3.28	2.19/2.06
2. Adjust the lighting	0.68/0.68	2.47/2.36	1.68/1.62
Independent variable			
Attitude – *Please tell us what you think about the reduction in electricity use at work*			
Cronbach's alpha: single-person office = 0.86, shared = 0.84			
1. Not good at all– very good	0.68/0.69	3.94/3.77	1.00/1.08
2. Not important at all – very important	0.88/0.88	4.04/3.09	0.972/1.01
3. Not beneficial at all – very beneficial	0.93/0.84	4.10/3.99	0.934/1.01
Injunctive norms – *How much do you agree or disagree with each of the following statements about your co-workers?*			
Cronbach's alpha: single-person office = 0.84, shared = 0.83			
1. Most of my co-workers expect me to turn off the computer/monitor when leaving my workstation	0.64/0.64	2.83/2.68	1.34/1.37
2. Most of my co-workers expect me to turn off lights when leaving the office	0.74/0.74	2.99/2.89	1.35/1.45
3. Most of my co-workers expect to shut down or change the A/C and heater thermostat settings when leaving the office	0.77/0.79	2.37/2.32	1.26/1.32
4. Most of my co-workers expect me to save energy at work in general	0.90/0.83	2.78/2.57	1.23/1.22
Descriptive norms – *How much do you agree or disagree with each of the following statements about your co-workers?*			
Cronbach's alpha: single-person office = 0.95, shared = 0.93			
1. My co-workers are concerned about using too much energy	0.91/0.86	2.62/2.44	1.14/1.19
2. My co-workers pay attention to their energy use	0.94/0.92	2.64/2.48	1.15/1.22
3. Many of my co-workers are trying to reduce their energy use	0.93/0.93	2.72/1.54	1.13/1.22
Perceived behavioral control (PBC) *– How much do you agree or disagree with each of the following statements?*			
Cronbach's alpha: single-person office = 0.86, shared = 0.88			
1. Whether or not I save energy at work is completely up to me	0.79/0.81	3.45/3.11	1.19/1.33
2. Adopting energy saving practices in my workplace is entirely within my control	0.85/0.92	3.31/2.95	1.24/1.36
3. I am confident that if I want, I can save energy at work	0.83/0.81	3.74/3.40	1.04/1.28
Ascription of responsibility (AR) *– How much do you agree or disagree with each of the following statements?*			
Cronbach's alpha: single-person office = 0.82, shared = 0.89			
1. I feel jointly responsible for the energy use at work	0.83/0.82	3.45/3.21	1.17/1.28
2. I feel responsible for reducing energy use at work	0.89/0.91	3.51/3.19	1.11/1.20
3. Because I use energy during work, at least somewhat, I am responsible for energy use at work	0.82/0.83	3.73/3.48	1.01/1.15
Ease of access to building environmental controls *– How conveniently can you control the following options?*			
Spearman-Brown Coefficient: single-person office = 0.51, shared office = 0.63			
1. Ceiling light	0.58/0.67	3.37/3.12	1.82/1.74
2. Thermostat (heating and cooling)	0.58/0.67	2.26/2.48	1.89/1.80

Numbers on the left are for single-person offices; numbers on the right are for shared offices.

can be explained. In this study, the following fit indices were examined: the root mean square error of approximation (Steiger, 1990; Li et al., 2019), the comparative fit index, and the standardized root mean square residual (Bentler, 1990; Hu and Bentler, 1999; Li et al., 2019). In general, a model with good fit has RMSEA $\leq$ 0.05 (Kline, 2011), CFI $\geq$ 0.90 (Hopper et al., 2008; Li et al., 2019), and SRMR $\leq$ 0.08 (Schreiber et al., 2006; Kline, 2011). Other analyses, including descriptive statistics, correlation tests, one-sample *t*-tests and independent sample *t*-tests were conducted with R 3.6.1. An alpha level of 0.05 was chosen to determine the significance of results.

Overview of Survey Responses

In general, participants reported themselves as having a positive intention to save energy and as performing some levels of energy-saving behaviors. Participants' average ratings on the independent variables that relate to the energy-saving intention (Intention) and behavior (Behavior) were also statistically higher than the neutral point (all p's < 0.001). Independent-sample *t*-tests showed that occupants in single-person offices have higher energy-saving intentions ($M = 3.41$, $SD = 1.09$) than occupants in shared offices ($M = 3.22$, $SD = 1.10$), $t(852) = 2.54$, $p = 0.011$. Attitude, descriptive norms, PBC, AR, and perceived ease of

TABLE 2 | Comparisons on the means of independent variables in single-person and shared offices.

