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The Importance of Comfort Indicators in Home Renovations: a Merger of Energy Efficiency and Universal Design

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Abstract: Literature, governmental and policy goals reveal a need to merge the, until now separately considered, concepts of Universal Design (UD) and Energy Efficiency (EE) in home renovations. Using the concept of Comfort from the perspective of homeowners, as a framework that unifies UD and EE, a list of 21 comfort indicators was developed.
This paper discusses a survey undertaken with 145 homeowners to check whether these comfort indicators were indeed important from a homeowner's perspective when building or renovating their home. It also looked at their relative importance and any possible interconnections between the indicators. In addition, the survey explored the triggers and goals of home renovations.
The results show that the developed list of comfort indicators can be considered reasonably concise and complete. Comfort factors fall into 3 groups of importance with EE associated indicators located somewhere in the middle pack. This order does not significantly change between people who plan to build a new home, those who plan to renovate, and those who do not have concrete plans yet.
The deeper understanding of indoor comfort indicators and their importance for homeowners supports our efforts to develop a user-focused synergetic merger of UD and EE under the umbrella of indoor environmental comfort in practice and research.

Keywords: comfort, indicators, home renovation, energy efficiency, universal design

Introduction

Two governmental and policy goals - increasing energy efficiency in homes and increasing the ability of homes to accommodate people during their whole life - have been separately considered in practice and research until recently. The housing stock in Belgium consists of a high proportion of single family homes that are energy inefficient and unsuitable for people with disabilities (Van den Broeck, 2015). This context presents an opportunity to combine energy efficiency and universal design into renovation concepts that create more value for individual homeowners and society at large.

Merging the concepts of energy efficiency (EE) and Universal Design (UD) is however fraught with difficulties due to their very different nature (Kapedani, Herssens, & Verbeeck, 2016). In order to bridge these two fields and provide a better relation between the wider goals of policy makers and the more narrow and immediate goals of individual home owners, the concept of comfort has been employed. The meaning of comfort in the context of home renovations was explored through 3 qualitative studies with different groups (UD professionals, home owners, architecture students). It resulted in a framework describing

indoor environmental comfort (IE Comfort) which includes aspects of both EE and UD (Kapedani, Herssens, & Verbeeck, 2017).

The terms used by study participants to describe comfort in combination with literature on building quality assessment were refined into a list of 20 indicators of indoor environmental comfort. They include 4 EE related indicators (*air quality, temperature, noise, light*) and 16 spatial and design indicators for lifelong-living (LLL) such as *usability of spaces, flexibility, accessibility, etc. (see Fig. 1 for full list of indicators).*

It should be emphasized that although this specific definition of indoor environmental comfort is in large part derived from a layman's understanding of the term, it does not have the same meaning as the term "comfort" in common use. The latter can have a variety of intuitive and sometimes vague interpretations depending on personal, social and contextual factors. For the remainder of this paper "IE Comfort" is used to refer to the concept described above as an overarching combination of EE and LLL indicators, while the common usage is described simply as "comfort".

The framework and indicators for IE Comfort are useful for understanding the conceptual relationship between Energy Efficiency and Universal Design. However they are not yet validated. The question remains whether these IE Comfort indicators are indeed important to homeowners in the construction or renovation of their home and, if so, how they might be related to each other and to the triggers and goals for renovation. In order to address these questions a survey was undertaken, the results of which are discussed in the following paper.

Methodology

The survey was administered in person either digitally or in paper form to 145 attendees at the Batibouw 2016 construction fair in Brussels. The Batibouw event was selected because it is generally frequented by our target group for the survey: people who are interested in undertaking new construction or renovation work on their homes.

The main goal of the survey was to understand the importance of IE Comfort indicators from the perspective of homeowners. Of particular interest was the importance of indicators relative to each other and their interconnections. Respondents were presented with one question asking to select which factors from the list were important in their new construction or renovation. To ensure the respondents had a similar understanding, each term was explained with a brief phrase. The word "comfort" was not mentioned in this specific question. Multiple choices were possible and the list was randomized in the digital version of the survey.

In addition, the reasons for renovation were explored. The initial reasons that catalyzed people to think about a renovation might evolve and include other aspects into the final scope of renovation. Therefore these are separated into *triggers*, the catalyst causes of renovation, and *goals*, the evolved objectives of the renovation. The triggers and goals were questioned separately. Our hypothesis was that comfort, in its intuitive interpretation, is a more important goal than energy efficiency, lifelong-living, or technical factors. The questions were asked only to respondents who indicated that they had plans to renovate. Multiple choices were possible.

