Introduction

3D visualisations are the graphic tools most widely used by planners and engineers to communicate the design of future urban spaces. Professionals and academics recognize the value of this tool to facilitate dialogue between technical experts, policymakers and the public because these depictions translate "technical information" into a common graphic language and facilitate decision-making (Lewis et al., 2012).

With the rapid technological progress of numerous software programmes able to generate digital models, unlimited texture libraries and increasingly more powerful computers, currently, digital perspectives can be identical to photographs of built architectures.

Although a space can only be fully understood after experiencing it physically, the images that represent it at least offer a choice of concrete or "abstract" characteristics that allow us to experiment partially with what we would feel in the represented space. Virtual images, as a medium for expressing the future project, allow the designer of the image to manipulate all the spatial and environmental conditions to enhance the final image, whether or not it is faithful to the space it represents. The geometry of the digital model can be changed to achieve a better perspective, use impossible textures, hide with nature the things that bother us about the space or add people to improve the whole. There is, however, the risk that some visualisation factors may communicate the wrong message in the image, so observers will not fully understand the urban proposal (Lewis, 2012). The process of preparing the visualization and choosing the environmental factors is therefore critical for ensuring accurate representation of the urban proposal. The effect of these factors on the understanding of the image must be determined by delving into affective response and evaluation of environmental visualisations. To date, however, there have been few contributions in this field (Lange and Bishop, 2005; Orland et al., 2001).

To address this gap, the present paper intends to analyse the user's response to each design attribute in the 3d visualisations of the urban proposal in order to contribute objective information on the visualisation process.

Until now the main object of study in this field has been to find out whether 3d visualisation is faithful to the space it represents and is therefore valid for assessing the space it represents. From the theoretical perspective, various authors have identified frameworks for evaluating the quality, understanding and credibility of a simulation (Appleyard, 1977; Appleton and Lovett, 2003; Radford et al., 1997; Sheppard, 1989). From a more experimental viewpoint, many studies also compare users' reactions to a real space and the same space represented using virtual reality tools. Thus, for example, Rohrmann and Bishop (2002) found that simulations of urban environments are generally acceptable as a representation tool. A later study (Bishop and Rohrmann, 2003) on urban parks, found that computer simulations could provide valid results for many aspects of perception of the environment. Westterdahl et al. (2006) also found that virtual reality is a very valid means of representation. Wergles and Muhar (2009) however, concluded that simulations were incapable of transmitting subtleties concerning relationships between objects, textures, ageing, although it is true that the images shown were not highly realistic. De Kort et al (2003) found that for the analysis of spatial dimensions and cognitive tasks, the real environment was much more precise, whereas user responses to a list of bipolar adjectives was quite similar in both environments (real and virtual), only adjectives concerning excitement were much lower in the simulated environment.

Another line of experimental works studies the differences in the perception of space in relation to the technique used in the simulation. Bates-Brkljac (2009) compared the perception of images created with digital and manual techniques, showing that computer-generated images communicate the project better than the hand-drawn perspective. They also found differences in perception between architects and non-architects. In another study (Daniel and Meitner, 2001) where simulations of the same landscape with different degrees of realism-abstraction were observed, it was found that the response when evaluating the beauty of a landscape is very different in the different types of images and so this aspect of representation should be taken into account when using virtual simulations to validate future landscapes. Bergen et al (1995) compared the appreciation of beauty of a landscape in photographs and renders, obtaining better results with the photographs.

Far fewer contributions, however, analyse what lies behind the evaluation process. Also relevant are contributions from environmental psychology in the study of human response to photographs of environments identifying the elements of the image associated to the preferences. For example, in residential environments, it has been found that homogeneity of houses in the same environment (Stamps, 1994) or the presence of trees (Stamps, 1997; Ulrich, 1986; Wohwill, 1983) help to improve the assessment. In contrast, electric cabling, cars (Nasar, 1988; Stamps, 1997) or the presence of unkempt nature (Herzog and Gale, 1996) are associated with negative assessments.

