



Proof-of-concept of a questionnaire to understand occupants' comfort and energy behaviours: First results on home occupant archetypes



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ABSTRACT

Background: This paper demonstrates the effectiveness of the TwoStep cluster analysis and the development and first results of a new questionnaire for measuring comfort, health, and energy habits. The justification for the questionnaire is to consolidate into one instrument questions of six specific domains about occupants' energy consumption patterns, from the behavioural and psychological perspectives.

Methods: The questionnaire was developed from a literature review, iterative conceptualization, and testing. The resulting instrument was administered to a sample of home occupants, comprising of bachelor students of Architecture of the Delft University of Technology. The objective of the study was to examine the effectiveness of the TwoStep cluster analysis to produce occupant profiles. 316 emails were sent out inviting participants to complete the questionnaire.

Results: With the TwoStep cluster analysis, it was possible to distinguish six different archetypes of occupants based on their behavioural characteristics. These were the Relaxed Optimists, Unconcerned Indifferents, Restrained Sensitives, Positive Absolutists, Incautious Negativistics, and Resigned Savers.

Conclusion: The results provide promising evidence of the questionnaire's potential to distinguish different occupant energy consumption profiles based on distinct psychosocial domains in a single and concise instrument, while also showing that the analysis method is appropriate for the type of variables gathered. The value of recognizing these profiles allows for a better understanding of occupants' differing energy consumption patterns in their homes and tailoring interventions to their specific needs.

1. Introduction

To ensure a future with lower energy consumption, there is the need to address both technologies and human behaviour. However, an unequal amount of research and development has been addressed to the fields of energy engineering for the development of more energy efficient technologies [1,2]. Part of the issues is that traditionally in the development of comfort-providing technologies, comfort is limited to single parameters of the four IEQ factors, therefore ignoring interactions between factors as well as differences between comfort receivers. In spite of technological advancements, energy consumption does not seem to decrease at the rate it should [3]. This phenomenon is likely due to the behavioural component of energy consumption, which remains underinvestigated [4]. Several behaviours performed at home can be considered comfort-making activities. This is because most activities carried out at home, are done to bring one's current state into a more neutral one, a process called homeostasis. As a result, many of those activities result in the reduction of stress [4]. Therefore, it is

imperative to better understand occupants' behaviours as well as the motivations behind such behaviours. In behavioural terms, the motivations behind a behaviour can be divided into needs, attitudes, and emotions. Additionally, it has been determined that two particular types of behaviour are of importance in comfort-making -while also being understudied-these are controllability actions and habits. Exercising both control and habits is stress relieving; however, due to the unconscious and automatic nature of such behaviours, they remain understudied [4]. To better understand occupants' behaviours in their homes, the motivations for such behaviours, and the relationships between behaviours, energy use, and comfort and health, a comprehensive questionnaire was developed. The questionnaire was administered to a sample of home occupants, and analysed with a cluster analysis method. Thus, the aim of this study was to 1) develop a questionnaire that enables the understanding of psychobehavioral constructs of occupants in terms of interactions with energy consuming technologies in the home context and 2) to determine whether it is possible to define homogenous groups based on the respondents' attitudes towards

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Table 1
Questionnaire sections and description of instruments upon which they are based.

Section	Definition	Composition of questions
Personal and building characteristics	General demographic characteristics about the respondent and their home.	Age, gender, nationality, home location, size, number of rooms.
Locus of control	Belief of control over outcomes: a spectrum ranging between ‘internal’ (based on the individuals’ own behaviours) and external (due to circumstance, luck, other people) [6].	9 statements for External and 9 for Internal residential control beliefs, adapted from the Locus of control scale by Levenson [7]
Emotions	Affective conditions that are the reaction to something; they influence an individual’s motivations to act in certain ways [8]	14 positive and negative emotions, based on the PrEmo2 questionnaire by Laurans and Desmet [9]
Health	Health status and symptoms adapted from the OFFICAIR project questions on health and symptoms by Bluysen et al. (2015) [5].	18 diseases or conditions and 11 symptoms related to sick building syndrome, with a follow up question of whether the symptom is related to indoor environment.
Affordances	“Offerings or action possibilities in the environment” [10]	Elements of the home which the respondent finds or not important for their subjective feeling of comfort. 11 items in 5-point Likert scale
Attitudes towards energy	“a learned, global evaluation of an object (person, place, or issue) that influences thought and action.” [11]	Willingness to change behaviours and efforts to carry a sustainable life. Semantic differentials rated with a 5-point Likert scale were developed.
Energy-consuming habits	A counter-intentional and not fully-conscious form of behaviour performed as an automatic response to specific contextual cues and that helps to attain a goal or state [12].	From Maréchal’s (2010) [14] adaptation of the Self-Report Index of Habit Strength, by Verplanken and Aarts (1999) [15]

energy, emotions to home environment, locus of control in the home, and needs by using the Two Step cluster analysis method.