In the analysis, descriptive statistics were used for ranking of IE comfort indicators, renovation triggers and goals. To understand which choices were significantly more chosen than another a two-proportion z-test was employed. Spearman rank correlation allowed the comparison of ranking order differences between respondent groups.

Crosstabs were used to test independence of two indicators. Due to the large number of IE comfort indicators a chi-square test for each combination could lead to a significant number of false positives. Therefore a set of 37 (from a possible 210) combinations was selected for testing. First, combinations of indicators with the same level of importance were selected for testing. Then a few more combinations were selected based on reasonable hypothesis of correlation such as *Natural light* with V*iews to outside* and *Privacy*.

Limitations

This study is based on the hypothesis that the list of indicators assembled indeed represent comfort in the indoor environment. The definition of comfort is an elusive, complex, and contested subject, no less so in the fields of EE and UD. Our goal here is not to test this hypothesis, but instead to develop a practical understanding of aspects that are important from the perspective of homeowners in the construction or renovation of their home – aspects which are related to EE and UD and can be grouped under the umbrella concept of comfort.

The number of comfort indicators selected may have to do with people's cognitive load and attention span since it is difficult for people to concentrate or remember long lists of items.

The selective sampling of attendees in a construction fair means that our survey sample is not representative of the Flemish population (e.g. people under 40 are overrepresented), however it better represents a subgroup which is considering renovation or construction works. The size of the sample is often too small for deeper statistically significant analysis into the choices of sub-groups such as the elderly (over 60 years old, n=17).

Results

Sample description

The majority (59%) of respondents was under the age of 40 and 55% has a college or university degree. They fall into 3 roughly even groups when describing their construction plans as having no concrete plans yet (34%), planning to build a new home (31%), and planning to renovate their home (35%). 82% of those with concrete plans for new building or renovation was planning to be owner-occupiers, which is consistent with the very high rates (70% in 2013) of home ownership in Belgium (Van den Broeck, 2015).

Those respondents who had plans to build a new home are obliged by law to hire an architect. Renovators however are not always obliged and, when asked, only 44% of them involved the services of an architect in their renovation project.

The house elements that respondents planned to modify comprised mostly of work on the building envelope (insulation, windows and doors) and light interior renovations (bathrooms and kitchens, interior finishes, but no structural changes or walls moved).

Indoor Environmental Comfort indicators

About half of the 145 respondents choose between 7 and 12 aspects that are of importance to them. Only 2 people are "single-issue" builders/renovators, and 3 people find 19 different indicators important. No-one selected more than 19 indicators (out of a list of 22, of which one was "other").

The chart in Figure 1 shows the percentage of respondents who selected each indicator as important to them. *Natural light* is the indicator that is important to the largest number of people (83%) while *Artificial light* is important to just over 12% of respondents.

A two-proportion z-test shows that the rest of the indicators fall into 3 groups of importance where the indicators within the group are statistically equal to each other ($p>0.05$). These groups are also visually apparent and illustrated in Figure 1. The indicators *Elegance* and *Accessibility* can be considered as either part of the first group (since the difference between *Accessibility* and *Maintenance* is not statistically significant, $p>0.05$) or the second group (since the difference between *Elegance* and *Noise* is not statistically significant).

Rank correlation was used to compare the order of importance for the people who were planning a new-built house (n=45), those who were planning a renovation (n=50), and those who had no concrete plans at the time (n=50). The order of importance is very similar between the 3 groups (Spearman correlation coefficients between 0.84 and 0.87 with $p<0.001$).