Most of these works analyse user preferences based on their affective response established in other works, like the framework proposed by Mehrabian and Rusell

(1974), who identify pleasure, arousal and dominance as the three basic dimensions for describing individuals' emotional responses their environment. The use of assessment variables established in works carried out in other contexts and not by the observers themselves is one of the main criticisms of some approaches like Kansei Engineering (Nagamachi, 1995). This methodology considers that an individual’s judgement is not only influenced by the stimuli (a combination of objective and subjective parameters) but also by the scheme of concepts of a specific group of users (semantic space). Thus, to appropriately evaluate a situation, the assessment variables must be adapted to the observer’s mental scheme. This conceptual structure must be designed before any relationship can be established between each perceived symbolic or physical attribute and the global evaluation of the product.

The introduction of a Kansei Engineering system requires the following process (Schütte et al., 2004). In a first phase, user response is obtained and quantified in terms of evaluating the product’s “sensorial attributes”. The most commonly used technique for measuring user perception of a product in Kansei Engineering studies is semantic differential (Osgood et al., 1957). This technique consists in following a given structure in questionnaire design using kansei words as scales for evaluating the sample stimuli. In a second phase, after obtaining users’ affective dimensions or semantic axes (kansei words), attempts are made to obtain inference rules between the design elements and semantic axes or perception variables. Alhought this relationship has been frequently studied in the design of consumer products, there are very few applications in the field of environment assessment (Lee et al., 2009; Wang et al., 2010; Wang et al., 2011).

The aim of this study is to analyse affective users’ response to each design attribute in the 3d visualisations of urban design proposal. The analysis includes aspects of the observers themselves (their previous spatial experience through training in architecture) and intention before the stimulus (assessment of the image or the project it represents), both relevant aspects according to the model in Nasar (1994). The intention here is to answer the following questions: in the assessments of computer visualisations that represent urban design proposals (a) is it possible to identify design attributes that provoke positive assessments?, (b) is there any difference in user evaluation in relation to intention: assessment of the image or the project?, (c) are there any differences in assessments in relation to the observer's training: architects and non-architects?
To answer these questions we use SD in the context of Kansei Engineering.

The findings will provide objective information on the visualisation process, and thus enable visualisation preparers to produce images that faithfully match the planner`s or designer`s intention.

Material and methods

The methodological development focused on two field studies which collected interviewees’ evaluations of the stimuli presented. Table 1 reflects the basic characteristics of both phases.

Phase I

Identification of affective factors in urban proposals

In the first field study 150 individuals evaluated 52 digital perspectives of urban spaces representative of the proposals presented in recent international urban design competitions (see Figure 1).

In this study it was very important for the stimulus to have sufficient variability, because the aim is to obtain a representation of opinions on computer visualizations and it must be as varied as possible. The main characteristic of the sample of individuals was that half had training in architecture and the other half did not, thereby reproducing the real make up of the juries in architecture competitions. Sample size was chosen with the criterion of a minimum of 6 observations for each variable to be included in the factor analysis, indicated as sufficient in Field (2005).

The questionnaire had to reflect a set of expressions or adjectives that describe observers' affective responses to the urban proposal. They were selected following the process established by Schütte et al. (2004) and Llinares and Page (2008). First of all 130 words and expressions were chosen (from web pages showing digital perspectives and photographs of projects, journals and professional magazines and interviews with architects and planners, digital image designers and non-experts) that people use to express urban design attributes. Then the affinity diagram technique was applied (Terninko, 1997), reducing the expressions to 43. This technique consists in forming groups of similar words and assigning one significant word to embrace all the expressions in the group.

Development of the field study: Interviewees were shown the questionnaire through a digital platform. They had to complete the questionnaire quickly as the aim of the work was to reflect their first impressions. Statistical analysis of the opinions used SPSS 16.0

statistical software. Principal components factor analysis provided the set of independent concepts or semantic factors which evaluators use to describe their sensations in relation to the digital image (Basilevsky, 1994; Flury, 1988). We selected only principal components with eigenvalues greater than one, and used a further Varimax rotation to obtain the semantic axes factors. Finally, internal consistency of the dimensions was evaluated by Cronbach's Alpha coefficient (Streiner, 2003). Statistical analyses were carried out using the statistical package SPSS.

