A holistic approach to comfort in offices

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Abstract
In the field of building design a rather conservative culture dominates: during the design process, standards are used to achieve physiological comfort. Physiological comfort is a necessity in order to achieve psychological comfort and eventually occupant satisfaction and overall wellbeing. To achieve occupant satisfaction and wellbeing, physiological comfort as well as psychological comfort have to be met. Psychological comfort can be defined as a sum of six distinct components: self acceptance, personal growth, purpose in life, positive relations with others, environmental mastery and autonomy. Salutogenesis provides a theory which describes a positive approach in psychological wellbeing. In this research, the knowledge from psychology is combined with knowledge on the traditional design approach to develop a holistic solution to create overall comfort. The current design approach provides a threshold level for physiological comfort, while manageability, comprehensibility and meaningfulness provide psychological comfort.

Keywords: Holistic approach, comfort, psychological wellbeing, salutogenesis

1 Introduction
The indoor environment in office buildings which have been designed according to the latest standards still result too often in dissatisfaction and discomfort among building occupants. One of the causes of this problem is the current design practice which commonly focuses on physiological comfort and energy reduction. Research has shown that more (psychological) aspects are important for the health, overall wellbeing and satisfaction of building occupants [Huisman et al, 2012]. However, findings from psychology remain scattered and poorly linked to the engineering and design disciplines that might make use of it [Veitch et al, 2007]. This indicates that the required knowledge and theories to increase the productivity and satisfaction in offices is possibly available already among psychologists. This research responds to this existing gap, by investigating and identifying the (psychological) aspects which remain underexposed or even neglected during the current design practice. Secondly, designers and facility managers continue to ask for demonstrable proof on how the indoor environment influences organizational outcomes [Veitch et al, 2007]. Lots of studies suggest that the productivity is increased by a positive indoor environment, although there is a lack of information on how this positive indoor environment can be designed or what the actual effect on the organizational outcome will be.

2 Methodology
2.1 Theoretical framework
In this research, the knowledge from psychology is combined with knowledge on the current design practice to develop a holistic solution to the aforementioned problem. The current
design practice provides a threshold level for physiological comfort, while the salutogenesis theory provides psychological comfort. A holistic approach is here defined as a design approach for the indoor environment which aims at promoting the health of building occupants. It is important to realize that health in this context considers the state of complete physical, mental and social wellbeing of building occupants [World Health Organization, 1948].

The thermal comfort standards describe values for indoor environmental parameters, like temperature and ventilation rate, to accomplish less than the maximum allowed percentage of dissatisfied people. The environmental comfort model of Vischer, see Fig. 1, states that a workspace either supports the tasks and activities that are being performed there (comfort condition), or it fails to support them and in fact slows them down (uncomfortable condition and cause of stress) [Vischer, 2005, cited by Vischer, 2007]. Depending on the tasks they are performing, employees are more or less affected by environmental factors such as lighting, furniture layout and ergonomics, noise level and temperature.

2.2 Salutogenesis: Health promotion

From a research perspective, health can be divided into a pathogenic and salutogenic starting point according to Dilani [Dilani, 2008]. Pathogenic research focuses on disease prevention, while salutogenic research is based on identifying wellness factors that maintain and promote health, rather than investigating factors that cause disease [Dilani, 2008]. Therefore, this research will aim to develop a salutogenic design approach for the indoor environment in offices. Aaron Antonovsky was the founding father of salutogenesis [Antonovsky, 1979]. He developed a salutogenic model which focuses on factors that support human health and well-being, rather than on factors that cause disease. The evidence proves Antonovsky’s salutogenic model as a health promoting resource that improves resilience and develops a positive subjective state of both physical and mental health, quality of life and wellbeing. The model can be explained in terms of “sense of coherence” (SOC) and “generalized resistance resources” (GRR’s). In Antonovsky’s [Antonovsky, 1979] formulation, the sense of coherence has three components:

1. Comprehensibility: A belief that things happen in an orderly and predictable fashion and a sense that you can understand events in your life and reasonably predict what will happen in the future;
2. Manageability: A belief that you have the skills or ability, the support, the help, or the resources necessary to take care of things, and that things are manageable and within your control;

Figure 1. The adapted ‘Habitability’ pyramid of Vischer [Vischer, 2005, cited by Vischer 2007]
3. Meaningfulness: A belief that things in life are interesting and a source of satisfaction, that things are really worth it and that there is good reason or purpose to care about what happens.

