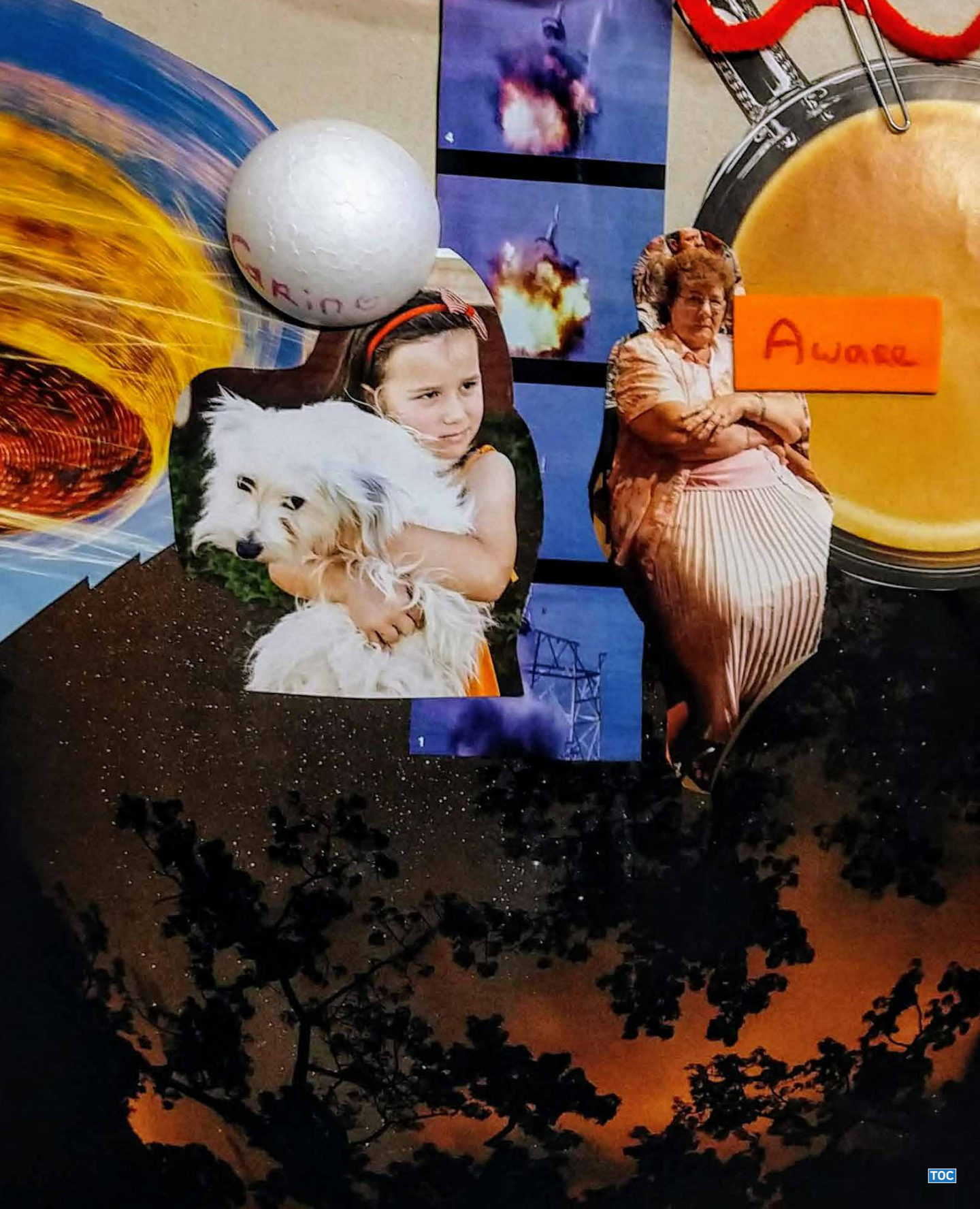


TOC

# 3 Questionnaire testing, validating, and preliminary results

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

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

ABSTRACT

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 questions of six specific domains about occupants' energy consumption patterns, from the behavioural and psychological perspectives into one instrument.

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.

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.

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.

KEYWORDS

residential, occupant segmentation, energy use, questionnaire, comfort behaviour

## 3.1 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 (Gaffigan, 2008; Sovacool, 2014). 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 (Majcen, 2016). This phenomenon is likely due to the behavioural component of energy consumption, which remains underinvestigated (Ortiz, Kurvers, & Bluyssen, 2017). 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 (Ortiz et al., 2017). Therefore, it is imperative to better understand occupants' behaviours as well as the motivations behind such behaviours. In behavioural terms, the motivations behind 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 (Ortiz et al., 2017). 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. In addition, 2) to determine whether it is possible to define homogenous groups based on the respondents' attitudes towards energy, emotions to home environment, locus of control in the home, and needs by using the Two Step cluster analysis method.

# 3.2 Method

## 3.2.1 Questionnaire

According to Ortiz et al. 2017, 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 3.1.

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 (P. M. Bluyssen et al., 2015).

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 3.2. This resulted in eleven items for habits and affordances, and nine for control (for both internal and external).

TABLE 3.1 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) (Lefcourt, 2014). | 9 statements for External and 9 for Internal residential control beliefs, adapted from the Locus of control scale by Levenson (1981) |
| Emotions | Affective conditions that are the reaction to something; they influence an individual's motivations to act in certain ways (Ortony et al., 2012) | 14 positive and negative emotions, based on the PrEmo2 questionnaire by Laurans and Desmet (2012) |
| Health | Health status and symptoms adapted from the OFFICAIR project questions on health and symptoms by Bluyssen et al. (2015). | 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" (McGrenere & Ho, 2000) | 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." (Perloff, 2010) | Willingness to change behaviours and efforts to carry a sustainable life. Semantic differentials rated with a 5-point Likert scale were developed, from questionnaire construction from Ajzen (Ajzen, 2006). |
| 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 (Wood & Rünger, 2016). | From Maréchal's (2010) (Maréchal) adaptation of the Self-Report Index of Habit Strength, by Verplanken and Aarts (1999) (Verplanken & Aarts, 1999) |

TABLE 3.2 Constructs and related Items retrieved from literature relating to psychosocial and physiological comfort

| | Habits | Control | Affordance |
|---|---|---|---|
| Physiological | – Cleaning up | – Cleanliness and orderliness | – Clean and order environment |
| | – Warming up<br>– Freshen up | – Climate (daily basis control of ventilation and temperature) | – Appropriate air freshness<br>– Appropriate temperature<br>– Appropriate acoustical environment<br>– Appropriate lighting |
| Psychological | – Cooking | | |
| | | – Atmosphere (long term control of climate) | – Control systems of climate |
| | – Relaxing | – Choice for relaxing | – Possibility for relaxing |
| | – Personalizing the place | – Personalization/identification | |
| | – Socializing in person<br>– Socializing online<br>– Hobbies | – Possibility for performing activities | – Freedom of expression<br>– Freedom of action |
| | – Create privacy | – Possibility for privacy levels | – Appropriate privacy |
| | – Create the mood | – Possibility of changing mood for occasions | |
| | | – Possibility of controlling layout | – Appropriate layout and sizes |

### 3.2.2 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, 1981) 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 (Oswald, Wahl, Martin, & Mollenkopf, 2003). 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, 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 (Wood & Rünger, 2016). 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 Maréchal (2010) 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 (Zachariae, 2009b). The instrument used for this topic was the PrEmo2 by Laurans and Desmet (2012) 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 (Laurans & Desmet, 2012). 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.

Attitudes can be divided into two dimensions: emotional and cognitive, the former being unconscious, the later conscious. The emotional dimension refers to the individual's feelings in response to the idea of energy, while the cognitive dimension refers to an individual's beliefs about energy. The questions were developed with the guidelines proposed by Ajzen (2006), for which six items related to energy and energy consumption were selected and paired with five-point scale semantic differentials, for the assessment of the emotional dimension of attitudes. The use of these guidelines has been validated in a variety of fields to measure attitudes. Additionally, to assess the cognitive dimension of attitudes, willingness to change consumption behaviours was also included in the attitudes section ("I am willing to change a particular behaviour that I do at home in order to be more sustainable.").

Affordances are elements that the environment provides so that a person can perform an action. This section was the only section that was developed without other tools, by selecting from the housing literature elements that are related to psychosocial and physiological comfort. These were rated on a 5-point scale in which a high rating indicated high importance of the item to be an affordance for comfort.

