Spatial Cognition in Architectural Design

Anticipating User Behavior, Layout Legibility, and Route Instructions in the Planning Process

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Anticipating User Behavior, Layout Legibility, and Route Instructions in the Planning Process

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Contents

Architects Seeing through the Eyes of Building Users⋆
A Qualitative Analysis of Design Cases

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Abstract. Spatial cognition and wayfinding research as well as design cognition are well established as fields of research. It is nevertheless largely unknown how architects reason when they try to integrate wayfinding-friendly factors into their designs. In two semi-structured interviews we asked architects to give critique on real-world example cases as well as to solve predefined design tasks. The qualitative analysis focuses on perspective taking and other skills related to the anticipation of users in the building. The main finding is that the anticipation of visual access for single locations is done well but that multiple locations are seldom considered. A consequence would be that anticipation of users' perspective is restricted to episode-like cognitive walk-throughs.

1 Introduction

To orientate oneself is an indispensable human ability in most everyday activities. Although in most cases navigation succeeds without much difficulty everybody has already made the experience of being disoriented or lost. Moreover, disorientation is not limited to unknown and pathless territory but is a recurring phenomenon of human existence. Our research in the field of human spatial cognition investigates how people perceive, reason and memorize architectural space. Towards navigation the question is what properties make built environment easy or difficult to navigate. More practically speaking: How can buildings be designed such that they facilitate wayfinding and spatial orientation?

When asking for wayfinding-critical environmental properties, at the same time, the architectural designer who to a large portion shapes this very environment comes into play. Investigating how better designs should *be* implies thinking about how it can be *achieved*. As cognitive scientists are interested in relevant informations and skills a designer needs to achieve wayfinding-friendly designs. Architectural design processes have been studied intensively in the Design Cognition community. (See for example Akin [1] and Goel & Pirolli [2])

Some researchers touch wayfinding issues in architectural design: For example, Weisman [3] identifies factors of architectural legibility, Arthur & Passini

⋆ I would like to thank Georg Vrachliotis as well as my interview partners: Thank you for spending your time and having the patience for giving such informative answers.

[4] give a prescriptice model for systematic wayfinding design. It is nevertheless largely unknown how architects reason when they try to integrate wayfinding-friendly factors into their designs. One of the reasons might be that wayfinding is mostly treated implicitly in the discipline of architecture.

Research in the field has to consider the possibility that architects are able to create navigation-suitable designs although never thinking explicitly about wayfinding. Goldschmidt [5] identifies both declarative and procedural knowledge as important in the design process. To address implicit and explicit design knowledge our investigation combines semi-structured interviews on the role of wayfinding in architectural design with example cases and design tasks.

1.1 Explicit Aspects of Designing for Wayfinding

Explicit Wayfinding design issues subsume everything that designers do with the intention to improve their designs in terms of navigability. Here, the present paperfocuses on the anticipation of the users' situation in the object (building or building collection) to be designed. *Perspective shift* refers to perspectives in the visual, true sense of the word and means the anticipation of a user's direct perception from her point of view.

Perspective taking refers to perspective in a metaphorical sense and emphasizes discrepancies between the designing architect as an expert of the building and the user as a layperson, possibly new to the building. Arthur & Passini conceptualize "wayfinding design" as the systematic structuring of the environment as well as providing relevant information to the users such that they can efficiently solve relevant navigation tasks. Perspective taking means the anticipation of the user's informational circumstances in the designed environment.

1.2 Implicit aspects of Designing for Wayfinding

In contrast to the explicit aspects discussed in the section before, implicit wayfinding design knowledge subsumes all aspects in architectural design which have wayfinding related consequences but are not considered as such by the designing architect. As no connection to wayfinding is given by the designers themselves the identification of these factors must be theoretical or based on empirical research. Weismans four factors, visual access, signage, architectural differentiation and floor plan complexity provide a relatively general theoretical base. Our own empirical work and formal architectural analysis [6] provides us with profound knowledge about wayfinding problems in one particular building wich is therefore used as example Case 2 (see below).

Continuing previous work by Hölscher et al. [7] the present study not only relies on pure interviews but also asks informants to investigate existing cases with respect to navigation. In addition, informers of the present study actively carry out design tasks. The open role of inplicit knowledge in wayfinding design is the majour reason for employing critiquing and design tasks.

2 Method

In order to investigate relevant knowledge in wayfinding design, in the first part of the interview we asked our informers about the architectural design process in general and the role wayfinding plays in it. To address implicit wayfinding relevant knowledge, we then provided two example cases. For each case our informers were asked to examine the provided floor plans and to give some critique with respect to wayfinding. For Case 1 they also completed an example design task.

2.1 Example cases and design tasks

In the first case they were then asked to place a waiting area in the hall of a hospital[1]. After completing this design task, the location where the waiting area has been placed in reality was revealed. Finally, they were asked to evaluate the present state plan and anticipate possible navigation errors of a visitor coming down the stairs and trying to find her way back to the main entrance area.