Phase II

Identification of design attributes influencing the success of digital images in urban proposals

The second field study comprised a sample of 75 individuals. Again, it was considered important to have the same number of architects and non-architects. The set of stimuli for Phase II were 27 images of an urban proposal. Determining the relationship between design attributes and affective factors requires establishing relationships between many variables and a broad range of responses are needed. It is therefore advisable for users to give their opinions on a sample of computer visualizations with a variety of characteristics. This variety of characteristics or design attributes may cause the appearance of confounding factors, not fully controlled for, thereby creating bias in the results. The solution described was adopted to reduce bias by introducing the set of characteristics or attributes in a random fashion (Kish, 1995).

The questionnaire contained the following information: (1) affective factors obtained in Phase I, (2) design attributes that make up the image. The following set of attributes was determined: nature, colour, people angle of the shotarchitecture, sky and urban furniture (3) global assessment of the proposal and of the image, with the questions: (a) good image: if you were on a panel of judges of architecture, I would consider it a good image and choose it to be assessed in greater depth in a subsequent stage, (b) good project: if you were on a panel judging architecture, I would like this project to be built in my municipal area or neighbourhood.

Development of the field study: Participants were told about the purpose of the study, without specifying the exact data to be studied in order not to condition observer response. They were told the responses had to be fast and intuitive, without defining a time period in order not to pressurise the observers over the duration of the experiment. Participants' responses were analysed using statistical software SPSS following the scheme presented in Table 2.

Results

Phase I

Identification of affective factors in urban proposals

Factor analysis compiled the initial set of 43 expressions to 6 independent factors, able to explain 59.12% of the variance (see Table 3).

Axis 1 represents tranquillity and wellbeing, with tranquility, harmony, no stress, no chaos as main concepts. Axis 2 comprises the adjectives innovative, futuristic, singular and fashionable. It is related to the concept of innovation of the proposal. Axis 3 corresponds conceptually to happiness and warmth, of the image. Axis 4 represents the dimension nostalgia, romanticism and sensitivity. Axis 5 refers to functionality and the sensation of popular and proximity of the image. Finally, axis 6 represents the monumentality dimension with the expressions luxury, huge and exotic. Cronbach's Alpha values for 6 dimensions ranged from 0.631 to 0.900, showing that these scales have considerable reliability. According to Hair et al. (2006) Cronbach's alpha below 0.6 shows an unacceptable level of reliability in exploratory studies.

Phase II

Identification of design attributes influencing the success of digital images in urban proposals

a. Identification of critical affective factors in a digital urban proposal

This analysis includes the following stages:

a. 1. Analysis of affective factors and the global assessment

Analysis of means of the set of affective factors provides the following profile (Figure 2). The set of digital images in the sample are assessed as innovative, able to transmit the sensation of calm and well-being. There are also perceived as functional and cheerful. In general, they do not provide a sensation of nostalgia or monumentality or luxury. The images are generally given a positive assessment, as well as the projects they represent, but with lower scores.

a. 2. Analysis of the impact of affective factors on the global assessment of the proposal

Spearman's correlation coefficients indicate that the set of affective factors have a significant impact on the global assessment of both image and project ($p<0.05$). As

Figure 3 (a) shows the assessment profile is very similar for the image and the project. The sensation of tranquillity and well-being appear in first place in both assessments. The greatest discrepancy is with the sensation of innovation, which becomes more important when assessing the image rather than the project.