Health was a tool unaltered from the OFFICAIR questionnaire by (P. M. Bluyssen et al., 2015). Health was included since it not only is related to general comfort, but also because the items composing the questionnaire are all related to stress, which is a determinant of one's health. This questionnaire was used since it is the most widely used for assessing health in the indoor environment, while also taking into account symptoms and stress.

### 3.2.3 Study design

In the 2016 Fall semester at the Delft University of Technology, the second year bachelor's students were requested to fill out the resulting questionnaire. There were 316 students enrolled in the course, and each one received the invitation link. This link was unique to the specific email address to which it was sent, therefore only valid for the original recipient. The protocol was as follows: the day when the questionnaire was distributed, students were introduced to it with a live announcement in their course. After receiving the email with a link to it, students had two weeks to complete the survey. One week before closure, a reminder email was sent. The introduction e-mail instructed the respondent about the purpose of the questionnaire, in addition to providing procedural information, such as reminder and closure dates, expected time to fill out (about 30 minutes), and possibility of pausing and resuming at a later time. When starting the questionnaire, a consent form was presented to the student, where they were assured that data would be confidential and only used for this project. Additionally, they were informed that skipping questions was possible if they felt uncomfortable answering them.

### 3.2.4 Data management and analysis

The questionnaire was developed with the Qualtrics® online platform. Data was downloaded for analysis as an SPSS® file. Before analysis, some cases in the database were removed, such as those that were not more than 80% complete, as well as two questionnaires answered by non-students – i.e. course coordinators or teachers.

### 3.2.5 Clustering

This study utilized the TwoStep cluster analysis approach. Although there are several clustering approaches, this method has traditionally been used in marketing, for customer segmentation, and gained recent popularity in health-related research, especially for the exploration of health behaviours, eating disorders, and alcoholism in the homeless, among others (Ambrosini et al., 2017; Dietrich, Schuster, & Connor, 2014; Fleury, Grenier, & Bamvita, 2015; Pugh & Waller, 2017; Zaretzky, Flatau, Spicer, Conroy, & Burns, 2017). The advantage of the TwoStep analysis over other types of clustering approaches is that it allows for the segmentation of both categorical and continuous variables in a simultaneous manner, allowing for a minimal degree of data preparation and handling for the analysis. Therefore, it enables analysing demographic, health, psychographic, and behavioural data– which is of relevance in the present questionnaire (Norušis, 2012).

The TwoStep analysis was performed as indicated by Norušis (2012) using IBM SPSS Statistics 23. The technique is performed as follows: first, grouping the cases into pre-clusters and subsequently, the pre-clusters are administered a regular hierarchical clustering. As a result, an assortment of solutions with different number of clusters is produced. When a final cluster solution is achieved, it is necessary to validate the model with four steps. First, the silhouette measure of cohesion of the clusters model is recommended to be above 0.0 and preferably 0.2, to ensure validity of both within-cluster and between-cluster distances. Second, Chi2 tests and t-tests are performed with categorical and continuous variables respectively: all variables in the solution need to be statistically significant ($p<0.05$), this is done iteratively, removing non-significant variables until reaching the final model in which all variables are statistically significant. Third, it is recommended that variables of the final solution have a higher prediction score than 0.02; thus removing any variable below it. Finally, the database is randomly split into two, and the final solution model is applied to each of the halves, for which the solutions must be similar (Norušis, 2012; Tkaczynski, 2017).

# 3.3 Results

## 3.3.1 General characteristics of respondents & Participation rate

316 invitations were sent out to the students enrolled in the course “Technology 4 Construction and Climate Design”, of which 245 attended actively the course. A total of 223 completed the questionnaire, thus the response rate was 91.0%. The mean (SD) age was 20.3 (2.2) years, with ages ranging from 18 to 30.

## 3.3.2 TwoStep Cluster analysis and Validation

A TwoStep cluster analysis was performed initially by utilizing the original 65 variables, belonging solely to the behavioural constructs (emotions, attitudes, control, habits, and affordances), since the clusters have to be based on the behavioural expressions of homeostasis. Therefore, variables pertaining to demographics and health were not used to produce clusters. The TwoStep cluster analysis produced a final solution of six clusters, with 25 segmentation variables, with 193 respondents: 30 respondents were automatically excluded from the analysis by the TwoStep Cluster process, due to missing data. The size of the smallest cluster is 19 respondents (9.8%) and the largest being 49 (25.4%) (Figure 3.1).

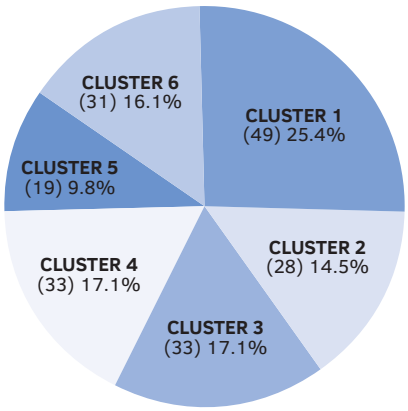


FIG. 3.1 Cluster Sizes: (respondents) Percentage.



TOC

The final solution presents a silhouette measure of cohesion and separation of 0.2, this score ensures that the within- and between-cluster distance is valid amongst the 25 variables, indicating variation between variables. Comparison of means analyses ensured that the final 25 variables were statistically significant, and hence they varied between clusters. Additionally, the variable with the lowest score for predictor importance was found to have a rating of 0.09, well above the recommended 0.02. Finally, randomly splitting the database into two, rendered comparable results in terms of the final solution, with minor changes determined (Table 3.3).

Descriptive statistics were produced from every variable, as frequencies, percentages, minimum and maximum, quartiles, mean, and standard deviation. Based on the descriptive results, as shown in Figure 3.2,, the most salient characteristics of each of the groups were used to name the groups –henceforth referred to as archetypes. Archetype 1: “Relaxed Optimists”; Archetype 2: “Unconcerned Indifferents”; Archetype 3: “Restrained Sensitives”; Archetype 4: “Positive Absolutists”; Archetype 5: “Incautious Negativistics”; Archetype 6: “Resigned Savers”.

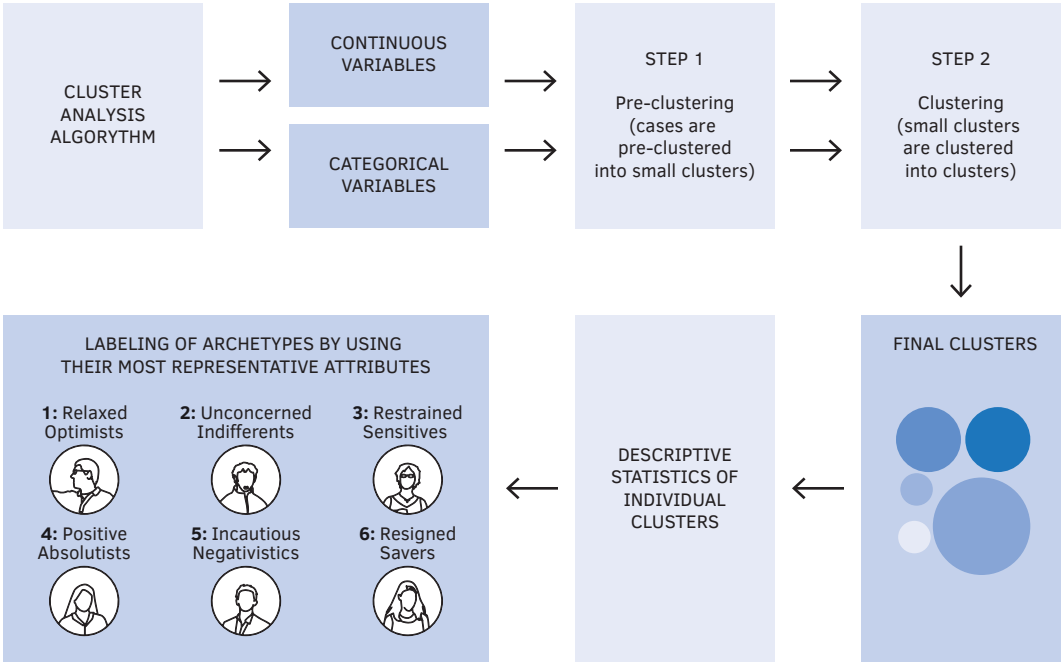


FIG. 3.2 Flow diagram of process from Two Step Cluster Analysis to Archetype naming.