Antonovsky [Antonovsky, 1979] defines generalized resistance resources as “any characteristic of the person, the group, or the environment that can facilitate effective tension management”. GRR’s determine which specific resistance resources are available to a person [Antonovsky, 1979]. It is believed that enrichment of GRR’s enhances workers’ comprehensibility, manageability and meaningfulness. In other words, it leads to the enhancement of the sense of coherence [Yamazaki et al, 2011]. Research done by Yamazaki et al, states that studies on workplace conditions that can enhance workers’ SOC are extremely important, as they suggest the possibility of changing the work environment, in addition to the attempt to directly change workers [Yamazaki et al, 2011]. These studies have suggested that the workplace with greater job discretion, good communication, a supportive atmosphere, and respect shown to workers is likely to enhance workers’ sense of coherence [Yamazaki et al, 2011]. Given that the workplace is where most people spend a large percentage of their waking hours, the relationship between SOC and work is an area of interest. Strümpfer and Cederblad et al. have studied this area extensively and say that having high SOC will result in the person [Strümpfer, 1990, cited by Breda, 2001] [Cederblad et al, 1994, cited by Breda, 2001]:

- Making cognitive sense of the workplace, perceiving its stimulation as clear, ordered, structured, consistent and predictable information;
- Perceiving his/her work as consisting of experiences that are bearable, with which (s)he can cope, and as challenges that (s)he can meet by availing him-/herself of personal resources or resources under the control of legitimate others;
- And making emotional and motivational sense of work demands, as welcome challenges, worthy of engaging in and investing his/her energies in;
- Confronts stressors, is capable of clarifying and structuring the nature of the stressor;
- Believes that the appropriate resources are available and can be mobilized to deal successfully with the challenge and is motivated to deal with it.

According to research done by Bond and Galinsky the effectiveness of the work environment strongly correlates with job satisfaction and job retention when considering value drivers that focus on the ‘whole person’ [Bond and Galinsky, 2006]. Furthermore, research done by Strümpfer and De Bruin and Rothmann and Venter provides evidence of a strong relationship between sense of coherence and job satisfaction [Strümpfer and de Bruin, 2009] [Rothmann and Venter, 2010]. Another research, performed by Strümpfer and Bruin, collected data on the relationship between sense of coherence (SOC) and job satisfaction (JS) from published sources, unpublished theses and unpublished reports [Strümpfer and de Bruin, 2009]. The results show that SOC accounted for approximately 25% of the variance in job satisfaction. These findings support the hypothesis that a manageable, meaningful and comprehensible indoor environment results in enhanced satisfaction.

2.3 Means-end chain theory
The first step in the development of a holistic design approach considers the determination of the needs of building occupants in regard to the indoor environment in offices. This was done with the use of the means-end chain theory which originates from consumer psychology [Gutman, 1982]. The indoor environmental components are considered as products which can be used by building users to achieve their values. The means-end chain theory is a theory
which is commonly used in consumer psychology to determine the needs of individual humans in regard to a certain product [Reynolds and Olson, 2001]. This theory presents the relation between an individual person and a product as a means-end chain. The means-end chain involves three elements: attributes (A), consequences (C) and values (V). Attributes are external properties or aspects of products. Consequences are defined as the results which are experienced by an individual person while using the product and the values refer to the fundamental needs of humans. According to the means-end chain theory, people continuously use their values to make decisions between possibilities. During a ladder interview, which is performed in a one-on-one setting, the ‘why-question’ can be considered as basis [Reynolds and Olson, 2001]. The respondent is repeatedly confronted with the question: “Why is that important to you?” which eventually leads the respondent towards a high level of abstraction. The result of a ladder interview is an overview of the relations between attributes (A), consequences (C) and values (V).