Case 2 is a bit more open since it does not include a specific design task. We presented to them floor plans of the conference centre Heinrich Lübke Haus, Günne, Germany. This case was chosen because we have already collected empirical data regarding wayfinding in the building. (See [6])

2.2 Data Collection and Analysis

During the interviews videos were recorded in oder to capture drawing actions, pointing gestures on the drawings as well as verbal utterances. Content-based transcription was the first step of data analysis where all potentially *relevant* utterances had to be transcribed such that their content was captured. An utterance was considered as relevant if it refered to one or more of the following: overall building structure, circulation system, signage, visitors of the building, wayfinding and orientation issues, perspectives different from plan view, planning decisions. In parallel to the transcription drawing elements and areas pointed to via gestures were numbered in the drawing such that the transcription can refer to such areas precisely.

3 Results

3.1 Case 1

Examination phase: Both informers stated having analyzed the building from the main entrances along the "main circulation"[2] – "as if one would enter [it] oneself"[3]. Both made extensive use of circulation-related vocabulary, e.g. path,

[1] Universitätsklinik (University Clinical centre) Freiburg, Germany
[2] "Erschließung" (both Interviews)
[3] "als wenn man sie selbst betreten würde" (Interview 2)

entrance, circulation, axis to state the most prominent ones. In the second interview “direction” and “movement” were also frequently used. An other group of concepts employed by both is reflected in concepts referring to the function of different zones. In the first interview “zone” and “usage”[4] were explicitly mentioned.

Design phase: Our informers consistently analyze the situation in the hall (where they had to place the waiting area) in terms of pathways and flows of visitors and visualize their analysis on transparent paper on top of the plan view. (See Fig. 1)

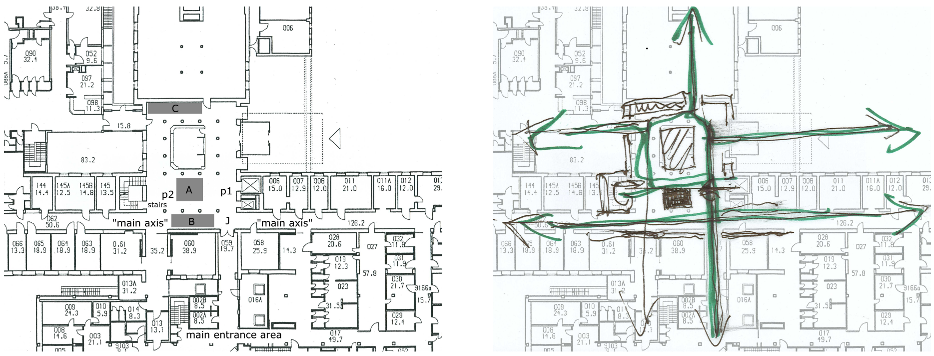

Fig. 1. Case 1: Ground floor plan showing the hall where the waiting area had to be placed (left). Informer 2 analyzes main pathways and visitor flows in the hall (right).

For the actual design, basically three possible locations A, B, C are taken into account (See Fig. 1) where B is the present solution in reality. While reasoning about what solution to choose both informants frequently refered to the main visitor flows in the hall. Both rejected B pointing out the “main axis” passing through that area. Informer 2 referred to lack of outlook after rejecting some possible solution (which is unfortunately unknown because the pointing gesture is not visible in the video). The final decision is consistently made in favour of an “island” solution at location C.

Anticipation of navigation difficulties caused by the actually realized solution After revealing B as the location for the present solution the task was to anticipate probable navigation errors for a person coming down the stairs and trying to find the way back to the main entrance area. Indeed, they both considered the blockage of the main axis as the central problem as well as they realize that the visual contact to the central junction J is broken. However, they anticipate quite different navigation errors which seems be caused by differences in the preceeding navigation episode. Namely: Informer 1 consideres position *p1* as stop

[4] “Nutzung”

location after coming down the stairs whereas Informer 2 considers position *p2*. Informer 1 then concludes that the way back to the main entrance, *orthogonal* to the main axis (down in the diagram), will be taken whereas Informer 2 decides for the pathway *along* the main axis (to the right in the diagram).

3.2 Case 2

Again our informers examined the building – this time the geometry and zones of usage where more prominent which seems to result from the building plan.[5]

Interestingly, the spontaneous conclusion with respect to navigation is consistently that the building is clearly laid out. Only after mentioning empirical results demonstrating serious navigation difficulties these are detected of our informers as well. Furthermore, their conclusion differed in so far as they emphasized different usability hot spots. (see [6]) This, like in Case 1, seems to depend on the navigation episode considered which was induced by the interviewer. Whereas Informer 1 focuses on lack of visual contact to the main stairs in the building – the task was to consider a visitor trying to find to the basement. Informer 2 primarily finds the non-congruency of ground floor and basement – he shifted attention to the basement after being asked to pay more attention to wayfinding issues (without mentioning a specific example).

