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Towards an Occupant Based Conceptual Model

Case of the natural luminous ambience

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ABSTRACT: Dealing with thoughts based on the ambience notion, the present research work makes for a contribution consisting on the development of an occupant based model for the natural luminous ambience. One of the ambience notion virtues is the supply of the architectural research with specific to architecture theoretical bases whilst preserving its links to other fields with an environmental spirit. This notion provides new components for the study of the environmental physical stimuli within the built spaces that is the requirement of the plurisensoriality. Hence, the proposed conceptual model will be beyond the conventional ones because it associates the context particularities, the luminous environment and the architectural space to the user. An office building from an east-southern Algerian city under a clear sunny has been chosen as a case study to apply this conceptual model. The field research work proves the feasibility of the model and indicates the hierarchy of the hypothesized relationships but also reveals the unsuitability of some statistical analysis methods.

Keywords: daylight, ambience, occupant, building design, conceptual model, comfort, clear sky

INTRODUCTION

Daylight is increasingly perceived as an influent design parameter, an efficient energy saving strategy as well as for enhancing productivity stimuli among other benefits [1, 2, 3, 4]. Previous research revealed that users are of great significance for the success of daylighting design. They also stress the importance of daylighting design to achieve primarily the occupants' comfort [5, 6, 7, 8].

In architectural daylighting studies, the most used conceptual models are performance study oriented and thus solely quantitatively characterized. The models developed by M. Fontoynt [9] and F. Moore [10], for example, are limited to an association between: i) climatic conditions (the sky types), ii) the external environmental conditions (the surrounding built environment), iii) the internal physical properties (forms, colours, textures...), and iv) the daylighting device (window, solar protections...). The importance and the influence of such parameters are unquestionable but they are insufficient for delimiting the phenomenon. Besides, the user related models developed by other disciplines like the environmental psychology or environmental ergonomics did not pay sufficient attention to the architectural space.

The ambience notion outstands from all the previous approaches because it provides the architectural field with specific to architecture theoretical bases whilst preserving its links to other fields with an environmental essence. This notion provides new components for the study of the environmental physical stimuli within the built spaces that is the requirement of taking into account the user's plurisensoriality [11, 12].

This paper aims to build up a conceptual model including the user, the architectural space and the natural light as an environmental stimulus. The development of this model follows the social sciences conceptualization process and is achieved in respect to the notion of ambience.

CONCEPTUALISATION AND MODELS

Conceptualizing is a necessary and prior process to every scientific research aiming the measure of a real phenomenon [13]. Because it is an abstract notion the concept must be conceptualized in order to measure it in real conditions. For, the recourse to models is not an unknown practice in the scientific research field. Models are always built up even if they are never exhaustive, universal and perfect when applied. The conceptual model is a construction-selection. Consequently, it is

often admitted that the attention is focalized on the inescapable aspects for the researcher itself [14]. The model is therefore worked out by the researcher. It aims describing the structure of his investigation object unless without being absolutely complete and perfect, therefore [15].

The present investigation adopts the systemic conceptualisation that is developed through a deductive reasoning. This latter is based on the great authors' paradigms and which the efficiency has already been empirically tested [14]. The most common operationalization process steps from the definition of the concept dimensions. It is followed by the designation of the components (sub-dimensions) and then selecting their indicators. These latter are the means allowing the direct and objective measurement of a concept from where it is effectively conceptualized [16, 17]. The concept is as complex as it will require more decomposition including dimensions, sub-dimensions, components, sub-components, indicators and indices. But, the concept is also as simple as it could be decomposed directly from dimensions to indicators.

Certain imperfections may operate during the field measurements. So, it is generally recommended increasing the number of indicators [18]. Measuring is a classic operation but every scientific discipline possesses its own indicators. But, an indicator did not present the same accuracy degree for two different scientific disciplines. Thus, it would be more useful to search for more precise indicators in order to achieve the greatest extent of objectivity [14, 16]. Also, the measurements undertaken, on the basis of the same conceptual model, could be restricted to a certain number of components as they could be focussed towards a specific purpose. Finally, some indicators could be transformed to indices (calculated measures). However these indices could only be drawn from the indicators of quantitative nature [13].