	Single-person offices		Shared offices				
	M	*SD*	*M*	*SD*	*t*	*df*	*p*
Attitude	4.03	0.86	3.89	0.90	2.35	852	0.019
Injunctive norms	2.74	1.07	2.62	1.10	1.68	852	0.093
Descriptive norms	2.66	1.08	2.49	1.13	2.30	852	0.022
Perceived behavioral control (PBC)	3.50	1.03	3.15	1.19	4.51	852	0.000
Ascription of responsibility (AR)	3.56	0.99	3.28	1.10	3.82	852	0.000
Ease of access to controls	3.64	1.24	3.33	1.30	3.42	788	0.001

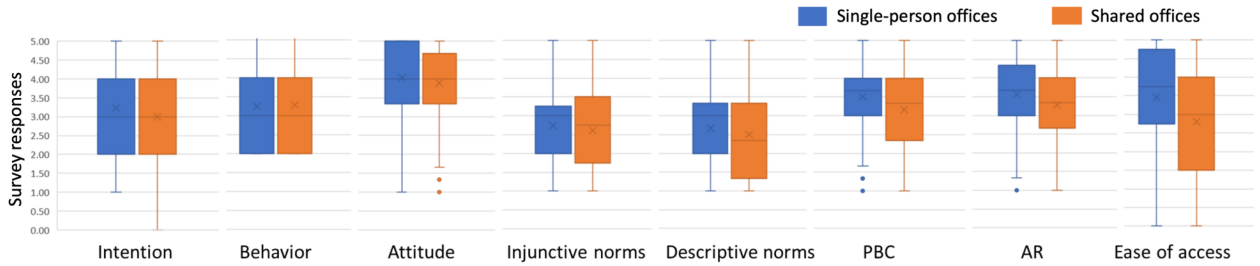

FIGURE 2 | The distribution of variables in single-person and shared offices.

access to building controls were also higher in single-person offices than in shared offices (**Table 2**). **Figure 2** shows the distribution of all variables.

Table 3 presents the correlations between all variables of interest and shows that all independent variables are moderately related to each other. Among single-office occupants, injunctive norms and description norms had the highest correlation ($r = 0.65$, $p < 0.001$); among shared-office occupants, AR and PBC had the highest correlation ($r = 0.63$, $p < 0.001$).

Model Fit of Extended TPB for Single-Person Offices

We fit the data of single-person offices on the proposed extended TPB model, and the overall model fit was good: $\chi^2(4) = 14.44$, $p = 0.006$; CFI = 0.97, RMSEA = 0.08, and SRMR = 0.04. Approximately 57.0% of the variance in Intention was accounted for by the variables in the model, while 12.9% of the variance in Behavior was accounted for. **Figure 3** presents the standardized path coefficients with larger numbers indicating larger predictive power. All significant paths were marked in blue.

As shown in **Figure 3**, AR had the largest impact on Intention: one SD increase in AR led to 0.56 SD increase in Intention. Injunctive norms and attitude also had positive effects on Intention. Descriptive norms, PBC, and ease of access to controls, in contrast to our hypotheses, had no significant effects on Intention. Interestingly, neither PBC nor ease of access to controls showed a positive effect on Behavior. Intention, as the TPB hypothesized, significantly contributed to Behavior. **Table 4** lists the indirect effects the independent variables had on Behavior via Intention. AR had the strongest indirect effect on Behavior, followed by injunctive norms. Other variables failed to demonstrate any significant indirect effects.

Model Fit of Extended TPB for Shared Offices

We then fit the data of shared offices on the extended TPB model, and the model fit was also good: $\chi^2(4) = 10.92$, $p = 0.027$; CFI = 0.98, RMSEA = 0.06; and SRMR = 0.03. While 53.9% of the variance in Intention was accounted for by the variables in the model, 20.6% of the variance in Behavior was also accounted for. **Figure 4** presents the standard path coefficients.