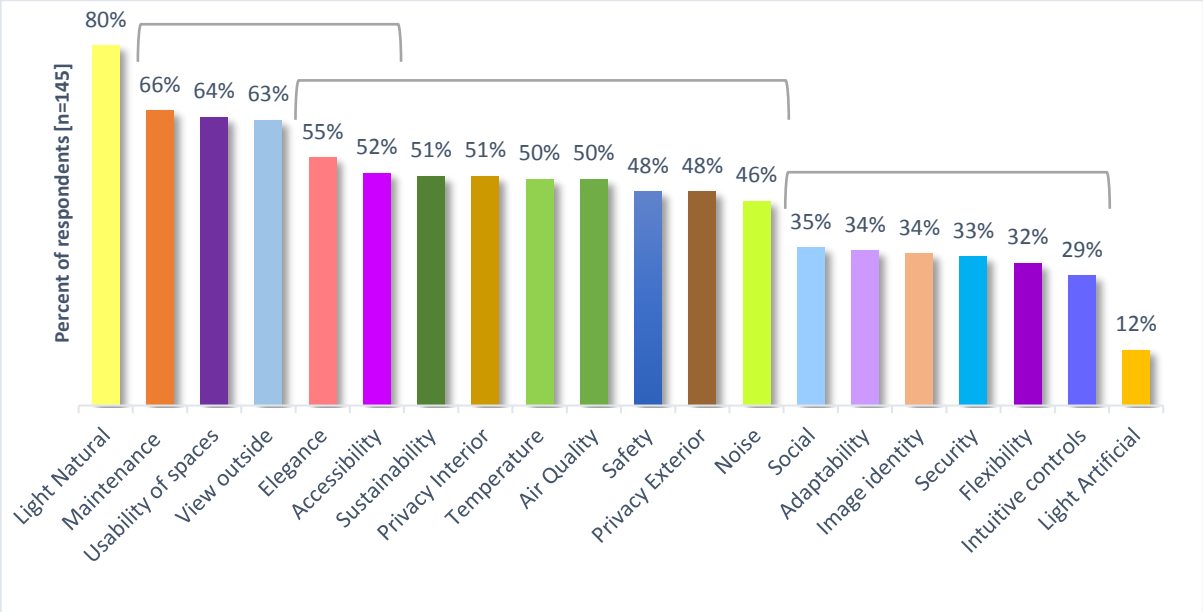

Figure 1. The proportion of respondents who selected each indoor environmental comfort indicator as important. It does not show the amount of importance placed on each indicator.

Elegance is dependent of both EE related indicators (*Temperature* and *Noise*, $p<0.01$) and live-long living indicators (*Flexibility*, *Intuitive controls* $p<0.05$, *Usability of spaces* $p<0.01$). While *Adaptability* and *Flexibility* are dependent ($p<0.01$), there is no statistically significant dependency between *Usability of spaces, Maintenance*, and *Accessibility*. EE-related indicators – *Temperature*, *Noise*, *Air quality* - are dependent to each other ($p<0.01$).

Those who selected *Social activity* in the home as important also tended to select *Adaptability*, *Flexibility*, *Image & Identity*, *Privacy*, *View to outdoors* ($p<0.05$) and *Natural light* ($p<0.01$).

There is also a statistically significant dependency between *Age* and the importance of *Usability of spaces* in the home ($p<0.01$). People younger than 40 were more likely to select *Usability* than those who were older. However, *Age* was independent of *Accessibility*.

Triggers and goals

An increase in *Comfort* was selected by the largest number of people as a renovation trigger (70%) as well as renovation goal (68%) (see Fig. 2). Increasing *Energy Efficiency* is the second most important trigger and goal (54%). Other triggers range between 20% and 30% while

other goals range between 18-42%. The difference between *Comfort* and *Energy Efficiency* is statistically significant ($p<0.05$), and so is the difference between *Energy Efficiency* and other triggers ($p<0.01$) and other goals ($p<0.05$).

There is very little change between triggers and goals with the exception of *Environmental sustainability* which is a trigger for 26% of respondents but becomes a goal for 42% of them ($p<0.05$). While 68% of those who selected *Energy Efficiency* as a renovation trigger had *Environmental sustainability* as a goal, 100% of those who were triggered by desire for greater *Environmental Sustainability* had *EE* as a goal ($p<0.05$).

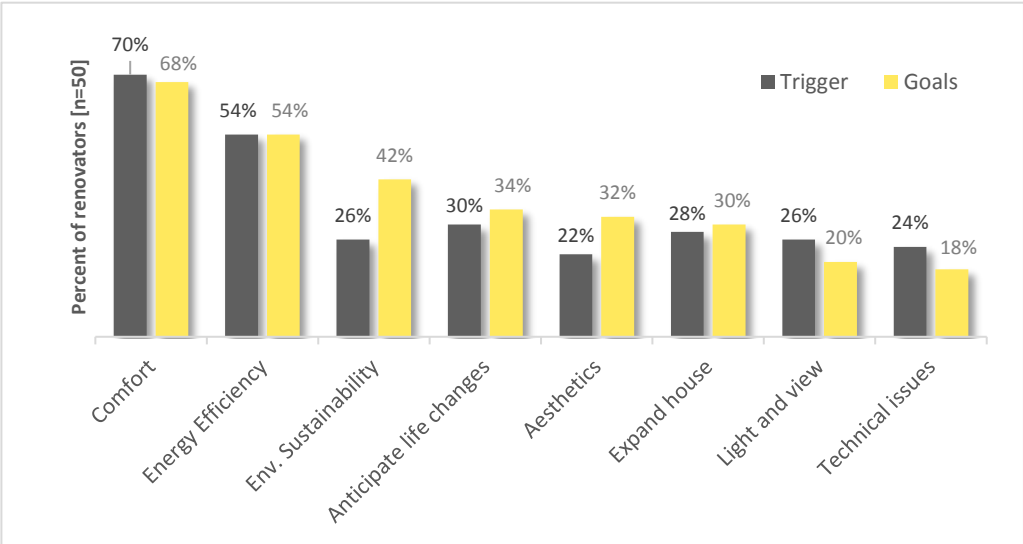

Figure 2. Triggers and goals of home renovations.