Separating the collective of architects and non-architects heightens the differences. Thus for architects (Figure 3 (b)) the profile of the evaluation differs quite a bit when assessing either the project for a proposal or the image that represents it. For this collective, assessment of the image depends on the set of affective factors. However, the assessment of the project depends basically on the sensations of functionality, tranquillity and nostalgia. In the group of non-architects the profiles show greater similarity (Figure 3 (c)). Remarkable in this group is the sensation of cheerfulness and warmth when evaluating the project and the lack of importance of functionality, a factor that does not impact either the assessment of the image or the project.

b. Identification of design attributes associated to critical affective factors

Following a very similar scheme this analysis reflects the following stages:

b.1. Analysis of the design attributes

Analysis of the averages for the set of design analysis shows positive assessments for people, colour, viewpoint, architecture and nature and neutral assessments of urban elements and even the sky (Figure 4).

b.2. Analysis of the impact of design attributes on the critical affective factors

A nonparametric Spearman correlation coefficient was applied between the affective factors and the assessment of the set of design attributes of the digital image in order to determine the relationship.

Tranquillity-Wellbeing: both for architects and non-architects the sensation of tranquillity and well-being appear to be related to nature, colour and certain urban elements ($p<0.05$) (Figure 5).

Innovative – Futurist: Figure 6 shows how for both groups the sensation of innovation is basically lined to architecture and colour ($p<0.05$).

Cheerful – Warm: cheerfulness and warmth are caused by order of importance, by colour, nature, people and the sky ($p<0.05$). Although both groups agree on the importance of colour there are certain differences with the other elements as can be seen from Figure 7.

Nostalgic – Romantic: the sensation of nostalgia and romanticism is linked to the sky, nature, colour and with less emphasis on urban elements ($p<0.05$). In this case, there are remarkable differences between architects and non architects. For architects, nature, colour and the sky cause the sensation of nostalgia, however, for non architects only the sky is linked to that sensation (Figure 8).

Functional: Functionality is related to the architecture, urban elements and nature ($p< 0.05$). Here the differences in relation to training are also important. For non architects, functionality is transmitted by urban elements whereas for architects it is transmitted by the architecture (Figure 9).

Monumental: the sensation of monumentality appears to be positively related to architecture and negatively to urban elements ($p<0.05$). The differences between the groups are also significant. For the architects, monumentality is linked to the architecture, this is also the case with non architects but for them it is also negatively related to people, urban elements and colour (Figure 10).

Discussion

The aim of this paper is to analyse the relation between the design attributes of an urban design proposal and the affective users' response. It has also been analysed whether intention in the assessment and training of the observer influences that relationship.

In a first phase, Semantic Differential has been used to measure the subjective component of the affective state which both groups are able to recognise when seeing an urban visualization through 6 independent concepts (which explained 59% of the variance). These axes or factors are by order of explained variance: tranquillity-harmony; innovation; happiness-warmth; nostalgia-romanticism-sensitivity, functionality and monumentality-luxury. Similar variables although labelled differently have also been obtained in previous studies on assessments of surroundings. The factor tranquillity, labelled as "serene" (Grahn and Stigsdotter, 2010), "quietness" (Appleyard, 1981; Van Herzele, 2005) or "peaceful" (Llinares and Page, 2008). Innovation in the work of Jarvis (1993), but also found in other works labelled as "originality" (Küller, 1980; 1991) and "singular" (Llinares and Page, 2008). Happiness and warmth seem to be related to the sensation of "pleasure" (Gurbindo and Ruano, 1989; Mehrabian and Russell, 1974). Nostalgia-romanticism-sensitive labelled as sensitive (Lynch, 1981). Functionality and proximity labelled as "comprehension" (Bishop and Rohrman, 2003; Rohrman and Bishop, 2002; Wergles and Muhar, 2009), "legibility" (Kaplan, 1987; 1992), or "familiarity" (Herzog et al, 1976). Finally, the factor monumentality and luxury appears to be related to the factor labelled as "luxury" in other works (Jarvis, 1993; Llinares and Page, 2008; Llinares and Iñarra, 2014).