THE NOTION OF AMBIENCE

In the architectural field, the research works on the ambience go beyond the definition of this notion as a situation associating people and the environment where they are localised. They stress on the sensorial aspects emerging from a certain physical stimulus that are taken for signals (sound, light, smell...). This differs from previous investigations where they were thought as primary human needs [15]. A signal would be insignificant if it is not perceived. So, a focus is made on the users-receptors' behaviour. Architecture and the built environment are indeed more seen as an inhabited place than a visual form [11].

It has also been revealed that inside an architectural space the ambience is multiple that is to say it is not

related to a single signal. This makes characterizing the notion of ambience as inescapably complex. Additionally, the context has been attested as an influent parameter in the characterization of an ambience. The context could act as [12]: i) a physical interior environment with specific formal and spatial properties, ii) a physical exterior environment creating particular stimuli, and/or iii) by means of users dependently of their cultural, social and climatic context. Researchers pay also a particular attention to the built environment (urban as well as architectural spaces). A formal characterisation is used because the architectural space remains the study object.

At this stage, the notion of ambience could be conceptualized and basically modelled as a complex interaction of reciprocal influences between: i) the context (cultural, social and climatic) of the architectural space, ii) the architectural space by means of its form and function, iii) the physical environment related to a stimuli (thermal, lightning, sounding, smelling...), and iv) the user through its perceptions and behaviours.

THE NATURAL LUMINOUS AMBIENCE

In respect to what has been previously presented, the basic model of ambience is converted to an ambience integrated model. This is carried out by means of a precision of the physical stimulus that is natural light (including both sunlight and daylight). The proposed integrated model for the luminous ambience consists on hypothetic relationships between: i) the luminous environment, ii) the architectural space, iii) the context, and iv) the user. However, the model four concepts are still abstract and need to be operationalized. For, a substantial literature review allows defining the dimensions, components, indicators and indices for every concept from the conceptual model [19]. A special focalisation to carry out this process was made in respect of the architectural field specificities.

The luminous environment Three dimensions allow defining the luminous environment: i) a physical energy as it is the visual expression of the radiant energy emitted by both natural and artificial sources, ii) a visual stimuli acting as an environmental sign transmitted through the visual system to the human brain, and iii) an information for the perception because it gives an objective data related to the luminous ambience.

The first dimension is decomposed to four components: i) the luminous flux, ii) the luminous intensity, iii) the illuminance, and iv) the luminance. At the architectural space level, this could be measured by means of four indicators: i) exterior horizontal illuminance, ii) internal horizontal illuminance, iii) vertical illuminance at the exterior face of the window,

iv) vertical illuminance at the interior face of the window. Three indices could be calculated on the basis of these indicators: i) the daylight factor on the basis of the first and second indicators, ii) the clear sky indices based on the second and the third ones, and iii) the luminous flux through the fourth indicator associated to the window surface.

Accommodation, adaptation, visual field, and light colour are the four components characterising the natural light as a visual stimuli. The accommodation and the adaptation deal with the human visual system. In practice, they could be quantified respectively on the basis of the sharpness of the picture seen by the human eye and the openness and closeness diameter of the pupil. This latter is limited to a ratio of 1 to 16. Closer to the architectural space, the visual field is however not less complex. An extensive literature divides the human visual field to three parts including the central field, the enviroing field (ergorama) and the distant field (panorama). But from a practical point of view, it would be unattainable to distinguish between the three fields. Thus, researchers simplify this partition from three to two parts namely: i) ergorama, central closer or micro-visual field, and ii) panorama, enviroing distant or macro-visual field. Three indicators could be used to characterize the light colour: i) luminosity, ii) tint, and iii) saturation.