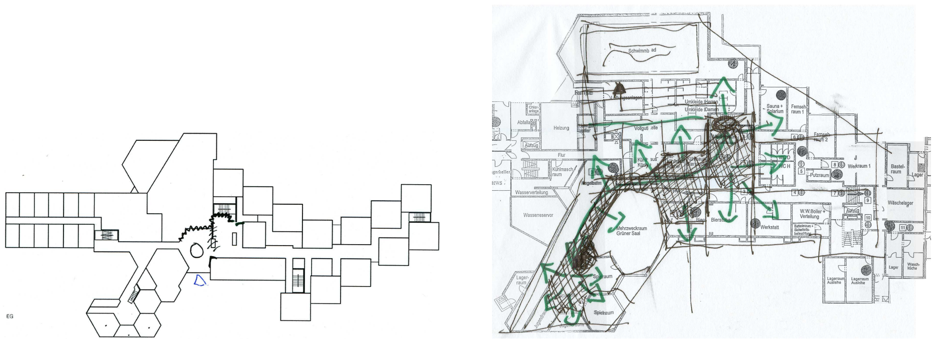

Fig. 2. Case 2: Informer 1 (left) recommended to remove several elements in the entrance hall and use glass walls in order to improve visual access to the central staircase. Informer 2 (right) redesigned the circulation system in the basement such that it resembles that in the ground floor more closely.

4 Discussion

Our findings suggest that architects are able to anticipate the situation of a user in a particular location in the building. During evaluation of the present solution in Case 1 navigation difficulties and ego-centered views were anticipated

[5] different areas of usage employ their own geometric typus, respectively.

well for a single location. However other potential difficulties with respect to visual access from further nearby locations with different characteristics were not spontaneously found. This is reflected in the fact that both informers adequately anticipate visual access. However, depending on the assumed location they come to different conclusions about potential errors. Our Informers seem to have restricted their anticipation to single but relevant points.

Further support comes from the fact that our informers largely refer to circulation either by egocentric but episode-like movement anecdotes or reason from an allocentric view about axes, flows and paths which refer, however, to aggregate movements. Especially during the pre-design analysis pathways and visitor flows are considered more like location factors than as actual navigation relevant circulation elements.

The reason for this “single-point anticipation” might be the high amount of information to be processed. Lee et al. ([8]) for example mention cognitive limits as one source of design errors. Design tasks involve large amounts of data and designers therefore rely extensively on drawings as external representations. [9] Following this interpretation, reasoning about wayfinding would be restricted to the anticipation of prototypical navigation scenarios.

Further studies will therefore investigate the role of external representations in the anticipation of visual access from multiple locations. More restricted design cases with sophisticated visual structure will be employed. An other issue will be the analysis of visual attention during such tasks – pimarily based on drawing actions, pointing gestures already collected but also via eye tracking in future studies.

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Isovist Characteristics of Stopping Behaviour

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Abstract. This paper presents a method for analyzing the isovist characeristics of stopping behavior in a virtual simulation of the Tate Gallery. All spaces in the virtual environment were filled with an array of points from which an isovist was generated and whose attributes were calculated and stored. The resultant 'set' of attributes was considered, in statistical terms, to be a 'population'. A second series of isovists were computed, generated at the pause point locations (where experiment-subjects paused whilst exploring the simulation). Again, the attributes of these isovists were calculated and recorded and were held to be a 'sample' of the wider 'population'. Using the z-test and central limit theorem, the sample of pause-point isovists was compared to the population to determine how likely it was that the sample was generated randomly. The results suggest that people are not pausing randomly; they are pausing in locations providing maximum visual information.

Keywords: isovists, visibility graph analysis, VGA, wayfinding behaviour.

1 Introduction

Visual field analysis has proved a useful and robust tool in the arsenal of spatial analysis techniques and has been effectively applied to the spatial analysis of buildings and, to a lesser degree, urban neighborhoods. In particular, the type of spatial representation termed the *isovist*, as coined by Benedikt [4], [5] has had considerable utility and longevity. An isovist is simply a polygonal representation of a two-dimensional slice through the potential visual field; it is usually constructed at eye-height and parallel to the floor plane. However, the notion of the isovist is strongly related to previous methods that attempted to represent or describe the visual experience of an environment. Most significantly, it can be seen to be strongly related to Gibson's *optic array* [12], [13], a theoretic entity effectively constituting a three-dimensional isovist. Another notable antecedent lies in attempts by Lynch to represent the continuous, visual experience of routes through complex environments [18] which, in turn, related to his conviction that functional neighborhoods should be *legible* [19], namely should contain a number of *imageable* visual/spatial attributes. A recent attempt to redefine Lynch's work on legibility with methods of visual, spatial and configurational analysis was recently undertaken by Conroy Dalton and Bafna [7] which demonstrated relationships between isovist characteristics of urban environments and a number of Lynch's city elements (in particular, nodes, landmarks and edges). Aligned work, on the classification of urban types, can be found in a paper by Batty [8]. Other work on the experience of landscape has its origins in early work by Appleton [2]. In more recent years, space syntax (a family of theories and techniques examining the relationship between space and society) have employed isovist analyses to quantify the visual experience of complex spatial environments [14], [16], [17] and this work has been extended to take into account the configurational properties of visual fields, that is to say, examining the set of visual relationships between distinct locations. This work has been pioneered by Turner et al. [21], [22], [23], however, such work on networked visual models can ultimately, in turn, be related to early work by Braaksma [6].