As shown in **Figure 4**, AR had the largest impact on Intention: one SD increase in AR led to 0.46 SD increase in Intention. Descriptive norms and attitude had positive effects on Intention. Injunctive norms, PBC, and ease of access to controls, in contrast to our hypotheses, had no significant effect on Intention. It is important to note, for shared offices, both PBC and ease of access to controls had positive effects on Behavior, as we hypothesized. Intention also contributed significantly to Behavior. **Table 5** lists the indirect effects the independent variables had on Behavior via Intention. AR had the strongest indirect effect on Behavior, followed by descriptive norms and then attitude. Other variables failed to demonstrate any significant indirect effects.

DISCUSSION

Summary of Major Findings

Our results show that the extended TPB model applies to both single-person offices and shared offices when modeling energy-saving intention and behaviors. However, additional variables need to be added to boost the explanatory power of the model,

TABLE 3 | Means, standard deviations, and correlations for single-person and shared offices.

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. Energy-saving behavior	2.24/2.28	1.37/1.35								
2. Energy-saving intention	3.41/3.22	1.09/1.10	0.36**/0.39**							
3. Attitude	4.03/3.89	0.86/0.90	0.19**/0.27**	0.49**/0.52**						
4. Injunctive norms	2.74/2.62	1.07/1.10	0.32**/0.37**	0.50**/0.45**	0.33**/0.32**					
5. Descriptive norms	2.66/2.49	1.08/1.13	0.29**/0.32**	0.43**/0.53**	0.30**/0.35**	0.65**/0.62**				
6. Perceived behavioral control (PBC)	3.50/3.15	1.03/1.19	0.19**/0.37**	0.45**/0.50**	0.33**/0.45**	0.41**/0.50**	0.39**/0.48**			
7. Ascription of responsibility (AR)	3.56/3.28	0.99/1.10	0.28**/0.37**	0.73**/0.68**	0.59**/0.55**	0.48**/0.53**	0.46**/0.50**	0.50**/0.63**		
8. Ease of access to controls	2.82/2.80	1.41/1.44	0.10*/0.24**	0.20**/0.23**	0.12*/0.11*	0.32**/0.33**	0.29**/0.27**	0.25**/0.31**	0.18**/0.25**	0.17**/0.34**

*M and SD are used to represent mean and standard deviation, respectively. The numbers on left are for single-person offices and the numbers on the right are for shared offices. *p < 0.05; **p < 0.01.*

especially in explaining behaviors. For both types of offices, AR is the strongest predictor of energy-saving intention, and it also has the largest indirect effect on behaviors. Having a positive attitude toward energy saving also contributes to a positive intention to save energy, but its indirect effect on behaviors is only significant in shared offices.

There are a few interesting differences in the results between the two types of offices. First, injunctive norms have a significant impact on energy-saving intention for occupants of single-person offices, while descriptive norms have none. Conversely, descriptive norms have a significant impact on energy-saving intention for occupants of shared offices, while injunctive norms have none. It is likely that descriptive norms (i.e., how co-workers are actually doing in saving energy) are more salient in shared offices and, therefore, more influential. Because descriptive norms are less noticeable in single-person offices, occupants have to refer to the injunctive norms (i.e., what they believe their co-workers approve of) in forming their Intention. This finding is consistent with the previous finding that the influence of descriptive norms is particularly significant when the PBC is low, which was the case in shared offices. We suspect that shared-office workers are trying to restore a sense of certainty in a physically less controllable environment by seeking out clear social cues from their peers.

Another striking difference is, while neither of the control-related variables (i.e., PBC and ease of access to controls) are directly predictive of energy-saving behaviors in single-person offices, both variables are significant predictors for occupants in shared offices. One possible explanation is that both PBC and ease of access to controls are significantly higher in single-person offices than in shared offices and, therefore, are possibly taken for granted. One interesting side finding is that shared-office occupants had somewhat lower energy-saving intention and AR than single-person-office occupants. This is, in some sense, consistent with what the "tragedy of the commons" argues, that a large number of players in a public good dilemma often leads to little cooperation amongst the players (Hardin, 1968). Some researchers have indeed referred to energy use as a social dilemma itself (Samuelson, 1990; Höfer and Rommel, 2015). However, the impaired cooperation is not inevitable because people are not always gain-maximizers, and they rely on social norms to take actions (Ostrom, 1999). In our sample, neither descriptive norm nor injunctive norm were that positive among shared-office occupants, which may explain the lower AR and intention to save energy.

Implications

This work highlights the following key suggestions that could be of interest to building architects, engineers, managers, and policy-makers.

