EVALUATING HOW SOCIAL PSYCHOLOGICAL ASPECTS AFFECT THE CHOICES OF OCCUPANT BEHAVIOURS: A MODIFIED MOTIVATION, OPPORTUNUITY AND ABILITY APPROACH

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This study evaluates the impact of social psychological aspects on adaptive and nonadaptive occupant behaviours in offices. The evaluation is based on a survey synthesising previous research insights on social science theories, where subjective aspects were considered by adapting a modified motivation, opportunity, and ability framework. A questionnaire was distributed across the general office building population in New Zealand, and 247 valid answers were achieved. A Structural Equation Modelling (SEM) approach was used to evaluate the subjective effects on the choices of occupant behaviours. The results showed that the attitudes, personal norms, organisational support, behavioural interventions, and perceived knowledge (factor loadings >0.50) were significant indicators of adaptive behaviours and positively affected the choices of occupants' adaptive actions. Overall, the study outcomes enable the improvement of occupant energy saving behaviours by applying subjective aspects related to the office environment. Furthermore, this study provides insights for investigating occupants' social and psychological perspectives on energy saving in their workplaces amid the COVID-19 and post lockdown situations.

Keywords: ability; motivation; occupant behaviours; opportunity; social psychology

INTRODUCTION

Occupant behaviours (OB) are usually treated as static, deterministic schedules, or settings in building energy performance simulation, ignoring their diversified and dynamic nature (Hong *et al.,* 2018). Specifically, that kind of office design leaves occupants dissatisfied with the indoor environment and the fluctuations of thermal, visual, air quality, and aural conditions, leading to fewer opportunities to save energy (Wagner, O'Brien and Dong 2017). Additionally, the evolving flexible working practices because of the COVID-19 pandemic are expected to significantly affect the operation of offices (Mantesi, Chmutina and Goodier 2022). A significant opportunity is presented to reconsider the human-building interactions while promoting more energy efficient office buildings in the post-pandemic era (Mantesi *et al.,* 2022). It is vital to focus on reducing energy use and CO2 emissions to tackle

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climate change as buildings reopen with flexible working solutions and complex energy operations.

The influence of social psychological concerns is critical when understanding occupants' impact on building performance and energy (Day and O'Brien 2017). For example, D'Oca *et al.,* (2017) conducted an online survey across 14 universities and research centres in the United States, Europe, China, and Australia. The occupants' response to interacting with building control systems and intention to share controls were considered. The influential factors are motivational drivers, group behaviour, ease and knowledge, and satisfaction productivity. Most recently, the environmental, contextual, and personal factors were extracted from the relevant groups, and all other factors such as attitude: Behavioural beliefs, normative beliefs, subjective norms: Motivational drivers, and perceived behaviour control (PBC): Knowledge controls, ease to share, perceived comfort were categorised as subjective aspects (Bavaresco *et al.,* 2020). For example, the positive attitude of occupants motivates them to perform more energy saving behaviours (Li *et al.,* 2019). Evolving operations in future offices can achieve energy efficiency through technical and social dimensions (Mantesi *et al.,* 2022). These studies further suggest that the energy research practices based purely on objective factors of OB may not highlight valuable insights from subjective aspects of OB in buildings.

Researchers have recently given more attention to studying the impacts of social psychological factors that significantly improve occupant energy behaviour modelling for building performance simulation (BPS) (Ding *et al.,* 2018). Past studies adapted social science theories like the theory of planned behaviour (TPB) (Shi, Fan and Zhao 2017), social cognitive theory (SCT) (D'Oca *et al.,* 2017), and the motivation, opportunity and ability framework (Li *et al.,* 2019) to study the effect of social psychological aspects on energy saving behaviours. Structural Equation Modelling (SEM) analysis was considered appropriate to analyse these impacts (Li *et al.,* 2019; Shi *et al.,* 2017).