From the references above, it can be seen that isovist analysis is becoming an increasingly popular method for representing and quantifying the visual experience of an environment. However, very little work has been done of the relationship between visual field measures and associated behavior, particularly at the small-scale resolution permitted by isovist analysis. Studies on the Tate Gallery [23] show a correspondence with isovist measures. Equally, measures of stopping and engagement at science museum exhibits were shown to correspond with isovist measures of the location of particular exhibits in work by Peponis, Wineman and Conroy Dalton [20]. However, one of the most interesting studies demonstrating a clear correlating with behavior, spatial judgment and isovist properties was demonstrated in a paper by Wiener and Franz [24], where subjects were able to effectively locate regions of high and low isovist area (corresponding to best 'overview' and 'hiding' places). The objective of this paper was to determine whether there was a relationship between people's stopping behavior in a virtual environment and fine-scale visual field analyses of those environments. One hypothesis being tested was that people pause or hesitate more frequently when they are lost or disorientated and that an examination of the locations of pause points could reveal locations where people have become lost. An alternative hypothesis was that people pause in locations that contain more visual information to aid them in re-orientating themselves. In this case, people would not necessarily pause in locations where they were lost, but rather in locations where they were able to relocate or reorient themselves.

2 The Experiment

The experimental environment was a simulation of the Tate Gallery. This experiment initially served as a pilot-study for a much larger study (based on seven virtual worlds) into navigational behavior, published in full by Conroy [10]. Equally, one of the associated experiments (from the larger study) has been further documented in subsequent paper by Conroy Dalton [8].

There were 25 volunteer subjects who participated in this study; the male to female ratio was 3:1. They had a diverse range of experience of virtual environments, ranging from complete novices to those with a high degree of familiarity. The plan of the virtual Tate Gallery is shown in figure 1. The location where the subjects began the experiment is the bottom-centre entrance: the main entrance of the real gallery.

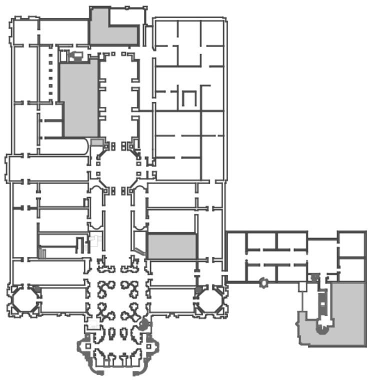

Fig. 1. Plan of the Tate Gallery simulation

The virtual simulation was run on a Silicon Graphics computer with a head-mounted display and a 3d mouse. The HMD provided the subject with an immersive, stereo, full colour LCD visual display and a wide field of view; the horizontal field of view of this headset was 105° with a vertical field of view of 41° and a 40° horizontal overlap. The virtual Tate Gallery was initially modelled using the 2d/3d CAD application MicroStation and then exported as a 3d DXF file. A scripted user event programmed into the world calculated the position of the subject and the orientation of their head ten times every second and saved it as a ASCII text log-file.

3 Measures of Isovist Arrays

The spatial layout of the Tate Gallery was analysed using the computer application OmniVista [9]. OmniVista calculates two dimensional, planar isovists, parallel to the ground plane, identical to Benedikt's original methods of isovist calculation [4]. After importing the building plan, a grid of points was generated throughout the environment, flooding all navigable space. The horizontal and vertical spacing of the grid points was set to four metres. Each one of these grid points was used as a viewpoint from which a single isovist was generated and its attributes calculated and stored. The geometric properties calculated for each isovist location are listed below and the measures that were used by Benedikt in his paper [4] are marked with an asterisk: area*, perimeter, area to perimeter ratio, circularity*, dispersion and absolute dispersion, drift, maximum, mean and minimum radial length and standard deviation, variance* and skewness* of the isovist radials. A brief explanation of how some of the less-commonly used measures were calculated is included in the following section.

Dispersion [10] is the difference between the values of the mean and the standard deviation of the isovist's radial lengths. This measure can take either a positive or negative value. Drift [10] is an exceedingly interesting measure; it is the distance between the location from which the isovist is generated and its 'centre of gravity'. The centre of gravity of an isovist is calculated as if the isovist were a polygonal lamina of negligible but uniform thickness. This measure can only take positive values. Drift will tend towards local minima at the centres of spaces and along corridors. Similarities exist between areas of low drift and the axial breakup of spaces.