2. Method

2.1. Questionnaire

According to Ortiz et al. [4], it is proposed that ‘energy use’, and more precisely the interactions between occupants and energy-consuming technologies, are a consequence of striving for homeostasis –a term used in this framework to define a neutral state, lack of physical and psychological stress or discomfort. As a result, the questionnaire focuses on the behavioural expressions of homeostasis and the intentions and motivations behind such behaviours. The constructs that culminate in behaviour that were chosen to be assessed in the questionnaire, as well as the seven sections composing the questionnaire, are presented and defined in Table 1. These sections are a combination of several instruments adapted for this study. One of the main challenges for the creation of the questionnaire was to produce variables that measure the different constructs while being context-specific –the context of the home. Therefore, the already-validated instruments had to be adapted. This adaptation was performed by adjusting the wording of current questionnaires with the specific context of this study, namely the items found to be important for psychosocial and physiological homeostasis. The general characteristics, the attitudes, and the affordances questions were produced without the use of pre-validated questionnaires, while the health section was unaltered from the OFFICAIR study questionnaire [5].

Based on these constructs, a total of fifteen major items were identified in the literature as elements that enable occupants to achieve social, psychological and physiological homeostasis, namely cleanliness and orderliness, IEQ factors (air quality, thermal, acoustical, visual comfort), control of climate, relaxation, personalization, freedom of expression, freedom of action, hobbies, privacy, mood of home, size, and cooking. The fifteen elements were then adjusted for each construct into questionnaire items. Depending on the constructs, some of the items were merged with the goal of gathering relevant and coherent data pertaining to the construct in question. The final items for each of the constructs are shown in Table 2. This resulted in eleven items for habits and affordances, and nine for control (for both internal and external).

2.2. Instruments

Locus of control has been identified as a main contributor to

psychological wellbeing. This is because control beliefs are important for coping with everyday stress as well as life transitions. The locus of control scale by Levenson [7] was used since it is the best established questionnaire for measuring an individual’s locus of control, having been used in several fields, including nursing and housing for the elderly [16]. It was adapted for the domain of the home environment, thus, by utilizing concepts of the immediate residential environment, social support through the home, as shown in Table 2. Based on this, a total of 18 statements were generated. The formulation of these items was based on the “Internal Control” and “External Control” dimensions of the original instrument, with nine items per dimension (i.e. Internal control: “It is up to me whether my home is kept in a tidy and clean state”. External control: “I can’t completely control the cleanliness and tidiness of my home: they are the result of time”). Items were assessed on a five point scale, with a high score indicating higher degree of perceived control.

Habits have been identified as adaptive behaviours that are semi-unconscious, repetitive, goal-oriented, and environment dependent [13]. Habits are performed to achieve a psychological reward, and as a result, they have been shown to play an important role in stress. In this study’s questionnaire, an adapted version of the Self-Report Habit Index by Marechal [14] was used. This version was used since it has been validated in previous questionnaires for people’s habits in relation to energy use. This scale is composed of four items denoting the automaticity of habits (i.e. “In general Behavior X is anchored in my practices”; “...I do while being able to think of other things”; “...would be difficult to change”, etc.). This is done for each of 11 behaviours identified in the housing literature to be common house habits (i.e. cooking, cleaning, light control, etc.).

Behavioural theories contend that emotions are an important contributor to human behaviour and health, and are strongly linked to comfort, since emotional, behavioural, and cognitive processes interact with the nervous and immune systems [17]. The instrument used for this topic was the Premo2 by Laurans [9], a non-verbal emotion self-report tool. Although several tools exist for assessing people’s emotions, this instrument in particular is one of the few using a non-verbal method, while also being specifically developed to assess one’s emotions towards a product or object. It is used to describe users’ extent of emotions in relation to their experience of interaction with a product. It was adapted to reflect emotions in relation to the home. The tool covers four domains of emotions: general wellbeing, expectation-based, social context, and material context [9]. Twelve emotions are depicted, half of them positive and half negative emotions, which are to be rated on a 1 to 5 scale, with a high scale reflecting strong feeling of the particular emotions and 1 not feeling it at all.

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