

The psychophysics of well-being

Methodological approach of the socio-psychological monitoring of the VELUX LichtAktiv Haus

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ABSTRACT: Is it possible to quantify scientifically the well-being in an energy-efficient house? The socio-scientific monitoring of the LichtAktiv Haus (LAH) and the psychophysics of living can provide new insights into this topic. In fact, subjective indicators of residential well-being in energy-efficient houses can well be captured and reported back to the architects. So far, the exploration of subjective aspects in architecture mainly concentrates on life-style preferences and on research on aesthetical and architectural psychology issues where it is often taken for granted that particular physical building parameters have positive effects on residents' well-being. While there are many studies of residential behaviour, style of living and related preferences, research on the psychophysics of housing well-being is still in its infancy. This is particularly true with regard to sustainable building and living conditions and the effects these have on the well-being of the residents and the shaping of their attitudes. The basic idea of the well-being study of living in the LAH is a three-dimensional attitude model that distinguishes between three categories of reactions to attitudes – affective, cognitive and conative – that can manifest themselves verbally and non-verbally and for which measurement instruments are readily at hand. The brightness, functionality or social environment of the LAH, for instance, trigger certain feelings in the occupants (affect), give rise to certain opinions (cognition) and influence behaviour (conation). These reactions can be measured and formed into a compound index.

Keywords: well-being; living experiment; scientific monitoring.

INTRODUCTION

In view of the problems of limited fossil energy resources, air pollution and climate change, it is necessary to implement collective energy-saving measures and to use renewable energy sources, which would also lead to a reduction in CO₂ emissions. A key area for implementing energy-saving measures and reducing CO₂ emissions is the housing sector - by using renewable energies and applying energy-saving measures in residential housing, it would be possible to save countless tons of CO₂. However, it is not enough to use energy-saving measures in new builds alone. For social, ecological and economic reasons, a large proportion of the existing housing stock cannot be replaced by new builds and in Germany much of this existing housing is made up of "settler houses" dating from the early 1950s. These settler houses are simple constructions, which were put up quickly after the second world war to replace the housing that had been destroyed. Their architectural design has long since ceased to meet the needs of the current third generation. It is necessary to come up with measures to upgrade the energy systems to suit the needs of new groups of residents.

If these needs are met, it would be possible to gradually regenerate these housing estates. We must remember that positive development of these peripheral urban locations relieves the pressure on central inner-

city areas and prevents further ecologically undesirable land use in the surrounding countryside.

The question in Germany is *not* where people would move to or what kind of house they would build, if it were merely a matter of preference. Such a question might still be appropriate, if at all, in places where there is sufficient building land available and land sealing is less of a problem, such as in North America. In the case of Germany, however, the question must be: How can the existing housing stock be sensibly renovated?

It should be pointed out that the problem of renovating old houses or settler houses must be viewed from the perspective of many very different disciplines. Renovation requires the interaction of architecture, engineering, political science, psychology, sociology and urban planning. The study of these aspects is only in its initial stages, both in terms of the availability of data and the development of theory. The focus of this report is to examine the psycho-social area or aspects that can be treated in genuinely social-scientific terms. The main object of the study is the human-home interaction and residential well-being. By understanding residential well-being, we are better able to understand the acceptance of renovation measures.

The study of the human-home interaction or housing well-being can be divided first of all into the

representation of a concept of "human-home interaction or housing well-being as a multi-dimensional construct", which is itself the result of a one-year exploration. Secondly, this report outlines the method used in the exploration of this concept and in its development and validation. Thirdly, it presents the initial results of the exploration and allocates them to the components of the newly developed concept. Fourthly and lastly, using the newly developed concept and based on the method proposed by Bernd Wegener [3] for designing a standardized instrument, it provides an overall final evaluation of the measurement of the human-home interaction and residential well-being.

HOUSING WELL-BEING AS A MULTI-DIMENSIONAL CONSTRUCT

In order to obtain a conceptual understanding of the study object, it seemed reasonable to have a multi-component view of the human-home interaction and housing well-being as a multi-dimensional construct and to conceive it terms of traditional sociological attitude models. If housing well-being is understood as an attitude, it is possible to use a definition of attitude that stresses its evaluative element [1]. In this way attitude is understood as an individual mental evaluation of objects, which is reflected in different dimensions.