Starting with the meaning structure analysis is the same as the content analysis for the correspondence analysis. The numbered categories are used to score each element in each ladder producing a matrix with rows representing an individual respondent’s ladder. From this matrix can be derived how often one element results in a subsequent element. The relations between attributes, consequences and values can be either indirect or direct. The final result is known as a Summary Implication Matrix (SIM), in which each cell indicates the number of times directly and indirectly all row elements lead to all column elements [Reynolds and Olson, 2001]. The SIM is used to develop an Hierarchical Value Map (HVM), this is a map which represents the chains between the aggregated ladders. To avoid confusion, the term “ladder” will refer to the results from individual respondents while the term “chains” will be used in reference to sequences of elements which are derived from the SIM [Reynolds and Olson, 2001]. Fig. 2 illustrates this relation between ladders and chains.
Means-end chains of individual persons can be derived with the use of the ladder interview technique. This technique considers an in-depth interview in a one-on-one setting. During a ladder interview, the question ‘Why is that important to you?’ plays a central role. By asking why a certain property of the indoor environment is considered as important by an individual human, the means-end chains of an attribute develops. Eventually this process results in a value which is accomplished with the use of the attribute. Two types of analysis are applied to the results from the ladder interviews. The first one is the correspondence analysis, this statistical analysis is used to determine associations between variables. Correspondence analysis is a method for exploring associations between sets of categorical variables. The analysis of the results of multiple ladder interviews consists of three phases. During the first phase, an content analysis of all the elements from the ladders is applied [Reynolds and Olson, 2001]. The first step of the content analysis is to record the entire set of ladders across respondents on a separate coding form. The next step is to develop a set of categories that reflect everything that was mentioned in the interviews. The results from this analysis are used as input for the subsequent questionnaire. The second analysis is the meaning structure analysis. The results from the ladder interviews are represented in a hierarchical value map which shows both qualitative and quantitative information. From this map was derived how specific properties of the indoor environment are used by humans to achieve certain values. These values correspond with the physical or mental condition which is desirable for the building occupants at the office. Additionally, the hierarchical structure of the map provides information on the relative importance of properties of the indoor environment. These results are useful in the design process when different design variants are analyzed. In summary, the results from the ladder interviews explain how to design an indoor environment which satisfies building users. The results can be further analyzed by a regression analysis.

A regression analysis is a method which is used to estimate the relationships among variables. The aim of the analysis is to define the relationship between dependent and multiple independent variables. The result from the regression analysis provides understanding on how the dependent variable changes when the independent variables are varied. The variation is in this research a result of the different case buildings which have been used to select the respondents. The regression analysis is performed in SPSS and the procedure consists of several steps.

3 Experiments

During the ladder interviews, respondents in multiple office buildings were asked which properties they considered as important in the indoor environment of the office and why. During the research, seven office buildings are used as case studies to perform interviews and questionnaires. Additionally, the building services of the office buildings are analyzed to determine the quality of the indoor climate. The building occupants of the case buildings are used as respondents for the interviews and questionnaires. The ladder interview technique is used to reveal means-end chains between physical characteristics of the indoor environment and values which are important to humans in regard to the indoor climate. The respondents in the first step of this research were building users of three out of the seven selected office buildings in the Netherlands. In order to get representative results, the respondents are chosen as diverse as possible within one office building. Selection criteria include age, gender, job description and location within the building.

The interview can start either by ordering the characteristics of a product or by preference between multiple products [Reynolds and Olson, 2001]. If preference is used, the interview continues by asking why this product has the preference of the respondent. When ordering of characteristics is used, the characteristics which are derived from the interview
will be used for laddering. The ladder interview technique has been developed specifically to create means-end chains. Laddering is an interview technique which can be used to determine the purposes of product consumers. In this research is chosen to select a product based on preference since it is desirable to ladder multiple product aspects and more in-depth answers are derived. The products are the indoor climate and its systems. Based on evidence from literature, ten photo collages of three to six products have been created for the interviews (see Figure 3). These photo collages are used as stimulus material to guide the respondents in a certain direction. Each collage represents one important component of the indoor environment. These are the components which are used: Heating; Cooling; Ventilation; Solar shading; Windows; Electrical lighting; Interior; Location of control systems; Design of control systems and Workplace concept.

