Building and Environment 96 (2016) 260–269

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Factors affecting optimal lighting use in shared hospital environments: A case-study

Pimkamol Maleetipwan-Mattsson*, Thorbjörn Laike, Maria Johansson

Department of Architecture and Built Environment, Lund University, Sweden

ARTICLE INFO

Article history:
Received 11 August 2015
Received in revised form
22 November 2015
Accepted 23 November 2015
Available online 27 November 2015

Keywords:
Behavioural change
Energy use
Energy saving
Hospital
Light switch
Lighting

ABSTRACT

Lighting in hospitals consumes non-negligible quantities of energy, and it would be very desirable to reduce this consumption. In shared hospital environments such as staff rooms or dayrooms, behavioural changes can reduce energy usage and support occupant satisfaction without requiring advanced technological solutions. The objective of this paper is to identify critical factors affecting occupants' optimal use of lighting in such environments. The Theory of Affordances and Theory of Planned Behaviour (TPB) were integrated to link design characteristics of lighting control user interfaces with perceived behavioural control (PBC), which together were expected to influence occupants' optimal lighting use. The effects of different designs for everyday interfaces (i.e. light switches) on occupants' lighting use were investigated by means of a self-report questionnaire ($n = 42$), field observations, and measurements conducted in a dining room and a dayroom at a hospital in Sweden. A significant relationship was found between the perceived affordances of the switches and PBC. However, there were no significant associations between TPB factors and behaviour. The variables identified to affect optimal lighting use were satisfaction with lighting, a subscale measuring attitudes (i.e. affective-related beliefs), and general lighting-use behaviours. The design of the interfaces also had an effect on lighting use. These results indicate that individual-based factors and the perception of interface designs should be considered in parallel when designing interventions to reduce energy usage due to lighting in hospitals.

1. Introduction

Hospitals consume large amounts of energy because they are in continuous operation. Artificial lighting accounts for a large proportion of their electricity consumption; estimates range from 26% [1] to about 36% [2].

Buildings' design features (i.e. their size and number of windows) have been found to affect the length of time the lighting is on in hospital environments [3]. Occupant behaviour is another crucial factor that can cause deviations in energy use in such buildings [4,5]. Previous studies have shown that a lot of energy is wasted due to occupants' behaviour, i.e. leaving lights on unnecessarily, particularly in unoccupied spaces [4,6]. Such behaviour often occurs in shared environments (or temporarily owned spaces) because the occupants usually do not feel directly responsible for switching off the lights [7].

Energy saving issues are likely to be neglected in hospitals due to the viewpoint that patient comfort should be maximised. However, modern technologies and management strategies make it possible to achieve current levels of comfort while substantially reducing energy consumption [8]. Another potential way of reducing energy consumption is to promote behavioural change, which has little or no cost, requires no advanced technological knowledge, and can provide considerable energy savings in both new and existing buildings [6]. This effective approach can be applied to shared hospital environments such as offices, staff rooms and dayrooms if they are equipped with lighting systems having occupant-controllable manual overrides. It is well known that lighting has important effects on the well-being of building occupants [9–11] and that most people prefer having manual overrides for lighting control [12].

Modern buildings often have feedback systems such as monitors that display energy usage with the aim of encouraging occupants to change their energy use behaviours. However, such systems are not suitable in shared hospital environments because their occupants typically only use shared facilities for short periods of time, making

* Corresponding author.
E-mail address: pimkamol.mattsson@arkitektur.lth.se (P. Maleetipwan-Mattsson).

http://dx.doi.org/10.1016/j.buildenv.2015.11.026
0360-1323/

it difficult to provide individualised feedback. Tetlow et al. [7] found that visual prompts increased the likelihood that office occupants would switch off lights when they finish using a meeting room. Posting signs to prompt occupants to switch off lights when they leave a room was also shown to facilitate energy and cost savings in a hospital [13]. However, there are also indications that this kind of approach may suffer from user acceptance issues [14].

There are many intervention strategies that could be used in any given case, and that the most appropriate will depend on the behaviour targeted and the factors affecting it [15]. If the behaviour is strongly related to individual-based factors (e.g. attitudes, affect, norms or habits), the intervention should target changes in such factors. If the behaviour is strongly related to the physical environment, an environmental intervention designed to encourage the behaviour should be implemented [15]. In a study of two three-storey office buildings [16], Swenson and Siegel found that interactive environmental interventions increased the occupants' stair usage, thereby reducing energy consumption due to elevator use.

Thus, it is important to identify the factors that affect occupants' use of electric lighting before attempting to design and implement an intervention aimed at reducing their lighting use and the associated energy consumption. Previous investigations into lighting use by the occupants of office buildings have focused on the effects of different types of lighting controls and user interfaces as well their location within the building [17–20], as well as individual-based factors such as attitudes to energy usage [4], and norms [7]. However, to the authors' knowledge there have been no such systematic investigations into occupants' use of lighting in hospitals, especially the shared environments.