Maximum, mean and minimum radial lengths are calculated by measuring the lengths of isovist radials at specified intervals (for example every one-degree). These attributes are generated by calculating the maximum length of any radial (or the longest line of sight), the mean length of all the radials (another measure of 'spikiness') and the minimum length of the radials (or the distance from the isovist generating-point to its closest occluding surface). Standard deviation, variance and skewness of radials are also a family of measures based upon the distribution of the radial lengths of an isovist. Skewness is the third moment of the radials, a measure used by Benedikt, who suggested that it is a good indicator of asymmetry of the perimeter of an isovist polygon.

When the full set of attributes have been calculated for each isovist, the relationship between every isovist viewpoint and every other isovist viewpoint may be examined and a graph representation of intervisibility or the *visibility graph* is constructed. There are two possible types of visibility connection, termed first and second order relationships by Turner et al. [22]. The calculations performed by OmniVista use a first order visibility relationship. Once the visibility graph has been generated, it is used to develop a set of *syntactic* (as used in space syntax) measures. The values calculated are connectivity, mean depth, radius 3 depth and total depth.

4 Results of the Pause Point Data Statistical Analyses

If the complete set of all possible isovists is held to be a *population*, then this population can be compared to a *sample* of isovist properties calculated for each of the pause point locations. There are many methods for comparing a sample to a population to determine how *representative* that sample is of the whole population. The two methods used in this paper are the central limit theorem and the z-test. The z-test relies upon the population being approximately normal whereas the central limit theorem can be applied to a completely random population.

In essence, the sample of isovist measures for each pause point location is compared to the population of the equivalent measure for each grid isovist location. Two values of z are calculated for each measure (one using the central theorem limit and one using the z-test). If z is less than a specified value then there is a 95% confidence that the sample could have been randomly drawn from the population. In other words, subjects are pausing randomly and the visual and spatial layout of the environment has *no effect* upon their stopping behaviour. If, however, the value of z is greater than this amount, then it is unlikely that the sample of pause points was drawn randomly from the population of the grid isovist locations.

According to the results of the tests, the attribute that is least likely to have been randomly drawn from the population is drift. The mean value of drift for the population is 6.86m whereas the mean of drift for the sample of pause points is 4.81m. Since drift tends to towards local minima at the centres of spaces (both rooms and corridors) then it seems appropriate that people should be stopping in these locations. The results also indicate that people were pausing in locations with a much higher than average isovist perimeter value (651.11m compared to 457.66m) and consequently a much smaller area/perimeter value (5.17m compared to 5.85m) and locations which offered longer lines of sight (173.22m compared to 113.22m). All of these results are related: locations which permit the viewer long lines of sight would consequently have a larger than average perimeter and lower area to perimeter ratio. In the Tate Gallery, the parts of the building whose isovists have a high perimeter value are predominantly located at the ends of long visual axes (for example at the entrance looking towards the main galleries). The areas of greatest isovist perimeter, however, are mostly concentrated at the junctions of the major visual axes. These locations appear to be ideal locations for subjects to stop; pausing at locations with a longer than average line of sight is strategically sensible. Locations with an unusually high isovist perimeter value, at the intersection of major visual axes, are locations where a route choice decision needed to be made. Pausing at such a point to scrutinise the environment would appear to be natural wayfinding behaviour. Reinforcing the above results is the fact that people are also stopping in locations with much higher than average radial standard deviation, variance and skewness, which also occur at the intersections of the major visual axes throughout the gallery.

In terms of space syntax measures, it also appears that people are pausing strategically. Subjects are stopping in locations with a higher than average isovist connectivity (212.12 compared to 161.87) and are pausing in locations with a lower than average mean depth (3.84 compared to 4.24). In summary, people are pausing in locations that are highly connected and highly integrated in terms of the building as a whole. They are pausing in locations where they are more likely to glean the maximum information about the configuration of the building (both local and global information).

5 Conclusion

This paper concludes that subjects do not appear to be pausing randomly in the virtual Tate Gallery. People are pausing in locations offering strategic visual properties, locations that afford unusually long lines of sight and large isovist areas. These are also the kinds of locations where the isovists are highly integrated as well as spatially connected. Lastly, it seems that people are pausing in locations far from any occluding surfaces such as internal walls (which would limit available environmental information). It may be summarised that the subjects are being exceedingly strategic in terms of where they stop to survey the worlds. They pause only in locations offering maximum visual, local/global information, reducing the necessity to pause more frequently. People’s navigational tactics can therefore be seen to be both strategic and maximally efficient.