In New Zealand, it is yet to recognise how different social psychological factors influence the perceptions and behaviours of occupants in offices relating to their contribution to energy and climate impact. The organisations must understand occupants' attitudes, beliefs, personal norms, and knowledge to change their behaviours. Accordingly, the study aimed to identify the significant social psychological factors influencing occupants' energy behaviours by adapting a modified MOA framework. The paper contributes to better understanding OB in office buildings while considering subjective aspects derived from social science theories. Furthermore, the implications of this study can be used to rethink the human-building interactions to promote energy efficient offices in the post-pandemic era. The paper first explains the MOA framework adapted for the study to evaluate the impact of social psychology aspects on adaptive and nonadaptive OB in offices. The following sections of this paper present the research methods, results and discussions, and the conclusions, including research implications, limitations, and future research.

Application of modified MOA framework

Initially, Li *et al.,* (2019) developed an integrated MOA framework that includes the social psychological factors influencing occupants' energy saving behaviours in buildings. Accordingly, motivation (M) measures an occupant's concern over individual energy consumption and their behaviour involving saving energy.

Opportunity (O) measures the occupants' accessibility to the information related to energy conservation, environmental, and interpersonal factors influencing their energy saving intentions. Ability (A) is how occupants interpret the information on energy saving behaviour based on their past knowledge of energy use, impacts, and consequences.

In the integrated MOA framework, motivation includes measures like attitude, personal norms, the ascription of responsibility, and the awareness of consequences towards energy savings. Personal norm indicates occupants' self-obligation to commit energy saving behaviours (Schwartz 1977). Earlier studies have evident the direct impact of personal norms on occupants' environmental intention and behaviour (Kim and Seock 2019). However, the awareness of consequences and the ascription of responsibility that show the awareness and responsibility of individuals for taking energy saving behaviours are antecedent constructs contributing to personal norms (Zhang, Wang and Zhou 2013). Furthermore, Li *et al.,* (2019) explained the attribution of responsibility and personal norm load on the same factor based on the factor analysis.

The integrated MOA framework also includes subjective norm, descriptive norm, organisation support, accessibility to control, and time availability in the opportunity component. The subjective norm is the "perceived social pressure to engage or not engage in the behaviour" (Ajzen 1991: 188), while the descriptive norm captures the perceptions of others' behaviours (Forward 2009). However, integrating descriptive norms to identify the behaviours requires greater attention from individuals toward their co-workers in the office setting, especially in shared offices (Xu *et al.,* 2020).

Additionally, the commitment and encouragement of an organisation positively support its employees' pro-environmental behaviour (Xu *et al.,* 2017). Similarly, integrating behavioural interventions such as energy feedback and awareness messages promotes the occupants' energy saving behaviours (Mulville *et al.,* 2017). Accessibility to control assess the individual's degree of actual controllability over the building systems such as heating, cooling, lighting, and ventilation (Li *et al.,* 2019). For instance, when occupants have more control over the environment, they change their energy behaviours (McMakin, Malone and Lundgren 2002). Although time availability was considered in Li et al.'s framework, the subsequent factor analysis showed that the factor does not affect energy saving behaviours. The time required for those behaviours is possibly not much (Li *et al.,* 2019).

The ability component in the integrated MOA framework includes PBC, perceived knowledge, and the actual knowledge of the building occupants. According to Ajzen (2002), the PBC perceives the ease or difficulty of performing any behaviour. Moreover, perceived knowledge explains how occupants perceive their knowledge of energy saving, while actual knowledge has been used in existing studies to measure occupants' psychological abilities to perform behaviours (Li *et al.,* 2019). For example, occupants with higher perceived and actual knowledge of energy consumption and related savings are more likely to save energy than occupants without much knowledge (Abrahamse and Steg 2009).

Although the integrated framework provides researchers with a systematic approach to investigating the determinants of energy saving behaviours in the office environment, additional research is necessary to justify the performance of this framework on energy saving behaviours. Hence, the current study adapted a modified MOA framework in the context of New Zealand to verify the application of social

psychological aspects to improve occupants' energy saving behaviours. The modified framework includes only the attitude and personal norms, while the aspects relating to individuals' awareness and responsibility can also be addressed under the personal norms. Furthermore, this framework includes all three ability indicators and subjective norms, organisation support, behavioural interventions, and accessibility to control under the opportunity component, as illustrated in Figure 1.