The attitude model used here is based on the concept of a three-component view of attitudes developed by Rosenberg/Hovland which is widely used to this day. This three-component model stresses the three categories of reactions to attitudes: It distinguishes between cognitive, affective and conative reactions, which can manifest themselves verbally and non-verbally and can be measured. [2]

If we relate it to the study object, residential well-being, the model can be used as follows for evaluating renovation measures:

In the evaluation process housing well-being is understood as an attitude, as an individual mental construct that has an evaluative component and represents a evaluative judgement. The concept assumes that housing well-being is a latent construct, as a result of which the operationalization of the study object is of decisive importance in the evaluation process.

The time t_1 represents moving into a new home. There is a certain evaluating attitude to the new home and this can be measured by means of verbal and non-verbal indicators. This judgement is influenced, among other things, by experiences on the affective, cognitive and conative level gathered up to time t_0 , i.e. before moving in (hence the questions about living conditions before moving in).

By the time t_2 some time has already passed and the occupants are interacting with their new home (human-home interaction). This interaction between evaluating attitude (t_0) and the various stimuli of the new home (e.g. temperature, functionality, social interaction), produces reactions in the dimensions of affect (it triggers certain feelings), cognition (it gives rise to certain opinions) and conation (it influences behaviour). Once again, all these reactions can be measured by various indicators at time t_2 .

Personal experiences alter the evaluating attitude, i.e. the housing well-being or the evaluation of it, at time t_3 , so that it is necessary to measure it again.

One can see that this model describes a circular process which is maintained by values based on experiences and other influences (e.g. weather conditions, time of year, social interactions). Even though it only provides a temporary measurement of residential well-being, which is a constantly changing variable, it is assumed that these changes diminish after a sufficient period of time, since the number of new impressions decreases, with the result that it is possible to make a relatively sound assessment of the liveability of a new home. Ideally, the evaluation process should allow for an estimation of the significance of the various affective, cognitive and conative components involved in forming the attitude. This produces the following evaluation or research scheme:

METHOD

Since the development of theory and the data pool available for understanding human-home interaction and housing well-being are still in their early stages, and in order to increase the contribution towards theoretical considerations, the study area was carefully explored and an initial empirical study was conducted on the construct of human-home interaction and residential well-being. An opportunity to do this was provided - in connection with the International Building Exhibition (IBA) and its 60+ building, social and cultural projects in Hamburg - by a (physical and psycho-social) study commissioned by VELUX to accompany its IBA contribution, the LichtAktivHaus (LAH) in Hamburg-Wilhelmsburg.

The VELUX IBA project belongs to a series of pilot projects ("Model Home 2020") run by the VELUX company. VELUX intends the pilot projects to show how different types of house can be built or renovated to be energy-efficient and how VELUX products can be used in them without violating their credo, which states: "With our Model Home 2020 experiment we are looking for the house of the future. Our vision is of sustainable

buildings that adapt to people – not the other way round." They therefore subject their Model Homes to real-life tests and, in the case of the LAH, they have even commissioned both physical and psycho-social monitoring.

Since December 2011 the LAH has been occupied by a selected family – comprising father, mother and two sons then aged 5 and 8 years – and thus subjected to a real-life test. The family's motivation to take part in the two-year trial was based on their latent desire to move into a larger dwelling and their need for more space, especially for the children. For the purpose of the trial, the family moved out of its 3-room flat in an old apartment building in Hamburg-Harburg to Hamburg-Wilhelmsburg, where they continued their normal family life in the LAH. Both parents work in Hamburg and the sons continue to attend the same school as before in Hamburg-Altona.

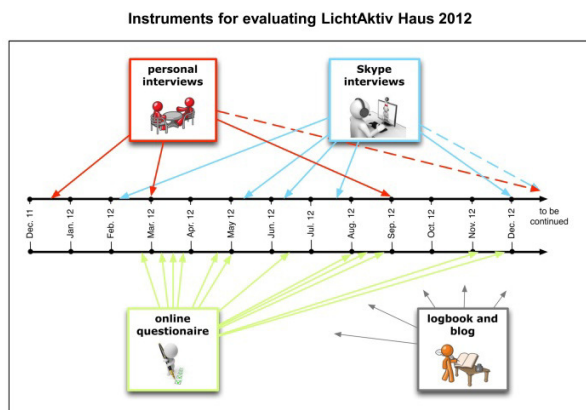


Figure 1: Research design

The study design used for monitoring the trial comprises a series of measures oriented towards the five problem areas in measuring well-being (aggregation, weighting, evaluation, perception, selection) [3] and the proposed construct of residential well-being. First of all came the compilation of the relevant dimensions (selection problem). To this end, a detailed group discussion was held at the start to discuss predetermined aspects with the family and subsequently refine them. The family records all their assessments of their living conditions using the diary method – via a digital logbook (accessible also to the monitoring team) and a public blog. In addition, approximately every four weeks the respondents complete an online questionnaire including both open and closed questions about the various dimensions of well-being. Approximately every 4 to 8 weeks, more in-depth structured interviews are conducted with the parents in the form of video calls. Finally, longer (also structured) interviews are

conducted in the model home itself at the end of each season.