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Digital Design with Style: Characterising Digital Architecture in 3D Virtual Environments for Design Collaboration

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Abstract. 3D virtual environments (3DVE) have the potential to make a major impact on global design teams by supporting distant design collaboration. To maximise the effect of 3DVE as a design tool for collaboration, it is important to explore alternatives other than 3D geometrics for representing digital architecture in 3DVE in order to better support the variety and complexity of design languages that are commonly required for exploring architectural designs during collaboration. To achieve such aim, one important step is to gain a formal understanding of 3DVE as a design tool and current designs in 3DVE. This paper presents the stylistic characterisations of digital architecture in 3DVE based on various design examples. The findings provide a base to develop and integrate alternative design elements other than 3D geometrics in 3DVE for supporting sophisticated design collaboration.

Keywords: Digital architecture; 3D virtual environments; design collaboration; stylistic characterisation.

1. Introduction

The increasing globalisation requires architecture and design firms to collaborate across time zones and geographical locations. This has post new demands on the design industry in terms of additional time and financial inputs for relocating human and design resources. 3D virtual environments (3DVE) have the potential to make a major impact on global design teams by supporting distant design collaboration. Collaborative 3DVE provide a design platform where the design team can be co-located without physically being there. However, similar to many other computer aided design (CAD) modelling tools, design representations in traditional 3DVE also focus on the representations of 3D geometric forms. This low level of representation is inadequate to support sophisticated design collaboration where the team develop, communicate and externalise ideas that are far more complex than 3D geometrics.

To maximise the effect of 3DVE as a design tool for remote team collaboration, it is important to address the issue of design representation of digital models in 3DVE. A research project has set out to explore alternatives for representing digital architecture in 3DVE in order to better support the variety and complexity of design languages that are commonly required for exploring architectural designs during collaboration, for example, layout, spatial adjacency, volume, closure, openness, orientation and way finding. To achieve such aim, one important step is to gain a formal understanding of 3DVE as a design tool and current designs in 3DVE. This paper presents the stylistic characterisations of digital architecture in 3DVE based on various design examples. The findings provide a base to develop and integrate alternative design elements other than 3D geometrics in 3DVE for supporting sophisticated design collaboration.

2. Stylistic Characterisations of Digital Architecture in 3DVE

To characterise art and design we usually refer to the concept of style [1]. In general, styles can be understood as conventions or agreements that are used to recognise similarities or differences among design instances for design studies and design practices. A specific style is exemplified when several design instances "each create a similar impression" [2]. Depending on the actual design domain, the style may be further described with a set of formal properties such as shape, colour, arrangement, texture, size and orientation [3]. The study of style is mainly concerned with the characterisation of these properties. Architectural design has a long association with style. The charm and complexity of different architectural styles lies in the reflections of their cultural references, geographical references, historical references and references to individual artistries. Digital architecture on the other hand has less-developed design theories and principles, and its design examples are comparatively limited. The rest of the section therefore aims at categorising the characterisations that distinguish different designs of digital architecture in 3DVE by observing selected current examples. We call these characterisations stylistic characterisations of digital architecture.

The view of 3DVE as functional places that support an extended range of activities online provides a common ground for designing digital architecture. This common ground highlights two key issues: activities and metaphor. Firstly, 3DVE exist for certain purposes supporting various professional activities. Secondly, their designs apply the metaphor of architecture. Based on this understanding, designing digital architecture in 3DVE can be divided into the following four phases: (1) To layout virtual places/areas: each virtual place/area has a purpose that accommodates certain intended activities. (2) To configure the virtual places/areas: each virtual place/area is then configured with certain objects, which provides visual boundaries of the place/area and visual cues for supporting the intended activities. (3) To specify navigation methods: navigation in 3DVE can be facilitated to consider the use of way finding aids or hyperlinks for assisting people's movements among different virtual places/areas. (4) To establish interactions: in general this is a process of ascribing behaviours to selected objects in each virtual place/area so that people can interact with the virtual place/area and with each other. Based on the outcomes of each design phase, we characterise the designs of digital architecture in terms of *space design and* *visualisation* (layout and object design), *navigation* and *interaction*. These are the three inseparable parts that provide an integral “impression” of 3DVE.

2.1. Space Design and Visualisation

First of all, space design and visualisation of 3DVE is affected by the use of the architectural metaphor. For example, in Figure 1, the image on the left shows a virtual campus design that strictly applies the metaphor of a campus, one in which visitors can find familiar references to their experiences in a physical campus. The image on the right is a virtual museum design that applies a more abstract metaphor and introduces different visual elements in addition to the conventional element that can be found in a physical museum. Visitors in this virtual museum need to explore and learn about the semantics of the abstract metaphor in order to fully absorb the environments.