Visual performance, visual comfort and agreeableness are the main components of the third dimension of natural light. The visual performance deals with the task to do. It could be evaluated in an architectural space by measuring the horizontal illuminance and the luminance on the work plane. The luminance values at different points on the work plane allow calculation of the contrast indices. The visual comfort has been identified as a situation of an easiest reception of the environment signals by the human eye. It could also correspond to the state of absence of trouble. Light colour and particularly colour rendering as well as glare are influent parameters for such situations. Colour could be measured through: i) the reflective properties of the internal surfaces, ii) its temperature, iii) colour rendering, and iv) subjective effects. The quantitative 'objective' evaluation of glare has always been an attractive research subject for various disciplines. In architectural research, the indicators allowing such evaluation are: i) the luminance values, ii) the illuminance (horizontal and vertical), and iii) the solar patch surface inside a room. These latter allow the achievement of different indices (average luminance, maximal luminance/ minimal ratio, vertical and horizontal ratios...).

For the case of the luminous environment, agreeableness translates an atmosphere that could be

qualitatively described by a 'correct' or 'pleasant'. The nominal qualification describing the appearance of a luminous environment is the indicator used to its measure.

The architectural space The architectural space presents a designer creative work expressing an intention. The designer pays clearly attention to the formal aspect. This aims to the achievement of a picturesque effect. Three dimensions are selected in order to define the architectural space: i) the conformation or the configuration, ii) the use and its elements (furniture, equipment...), and iii) the building materials.

The conformation is firstly examined through three kinds of indicators. The typological ones are side and top lighting. The topological indicators include: i) geometric (point, line, outline), ii) non-geometric (zones and areas), iii) partition continuity / discontinuity (opacity and transparency of the building materials), and iv) the space openness / closure (ratio of the openings area to the peripheral walls one). The morphological indicators deal distinctively with the conformation (floor area, façade wall area, ceiling height and space depth) and the opening (area, number, shape, location in the wall and relationship to the other openings, wall thickness, and solar protection type).

Secondly, the role of the opening in characterizing the conformation is defined by two sub-dimensions: i) the provided view outside measured by its type (natural or built landscape) and content (number of stratum constituting the view), and ii) the regulated privacy that is function of the performed activity frequency as well as the opening characteristics (area, location in the building floor and in relation to enviroing buildings, provided view outside and protection devices).

The use of an architectural space may serve as a parameter for the characterization of the architectural vocabulary elements. From the use point of view, a luminous ambience could be analysed on the basis of the most frequent activities. The achievement of these latter obviously needs satisfying some requirements including daylight. Accordingly, six indicators are drawn for this dimension: i) the primary function, ii) the most frequent activity, iii) the space where the activity takes place, iv) the shape of the space, v) the furniture arrangement, vi) the number of users in the space.

The buildings materials are important when studying the luminous ambience because they characterize the luminance. This latter is what we truly see in a luminous environment. Thus, the reflectance, transmission, colour, and thickness are the indicators characterizing this third dimension of the architectural space.

The context The climatic, the cultural and the social are the selected dimensions among the concept 'context' various ones. They are indeed closely related to the built environment. The climatic dimension is focalised towards the luminous climate at the macro and micro levels. The luminous macroclimate is operationalized by means of five qualitative and quantitative components. These latter allow the definition of several indicators: i) the landscape (the sun location in the sky, presence of clouds, ground nature and the scope of the sky in the landscape), ii) the type of the real sky (luminance, luminosity, colour and shadowing), iii) the luminous quality (sun movement, seasonal effects and number of clear and/or overcast sky days per year), iv) the sky condition (shadowing clearness), and v) the type of the sky model (extra-terrestrial energetic radiation, global energetic radiation, diffuse energetic radiation, global luminous radiation, diffuse luminous radiation, probable sunshine duration, real sunshine duration, solar angles, and cloudy sky parts). The later indicators let calculating four indices (clarity, nebulosity, cloud ratio, and sunshine duration).

The luminous microclimate means the luminous modified conditions due to the ground and the built environment specificities. Three qualitative and quantitative components are selected to define the luminous microclimate: i) the plastic quality (the facades surfaces reflectance properties, the facades surfaces clarity impression, the facades surfaces roughness properties, wideness and/or narrowness of the exterior spaces), ii) the pollution level (presence of an industrial activity nearby), and iii) the built environment structure (the facades surfaces reflectance coefficient, vertical and horizontal angles of the obstruction due to the built environment, and the window solar orientation).