This allows statements to be recorded in detail (perceptual problem) and then put into context with the respective evaluations (evaluation problem). While it is true that the study approach facilitated by the pilot scheme does not allow complete testing of the construct of housing well-being (in particular in view of the perceptual and selection problem), the following findings do confirm, however, that we are on the right track.

EXPLORATORY FINDINGS

1. AFFECTIVE – FEELINGS AND PERCEPTIONS

First of all we outline the **sensory impressions** of the family. This gives an idea of which aspects are to be allocated to the affective component of the attitude concept. This is represented in four sections (thermal, hygienic, acoustic and visual perception), which are based on the influencing factors currently used in architecture to distinguish levels of comfort.

The *thermal* aspect includes the perception of temperature, air draught and humidity. Whilst the occupants perceived the temperature in the LAH rooms to be neutral during the initial winter months, at the beginning of summer they tended to describe the room temperature as warmish to warm. If the sun is strong and on really hot summer days, the air in the rooms is found to be uncomfortable and too hot, so that additional manual ventilation is used to some extent.

As far as the cold season is concerned, there was a change from one winter to the next. In contrast to the months of January, February and March, the room temperature in October, November and December was not perceived to be neutral but warmish. It was never too cold for the family. Apart from some teething troubles, the functionality of the heating was generally described as very good.

In line with these findings, during the initial winter months the occupants were still saying that they were "seldom" cold and since the summer this changed to "very seldom". In this connection, the calls showed that the mother tended to feel the cold more easily than the father. Allowing for the stated reservations, the occupants rated the general room temperature as essentially satisfactory over the entire year.

Apart from room temperature, the respondents were also asked about their perception of air draught. They all agreed that there was a noticeable draught, especially in the living area, due to the transverse ventilation. Particularly on cold days and in the evenings, when the

occupants are less mobile, this draught is found to be restrictive. As regards humidity, it was found that the air was perceived to be neither too dry nor too humid, but neutral or optimal in all rooms throughout the whole year.

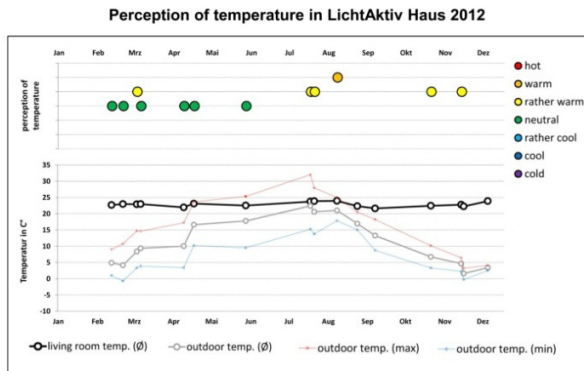


Figure 2: Temperature perception

As regards *hygiene*, that is to say air quality, a distinction has to be made between the children's rooms and the other rooms. In the case of the latter, the occupants found the air quality to be very good throughout the year with no unpleasant smells, but in the children's rooms the air quality was sometimes less than satisfactory. These rooms were stuffy, especially in the mornings. This fault is possibly due to the low ceilings, the lacking possibility of transverse ventilation and the fact that the air conditioning system is turned down overnight.

The perception of the *acoustics*, the third dimension of comfort, was also recorded. The respondents were asked not only about external noise, such as street noise, but also about the noise caused by the equipment as well as the effective of the soundproofing within the building. External noises that were mentioned included the nearby railway and also the motorway, which is not very far away. However, these noises were not found to be troublesome and the family quickly became accustomed to them. However, the noise made by the equipment, or more precisely the automatic opening and closing of the windows, was found to be increasingly loud and disruptive over the course of the first year.