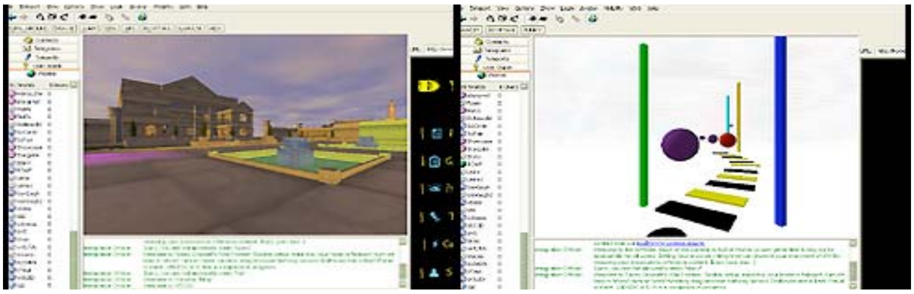

Fig. 1. Two examples from the AW educational universe (from left to right): Wec3D virtual campus and TCWF virtual museum.

The style of the applied architectural metaphor also affects the visualisation of 3DVE. In Figure 2, the image on the left is the reconstruction of a village, depicting the style of Van Gogh’s paintings, whilst the image on the right shows the simulation of a rather modern building.

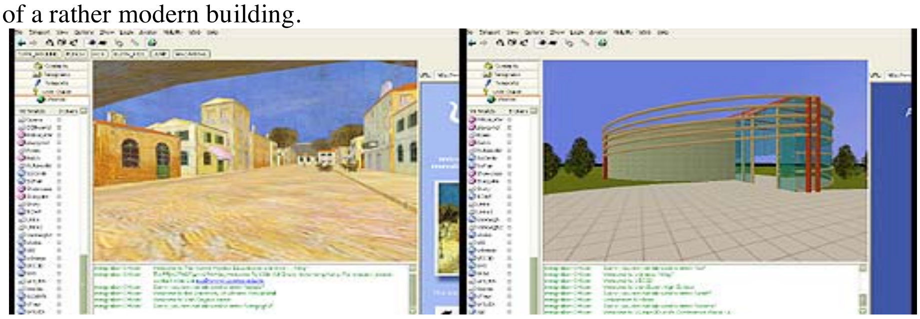

Fig. 2. Two examples from the AW educational universe (from left to right): VanGogh world and VLearn e-learning centre.

Finally, different uses of forms and layouts can also change space design and visualisation in 3DVE. For example, in Figure 3 the design shown on the left uses rectangles, one of the geometric primitives, as the basic design element. In contrast, the design shown on the right uses more organic forms. In Figure 4, the design on the left has its layout expanded vertically, following a spiral curve, while the one on the right has the layout expanded horizontally along a floating path.

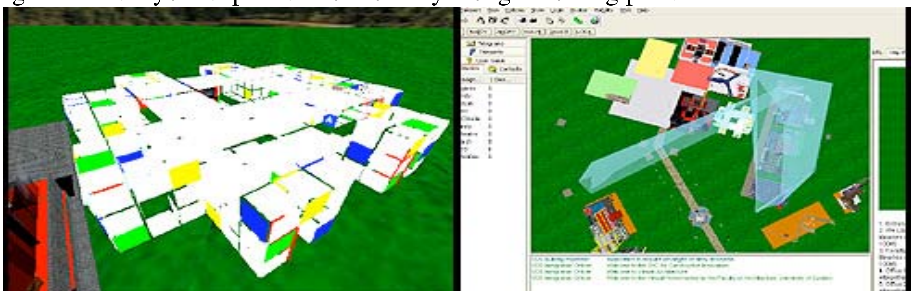

Fig. 3. Two examples from the AW University of Sydney universe, designed by students (form left to right): a virtual gallery and an information centre.

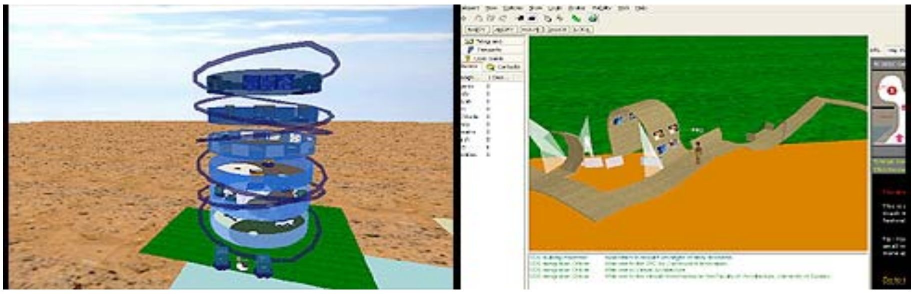

Fig. 4. Two examples from the AW University of Sydney universe, designed by students (form left to right): a virtual studio and a virtual gallery.

2.2 Navigation

Navigation in 3DVE has been studied with direct reference to way finding aids in the physical world [4, 5]. There are at least two kinds of way finding aids that can be integrated into 3DVE from the physical world: (1) The use of spatial elements; for example, paths, openings, hallways, stairs, intersections, landmarks, maps, signs and so on. (2) The use of social elements; for example, the assistance gained from guides (softbots) or other occupants.