First, the demonstrated importance of occupants' AR to energy saving in both shared and single-person offices asserts the need to cultivate biospheric values and to raise awareness of energy issues and their related negative consequences, because the sense of responsibility is likely to be derived from them (Stern et al., 1999; Chen and Knight, 2014). Organizations can set up rules and adopt a pro-environmental identity so that the

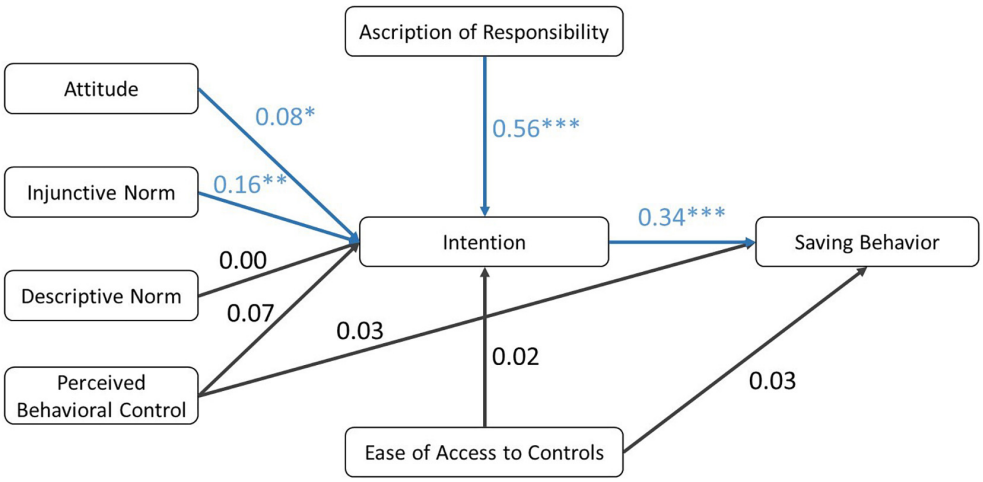

FIGURE 3 | Result of path modeling on the extended TPB model for single-person offices. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 4 | Indirect effects on Behavior for single-person offices.

			Indirect effect		
X	**Mediator**	**Y**	**Effect (standardized)**	***SE***	***p***
Attitude			0.027	0.014	0.055
Injunctive norms			0.055	0.015	0.001
Descriptive norms			0.000	0.015	0.976
Perceived behavioral control (PBC)	Intention	Behavior	0.024	0.014	0.070
Ascription of responsibility (AR)			0.189	0.032	0.000
Ease of access to controls			0.005	0.012	0.641

employees will perceive saving energy as part of their job duties and become more congruent with their own benefits. Policy-makers and other regulators should recognize and encourage organizations that take such a role in promoting energy efficiency and decarbonization.

Second, providing occupants with a certain level of control over the building environment is important for promoting energy-saving behaviors, particularly for shared-office occupants. Building environmental control features need to be designed to be more user-friendly. Many control features currently used in office buildings, especially thermostat controls, are not intuitive to use (Karjalainen and Koistinen, 2007). The employers also need to better educate their employees on how to use building control systems (D'Oca et al., 2017). In addition, because a building's control features can be physically or socially difficult to access, those features need to be designed in a way that minimizes social pressures or any conflicts that might arise when occupants operate them (Li et al., 2017). One study shows if there are automated indicators on the windows that tell the occupants it is acceptable and advantageous to open or close the window, the occupants become less concerned about the opinions of others (Ackerly et al., 2011). These indicators, in a sense, validate occupants' actions. When it is difficult to grant the occupants any direct control over the building environment, potentially due to a higher level of automation, occupants' feelings and opinions still need to be collected and fed back to the management and to the system. Brown et al. (2009) proposed a similar idea of incorporating occupant intelligence into the design of intelligent buildings (Kell, 2005). And equally important is that the occupants' perceived level of control will get boosted in doing this. Meanwhile, developing smaller areas in a shared office and enabling sub-space control can also increase the level of control and empower energy-saving behaviors for occupants. For example, an occupant leaving their space can turn off their own lights without affecting others.

Third, this study discovered an interesting and helpful distinction between the effect of injunctive and descriptive norms. The organizations are likely to promote energy-saving intentions and behaviors through enhanced descriptive norms in shared offices, where employees experience a high level of social interactions, and their behaviors are typically observable by others. This approach has been proven effective in a few studies (Carrico and Riemer, 2011; Xu et al., 2017). When this type of norm is hardly observable in single-person offices, then it is more crucial to have clear organizational rules or rewards for energy-saving behavior and to internalize the injunctive norms. This result reinforces the argument that we need to have different strategies for promoting energy saving in different office settings.