As far as *visual* perception is concerned, it is primarily the brightness of the living areas that is relevant. The occupants of the LAH were often impressed by the amount of daylight and saw it as a very positive aspect. The brightness of the rooms was praised, not only in the summer but also in the darker months, so that even in the winter it was possible to manage without artificial light for long periods in the

LAH. There was, however, a habituation effect. After they had moved in, the occupants were initially surprised at how much the daylight enhanced their level of comfort. Once they had become aware of daylight as a relevant factor in well-being, their demand and need for it also increased. Consequently, the occupants very quickly became accustomed to the amount of daylight and so were much more aware of the darker days. Associated with this was the finding that darkening of the rooms by the blinds to protect them from the sun was not always welcomed (and then the blinds were usually opened again manually).

2. COGNITIVE – THOUGHTS AND VALUES

The study has already produced many illustrative findings regarding the cognitive components of the attitude concept we developed. For example, the **functionality of the technical equipment**, i.e. the interaction between the occupants and the building's systems, played an important part in the evaluation of the LAH. This concerned not only the general operation of the building's systems but also problem-solving strategies and the practicability of nominal values.

Generally speaking, the occupants' feedback about the technical systems was very positive. The equipment works perfectly and does what it is meant to do. The functionality of the equipment is rated as good, both with regard to automated processes and also control options. We also observed that over time the occupants became more familiar with the equipment and, for example, gradually learned to use the many different settings offered by the building's systems. They regard the automation as helpful and labour-saving.

Automation is an asset because it prevents incorrect ventilation, for example. However, they do not really acknowledge the need for automatic air conditioning overnight and prefer undisturbed sleep to optimum air quality. At no time do the occupants feel controlled, because they always have the sense that they could override the technology if necessary.

It was found that the occupants developed a routine after a few months, so that the manual control of the systems to adapt to individual needs was regarded as completely normal and in no way problematic.

Since the **architecture** of the LAH is important for the comfort and satisfaction of the occupants, this was also included in the evaluation process. Again this was rated very positively and the occupants not only like the external appearance of the house but also its internal layout and architecture. The occupants particularly like the size of the house, which means that they can keep out of each other's way.

Apart from the amount of space, it is primarily the abundance of daylight that is thought to be responsible for the comfort of the home. However, the open and modern layout of the house and the high-quality materials also contribute to the perception of the LAH as being very comfortable. The new part of the house, with its many windows, was particularly praised for its brightness and spaciousness. During the warmer months of the year a lot of use is made of the sliding glass doors that open onto the garden, creating an open and almost "Mediterranean" ambience.

From a sociological perspective the logging of **environmental awareness and energy-consumption behaviour**, particularly any changes in them, is a particularly interesting aspect of the evaluation. It was assumed that moving into the LAH and the interaction with it, e.g. via the consumption monitor, would lead to greater awareness in these areas and a more sustainable way of thinking. And indeed this assumption was confirmed to some extent. The occupants of the LAH seemed to be more aware of energy consumption in particular and it can be assumed that the LAH had a positive influence upon their environmental awareness. Here, the consumption monitor plays a key role. By having energy consumption and energy yield values quickly available, the occupants adopted a consumption behaviour, which can be described as active: The ability to monitor energy consumption and energy yield in real time (the consumption monitor is checked daily) also seems to have a positive effect upon energy-saving behaviour. So far, these behaviour patterns seem to be relatively consistent, so it is reasonable to assume that a long-term behavioural change will establish itself.

The occupants' statement that they strongly identify with the sustainability aspect of the LAH and are "proud" to represent economical, future-oriented living is consistent with these observations.

Interviews with the family have also revealed that their **living preferences** have also changed slightly over the course of the year, due to their experiences in the LAH. Whereas, when they moved in, the extra space they gained compared with the old flat was seen as the most important feature of the new home, the longer they lived there the more they appreciated the brightness, the garden and the energy-saving dimension. Initially the occupants attributed their enhanced liveability primarily to the modernity and size of the house but, just a few months later, they regularly referred to the brightness of the living areas as a contributory factor to their increased sense of well-being. In response to the question of what their main criteria would be when looking for a house in the future, the family have now added brightness and energy consumption as top priorities to their list of

living preferences, along with house size. One can therefore conclude that living preferences can also be altered by positive experiences.

3. CONATIVE – BEHAVIOURS AND BEHAVIOURAL INTENTIONS

The third component of the attitude concept relating to human-home interaction and housing well-being is the behaviour to which attitudes give rise. From a methodical point of view, the logging of behaviour represents a particular challenge. Since the evaluation of the LAH is primarily concerned with day-to-day routines, e.g. the daily interaction with the building's technical systems, which obviously cannot be directly observed by outsiders, we had to rely on reported behaviour, that is to say the occupants' statements regarding their own behaviour. This type of behaviour measurement is prone to error, because, although there is usually a strong correlation between reported and actual behaviour, the latter is sometimes slightly modified through the process of recollection. None the less, reported behaviour constituted a significant part of the content of the interviews and the results are briefly outlined here.