METHOD

Data collection

The participants for the study were selected from the general population of employees who occupied office spaces in New Zealand. The occupants who work full-time and part-time in any type of office (private room, shared, and open-plan offices) in New Zealand were selected for the study. The total workforce of New Zealand who employed full-time and part-time as managers, professionals, community and personal service workers, and clerical and administrative workers equals 1,869,481, according to 2018 Census data (Stats NZ 2022).

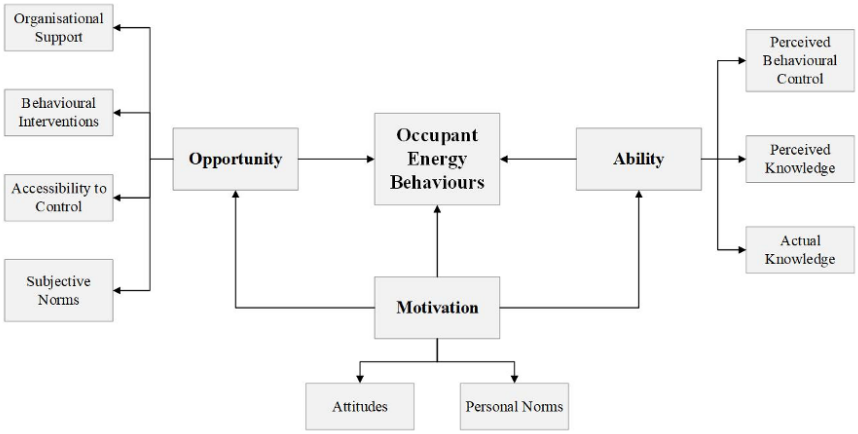


Figure 1: The Modified MOA framework (adapted from Li et al., 2019)

The study assumes a population proportion of 0.80 who regularly work in a designated office space. Specifically, this proportion was considered based on the New Zealanders' responses to remote working during COVID19 and post lockdown, where out of 2,560 respondents, only 22% suggested that they would like to work from home daily, and the majority (67%) prefer a mix of working remotely a few times a week or month (O'Kane, Walton and Ruwhiu 2020). Accordingly, the minimum sample size for the study equals 246 with 95% confidence and a margin of error of 5% (Saunders, Philip and Thornhill 2019). The survey was distributed in-person and online through the Qualtrics survey platform from July to November 2021. A total of 272 responses were received; however, only 247 proceeded for the data analysis after data removing the responses with missing data and screening out the responses with a standard deviation less than 0.25 value.

The selected sample included males (59.9%) and 85% of building occupants aged 30 or older. Most of the participants were New Zealand Europeans (50.6%), followed by Asians making up 19.4%. 88.7% of the participants indicated that they are employed full-time. Among the sample, 68.4% of the participants have been working for a year or more in the current workplace. Therefore, it can be assumed that most of the participants are familiar with the current workplace and their actions within the workplace.

Data analysis

Structural equation modelling (SEM) was used to analyse the collected data. IBM SPSS Amos 28 Network software was used to conduct an exploratory factor analysis and develop a measurement model. The SEM has been used in various contexts, especially in energy behaviour research, where many dependent variables exist (Bavaresco *et al.,* 2020; Li *et al.,* 2019). SEM is a statistical method that shows the relationships between manifest (observed variables) and latent variables and quantifies their impacts to test hypotheses developed based on the theoretical model (Schumacker and Lomax 2015). The latent variables are motivation, opportunity, and ability constructs and the observed variables are the defined social psychological factors presented in Table 1.