Three sub-dimensions are selected in order to operationalizing the cultural dimension of the context concept: i) the significations dealing with the users' perceptions and behaviours which the indicators will be developed as a part of the concept of 'user', ii) the unity of a human group (religion, origin, and language), and iii) the spatial and temporal paths (geographic area and original country). The social dimension is subdivided into two components: i) the social group as the human component (age, gender and education level), and ii) the social space that expresses the territorial component (job, dwelling type, workplace).

The user In the present research work, the user is that person mainly concerned by the activities taking place in the studied built environment. The user is also a human being having a psychological profile based on his personality and his own previous experience. This latter has been carried out as a group member affiliated to a social, cultural and climatic context. The whole is

conditioning his modes of perceiving and behaving towards his environment. Due to the complexity of the concept of 'user', the selected dimensions were those revealed by the researchers in the field as built environment related aspects. The first dimension consists on the user's relationships to the built environment which includes two sub-dimensions: i) perceptive actions, and behavioural actions. The indicators of the perceptive actions were defined from those cited in daylighting related literature. They include: i) beliefs and knowledge, ii) choices and importance, iii) preferences, iv) emotions and impressions, v) judgments, vi) evaluation, vii) spatial representation, and viii) satisfaction. The behavioural actions consist on two components: i) personal space, and ii) territoriality.

The interpersonal distance and position constitute the indicators of the first component. However, territoriality is more complex because it encloses six sub-components allowing several indicators: i) exclusive use (particular and repetitive use), ii) land marks in relation to the conformation (distinguished and particular configuration), iii) land marks in relation to other persons (location in relation to other territories, separating marks from other people), iv) individual liberty and environmental determinism (the influence of others on individual decision, space shape, and space area), v) territorial dominance (hierarchical order as expressed by the furniture arrangement and width of the view of the conformation), vi) physical boundaries (realised changes at the configuration level and division elements such as furniture).

The second dimension of the 'user' concept is his personality. The operationalization of this latter has been restricted to the environmental related aspects. Two components were revealed by the literature: i) the interpersonal differences, and ii) physical features. The first component is measured through the revealed differences from two perceptive actions that are satisfaction and evaluation. The second component is subdivided into: i) the visual acuity (glare sensibility and wearing corrective glasses), ii) the task realization (right or left handed person).

The model relationships In addition, the model suggests interactive relationships between the concepts expressing the research hypothesis. According to these relationships, the dimensions, sub-dimensions, components, sub-component, indicators and indices of the four concepts of the luminous ambience would be associated. It has been firstly hypothesised that the users from the same human group, with the same spatial and temporal paths, living under the same climatic conditions and belonging to similar social group and space, posses the same perceptive actions. Consequently, they will not behave differently towards the luminous environment

inside the architectural space. This will occur even if the architectural space varies (typologically, topologically, morphologically, in terms of building materials...). Secondly, it is suggested that the behavioural actions are significantly influenced by the natural lighting conditions in the same architectural space.

RESEARCH METHOD AND TECHNIQUES

The more appropriate methodology to approach a complex phenomenon like the luminous ambience is the diagnostic level post-occupancy evaluation method [34]. Its suitability remains largely from: i) its focalisation on the architectural space as perceived by its users (an environmental psychological place centred method), and ii) its ability to enclose several different research techniques. Hence, four of these latter are selected in order to collect the various needed data: i) the questionnaire, ii) the behavioural map, iii) the architectural survey, and iv) the photometric measurements. Because of the complexity of these data and their different natures, the analytical methods of their outcomes require a particular attention. Statistical analysis linear methods for qualitative data (multiple correspondences analysis) are those chosen because most information is qualitative (nominal or ordinal). The data resulting from the luminous environment indicators (photometric characterization) basically quantitative are converted to qualitative (ordinal) ones. This is a suitable manner to associate them to the other collected data in order to interpret them as a whole.