This paper endeavours to identify important factors affecting occupants' use of electric lighting (and hence their energy use) in shared hospital environments. The focus is on the use of lighting to achieve energy savings while supporting occupant satisfaction, which is referred to as "optimal lighting use" [21]. Specifically, this entails (i) turning lights on only when necessary, (ii) turning lights off when they are not needed, and (iii) adjusting lighting levels to satisfy individual preferences.

1.1. Factors affecting occupants' use of lighting

The preference for manual lighting overrides among building occupants may imply that their use of electric lighting is related to their degree of satisfaction with the building's lighting conditions. Literature results suggest that simple and easy-to-use interfaces may encourage occupants to use lighting optimally [12]. According to Steg and Vlek [15], lighting control user interfaces could be regarded as technical facilities that may affect occupant behaviour. If the interfaces are easy to understand, occupants are likely to use them in accordance with the controls' intended functions [22]. However, occupants will ultimately make their own behavioural choices, which may affect the efficiency of technical systems installed in buildings [23], and the relationship between such systems and behaviour may be mediated by individual-based factors [15].

It should also be noted that people act under the influence of their physical and social environment [24]. In non-domestic buildings, people may feel less responsibility for their own energy use because they have no responsibility for the utility bills [7]; additionally, they may not act in the same way as they usually do at home [4]. In such buildings, occupants' energy-saving behaviour may be influenced by organisational culture as well as social norms [25]. Moreover, Corraliza and Berenguer [26] pointed out that people, particularly those with pro-environmental attitudes, are more likely to embrace energy-saving behaviours (e.g. switching off heating in unoccupied rooms) if the situation (physical environment) is perceived to be facilitatory.

On small scales, design modifications (e.g. size and user support) of kettles were shown to effectively encourage users to reduce their water and energy usage [27]. This highlights the role design features can play in achieving energy savings. According to Lee, Luo and Ou [28], physical features such as an object's colour, shape and texture can evoke affective responses in a perceiver. In a study of four light switches [29], colours and shapes of these everyday interfaces were found to affect user perceptions with regard to particular design characteristics that may influence lighting energy use in public buildings.

1.2. Theoretical departures

A number of behavioural theories have been applied in research on individual-based factors influencing human behaviour. The Theory of Planned Behaviour (TPB) [30] has been widely used in this context, and was successfully employed to explain various types of behaviour, including energy-saving behaviour – specifically, using energy-saving light bulbs [31]. This theory states that the proximal determinants of behaviour are behavioural intention and perceived behavioural control (PBC), which refers to the perceived ease of performing the behaviour and/or the extent to which an individual feels that the behaviour is under their control. Intentions are determined by (i) attitudes, which reflect the individual's evaluation or appraisal of the behaviour; (ii) subjective (social) norms, i.e. the perceived social pressure to perform the behaviour from people such as family members, friends, and colleagues; and (iii) PBC.

However, the relative importance of the TPB factors seems to vary from behaviour to behaviour and between individuals [32]. Studies on walking and biking behaviours have shown that attitudes and PBC are more significant than social norms for predicting behaviours, and that the built environment has important effects on people's attitudes and PBC [33]. This latter finding provided a better understanding of factors influencing behaviour by demonstrating the need to include the physical environment in the TPB model.

In addition to TPB factors, many studies have examined the role of habits as predictors of behaviour. Habits are usually formed through behavioural patterns that are carried out frequently [27], and according to Verplanken and Aarts [34], general habits are particularly important because they may represent behaviours that are repeated in many different situations and have considerable impacts on individuals' well-being and health, or on the environment. Habits may involve selective attention, i.e. people may tend to focus on information that supports their habits and ignore other information or treat it as though it is irrelevant [15]. In the context of lighting use, it can be assumed that people who generally engage in lighting-use behaviours that contribute to energy savings (e.g. turning off the lights in occupied spaces) will do so wherever they perceive control over the behaviours; in contrast, people who generally leave the lights on when leaving a space may ignore information that promotes perceived control over lighting.

According to Ajzen [30], PBC may be reduced by a lack of relevant information or a situation with new and unfamiliar features, both of which may reduce the likelihood that an individual will exhibit a given behaviour. This suggests that lighting controls should have design features that provide behavioural information to promote PBC. The Theory of Affordances [35] provides a way of describing the ease of use or complexity of everyday interfaces (such as light switches) as perceived by users [36] that may influence usage of electric lighting. Affordances, in design, are properties of products that let users know how the products should be used [[36], p.9]. Applying this concept to elements in the physical