TOC

TABLE 3.3 Final Solution variables and predictor importance

| Predictor Importance | Final solution | First half solution | Second half solution |
|---|---|---|---|
| 0.8-1.0 | – Satisfaction (1.00)<br>– Joy (0.92)<br>– Fascination (0.87) | – Admiration (1.00)<br>– Satisfaction (0.89)<br>– Shame (0.88)<br>– Dissatisfaction (0.88)<br>– Internal control – freedom action (0.83) | – Satisfaction (1.00)<br>– Joy (0.94)<br>– Affordance- Safety (0.57) |
| 0.6-0.79 | – Admiration (0.74)<br>– Affordance- Safety (0.69)<br>– Pride (0.64) | – Joy (0.73)<br>– Attitudes – water heating (0.69)<br>– Affordance – Freedom of expression (0.69)<br>– Internal control – Personalization (0.61)<br>– Pride (0.60) | |
| 0.4-0.59 | – Affordance – Control (0.58)<br>– Affordance – freedom of expression (0.53)<br>– Dissatisfaction (0.40)<br>– External control – climate (0.40)<br>– Disgust (0.40)<br>– Internal control – freedom action (0.40) | – Boredom (0.59)<br>– Affordance – Spatial quality (0.57)<br>– External control – Climate (0.48)<br>– Affordance – Cleanliness (0.46)<br>– Disgust (0.43)<br>– Attitudes – behaviour change (0.40) | – Affordance- Safety (0.57)<br>– Affordance – freedom of expression (0.57)<br>– Disgust (0.53)<br>– Fascination (0.47)<br>– Pride (0.45)<br>– Admiration (0.44)<br>– Attitudes – behaviour change (0.41) |
| 0.2-0.39 | – Shame (0.33)<br>– Affordance – Air quality (0.30)<br>– Internal control – Relaxation (0.29)<br>– Affordance – cleanliness (0.27)<br>– Affordance – lighting quality (0.24)<br>– Boredom (0.20) | – Affordance – Control (0.36)<br>– Internal control – Relaxation (0.33)<br>– Affordance – light quality (0.32)<br>– Affordance – air quality (0.22)<br>– Fascination (0.22) | – Internal control – freedom of action (0.37)<br>– Affordance – lighting quality (0.36)<br>– Boredom (0.32)<br>– Affordance – cleanliness (0.30)<br>– External control – climate (0.27)<br>– Affordance – Control (0.27)<br>– Internal control – Personalization (0.25)<br>– Internal control – climate (0.21)<br>– Internal control – Relaxation (0.20)<br>– Dissatisfaction (0.20) |
| 0.00-0.19 | – Internal control – Personalization (0.19)<br>– Affordances – spatial (0.18)<br>– Attitudes – Behaviour change (0.16)<br>– Habits – Personalize the place (0.14)<br>– Attitudes – water heating (0.13)<br>– Habits – warm up (0.10)<br>– Internal control – Climate (0.09) | – Habits- warm up (0.18)<br>– Habits – personalize the place (0.06)<br>– Internal control – Climate (0.04) | – Attitudes – water heating (0.15)<br>– Habits – personalize the place (0.11)<br>– Affordance – Air quality (0.07)<br>– Shame (0.04)<br>– Habits- warm up (0.02) |

*Table 3.3 shows the final solution of the full database, in addition to the solutions of the database when split in halves. The predictor importance indicates the importance of variables predicating the model. It is suggested that variables with a low rating (0.02 or lower) should be avoided in the final solution. In addition comparison of the two halves with the final model shows relative minor changes in the importance of variables, thereby suggesting the variables of the final solution to be appropriate for the model.*

### 3.3.3 Description of identified Archetypes

In this study, the definition of an archetype is the representation of a home occupant segment that embodies the most salient attitudinal, emotional, and behavioural responses of that specific segment to the home environment and energy use. In traditional archetype studies, it is proposed that members of each archetype share similar subconscious cognitive processes. These processes influence the members of a segment -in this case the home occupants- to respond in similar ways to certain stimuli of their environment (Hogg & Reid, 2006).

In the following tables, (Table 3.4 to Table 3.10) the descriptive results of the individual clusters are presented.

TABLE 3.4 General Characteristics

| Characteristics | Total n (%) | C1 – 25.4% | C2 - 14.5% | C3 - 17.1% | C4 - 17.1% | C5 - 9.8% | C6 - 16.1% |
|---|---|---|---|---|---|---|---|
| **Personal** | | | | | | | |
| **Gender** | | | | | | | |
| Men | 115 (51.8) | 24 (49.0) | 18 (64.3) | 17 (51.5) | 18 (56.3) | 9 (47.4) | 16 (51.6) |
| Women | 107 (48.2) | 25 (51.0) | 10 (35.7) | 16 (48.5) | 14 (43.8) | 10 (52.6) | 15 (48.4) |
| **Age (years)** | | | | | | | |
| Mean (SD) | 20.3 (2.2) | 20.6 (2.4) | 20.1 (1.2) | 21.1 (3.3) | 20.0 (2.0) | 20.9 (2.4) | 19.9 (1.4) |
| **Highest education level** | | | | | | | |
| Primary or Secondary school | 179 (80.3) | 40 (81.6) | 22 (78.6) | 28 (84.8) | 26 (78.8) | 14 (73.7) | 22 (71.0) |
| Some college | 6 (2.7) | 1 (2.0) | 0 (0.0) | 2 (6.1) | 0 (0.0) | 1 (5.3) | 1 (3.2) |
| Completed Bachelors | 6 (2.7) | 1 (2.0) | 1 (3.6) | 2 (6.1) | 1 (3.0) | 0 (0.0) | 1 (3.2) |
| Completed Masters | 32 (14.3) | 7 (14.3) | 5 (17.9) | 1 (3.0) | 6 (18.2) | 4 (21.1) | 7 (22.6) |
| Doctorate | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| **Nationality** | | | | | | | |
| Dutch | 210 (94.2) | 48 (98.0) | 27 (96.4) | 28 (84.8) | 31 (93.9) | 17 (89.5) | 31 (100.0) |
| Greek | 3 (1.3) | 1 (2.0) | 0 | 2 (6.1) | 0 | 0 | 0 |
| Turkish | 2 (0.9) | 0 | 0 | 1 (3.0) | 0 | 1 (5.3) | 0 |
| Others | 8 (3.6) | 0 | 1 (3.6) | 2 (6.1) | 2 (6.1) | 1 (5.3) | 0 |
| **Interested in a follow-up** | | | | | | | |
| Yes | 71 (31.8) | 14 (28.6) | 5 (17.9) | 11 (33.3) | 12 (36.4) | 7 (36.8) | 14 (45.2) |
| No | 152 (68.2) | 35 (71.4) | 23 (82.1) | 22 (66.7) | 21 (63.6) | 12 (63.2) | 17 (54.8) |