![Figure 3. Photo collage of solar shading systems which is used during ladder interviews](image)

The next step in the research focused on investigating whether a holistic indoor environment has a (positive) effect on the building occupant. A questionnaire was distributed among multiple office buildings with different indoor environments. The questionnaire was distributed by mail among 250 respondents. With a response rate of 64.4%, the questionnaire was completed by 161 respondents. The questionnaire included six predictive variables. In order to get reliable results it is necessary to have at least 20 to 30 respondents per predictive variable. When dividing all 161 respondents among the six variables, each variable has almost 27 respondents, which is sufficient. The items in this questionnaire measure the effect of the indoor environment on humans by means of satisfaction, health, productivity and burnout.

4 Results

4.1 Ladder interviews

A total of 21 respondents in 3 case buildings participated in the interviews. The ladder interviews are first analyzed with the use of a correspondence analysis to define clusters. Secondly, the meaning structure analysis is applied. This analysis provides an hierarchical
overview of the environmental aspects and corresponding purposes which are considered as most important by building users. The last step in the analysis of the data from the interviews is to develop a morphological model with the use of a methodological design approach. This model aims at translating the theoretical results from the research into applicable solutions which are useful during the design process of an office building.

4.2 Correspondence analysis

Within his analysis method the figures which are derived from the correspondence analysis represent the relations between the different attributes, consequences and values. The smaller the distance between two points, the stronger the relation between the elements. The value of the inertia per dimension is comparable with the percentage of explained variance. In this Summary Implication Matrix, the inertia of the dimensions is considered as acceptable when the value is 30% or higher. Furthermore, each figure from the correspondence analysis represents two elements: either attributes and consequences, consequences and values or attributes and values. With the use of Fig. 4, clusters are composed. The Score in Dimension displays each row's score on dimension 1 and dimension 2. The scores are derived based on the proportions (mass) for each cell, column, and row when compared to total sample; the scores are representative of dimensional distance and are used in the graphs. In each cluster, the attributes, consequences and values which have a strong relation are joined together. These clusters are used in this research to formulate the items for the questionnaire. In the attributes-consequences analysis, the inertia of dimension one is 19% and the inertia of dimension two is 15%, which results in a total inertia of 34%. Fig. 4 illustrates the relations between attributes and consequences.

Figure 4. Correspondence analysis: Attributes and consequences – General analysis
With the knowledge and theories from literature in mind, five main clusters are extracted from this figure. These are the clusters from Fig. 4:

1. Furniture [A], Open/combi office [A], Noise nuisance [A], Neat and clean [A], Privacy [C], Social interaction/communication [C], Personal place [C], Beneficial for company [C]

2. Color [A], Appearance [A], Warm and clear electrical lighting [A], Inspiration and concentration [C], Atmosphere [C], Clear and spatial [C], Tranquility [C]

3. Surrounding environment [A], Big windows [A], View outside [A], Much daylight [C], Not feeling trapped [C], Positive energy [C], Variation [C]

4. Suffer from air related problems [A], No distraction [C], Enjoying yourself [C], Physical condition [C]

5. Location of the system [A], Radiation [A], Centralized and automatic [A], Constant [A], Information and settings [A], Saving time [C], Environment [C], Heat and cold sensation [C]

6. Manageable [A], Easy [A], Uniformity [A], Recognition and experience [A], Know how something works [C], Feeling [C], Adjust to individual needs [C], Functional [C], (Un)pleasant [C]