Table 1: Latent and observed variables (associated survey questions)

Latent variables		Observed variables/Indicators
Motivation	Attitude (At)	At1 - Saving energy at work is important to me
	Personal norms (PN)	PN1 - I feel responsible/obliged to save energy at work
Opportunity	Subjective norms (SN)	SN1 - My co-workers expect me to save energy at work
		SN2 - Most of my co-workers expect me to turn off electrical appliances
		SN3 - Sharing control over building systems with my co-workers is easy
	Organisation support (OS)	OS1 - My company encourages employees to save energy
		OS2 - My company rewards employees for saving energy
	Behavioural interventions (BI)	BI1 - The feedback on individual energy use by our building management team is important for me to change my energy-driven behaviour
		BI2 - Our building management team often sends energy use reports
	Accessibility to control (AC)	AC1 - I have personal control over most of the appliances (windows, doors, blinds, thermostat, lights, heaters, fans, computers) in my workspace
Ability	PBC	PBC1 - Saving energy during work is entirely within my control
		PBC2 - Actions I take to save energy depending on my comfort preferences
	Actual knowledge (AK)	AK1 - I am aware that reducing energy use at my workspace will reduce cost
		AK2 - I am aware that reducing energy use will reduce emissions
		AK3 - I am aware that reducing energy use in my workspace will improve my organization's image/reputation
	Perceived knowledge (PK)	PK1 - I often close windows, turn off the lights, heaters, fans, computers, etc., whenever I leave the office, and unplug appliances when not in use
		PK2 - If I feel slightly cold at the workplace, I would put on another layer of clothing instead of using the heater
		PK3 - If I feel slightly warm at the workplace, I would adjust my clothing level instead of using the air conditioner
OB	Nonadaptive behaviours (NAB)	NAB1 - I often report discomforts related to indoor environmental quality
		NAB2 - I am willing to accept and do nothing about the existing indoor environmental conditions in my workspace
	Adaptive behaviours (AB)	AB1 - I often adjust building appliances to satisfy my comfort preferences
		AB2 - I often adjust myself to the environmental conditions at my workspace by adjusting clothing, drinking hot/cold beverages, and moving through spaces

The survey questions included in Table 1 were adapted from previous literature. The questions relating to attitude, subjective norms, and PBC were adapted from Abrahamse and Steg (2009), personal norms from Zhang *et al.,* (2013), perceived and

actual knowledge, organisation support, behavioural interventions, and accessibility to control were adapted from Li *et al.,* (2019), while OB related questions were adapted from (Hong *et al.,* 2018).

In the current study, the dependent variable was OB, and the social psychology factors were the independent variables. In SME analysis, latent variables or constructs are assessed through the impact of observed variables or indicators. Latent variables can be endogenous (denoted Y) and exogenous (denoted X). The occupant behaviour was an endogenous variable, while motivation, opportunity, and ability were exogenous variables in the current study. The indicators were measured using a 1-5 Likert scale representing strongly disagree, somewhat disagree, undecided, somewhat agree, and strongly agree.

The SEM includes a few steps: Model specification, model identification, model estimation, model testing, and model modification (Schumacker and Lomax 2015). The model specification was conceptualised based on the theoretical framework explained in Figure 1. The model identification was made by establishing the degrees of freedom (df), equal to or greater than 1. A df = 0 shows either a saturated or under identified model. A df < 0 indicates an over identified model. Model parameters were estimated for the assumptions of the Pearson correlation coefficient and tested for the stander error. Then the model was tested for fit, evaluating if the original variance-covariance matrix and the model inferred variance-covariance matrix was similar. In case of a model does not fit the data, the modifications are allowed using the residual matrix, modification indices, and previous theories.

FINDINGS

Measurement Model Analysis

A confirmatory factor analysis (CFA) was conducted using AMOS to test the measurement model to assess the reliability and validity of the observed variables for each construct or latent variable. The SEM model was identified, establishing the df value, which in the current analysis, df=22 (>1). A few of the observed variables were removed from the measurement model due to low factor loadings (< 0.5) and re-run the estimation. Accordingly, CFA only explains the causal relationship between various social psychological factors (exogenous variables: Motivation, opportunity, ability) and adaptive behaviours (endogenous construct: Composite of AB1 and AB2). As shown in Table 2, all loadings were significant ($p < 0.001$ level) and higher than the recommended threshold value of 0.50. The CFA results showed an acceptable fit between the measurement model and the data set. The model fit indices, such as $\chi 2/df$ (< 3.00), GFI, CFI, and TLI (> 0.90), SRMR (< 0.08), and RMSEA (≤ 0.08) were used to test the overall goodness of fit of the developed model (Kline 2015). The results indicated that the above measurement model had a good level of fit with $\chi 2/df=2.521$, GFI=0.953, CFI=0.951, TLI=0.919, SRMR=0.0719, and RMSEA=0.079.