>>>

TABLE 3.4 General Characteristics

| Characteristics | Total n (%) | C1 – 25.4% | C2 - 14.5% | C3 - 17.1% | C4 - 17.1% | C5 - 9.8% | C6 - 16.1% |
|---|---|---|---|---|---|---|---|
| **Location of home** | | | | | | | |
| Delft | 151(67.7) | 33 (67.3) | 15 (53.6) | 24 (72.7) | 20 (60.6) | 12 (63.2) | 25 (80.6) |
| Amsterdam | 11 (4.9) | 2 (4.1) | 1 (3.6) | 3 (9.1) | 2 (6.1) | 1 (5.3) | 1 (3.2) |
| The Hague | 7 (3.1) | 2 (4.1) | 1 (3.6) | 1 (3.0) | 1 (3.0) | 0 | 2 (6.5) |
| Rotterdam | 4 (1.8) | 2 (4.1) | 1 (3.6) | 0 | 0 | 0 | 0 |
| Zoetermeer | 4 (1.8) | 1 (2.0) | 1 (3.6) | 0 | 1 (3.0) | 1 (5.3) | 0 |
| Other | 50 (22.4) | 9 (18.0) | 9 (32.4) | 5 (15.0) | 9 (18.0) | 5 (26.5) | 3 (3.6) |
| **Building Variables** | | | | | | | |
| **Building type** | | | | | | | |
| Apartment | 55 (24.7) | 14 (28.6) | 5 (17.9) | 9 (27.3) | 7 (21.2) | 5 (26.3) | 6 (19.4) |
| Gallery apartment (with main door in a common external corridor) | 41 (18.4) | 9 (18.4) | 7 (25.0) | 6 (18.2) | 5 (15.2) | 5 (26.3) | 5 (16.1) |
| Row house (with shared side walls) | 84 (37.7) | 20 (40.8) | 10 (35.7) | 10 (30.3) | 16 (48.5) | 6 (31.6) | 12 (38.7) |
| Semidetached house (sharing one common wall) | 7 (3.1) | 2 (4.1) | 1 (3.6) | 1 (3.0) | 2 (6.1) | 0 (0.0) | 1 (3.2) |
| Detached house (free-standing) | 18 (8.1) | 2 (4.1) | 4 (14.3) | 4 (12.1) | 2 (6.1) | 0 (0.0) | 1 (3.2) |
| Other* | 18 (8.1) | 2 (4.1) | 1 (3.6) | 3 (9.1) | 1 (3.0) | 3 (15.8) | 6 (19.4) |
| **Occupants** | | | | | | | |
| **Number of people living in same house** | | | | | | | |
| Over age of 18 – mean (SD) | 5.6 (4.6) | 5.6 (4.3) | 5.3 (4.0) | 4.8 (2.8) | 5.8 (6.1) | 5.1 (3.8) | 7.6 (6.6) |
| Under age of 18 – mean (SD) | 0.7 (1.0) | 1.1 (0.9) | 0.7 (0.8) | 0.2 (0.4) | 0.9 (1.0) | 1.0 (0.7) | 0.3 (0.5) |
| **Type of occupant** | | | | | | | |
| Family members | 53 (23.8) | 14 (28.6) | 10 (35.7) | 6 (18.2) | 10 (30.3) | 5 (26.3) | 3 (9.7) |
| Housemates | 148 (66.4) | 30 (61.2) | 18 (64.3) | 25 (75.8) | 20 (60.6) | 11 (57.9) | 23 (74.2) |
| (Un)married couple | 10 (4.5) | 2 (4.1) | 0 | 2 (6.1) | 1 (3.0) | 1 (5.3) | 3 (9.7) |
| Alone | 12 (5.4) | 3 (6.1) | 0 | 0 | 2 (6.1) | 2 (10.5) | 2 (6.5) |
| **Tenure** | | | | | | | |
| Owner | 38 (17.1) | 10 (20.8) | 6 (21.4) | 4 (12.1) | 10 (30.3) | 4 (21.1) | 2 (6.5) |
| Renter | 184 (82.9) | 38 (79.2) | 22 (78.6) | 29 (87.9) | 23 (69.7) | 15 (78.9) | 29 (93.5) |
| **Time residing in the house** | | | | | | | |
| Less than 6 months | 48 (21.5) | 10 (20.4) | 3 (10.7) | 8 (24.2) | 12 (36.4) | 1 (5.3) | 7 (22.6) |
| 6 to 12 months | 47 (21.1) | 8 (16.3) | 5 (17.9) | 6 (18.2) | 7 (21.2) | 2 (10.5) | 8 (25.8) |
| 1 - 5 years | 84 (37.7) | 20 (40.8) | 12 (42.9) | 14 (42.4) | 5 (15.2) | 11 (57.9) | 14 (45.2) |
| More than 5 years | 44 (19.7) | 11 (22.4) | 8 (28.6) | 5 (15.2) | 9 (27.3) | 5 (26.3) | 2 (6.5) |

* *8 respondents specified "Student housing" which is not a building type.*

TABLE 3.5 Health and Symptoms

| Health in the last 12 months | N (%) | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| Asthma | 15 (6.7) | 2 (4.1) | 3 (10.7) | 1 (3.0) | 1 (3.0) | 3 (15.8) | 3 (9.7) |
| Bronchitis/bronchial pneumonia | 12 (5.8) | 4 (8.2) | 2 (7.1) | 0 (0.0) | 2 (6.1) | 1 (5.3) | 3 (9.7) |
| Wheezing or whistling in the chest | 21 (9.5) | 4 (8.2) | 3 (11.1) | 3 (9.1) | 3 (9.1) | 3 (15.8) | 3 (9.7) |
| Other chest condition | 10 (4.5) | 1 (2.0) | 0 (0.0) | 3 (9.1) | 3 (9.1) | 1 (5.3) | 0 (0.0) |
| Hay fever | 61 (27.6) | 12 (24.5) | 4 (14.8) | 0 (0.0) | 10 (30.3) | 8 (42.1) | 14 (45.2) |
| Allergic rhinitis | 96 (43.0) | 22 (44.9) | 10 (35.7) | 14 (42.4) | 15 (45.5) | 11 (57.9) | 17 (54.8) |
| Eczema | 37 (16.7) | 6 (12.2) | 5 (18.5) | 5 (15.2) | 5 (15.2) | 2 (10.5) | 11 (35.5) |
| Dermatitis | 6 (2.7) | 3 (6.1) | 0 (0.0) | 1 (3.0) | 0 (0.0) | 2 (10.5) | 0 (0.0) |
| Other skin conditions | 30 (13.5) | 7 (14.3) | 5 (18.5) | 3 (9.1) | 4 (12.1) | 4 (21.1) | 3 (9.7) |
| High lipids in the blood | 1 (0.5) | 1 (2.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Diabetes | 1 (0.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (3.2) |
| High blood pressure | 3 (1.4) | 3 (6.1) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Heart conditions | 1 (0.5) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (3.0) | 0 (0.0) | 0 (0.0) |
| Migraine | 28 (12.6) | 7 (14.3) | 2 (7.4) | 4 (12.1) | 9 (27.3) | 1 (5.3) | 2 (6.5) |
| Depression | 24 (10.8) | 3 (6.1) | 3 (11.1) | 6 (18.2) | 4 (12.1) | 5 (26.3) | 3 (9.7) |
| Anxiety | 37 (16.7) | 10 (20.4) | 3 (11.1) | 7 (21.2) | 5 (15.2) | 6 (31.6) | 3 (9.7) |
| Psychiatric problems | 13 (5.9) | 3 (6.1) | 2 (7.1) | 3 (9.1) | 1 (3.0) | 4 (21.1) | 0 (0.0) |
| Other problems | 35 (15.8) | 6 (12.2) | 2 (7.4) | 10 (30.3) | 3 (9.1) | 5 (26.3) | 4 (12.9) |
| **Symptoms while at home -** At least once every 2-3 weeks, Related to indoor environment (yes and partly) | | | | | | | |
| Dry Eyes | 36 (7.4) | 6 (4.5) | 3 (3.6) | 8 (18.2) | 3 (3.3) | 7 (26.0) | 6 (8.0) |
| Itchy or watery eyes | 21 (4.8) | 1 (1.2) | 2 (2.0) | 5 (8.5) | 3 (4.0) | 5 (12.2) | 5 (12.5) |
| Blocked nose | 57 (20.0) | 11 (15.5) | 5 (16.0) | 9 (23.0) | 7 (17.0) | 7 (32.0) | 10 (29.3) |
| Runny nose | 40 (13.4) | 6 (8.0) | 5 (15.7) | 6 (12.9) | 6 (14.5) | 5 (20.4) | 6 (16.2) |
| Sneezing | 59 (22.7) | 13 (22.9) | 4 (11.3) | 6 (15.0) | 10 (23.5) | 9 (49.4) | 10 (31.0) |
| Dry throat | 37 (10.4) | 10 (13.9) | 1 (1.6) | 3 (5.3) | 8 (14.1) | 6 (27.1) | 5 (13.0) |
| Lethargy | 25 (9.4) | 6 (11.4) | 2 (5.2) | 5 (12.0) | 2 (4.5) | 5 (27.7) | 3 (8.0) |
| Headaches | 17 (5.6) | 3 (4.3) | 3 (9.5) | 0 (0.0) | 1 (2.0) | 4 (18.5) | 3 (7.2) |
| Dry, itchy, irritated skin | 24 (5.3) | 4 (4.2) | 3 (5.3) | 6 (7.4) | 2 (2.4) | 4 (16.6) | 1 (1.5) |
| Breathing difficulty | 11 (1.1) | 1 (0.3) | 1 (0.7) | 1 (0.8) | 1 (0.8) | 3 (5.5) | 3 (1.5) |
| Other symptoms | 4 (0.1) | 0 (0.0) | 1 (0.3) | 0 (0.0) | 1 (0.3) | 0 (0.0) | 1 (0.7) |