4.3 Meaning structure analysis

The information from the Summary Implication Matrix is used to develop a Hierarchical Value Map (HVM). The HVM provides a clear overview of the existing relations between attributes, consequences and values. This paragraph presents the HVM’s of the general analysis and the four sub-analysis. The lines which represent the relations between elements are labeled with numbers. The number before the dot indicates the direct relations between elements and the number after the dot indicates the indirect relations. A relation is called an indirect relation when it exists via another element, which is not represented in the model. If a relation exists only indirectly, the line is dotted. When the relation exists either directly or both directly and indirectly it is indicated with a solid line. The hierarchical value map is constructed in correspondence with the structure of Fig. 5. To emphasize this structure, the map is divided into three horizontal panes. The lower part of the hierarchical value map represents the attributes, the middle part the consequences and the upper part the values. When this information is translated for the indoor environment, can be concluded that the lower part of the figure consists of specific characteristics of the indoor environment while the higher part consists of goals with a high level of abstraction. From the hierarchical value map can be determined how people aim to achieve goals with the use of the indoor environment. From Fig. 5 can be derived which specific aspects are experienced as important for building users in achieving health, comfort, performance at work, relaxation and feeling at ease. For example, inspiration and concentration are considered as very influential for performing well at work. At the same time, can be derived from the figure which factors people mention that contribute to the experienced level of inspiration and concentration. According to the results from the interviews are noise nuisance (6.5), the view outside (7.5) and the degree of personal control (7.4) key elements in the perceived level of concentration and inspiration. This way, these results help designers to understand and anticipate on the needs and expectations of building users. Furthermore, an hierarchical structure is developed which can be helpful in decision making during the design process.
4.4 Multiple linear regression analysis

In this analysis, the relationship between the dependent variables and the independent variables is estimated, see Table 1.

Table 1 Results of regression analysis

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Meaningful indoor environment</th>
<th>Effective &amp; functional indoor environment</th>
<th>Comprehensible indoor environment</th>
<th>Manageable &amp; natural indoor environment</th>
<th>Annoying stimuli at the workplace</th>
<th>Relaxation at the workplace</th>
<th>Physical discomfort at the workplace</th>
<th>Total explained variance (R² adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective health</td>
<td>.297</td>
<td>.340</td>
<td>-.146</td>
<td>.258</td>
<td>.214</td>
<td>.157</td>
<td>.207</td>
<td>.247</td>
</tr>
<tr>
<td>Subjective productivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction with building</td>
<td>.285</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burnout</td>
<td>.400</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Subsequently, the internal consistency of the items which measure the same variable is verified and the actual variables are computed. Eventually a correlation analysis was performed, see table 1 to check whether any independent variables correlate strongly. If this was the case these variables were merged into one variable. Once all these steps were completed, the regression analysis was performed for each dependent variable.

5 Discussion and conclusions

This study, as described in this report, deals with the effect of the indoor environment on wellbeing and performance of building occupants in offices. Both the indoor environment and the human wellbeing and performance are very complex concepts. The salutogenesis theory is considered as main concept because findings from multiple researches provided evidence on the importance of manageability, comprehensibility and meaningfulness in the work environment. Since these are the building blocks of salutogenesis, these researches support the applicability of this theory in the indoor environment, Furthermore, Anthovsky’s theory focuses on promoting human wellbeing according to the bottom-up approach in which the human being is the central point of interest.
The laddering technique is in this research applied in a new context. To make the method applicable for the indoor environment it was necessary to change the procedure. Given the complexity of the laddering technique and the diversity of the indoor environment, the sample size was kept relatively small.

The standard procedure for taking ladder interviews differs from the procedure used in this research since the indoor environment cannot be considered as a usual product. In product marketing or consumer psychology, the interviewee gets the opportunity to physically use and touch the different products. This is not possible for this research because the aim is to determine how an indoor environment should be designed according to the needs of building occupants. For this reason, pictures were used to represent the different components of the indoor environment. To reduce possible effects, the photo collages were composed carefully and show a wide variety of possible systems and properties and respondents were always free to ask for more information about a certain picture if necessary. Moreover, research done by Reynolds and Gutman [1998] states that respondents start the ladder interviews in correspondence to the properties which are considered most important. This information supports the suitability of pictures as alternative for physical presence of a product.

The categorization of the attributes, consequences and values is very determinative for the results of both the correspondence analysis and the meaning structure analysis. If the categories were chosen more broad, more details are lost. If the categories were chosen more specifically, some results were not mentioned often enough to be included in the HVM and the correspondence analysis would give even more widely spread results.

The results from this research contribute to a first step towards a holistic approach to the design of the indoor environment. The results support the importance of psychological aspects in the indoor environment. Even more than half of the properties which are mentioned by respondents have a psychological nature. Furthermore, the usage of the means-end chain theory has proven to be successful in the context of the indoor environment.

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