SD offers a systematic method for obtaining subjective evaluation scales using independent valuation scales adapted to the evaluator's conceptual scheme. In this way we ensure that the variables are easily recognised by users. Although this methodology has been previously applied in landscape perception and environmental psychology (Echelberger, 1979; Küller, 1980; 1991), in our approach it is used as a first step within the context of Kansei engineering. In a second phase, an attempt is made to analyse the relationship between design elements and affective factors with the greatest impact on the global assessment. This relationship, has been studied in many consumer products, but there are very few applications to scenes of the urban environment (Lee et al, 2009; Wang et al, 2010; Wang et al, 2011)

The set of relationships between the design elements in the visualization and the responses of architects (Figure 11 (a)) and non-architects (Figure 11 (b)) to the image and the proposal it represents are summarised in graph form. There are three significant results:

Firstly, important perception differences have been detected in the evaluation in relation to the observer (architects and non architects). At the level of affective factors linked to the success of a proposal, the most important differences lie in functionality (of great importance for architects, especially when evaluating a project), the sensation of innovation, (important for both groups, but for architects it is fundamental in their evaluation of the image) and the sensation of monumentality is of greater importance for non architects. At the level of design attributes the architecture is relevant, especially for architects as it influences the sensation of functionality. However, functionality for non architects appears to be related to design elements. These findings coincide with those of many previous studies which have shown significant differences in evaluations the urban environment by architects and non architects (Devlin, 1990; Gifford et al, 2000; Groat, 1982; Nasar, 1989). The reason for these differences in the two groups' assessments may be because during their education, architects use specific schemes to judge buildings (Devlin, 1990). Thus various authors have already found significant differences during the period of training between students of architecture and students on other courses (Akalin et al, 2009; Hershberger, 1969).

Secondly, there are differences in relation to the intention of the assessment (assessment of the image versus assessment of the project). This issue has not been studied until now and yet it appears to be a key element. An urban proposal, winner of an architecture competition must obtain good assessments of both the image and of the project it represents. Thus a good assessment of the image is fundamental in an initial selection stage, while assessment of the project is fundamental in subsequent stages. And although both assessments are significantly related, there are important differences in the relationship models. Thus for non architects they appear to be similar decisions, however, for architects they are totally different assessments: a good image must be innovative, whereas a good project must be functional. The difference between both assessments may be due to the fact that assessment of the project involves greater understanding of the space or environment. In this regard, this assessment can be related to the concept of “functionality”, “comprehension” (Bishop and Rohrman, 2003; Rohrman and Bishop, 2002; Wergles and Muhar, 2009) and “legibility” (Kaplan, 1987; 1992), labels used in the literature to reflect the ability to understand the environment, more developed in architects.

Thirdly, it is possible to quantify the impact of design attributes influencing the assessment of an urban proposal based on affective factors. Colour, nature and architecture are basic elements in the proposal. In general, it can be seen that architecture and colour are key elements for generating the sensation of innovation. Colour, together with the presence of nature and urban elements are able to cause the sensation of well-being and tranquillity.

Colour appears as a relevant attribute for architects and non architects regardless of the intentions of the assessment (image or project). Polakowski (1975) already considered it to be one of the three basic design elements that influence judgements about visual quality. However, there is less agreement over the specific colour that provokes a given response (Burchett, 2002; Hard and Sivik, 2001), because, according to some authors it is a complex and unpredictable interface (Hard and Sivik, 2001). Theorists consider that this relationship is open to the influences of contextual, cultural, temporal and idiosyncratic factors (O`Connor, 2008); and may therefore be less predictable (Hard and Sivik, 2001; Janssens, 2001).

Nature appears as a second design factor, especially for architects as it influences the set of important affective factors for the assessment of both image and project. This attribute has often been studied. For example, Appleyard (1978) and Lennard and Lennard (1995) have pinpointed the aesthetic and visual properties of nature, specifically its colour, form and texture, as satisfying needs. Among others, Ulrich (1981), Kaplan (1983) and Han (2010) have shown that vegetation produces positive emotional responses. Other studies show that even in an urban setting people mention water, trees, and greenery as desirable elements in the public space (Balling and Falk, 1982; Carr et al, 1992; Kaplan, 1983).

Architecture is the third relevant design element in the assessment of an urban proposal. Nasar (1989; 1994) has already established that formal aesthetics, such as architectural style, proportion, rhythm, scale and building form contribute to an overall physical appearance and have strong effects on observers' preferences. In this line, other works show that the size and scale of place and the overall height and detail of the buildings are identified as important factors related to human feeling (Gehl, 1987; Lennard and Lennard, 1995).