TABLE 3.6 Emotions towards the home

| Emotions towards your home | Total | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| **mean (SD) / 1: I don't feel this at all – 5: I feel this strongly** | | | | | | | |
| **Positive emotions** | | | | | | | |
| Desire | 3.2 (1.1) | 3.2 (1.2) | 3.1 (1.0) | 3.2 (1.0) | 3.2 (1.2) | 3.1 (1.1) | 3.4 (1.0) |
| Satisfaction* | 3.6 (0.9) | 3.9 (0.6) | 4.0 (0.5) | 2.7 (0.7) | 4.2 (0.6) | 2.2 (0.8) | 4.1 (0.7) |
| Pride* | 3.3 (1.2) | 3.3 (1.0) | 3.1 (1.1) | 2.5 (1.3) | 4.2 (0.7) | 2.0 (1.0) | 4.1 (0.7) |
| Hope | 2.8 (1.2) | 2.5 (1.1) | 2.4 (1.1) | 2.8 (1.2) | 3.2 (1.1) | 2.6 (1.3) | 3.0 (1.0) |
| Joy* | 3.7 (0.9) | 4.0 (0.4) | 3.4 (0.8) | 2.9 (0.9) | 4.1 (0.4) | 2.5 (1.1) | 4.3 (0.5) |
| Fascination* | 2.7 (1.2) | 2.2 (0.9) | 2.3 (1.0) | 1.9 (0.9) | 3.9 (0.7) | 2.1 (1.2) | 3.7 (1.1) |
| Admiration* | 2.5 (1.2) | 2.1 (0.9) | 1.9 (0.9) | 1.9 (1.1) | 3.6 (0.8) | 2.0 (0.9) | 3.6 (1.0) |
| **Negative emotions** | | | | | | | |
| Disgust* | 1.8 (1.0) | 1.3 (0.6) | 1.4 (0.6) | 2.0 (1.1) | 1.7 (0.8) | 2.9 (1.3) | 2.1 (1.2) |
| Dissatisfaction* | 2.1 (1.2) | 1.6 (0.8) | 1.9 (1.1) | 2.5 (1.1) | 1.7 (1.0) | 3.4 (1.5) | 2.0 (1.0) |
| Shame* | 1.6 (0.9) | 1.2 (0.5) | 1.4 (0.6) | 1.4 (0.7) | 1.6 (0.8) | 2.6 (1.3) | 1.8 (1.2) |
| Fear | 1.4 (0.8) | 1.2 (0.5) | 1.1 (0.5) | 1.6 (1.1) | 1.6 (0.8) | 1.8 (1.1) | 1.5 (0.9) |
| Sadness | 1.4 (0.9) | 1.1 (0.4) | 1.2 (0.5) | 1.7 (0.8) | 1.4 (0.7) | 2.0 (1.3) | 1.6 (1.0) |
| Boredom* | 2.0 (1.1) | 1.7 (0.7) | 1.7 (0.7) | 2.5 (1.4) | 1.9 (1.0) | 2.7 (1.2) | 1.9 (1.2) |
| Contempt | 1.4 (0.7) | 1.1 (0.5) | 1.1 (0.4) | 1.7 (1.0) | 1.5 (0.7) | 1.8 (0.9) | 1.4 (0.7) |

* *Variables predicting final solution ($p<0.001$)*

TABLE 3.7 Affordances: Elements of the home environment necessary to achieve comfort.

| Environmental Affordances | | | | | | | |
|---|---|---|---|---|---|---|---|
| **mean (SD) / 1: I don't need it to feel comfortable – 5: Very important for my comfort** | | | | | | | |
| Adequate temperature | 3.6 (0.9) | 3.6 (1.0) | 3.3 (1.1) | 3.7 (0.9) | 3.8 (0.5) | 3.1 (0.9) | 3.6 (0.9) |
| Air freshness* | 3.9 (0.8) | 4.1 (0.7) | 3.5 (0.8) | 4.2 (0.8) | 4.2 (0.5) | 3.5 (1.1) | 3.6 (0.7) |
| Acoustical quality | 3.2 (1.0) | 3.2 (1.2) | 3.3 (0.8) | 3.3 (1.1) | 3.6 (0.8) | 2.9 (1.1 | 2.9 (0.9) |
| Lighting quality* | 3.5 (0.8) | 3.6 (0.7) | 3.3 (0.7) | 3.8 (0.9) | 4.0 (0.5) | 3.1 (0.9) | 3.3 (0.7) |
| Freedom of interaction | 3.7 (0.9) | 3.8 (0.8) | 3.4 (0.7) | 3.8 (1.1) | 4.1 (0.5) | 3.7 (1.0) | 3.6 (0.9) |
| Control of systems* | 3.1 (1.0) | 3.2 (0.9) | 2.9 (0.8) | 3.2 (1.1) | 4.2 (0.4) | 2.8 (1.1) | 2.6 (0.9) |
| Freedom of being* | 3.8 (0.9) | 4.0 (0.6) | 3.0 (0.6) | 2.8 (1.1) | 4.4 (0.4) | 3.7 (0.8) | 3.7 (1.0) |
| Privacy* | 4.0 (0.9) | 4.2 (0.8) | 3.2 (0.8) | 4.3 (0.7) | 4.5 (0.5) | 3.2 (0.9) | 3.7 (0.8) |
| Spatial quality (layout and size)* | 3.6 (0.9) | 3.8 (0.7) | 3.1 (0.8) | 3.8 (0.8) | 4.0 (0.7) | 3.2 (1.2) | 3.4 (1.0) |
| Cleanliness and orderliness* | 3.5 (1.0) | 3.6 (0.8) | 3.1 (0.8) | 3.7 (1.1) | 4.0 (0.8) | 2.7 (0.8) | 3.1 (1.1) |

* Variables predicting final solution ($p<0.001$)

TABLE 3.8 Locus of Control

| Control | Total | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| **mean (SD) / 1: Strongly disagree – 5: Strongly agree.** | | | | | | | |
| Internal control | | | | | | | |
| **Freedom of action*:** I am able to do everything I want in my home, in accordance to my personal ideas. | 3.5 (1.0) | 3.6 (1.0) | 3.8 (0.7) | 3.0 (0.9) | 4.2 (0.7) | 2.6 (1.1) | 3.5 (0.9) |
| **Privacy:** The feeling of privacy in my home is entirely determined by myself. | 2.9 (1.0) | 2.9 (1.1) | 2.8 (0.8) | 2.9 (1.0) | 3.2 (1.1) | 2.6 (1.1) | 2.8 (1.1) |
| **Spatial:** Regardless of the size of my home, I can make myself comfortable there. | 3.9 (0.9) | 4.1 (0.9) | 3.7 (0.9) | 3.7 (0.9) | 3.9 (0.9) | 3.6 (0.8) | 3.7 (0.9) |
| **Order and cleanliness:** It is up to me whether my home environment is kept in a tidy and clean state. | 3.9 (0.9) | 4.2 (0.8) | 3.9 (0.9) | 3.9 (0.8) | 3.8 (0.9) | 3.6 (1.1) | 3.7 (1.0) |
| **Climate*:** I carefully control the temperature of my home to keep me comfortable. | 2.7 (1.1) | 2.2 (1.0) | 3.1 (0.9) | 2.7 (1.2) | 2.9 (1.3) | 2.7 (1.0) | 2.8 (1.1) |
| **Relaxation*:** I am able to de-stress at home whenever I want. | 3.5 (1.0) | 3.7 (1.0) | 3.6 (0.7) | 3.1 (1.0) | 4.0 (0.7) | 2.6 (0.9) | 3.4 (0.9) |
| **Atmosphere:** It is up to me whether or not I make the atmosphere I want in my home. | 3.6 (0.9) | 3.7 (0.9) | 3.4 (0.8) | 3.6 (1.0) | 3.8 (0.8) | 3.1 (1.1) | 3.5 (0.9) |
| **Personalization*:** The way my home looks and feels reflects my personality. | 3.4 (0.9) | 3.5 (0.8) | 3.4 (0.8) | 3.2 (0.8) | 3.8 (1.0) | 3.1 (1.1) | 3.5 (1.0) |
| **Mood:** I make an effort to get the right mood in my home. | 3.6 (0.9) | 3.6 (0.9) | 3.4 (0.9) | 3.5 (1.0) | 4.1 (0.6) | 3.7 (0.9) | 3.5 (0.9) |