The reliability and validity of the measurement model were assessed through construct reliability, convergent validity, and discriminant validity of the measurement model. According to Table 2, construct reliability was assessed using Cronbach's alpha (α) to evaluate how the model variables consistently measure adaptive behaviours. Cronbach's alpha values for the model parameters in the study ranged from 0.726 to 0.831 and were greater than the acceptable level of 0.70. Also, the study used Composite Reliability (CR) to assess the construct reliability. However, the CR value

of each construct was less than the benchmark value of 0.60; thus, the model variables were not entirely established using the CR value (Kline 2015). The convergent validity measures how well the selected indicators measure the construct. The average variance extracted (AVE) was used to estimate the convergent validity of scale items. The AVE values of the scales were above the threshold value of 0.50, which shows the required convergent validity of the constructs (Kline 2015).

Moreover, the discriminant validity indicates the degree to which one construct differs from other constructs or the dependencies between latent variables, and this was assessed using Heterotrait-Monotrait (HTMT) Ratio. Accordingly, all HTMT ratios were less than the required limit of 0.85, and the discriminant validity was established (Henseler *et al.,* 2015). Additionally, Table 3 presents the study constructs' correlation estimates to show the relationships between latent variables. As shown in Table 2 and Table 3, all the correlations between constructs were lower than the SQRT of AVE values and support the discriminant validity (Henseler *et al.,* 2015). Therefore, considering the above results, the construct reliability and validity were established for each study construct.

Table 2: Results of confirmatory factor analysis

Constructs		Item	Standardized factor loading	Cronbach's alpha (α)	CR	AVE	SQRT of AVE	HTMT ratio
Motivation	Attitude (At)	At1	0.850	0.831	0.493	0.717	0.847	0.1704
	Personal norms (PN)	PN1	0.840					
Opportunity	Organisation support (OS)	OS1	0.550	0.726	0.358	0.515	0.717	0.5433
		OS2	0.910					
	Behavioural interventions (BI)	BI1	0.650					
Ability	Perceived knowledge (PK)	PK1	0.790	0.793	0.353	0.580	0.761	0.0654
		PK2	0.820					
		PK3	0.670					

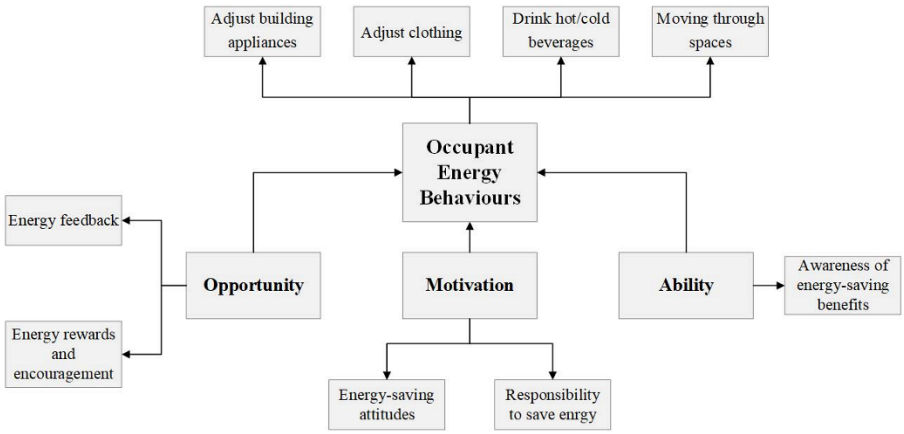
Table 3: Descriptive statistics and correlations

Constructs	Means	SD	At	PN	OS	BI	PK
Attitude (At)	4.1255	0.939	1.000				
Personal norms (PN)	3.8704	1.074	0.717**	1.000			
Organisation support (OS)	2.690	0.989	0.195**	0.239**	1.000		
Behavioural interventions (BI)	3.352	1.000	0.255**	0.315**	0.305**	1.000	
Perceived knowledge (PK)	4.172	0.788	0.434**	0.417**	0.167**	0.192**	1.000

Correlation is significant at the 0.01 level (2-tailed).