On a practical level, the fundamental contribution of this study resides in providing objective information on the affective response and preferences generated by the design elements in a digital urban proposal. Visualisations preparers must attempt to embody the intentions of a proposal in an image. With that aim, they include, in a discretionary way based on intuition, a considerable number of factors such as colour or ambient lighting, with no idea whether these elements will transmit the expected message appropriately, and could thus mislead the public and decision-makers about the potential benefits and impacts of the proposal (Forester, 1989).
Identifying design elements related to a certain evaluation will enable visualisation specialists to modify these parameters according to the intention of the image (Houtkamp, 2004). Obviously, a major ethical concern is to ensure proper use of this information. Lewis et al., (2012) emphasize the need for visualisation producers to abide by minimum ethical standards, such as those recommended by Sheppard (1989): visualisations must be comprehensible, representative, accurate, credible and defensible. This study has helped to identify the parameters visualisation designers need to emphasise to ensure that the image accomplishes the main objective of remaining true to the project that it represents. Furthermore, our findings show that non-expert

observers are more likely to not discern between the effects of the image’s allure (obtained by manipulating ephemeral variables) and the reality of the urban proposal. Visualisations are essential tools in public participation processes, so the use of accurate, credible examples would improve public involvement and more significantly, citizens’ satisfaction at the end of the project.

The limitations of this present work are given by the stimulus used. The sample of computer visualizations presents a broad range of variability, because an attempt has been made to gather a sample that is sufficiently representative of reality, reflecting all the techniques and styles used. This fact presents a limitation in that a given perception is produced by the possible combination of design elements in the stimuli. To control for the effect of each design element would require an excessively large sample of images to contemplate all the possibilities of combinations of attributes. The solution adopted has been to include these variables in a random manner (Kish, 1995), assuming that chance will generate equivalent distributions of the units in all the variables of interest.

In future studies, it would be interesting to analyse the impact of each of the categories or items of a given design attribute on the aesthetic response, based on those which have been identified in this paper as relevant for the overall evaluation (colour, nature and architecture). To do so, it would be necessary to control for the effect of each category of design, covering the mentioned limitation. This would require the generation of a sample of stimuli that combines all the potential design elements in a balanced way, in order to obtain predictive models.

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TABLE LEGENDS

Table 1. Purpose, subjects and techniques (Phase I & Phase II).

Table 2. Data treatment phases and techniques (Phase II).

Table 3. Factor analysis

FIGURE LEGENDS

Figure 1. Example of the stimuli (digital perspectives) used in the field study. Benicasim Boulevard Project: Enrique Fernandez Vivancos. Render: bgstudio.

Figure 2. Assessment of the set of digital perspectives in relation to the affective factors and the global evaluation (image and project).

Figure 3. Analysis of the impact of affective factors on the global assessment of the proposal (a) architects and non-architects, (b) architects, (c) non-architects.

Figure 4. Assessment of the design attributes of the set of digital perspectives in the sample

Figure 5. Radial representation of design attributes that impact on the sensation of tranquillity-well-being (a) both (b) in grey architects, in yellow non-architects.

Figure 6. Radial representation of design attributes that influence the sensation of innovative-futurist (a) both (b) in grey architects, in yellow non-architects

Figure 7. Radial representation of design attributes that influence the sensation of happy-warm (a) both (b) in grey architects, in yellow non-architects

Figure 8. Radial representation of design attributes that influence the sensation of nostalgic-romantic (a) both (b) in grey architects, in yellow non-architects

Figure 9. Radial representation of design attributes that influence the sensation of functional (a) both (b) in grey architects, in yellow non-architects

Figure 10. Radial representation of design attributes that influence the sensation of monumental (a) both (b) in grey architects, in yellow non-architects

Figure 11. Representation of the set of relationships between affective factors-design attributes and global assessment of the proposal (image-project) (a) architects (b) non-architects.