>>>

TABLE 3.8 Locus of Control

| Control | Total | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| External control | | | | | | | |
| **Freedom of action:** To a great extent, I do not plan the actions and activities that I carry out in my home. | 3.1 (1.0) | 3.2 (1.1) | 3.2 (1.0) | 3.3 (1.0) | 2.9 (1.0) | 3.5 (0.9) | 3.1 (0.9) |
| **Privacy:** Whether or not my home offers me the sense of privacy depends on fortunate circumstances. | 2.7 (0.9) | 2.6 (0.9) | 2.6 (0.7) | 2.7 (1.0) | 2.8 (1.0) | 2.6 (0.8) | 2.8 (0.9) |
| **Spatial:** Feeling comfortable in my home is a matter of the layout and size of my house. | 2.9 (1.0) | 2.9 (1.0) | 2.9 (0.8) | 2.9 (1.0) | 2.8 (0.8) | 2.6 (1.1) | 3.0 (1.0) |
| **Order and cleanliness:** I can't completely control the cleanliness of my home: they are the result of time. | 2.9 (1.0) | 3.0 (1.0) | 2.8 (0.9) | 3.1 (0.8) | 2.9 (1.2) | 3.5 (1.0) | 2.7 (1.1) |
| **Climate*:** The temperature in my home is pretty much determined by the house itself. | 3.2 (0.9) | 3.3 (0.9) | 2.9 (0.5) | 3.4 (1.1) | 2.8 (0.8) | 2.7 (1.1) | 3.7 (0.9) |
| **Relaxation:** Having a stress-free environment in my home is all luck: I cannot influence it. | 2.5 (1.0) | 2.3 (1.0) | 2.5 (1.0) | 2.8 (1.2) | 2.5 (1.1) | 2.5 (0.8) | 2.7 (0.9) |
| **Atmosphere:** The atmosphere in my home is the way it is, without me doing anything about it. | 2.7 (0.9) | 2.8 (0.8) | 2.7 (0.7) | 2.7 (0.9) | 2.4 (1.0) | 2.5 (1.1) | 3.1 (0.9) |
| **Personalization:** It is only a coincidence whether my home seems to reflect my personality or not. | 2.3 (1.0) | 2.3 (1.0) | 2.4 (1.0) | 2.5 (1.2) | 2.3 (1.1) | 2.4 (1.2) | 2.4 (1.1) |
| **Mood:** The mood of my home is something that just happens by itself. | 3.1 (1.0) | 3.2 (0.9) | 2.3 (0.7) | 3.0 (0.9) | 3.2 (1.1) | 2.5 (0.9) | 3.1 (1.1) |

* *Variables predicting final solution ($p<0.001$)*

TABLE 3.9 Attitudes towards energy and energy consumption

| Attitudes towards energy | Total | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| **mean (SD)** | | | | | | | |
| **Behavioural intentions** | | | | | | | |
| **1: Definitely yes – 5: Definitely not** | | | | | | | |
| Willingness to change behaviour to use less energy* | 2.2 (0.9) | 2.1 (0.9) | 2.5 (0.7) | 2.4 (1.0) | 1.8 (0.6) | 2.5 (1.1) | 2.2 (0.9) |
| Willingness to live with less comfort to save energy | 3.1 (1.0) | 3.1 (1.0) | 3.0 (1.0) | 3.2 (1.0) | 3.2 (0.8) | 3.2 (11) | 2.9 (0.9) |
| **Social comparison attitudes towards energy use** | | | | | | | |
| **1: much more than others – 5: much less than others** | | | | | | | |
| Space heating | 3.4 (1.0) | 3.4 (1.1) | 3.8 (1.1) | 3.3 (1.1) | 3.6 (1.0) | 3.3 (1.1) | 3.4 (0.9) |
| Water heating* | 2.9 (0.7) | 2.9 (0.9) | 3.2 (0.5) | 2.9 (0.7) | 2.7 (0.7) | 3.0 (0.9) | 3.1 (0.8) |
| Use of energy-consuming products | 3.0 (0.7) | 2.9 (0.9) | 2.8 (0.7) | 3.1 (0.7) | 3.0 (0.8) | 2.7 (0.7) | 3.1 (0.8) |
| **Actual expenditure knowledge** | | | | | | | |
| **Yes, I know – n (%)** | | | | | | | |
| Electricity | 6 (2.7) | 1 (2.0) | 1 (3.6) | 1 (3.0) | 1 (3.0) | 1 (5.3) | 0 (0.0) |
| Gas | 8 (3.6) | 1 (2.0) | 1 (3.6) | 2 (6.1) | 1 (3.0) | 1 (5.3) | 1 (3.2) |

* *Variables predicting final solution (p<0.001)*

TABLE 3.10 Habits

| | Total | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|---|
| **Yes, I use energy for behaviour X – n (%)** | | | | | | | |
| Relax | 63 (28.3) | 15 (30.6) | 7 (25.0) | 8 (24.2) | 10 (30.3) | 8 (42.1) | 7 (22.6) |
| Warm up* | 163 (73.1) | 30 (61.2) | 16 (57.1) | 29 (87.9) | 25 (75.8) | 15 (78.9) | 28 (90.3) |
| Clean up | 104 (46.6) | 25 (51.0) | 13 (46.4) | 15 (45.5) | 18 (54.5) | 9 (47.4) | 9 (29.0) |
| Personalize the place | 22 (9.9) | 5 (10.2) | 3 (10.7) | 4 (12.1) | 4 (12.1) | 3 (15.8) | 1 (3.2) |
| Socialize in person | 52 (23.3) | 12 (24.5) | 5 (17.9) | 7 (21.2) | 9 (27.3) | 9 (47.4) | 5 (16.1) |
| Socialize online | 117 (52.5) | 29 (59.2) | 17 (60.7) | 14 (42.4) | 18 (54.5) | 13 (68.4) | 19 (61.3) |
| Freshen up | 142 (63.7) | 34 (69.4) | 19 (67.9) | 18 (54.5) | 26 (78.8) | 10 (52.6) | 21 (67.7) |
| Feel privacy | 26 (11.7) | 5 (10.2) | 4 (14.3) | 5 (15.2) | 4 (12.1) | 3 (15.8) | 2 (6.5) |
| Do my hobbies | 61 (27.4) | 14 (28.6) | 9 (32.1) | 10 (30.3) | 8 (24.2) | 9 (47.4) | 7 (22.6) |
| Create a mood* | 74 (33.2) | 10 (20.4) | 7 (25.0) | 19 (57.6) | 18 (54.5) | 5 (26.3) | 9 (29.0) |
| Cook | 197 (88.3) | 46 (93.9) | 24 (85.7) | 26 (78.8) | 29 (87.9) | 18 (94.7) | 29 (93.5) |

* *Variables predicting final solution (p<0.001)*

## Archetype 1: Relaxed Optimists

**General characteristics:** The Relaxed Optimists (ROs), represents a quarter of the sample (n=49), they are balanced in terms of gender (51% women) and 32% reported to be interested in a follow up of the study. The ROs are the group with highest percentage of apartment occupiers (29%); however, most (41%) live in a row house, and 61% of them with on average 5.6 housemates.

**Health status and symptoms:** The ROs report the lowest rate for wheezing (8%) and depression (6%); but have the highest prevalence (8%) of hypertension or high blood lipids. They also report the lowest rates of different nasal-ocular as well as that of breathing difficulties (0.3%).

**Emotions:** As far as positive emotions are concerned, joy (4.0) and satisfaction (3.9) are high among ROs. For negative emotions, ROs feel them the lowest: disgust (1.3), dissatisfaction (1.6), shame (1.2), and boredom (1.7).

**Affordances:** ROs report privacy (4.2), air freshness (4.1); freedom of being (4.0), spatial quality (3.8) cleanliness and acoustical quality (3.6) as rather important for them to feel comfortable, with the least important affordance being having the possibility of controlling systems (3.2) (i.e. thermostats, shade controllers, etc.).

**Control:** ROs report low internal control for climate (3.2) representing the lowest for any group, while they also report the highest rates for controlling the indoor layout to achieve comfort (4.1) and that of cleaning and ordering (4.2). Relaxing (3.7), personalizing (3.5), and being free to do what they want (3.6) resulted in slightly above average ratings for ROs. For external control, relaxation is low (2.3), while the mood of their home is something they do not have to actively control to feel comfortable (3.2)

**Attitudes:** ROs are relatively willing to change their behaviours to save energy; however, they are more unwilling to give up comfort for the same end (3.1). Furthermore, they have the belief that they spend slightly less energy than others do.

**Habits:** ROs are the group that reports to spend least energy for changing or creating the mood (20%). Additionally, they are the second lowest group for energy expenditure for warming up habits (61%).

## Archetype 2: Unconcerned Indifferents

**General characteristics:** The Unconcerned Indifferents (UI) is made of 28 respondents (14.5%) and has the highest proportion of men (64%). They are the least interested group in a follow-up of the present research (18%). It is the group that needs to commute the most, with 53% living where they study, they represent the lowest percentage of apartment occupiers (18%); 36% live in a row house, while also being the group that lives the most with family members (36%).

**Health status and symptoms:** UIs have the lowest rates in rhinitis (36%) and "other problems" (7%). They also report the lowest rates in sneezing (11%) and dry throat (2%).

**Emotions:** UIs seem to have in general moderate feelings, both negative and positive. They report the lowest in desire, hope, and admiration (3.1; 2.4; 1.9), while also having the lowest rating for boredom (1.7); however their dissatisfaction is low (1.9); while having a high satisfaction (4.0), but moderate pride (3.1), joy (3.4), and fascination (2.3).