CASE STUDY

A field investigation took place in a contemporary office building located in the urban setting of the city of Biskra. It aims to apply the proposed occupant based conceptual model of the luminous ambience. Offices present the kind of buildings where good daylighting conditions are an inescapable issue for the users' comfort. Biskra city is located in the northern part of the Algerian Sahara which is characterized by a semi arid hot climate and a clear sunny sky almost year around. The office building houses a major state insurance company (Caisse Nationale de l'Assurance Sociale). The building is five storeys high organised around an uncovered courtyard and with four facades. The majority of offices are of a small size. Open plan offices are few but exist in every floor. A questionnaire was administrated, face to face, to thirty nine occupants (20% of the total number of occupants) in twenty four offices (42% of the total number of offices). Further, the occupants' behaviour was observed, particularly their reaction to daylight and sunlight. Along, a photometric characterization of the luminous environment was done for every questioned occupant. This characterization is made in respect to an improved protocol of measurements developed for this

research work [22]. Also, an architectural survey was made for every office concerned by the investigation.

RESULTS

Beside the specific outcomes related to daylighting evaluation and design [20, 21, 22], the research outcomes attest the feasibility of such conceptual model associating different concepts participating in the making of a particular phenomenon (e.g. the luminous ambience). Briefly, it could be said that the expected relationships have been attested but with various relevance degrees. The users' values and attitudes are in relation with their social context and previous experiences. The evaluation is however strictly related to the social context. Furthermore, it could be thought that the revealed relationship between the perceptive actions (positive impressions) and the architectural confirmation (content of the view outside enclosing sun and sky) is influenced by the cultural and climatic context (the Saharan Arab Islamic one).

Also, various relationships were attested between the behavioural actions and the four concepts of the luminous ambience model. The resorting to artificial lighting is, for example, related to the users': i) values and attitudes, ii) social and climatic context, iii) the architectural conformation (window location to the central axis of the office floor), and iv) the luminous environment (vertical illuminance on the window exterior face). The research attests the inability of the statistical analysis linear methods to allow analysing the relationships between variables of different nature. No regression analysis method was possible to be applied because the collected variables include qualitative nominal and ordinal ones. Thus, the relevance of the expected relationships was categorized as strong, average and weak (Fig. 1).

CONCLUSION

The notion of ambience has been revealed as a suitable theoretical frame to study the concepts enclosed in the interaction between user, architecture and natural light. It also has been attested that it is a pluridisciplinary approach able to associate different research techniques and methods.

The proposed conceptual model for the luminance ambience valued the user and remedy to the failure pointed out in the architectural daylighting design field. It includes and associates quantitative to qualitative aspects of the luminous ambience phenomenon.

Despite the complexity and the scope of the collected data, the conceptual model has been proved to be practical. It would be mainly useful to apply it for other

kinds of buildings. Furthermore, the data analysis methods, the gathered results and the revealed difficulties encourage the use of more suitable analysis methods (non-linear ones for example) and the extension of the application of such operationalization to other physical stimulus.

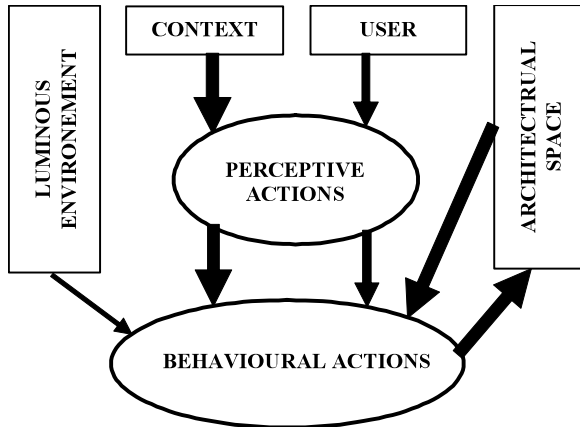


Figure 1: The validation of the hypothetical relationships between the concepts of the user based model for natural luminous ambience reveals a hierarchy decreasing from strong to average to weak.

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