There is no statistically significant dependency between the use of an architect and changes from triggers to goals for *Comfort*, *Energy Efficiency, Anticipate life changes*, and *Environmental Sustainability*.

Discussion

Several interesting findings can be gleaned from the results described above. About half of the 145 people choose between 7 and 12 factors that are of importance to them which demonstrates that IE Comfort is a multidimensional concept and that a home renovation (or new-built) needs to address several issues at once. All indicators were important to at least 30% of respondents while only 2% selected *Other*. Therefore the number of IE Comfort indicators presented to people can be considered concise and complete. The exception is *Artificial light* (12%), which suggests that this indicator can be left out in future studies.

Natural light stands out as the factor important to most people by far. Answering this demand for natural light has implications on many other indicators, such as *Temperature, Views, Privacy,* and *Accessibility*, where conflicts and synergies could be found. The next most important group of indicators are all LLL related while the EE indicators fall in the middle group. In other words spatial and design aspects are important more often than aspects that relate to energy use. This supports the idea that the appeal of energy efficient building or renovation by individual homeowners could be improved when packaged with (universal) design measures. The broader appeal of some LLL indicators, without being labelled as such,

suggests that these measures could serve as a "foot in the door" for other energy and LLL measures, since it is easier to expand the scope of a project than to start one from scratch.

IE Comfort indicators are similarly important to people regardless of whether they plan to build new or renovate, or have no concrete plans yet. It shows that their decisions on what and how to renovate or build are determined by other factors.

Comfort as the most common trigger and goal of renovation confirms our hypothesis that comfort, as intuitively interpreted, is more appealing to people than energy efficiency or lifelong-living separately. This finding is in alignment with a pan-European research by Velux (2015) which found that 95% of Europeans assign comfort an above average importance, higher than energy costs, functionality or daylight. Since IE Comfort is effectively a more structured form of common use “comfort” derived by eliciting its meaning from residents in the context of home renovations it is reasonable to say that there is great overlap between the two terms. Therefore it can be argued that IE Comfort would be more appealing to people than either EE or LLL separately.

It was observed that very few people changed their positions between triggers and goals. Environmental sustainability was an exception here indicating that there is a desire to make the project environmentally sustainable once the decision to renovate has been made, often for other reasons.

Although it seems logical to hand responsibility for design related aspects to architects, the results suggest that architects are involved in less than half of renovations. Even when involved in renovations or as mandatory in new construction, no impact on renovation goals and importance of comfort indicators for people could be measured in this sample. Further research could explore the role, and willingness, of designers in promoting UD and EE measures.

Design elegance is a key tenet of LLL (Froyen, Dujardin, & Herssens, 2015; Mace, 1998) and it is correlated with both EE and other LLL indicators. It suggests that whatever functional measures are proposed, people prefer them to be elegantly done.

Surprisingly Age is not correlated with any factors other than *Usable spaces*. Younger people (under 40 years old) seem to place more importance on functionality, size and layout. This may be an indication that older people, who have usually lived in their homes for longer, are simply used to the usability of their homes and have no interest or ideas on improving them. We would expect older people to be more concerned about LLL aspects as accessibility, safety or ease of maintenance. However this was not the case.

Conclusion

This paper explored the importance of indicators for comfort in the indoor environment in the context of homes built or renovated by homeowners. Here comfort is conceptualized as an integration of Energy Efficiency related aspects and aspects related to Universal Design.

The data support the idea that for homeowners comfort in the indoor environment is multifaceted and that our proposed list of indicators which includes both EE and UD related aspects can be considered concise and complete. It reveals that spatial and design indicators are important more often than energy efficiency related ones.

However, simply handing over the responsibility for more universally design and energy efficient homes to architects is not a solution due in part to their limited engagement in renovations. The development and decision making on the scope and important aspects of the project for the homeowner, consciously or not, happen very early in the process.

Comfort as renovation trigger and goal was shown to be more important than EE and LLL separately. This is an encouragement towards further employing IE Comfort as a user-focused concept for renovations which, while containing the same elements as EE and LLL, is also appealing to lay-people – the homeowners who as clients of the renovation of their own home are in charge of the vision, scope and final decision making on the project.

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