As revealed from the SEM analysis, only a few of the observed variables selected for the study related to the constructs of adaptive OB. The measurement model confirms that attitudes and personal norms contribute to motivation, organisational support and behavioural interventions contribute to opportunity, and perceived knowledge contributes to the ability of the building occupants. These relationships are illustrated in Figure 2. The motivation indicators attitude and personal norms have high factor loadings, and each shares a significant portion of variance with motivation (Li *et al.,* 2019). The finding also supports earlier findings that personal norms are a significant antecedent contributing to motivation (Kim and Seack 2019).

Figure 2: Social psychological factors influencing office occupants' energy behaviours



Similarly, organisational support and behavioural intervention improve occupants' opportunities and imply that the organisation's rewards and interventions, such as energy feedback and awareness messages, promote energy saving behaviours of the occupants (Mulville *et al.,* 2017; Xu *et al.,* 2017). Although Li *et al.,* (2019) emphasised the importance of organisational support and intervention to enhance subjective norms in energy savings, subjective norms did not contribute to opportunity in the current model. Similarly, the measurement model does not illustrate the relationship between accessibility to control and opportunity, while previous studies have opposite views (Li *et al.,* 2019; McMakin *et al.,* 2002). A likely reason for this could be the lack of personal control, while McMakin *et al.,* (2002) claimed that occupants change their energy behaviours when they have more control over the environment.

All three indicators of perceived knowledge showed high factor loadings in the current study as it implies that occupants' knowledge of saving energy improves the occupants' ability to exercise energy saving behaviours (Abrahamse and Steg 2009). However, interestingly, PBC and actual knowledge showed little influence in determining the occupants' ability. As saving energy in offices needs little effort and no detailed knowledge to perform the behaviour (Li *et al.,* 2019), the results on PBC and actual knowledge contrast with the previous causal relationship to ability.

Furthermore, the SEM measurement model developed for the study does not highlight the causal relationship between indicators of nonadaptive behaviours to the occupants' actions. This is a significant drawback that exists in past studies as well. The studies focused mainly on human building interactions such as lighting, heating, air conditioning appliances, and thermostats (D'Oca *et al.,* 2017; Li *et al.,* 2019; Shi *et al.,* 2017). Therefore, the current study results only provide the covariances between MOA constructs and adaptive behaviours. However, it is adequate to rethink the human-building interactions driven by social psychological aspects to promote energy efficient offices in the post-pandemic era (Mantesi *et al.,* 2022).

CONCLUSION

This study used a modified MOA framework to evaluate the impact of social psychology factors on OB in offices. As a result, the study established the significant social psychological factors influencing occupants' adaptive behaviours by developing the SEM measurement model. The results provide researchers with how social psychological constructs of occupants influence the decision-making of their

behaviours. Hence, the study assists building designers and energy modelers in improving the internal environment and building systems that suit occupants' comfort preferences, thereby tackling climate change in a post-pandemic era. However, for future research, the authors will examine to what extent these factors affect OB by creating path coefficients of direct and mediating effect models on behaviour. Thus, the measurement model will be extended to a structural model to test the hypothetical dependencies between endogenous and exogenous variables. Also, the current study assumed a population proportion of 0.80 considering the COVID19 and post lockdown situation in New Zealand. However, when the exact population proportion is unknown, it is usually considered 0.50, which gives a much higher sample. Therefore, further studies are required to consider a higher sample to refit the structural model for more reliable predictions.

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