Limitations and Future Research

Two limitations of this study should be acknowledged. First, the energy-saving behaviors of our participants were measured with self-reported surveys rather than field observations. However, because the participants knew that their answers were anonymous, the motivation to boost their answers should be minimal. Future research could use both actual behavior

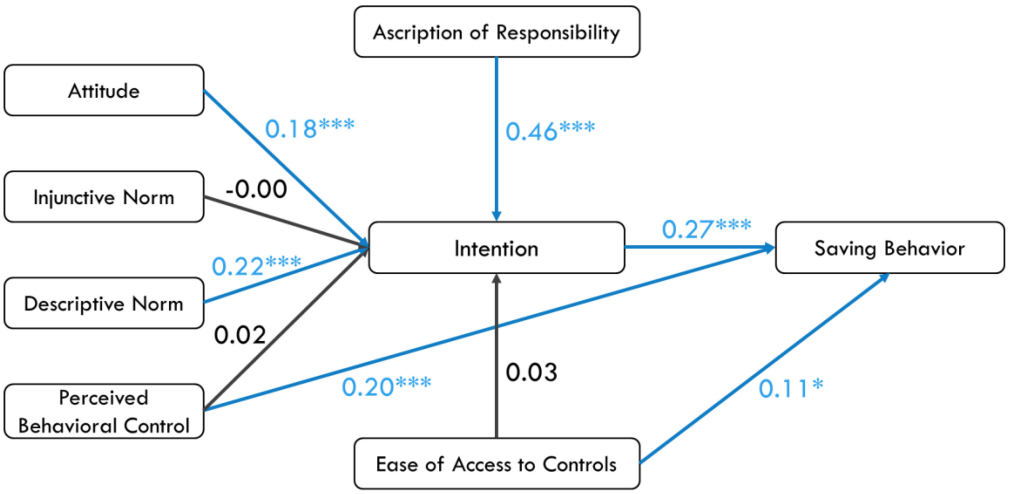

FIGURE 4 | Result of path modeling on the extended TPB model for shared offices. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 5 | Indirect effects on Behavior for single-person offices.

			Indirect effect		
X	**Mediator**	**Y**	**Effect (standardized)**	***SE***	***p***
Attitude	Intention	Behavior	0.050	0.014	0.000
Injunctive norms			0.000	0.012	0.988
Descriptive norms			0.059	0.016	0.000
Perceived behavioral control (PBC)			0.006	0.012	0.642
Ascription of responsibility (AR)			0.123	0.025	0.000
Ease of access to controls			0.008	0.010	0.395

measures and energy consumption measures to verify and add on to our model. Research on the possible discrepancy between energy-saving behavior and actual energy consumption may also be insightful in explaining some inconsistent findings. For example, while most studies show increased control leads to energy-saving behaviors, one study that compared the energy consumption of a Norwegian workplace (mostly private offices with full control of windows, blinds, and thermostats) and a United Kingdom workplace (mostly shared offices with much less control) found that the latter was about 10 times more energy efficient (Shahzad et al., 2016).

Second, although the fit of our path model is decent, the explained variances in energy-saving behavior are still small. This is mainly because our model only includes social-psychological variables, and other variables such as demographics and building contextual variables (e.g., feature responsiveness) were left out. A more comprehensive model with biological measures, contextual variables, and additional social-psychological factors should be able to tell a more complete story of workplace energy saving.

CONCLUSION

Considering both physical and social-psychological building factors, our study addresses the research gap in both occupant behavior and energy saving literature by identifying the unique contributors to energy-saving intention and behaviors in single-person versus shared offices. This study demonstrates the important roles AR and energy-saving intention have on energy-saving behaviors in different office settings. Importantly, this study makes one of the first attempts to compare the influence of injunctive and descriptive norms in different office layouts, which is important for a better understanding of office occupants' energy behaviors in office buildings. This study highlights the important relationships among building design and occupants' social-psychological factors for achieving a well-built working environment.

DATA AVAILABILITY STATEMENT

The datasets generated for this study will not be made publicly available because of IRB regulations.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by IRB office at the University of Tennessee. The participants provided their informed consent before participating in this study.

AUTHOR CONTRIBUTIONS

All the authors contributed equal amount of the research idea and contributed the writing. XX led the data analysis.

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