**Affordances:** The UIs are generally unconcerned by the affordances offered by the home environment, they report the lowest rating for affordances of air freshness (3.5), privacy (3.2), and spatial quality (3.1), while also lower-than-average ratings for lighting quality (3.3), control of systems (2.9), cleanliness (3.1), and freedom of action (3.0).

**Control:** UIs report the highest internal control for their home climate (3.1). They also report higher than average internal control scores for freedom of action (3.8) and relaxation (3.6). In external control, they report no need for creating private spaces (2.6), being the lowest score for all groups; while showing lower-than-average score for external control of climate (2.9) – supporting their high score in the internal scale of this variable.

**Attitudes:** UIs have the strongest refusal for willingness to change their behaviour for saving energy (2.5), while having the second highest lack of will for giving up comfort (3.0). Additionally, they report the highest ratings in comparing themselves to others, with the belief that they spend much less energy for both space and water heating (3.8 and 3.2).

**Habits:** Only 57% of UIs report to spend energy for warming up, which is the lowest rate of all groups.

## Archetype 3: Restrained Sensitives

**General characteristics:** The Restrained Sensitives (RS) is made of 33 respondents (17.1%) and has a balanced proportion of men and women (48.5%). 33% of them are interested in a follow-up of the study. The group is the oldest, with a mean age of 21.1. About 73% of them live in the same city where they study, and have the lowest rates of row-house occupiers (30.3%), while 27% live in an apartment. 76% live with housemates, however, they live with the lowest number thereof (4.8). Finally, they are the second largest renter group, with 88%.

**Health status and symptoms:** RSs score the lowest rates of prevalence in four diseases: asthma (3%), bronchitis (0.0%), hay fever (0.0%), and skin conditions (9.1%), making them in this regard, the healthiest group. Nevertheless, they do present the highest rate of 'other problems' (30%). However, in terms of symptoms, they present higher than average rates in dry and watery eyes (18% and 9%), as well as blocked nose and lethargy (23% and 12%).

**Emotions:** RSs have rather low positive emotions, scoring the lowest for both fascinations and admiration (1.9 both). With satisfaction (2.7), pride (2.5), and joy (2.9). On the other hand, their negative emotions result in higher than average scores: disgust (2.0), dissatisfaction (2.5), boredom (2.5), with the exception being shame (1.4).

**Affordances:** RS find sensorial affordances important for their comfort, namely air freshness (4.2), which is reported as highest of all groups, as well as lighting quality (3.8) and cleanliness (3.7) both having the second highest scores. As far as psychological affordances are concerned, they rate second highest with privacy, (4.3), spatial quality (3.8), and choice of control (3.2); however they score lowest with freedom of being (2.8).

**Control:** RSs report slightly lower than average rates in internal control, while slightly higher than average scores for external control. Thus, in internal control they report second lowest in freedom of action (3.0), climate (2.7), relaxation (3.1), and personalization (3.2). While for external, they score second highest for climate (3.4), and highest for relaxation and personalization (2.8; 2.5).

**Attitudes:** RSs show a very slight willingness to change behaviour to save comfort (2.4); this is however, the second highest score for unwillingness. Additionally, they score highest with willingness to give up comfort (3.2). Additionally, they report to spend slightly less than others on water heating (2.9).

**Habits:** RSs scored the smallest percentage in spending energy as a habit on online socializing (42%) as well las for cooking (79%), and the highest for creating the mood (57.6%), while for warming up, they represent the second highest group (88%).

## Archetype 4: Positive Absolutists

**General characteristics:** The Positive Absolutists (PAs) is made of 33 respondents (17.1) and has a high proportion of men (56%). They are the second youngest group (20.0) and 61% of them live where they study, thus, being the second group that needs to commute the most. About half of them live in row houses and 60% of them with housemates. It is the group with fewer renters: 70%, while also having the largest proportion of occupants living less than 6 months in the home (36%).

**Health status and symptoms:** PAs is the second healthiest group, with only high rates of "other chest conditions" (9%) and migraine being well over the average (27%). Additionally, they have the lowest rates of lethargy and dry eyes (4.5% and 3%) in terms of symptoms.

**Emotions:** PA have strong positive emotions towards their home, reporting the highest ratings for satisfaction (4.2), pride (4.2), hope (3.2), fascination (3.9), and admiration (3.6), while also exhibiting relatively low negative emotions.

**Affordances:** PAs report the highest rating in every single affordance, be it sensorial or psychological, therefore, for them, sensorial and psychological aspects are of high importance to feel comfortable.

**Control:** PAs show high internal control and low external control. They score highest of all groups on internal control for freedom of action (4.2), privacy (3.2), relaxation (4.0), atmosphere (3.8), personalization (3.8), and mood (4.1).

**Attitudes:** PAs report the strongest intention for behavioural change to save energy (1.8), though they report the strongest refusal for giving up comfort (3.2). Additionally, they report the strongest conviction of spending more water heating than others (2.7).

**Habits:** 75.8% of PAs report to spend energy for warming up, while the group has the largest proportion of spenders for cleaning and (55%) and freshening up the home (79%).

## Archetype 5: Incautious Negativistics

**General characteristics:** The Incautious Negativistics (IN) is made of 19 respondents (9.8%) and has the highest proportion of women (52.6%). About 37% report to be interested in a follow-up. 32% of them live in a row house, while they also have the highest percentage of gallery apartment inhabitants (26%). They are the group with smallest percentage living with housemates (58%) and the largest living alone (11%). 58% of them have lived between 1-5 years in their homes, representing the largest group for this period.

**Health status and symptoms:** INs is the group with largest prevalence of diseases. They rate highest in asthma, wheezing, rhinitis, skin conditions, high blood lipids, depression, anxiety, and 'other psychiatric problems'. They do rate with the lowest scores in migraine and eczema. Furthermore, they present the highest scores of all sorts of SBS symptoms, except for itchy eyes,

**Emotions:** INs present the highest scores in all negative emotions, and the lowest scores in all positive emotions, except for hope, fascination, and admiration. Therefore, they are the most emotionally negative group.

**Affordances:** INs report the lowest scores in importance for all sensorial affordances; and score lower than average in all psychological affordances.

**Control:** INs report the lowest ratings in internal control for all but two variables: climate and mood. For external control, they score the lowest scores in climate control options.

**Attitudes:** INs report the strongest refusal for willingness to change behaviours or to give up comfort (2.5 and 3.2). They also hold the stronger beliefs of being bigger spenders in terms of space heating, and appliance ownership (3.3 and 2.7).

**Habits:** For seven behaviours, INs represent the highest percentages of habitual energy expenditure, namely in relaxation, personalization, socializing online and in person, making privacy, doing hobbies, and cooking. They rate as the lowest spenders in freshening up (53%) while they are the third biggest spenders in warming up (79%).

## Archetype 6: Resigned Savers

**General characteristics:** The Resigned Savers (RS) is made of 31 respondents (16.1%) and has a balanced ratio of men to women (48.4%). They represent the youngest group, with a mean age of 19.9, while showing the highest interest in a follow up, with 45%. RSs have the highest percentage of people living in the place where they study (81%). 39% live in a row house, while 19% in an apartment, and report the largest number of adult co-occupants 7.6. It is the group with the highest rate of renters (94%).

**Health status and symptoms:** RS is the group with the second largest prevalence of diseases. They rate highest in bronchitis (9.7%), hay fever (45%), eczema (36%), and diabetes (3%). They do rate lowest in dermatitis, anxiety, and psychiatric problems. As far as symptoms are concerned, they rate highest in itchy and watery eyes, and lowest in dry skin, with the rest of symptoms having slightly over the average rates.

**Emotions:** RSs present the highest scores in three positive emotions: desire (3.4), joy (4.3), and admiration (3.6), while reporting higher than average scores for other positive emotions. RFs also have a tendency to experience negative emotions slightly stronger above the global average.

**Affordances:** RSs report lower than average scores in both psychological and sensorial affordances, while scoring lowest in choice of control of systems (2.6) and acoustical affordances (2.9). The have the lowest scores in importance on all sensorial affordances, while scoring lower than average in all psychological affordances.

**Control:** RSs report low scores in internal control, and some of the highest scores in external control. They report highest in privacy, spatial, mood, atmosphere, and climate. However, they report the lowest score in external control for climate.

**Attitudes:** For willingness to change behaviour, RSs report an average score of 2.2. They are however, the group that reports the strongest score on willingness to give up comfort to save energy (2.9). This is congruent with their affordance ratings.