We were very interested in the question of how the occupants interact with the building or how they manage with the **control of the technical systems**. At no point did the occupants display any reserves, and in fact, right from the start, they were thrilled with the systems and the possibilities for controlling them. As they became more familiar with the systems and the modification options, they also became more aware of system malfunctions and able to identify problems more quickly.

Because of the size of the LAH and its architectural variety, it seemed sensible to ask the occupants about their **room usage**, in other words where they preferred to be and in what situations. Here, the extension with the large living area was identified as by far and away the most used room. It is the main recreation room and is used for various activities throughout the year. Because of its spaciousness and brightness, it is particularly inviting for social activities and for receiving guests. Moreover, the large sliding glass doors would be opened in summer, so that the living room could merge with the garden and create a "Mediterranean" ambience. It also appeared that the occupants liked the idea of dividing the LAH into public (new build) and private (old house) sections and they also used the sections of the building in this way. In addition to the architecture of the house, the garden was repeatedly praised in the interviews and, although it meant having to do some work, it was said to have significantly increased their quality of life. The garden is used a lot, not only by the children but also by

the parents who enjoy being outside and organized regular barbecue parties in the summer.

This already indicates that there has been some change in the **social interaction** within the family since they moved into the LAH. Essentially, the new home has had a beneficial effect upon the social climate within the family. This is not only evident amongst the children, who are now considerably more relaxed and squabble a lot less than in their previous home, but also in the improvement in the occupants' overall mood ("it all seems right somehow"). This was primarily attributed to the extra space, in particular since this enables the children to get out of each other's way and thus prevents conflict. The move has also changed contacts with friends and acquaintances. The main reasons for this seem to be the additional space and the garden, which enable them to receive guests, so that they have had more social events in their own home since moving into the LAH, whereas before they preferred to go out to meet friends. By their own account, it was difficult in the old flat because they were short of space and also the flat was not particularly presentable. It should also be mentioned that the family feel very comfortable and well-accepted in the neighbourhood of the LAH and have now made many personal contacts with individual neighbours. They quickly got used to the new area and feel accepted there.

4. HOUSING WELL-BEING AS A EVALUATING ATTITUDE

If one understands housing well-being to be an evaluating attitude that is influenced by affect, conation and cognition, it would also seem meaningful to measure and interpret it as a stand-alone construct. The details of the results obtained so far are very important for evaluating the LAH but, at the end of the day, all that matters to the occupants is how well they feel in their new home. The positive aspects and criticisms discussed above can influence the well-being of the occupants in many different ways, which means that their general level of satisfaction cannot simply be deduced from them alone.

For this reason the occupants were always asked in the interviews to put their points of praise and criticism into the context of their general residential well-being. What was thus shown was that, despite isolated problems, the family reported a high level of living comfort throughout the year and always expressed great satisfaction with their new home. After a few months, the initial euphoria had been replaced by an underlying enduring satisfaction in all dimensions of living. Therefore, the increasing awareness of problems or deficiencies in the house did not impair the fundamental sense of well-being.

DISCUSSION

If we now try to sum up the results, it would appear that psycho-social monitoring has shown two things: firstly, how the occupants of the LAH feel and, secondly, how this can be measured. The first point is already an exciting finding in itself, but only becomes really valuable when it is put into the context of scientific theory and the development of a theory about the concept of human-home interaction and residential well-being. However, there is still some way to go before we can construct a standardized measuring instrument [3]: i.e. determining the weighting factors for the evaluations and finally the question of the aggregability (aggregation) of individual evaluations. Ultimately, social science research should then have an instrument for measuring "(sustainable) housing well-being".

Even if, as already mentioned, the specific results are derived from an exploration and can therefore not be generalized in the inferential statistical sense, there is some evidence in favour of their wider general validity: It is to be expected that the technical assistance of ventilation and energy saving used in this test would also increase housing well-being in other contexts and with other users. This can be explained in two ways. Firstly, they are consistent with partially transferable research results from the areas of psychology and sociology. Secondly, the significance of the findings about well-being depends upon the context. To put it more simply, a problem remains a problem and quantifying it only helps to assess its relevance from further perspectives. Besides, as far as scientific theory is concerned, the methodological propositions relating to the concept of housing well-being obtained from the preliminary considerations derive their significance not only through empirical validation but through theoretical substantiation.

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