**Habits:** For six behaviours, RSs represent the lowest percentages of habitual energy expenditure, namely in relaxation, cleaning, personalizing, socializing in person, creating privacy, and doing hobbies. However, they rate highest on warming up with 90% of them needing to spend energy for it.

## 3.4 Discussion

### 3.4.1 General

This study sheds light on how the TwoStep cluster analysis can be used as an instrument taken from marketing, to identify homogenous groups, in order to assist energy engineers, architects, and designers. It is worth noting that the aim of understanding motivation of energy consuming behaviours through occupant profiles is to achieve energy reductions through improved interactions between occupant and technology, rather than total energy reduction.

In this study, variables pertaining to psychosocial and physiological homeostasis, from a perspective of behavioural constructs (emotions, attitudes, control, habits, and affordances) in a specific domain (home environment and energy expenditure), were used to produce six groups, with a model of 25 predicting variables. It is worthwhile to note that all the constructs chosen as important for understanding behaviour (emotions, attitudes, affordances, control, and habits) were represented with the 25 final predicting variables produced by the TwoStep analysis. This suggests that both constructs and items were adequately chosen and are of relevance for the categorization of occupants in this context.

The descriptive statistics of each segment yielded insights into the mental constructs of the segments and their motivations of their own behaviours, along with health data, and demographics, and a better understanding of the energy use habits of each of the segments. This sort of data is valuable for researchers as it enables the customization of offerings to the segments, for the improvement of their health, comfort, and energy savings. Therefore, tailored-made solutions can be developed for each archetype based on their characteristics. In this study, for example, Archetype 5, the Incautious Negativistics, report the highest incidence of health problems, which is paired with weak positive emotions, strong negative emotions, low internal control, and highest number of energy expending habits. Though no correlation analysis was performed in the present study, it is worth comparing those descriptive results with earlier research that has shown that students with higher levels of external locus of control also experience higher levels of stress and higher levels of illness (Roddenberry & Renk, 2010). Moreover, in other studies, it has been found that there is a tendency for students who had a recent negative event to have an increased tendency of rhinitis, while in a Finnish study; it was found

that rhinitis was increasingly manifested when students experienced stressful life events (Bluyssen et al., 2016; Kilpeläinen, Koskenvuo, Helenius, & Terho, 2002). It has also been shown that pessimistic people tend to have more cardiovascular diseases, stress, and ill-health, and in general, live shorter lives (Byrnes et al., 1998; Costanzo et al., 2004; Kiecolt-Glaser et al., 2002)[29-31]. Therefore, this archetype represents the greatest social challenge, and thus should be considered a 'high priority' segment, since their health and energy expenditure need be improved, while taking into account their negative attitudes towards energy, and their specific locus of control. This group in particular presents an opportunity for future research, to find out the reasons why they spend more energy and their ill-health, while also understanding what their particular motivations for change could be, based on their attitudes and control levels. This archetype requires a different approach to the Positive Absolutists, who have high positive emotions, a high need of environmental affordances, and high levels of internal control.

In many cases, simply attempting to make people use less energy or change certain behaviours may be insufficient. This is because, in simple terms, there are two systems in which behavioural constructs arise: reflective and automatic (Thaler, Sunstein, & Balz, 2014). Traditionally, trying to achieve behavioural changes has been tackled from the reflective perspective: influencing behaviour with the role of rationality, information, or technology, by providing rational information that a person should understand, by offering incentives, and the like. However, it has been shown that these strategies are abstracted from the contexts in which behaviours occur, and additionally, knowledge and information do not drive behaviour. Automatic processes, related to emotions, attitudes, needs or habits –constructs which result in behaviour– are generally unconscious, irrational, and emotional (Kelly & Barker, 2016). As a result, behaviour is a blurred combination of both processes and therefore solely focusing on one strategy has proved to be insufficient. Thus, 'archetype-tailored' intervention points of two types could be implemented: hard and soft. Hard solutions address the reflective system, and their goal is to affect behaviours through contextual solutions –i.e. customized appliances, system controls, (semi)automation, defaults, and persuasive design. Soft solutions address the automatic system, affecting behaviour through the influence of emotions, attitudes, and needs.

Each of the constructs studied in this study have to be tackled with the adequate strategy to influence it. For example, attitudes can be tackled mainly with automatic strategies. Attitudes seem to be formed by attributing valence to an object (Vogel & Wanke, 2016). Changing attitudes is therefore conditioned: if the object is linked to a positive valence, the attitudes towards it may be positive. Thus, to change attitudes, the individual needs to be exposed to the object while linking it to another object with

a positive valance. In such a way the first object becomes more favourable (Vogel & Wanke, 2016). The problem of energy is that energy tends to be 'invisible' for the average user; therefore changing attitudes towards it proposes a different challenge.

Similarly, locus of control is linked to the concept of self-efficacy: the former being the degree to which an individual believes to have control over a certain behaviour, while the latter being the perceived ease of performing such behaviour (Ajzen, 2002; Bandura, 1994; Stewart & De George-Walker, 2014). In this survey, self-efficacy was not assessed since the survey focuses on beliefs about control (locus of control) rather than about how well the person thinks they will perform in given situations (Bandura, 1994). Based on this, it can be deduced that there might be people who regard their comfort as 'personally determined' (high internal control) (i.e. Archetype 4), but who believe they lack the skills needed to carry out the behaviour (low self-efficacy) that would result in comfort, this type of people would therefore see activities to improve their comfort as ineffectual. Therefore, understanding these measures can help designers and energy engineers to offer "comfort and energy-tailored interventions" by adapting these interventions to the occupants' locus of control. This approach has been used in nursing to generate behavioural change amongst alcohol consumers by offering them customized programs based on their locus of control (Strecher, McEvoy DeVellis, Becker, & Rosenstock, 1986). Because previous research suggests that locus of control is learned and conditioned from the environment, the strategies for its change should focus on the reflective system.

Finally, emotions can be used as a driver to change attitudes, as previously mentioned. Provoking emotions can be also useful to change behaviour, since emotions have a large effect on decision making and the final behavioural expressions (Zajonc, 2000). Strategies for this construct should therefore focus on the automatic system.

It is worthwhile to mention that these archetypes are not representative of the population, and a study with an extended sample should be conducted. For designing such interventions, however, further studies are needed: interviews, observations, or focus groups and participatory design techniques.

### 3.4.2 Limitations and future research

A few important limitations restrict this study: firstly, a self-reporting technique for gathering data of behavioural constructs was used; a method that in future research will be supported by other data gathering techniques, such as interviews

and observations. Secondly, this sample is limited to bachelor students, which was comprised of people with similar background, age, and educational level, likely resulting in generalizing beyond such sample inaccurate. As a result, in future research the sample should be extended, to have final clusters that are more representative of the population. Thirdly, the TwoStep analysis excludes from the analysis any case with missing data; therefore, if the amount respondents who have missing data is too high, too many cases are eliminated from the final model. In the present study, 30 cases were excluded from the final clusters due to missing data. Finally, the TwoStep cluster analysis, although appropriate for this study, may be overly descriptive compared to other types of analysis, this might result in lower quality solutions without the capacity of predicting behaviour. With a larger sample, further studies can be carried out, such as interviews with representatives of each of the archetypes, observations of their behaviours at home and measurements of IEQ conditions, and focus groups to design and develop bespoke intervention points. Additionally, it would be valuable to perform further statistical analyses, such as correlations between health and emotions or health and locus of control.

## 3.5 Conclusions

To conclude, it can be said that the findings of this study show that the method of analysis seems to fit the purpose of this study, which is to provide evidence that the TwoStep cluster analysis method is an appropriate technique to use with the chosen constructs and items constituting the questionnaire. One of the reasons for this is because that particular method allows using both categorical and continuous variables, which compose the questionnaire. Furthermore, the final model of clusters comprised variables belonging to items of all the constructs, showing that the selection of such items was adequate for this questionnaire. With the six resulting archetypes, the study asserts that occupants may have different needs and motivations that culminate in behaviours. Although qualitative research is needed with the intent to understand the quantitative database at a deeper level, it can be concluded that certain constructs do vary enough from archetype to archetype, which means that the home environment of each archetype could be shaped around the main needs of the specific archetype so as to better support efficient behaviours and habits.

Finally, the results of this study are an invitation to produce further investigations with an expanded and varied sample. Hence, this study can be used as a stepping-stone to enlarge the sample and to produce archetypes that are more representative of the population. The results of that future research, in their turn, would enable the development of empirical studies to support the quantitative findings with qualitative ones.

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