Besides these way finding aids originating from the physical world, 3DVE also have their unique forms of navigation where virtual places/areas are hyper-linked. Most 3DVE allow people to move directly between any two locations using hyperlinks. For example, in Figure 5, the design shown on the left has its areas spatially adjacent to each other. Therefore, people can travel from one area to another by following the relevant paths, signs and openings. The image in the middle is an interactive map for a virtual gallery. This map appears at several key locations of the gallery. Visitors can mouse-click on areas that are marked with numbers to teleport directly to the indicated locations in the virtual gallery. The image on the right captures a snapshot of a conversational softbot implemented with Active Worlds (www.activeworlds.com). This softbot is able to guide the visitors in the virtual environment by responding to their general enquires.

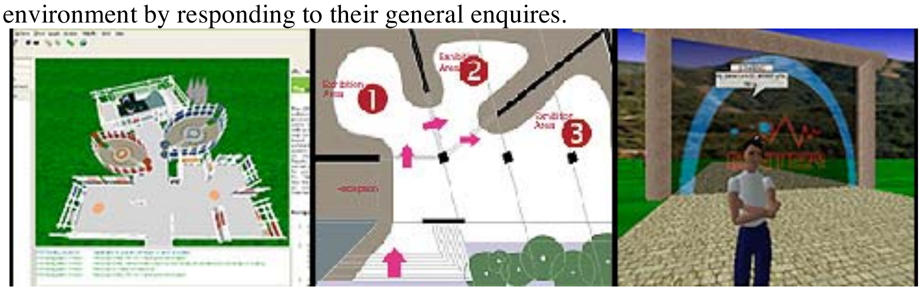

Fig. 5. Three examples from the AW University of Sydney universe:
(left) a bird's view of CRC world; (middle) an interactive map used in a virtual gallery designed by students; (right) a snapshot of a conversational softbot.

2.3 Interaction

Interactions in 3DVE are realised by triggering the behaviours of relevant objects. Designers can ascribe behaviours to selected virtual objects and carefully arrange the ways to trigger them in 3DVE to create very interactive designs. For example, Figure 6 illustrates three different states of a virtual studio showing how the studio can respond differently to the existence of its visitors by selectively showing/hiding parts of the design accordingly.

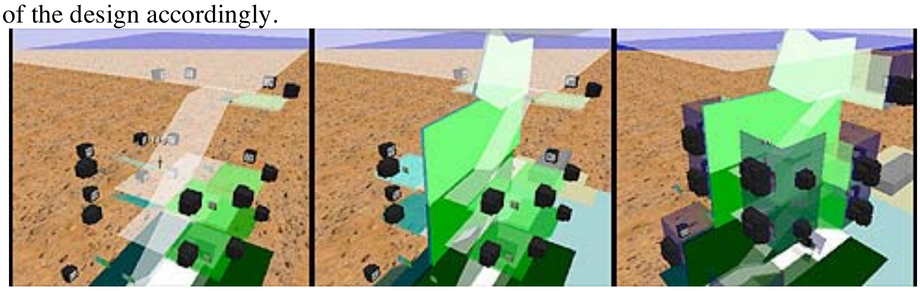

Fig. 6. A virtual studio designed by students at the University of Sydney.

3. Conclusion

The paper has discussed how digital architecture in 3DVE can be characterised in terms of *space design and visualisation*, *navigation* and *interactions*. Some of these characterisations can be similar to the qualities of styles in the physical world due to the use of the architectural metaphor. However, digital architecture also has many unique stylistic characterisations that are different from its physical counterparts, especially in terms of navigation and interaction.

By understanding the stylistic characterisations of digital architecture, it is then possible to develop design formalisms such as grammars [6] which can be applied to design and implement digital architecture that capture these spatial, visual and interactive qualities in 3DVE. In an ongoing study, we have developed a Generative Design Grammar [7, 8] that describes a specific style of digital architecture. Applied by computational agents, it is possible to dynamically design and implement digital architecture that captures this particular style in 3DVE, on behalf of the designers as needed. Generative Design Grammar uses four sets of design rules: layout rules, object placement rules, navigation rules and interactions rules to define the design conventions of space design and visualisation, navigation and interaction for digital architecture. The use of design rules has shown potentials in describing and addressing complex architectural design problems such as spatial adjacency, orientation, way finding and interactive method that are beyond the simple operations of 3D geometrics. For the future study, we will further explore the use of Generative Design Grammar as a design tool in 3DVE and the use of design rules for implementing and integrating stylistic design elements in 3DVE for supporting sophisticated design collaboration.

Acknowledgement

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A study of design collaboration in virtual environments: interacting with the external design representation

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Abstract. Recent developments in virtual environments have the potential to bring significant changes in the way that design-related professionals collaborate and design. Designing and collaboration has been changing with the introduction of these new design environments. The aim of the paper is to identify similarities and differences of interaction with the design representation between co-located sketching and remote designing in different virtual environments. Our results show that the type of representation has an effect on design behaviour and on the externalisation of design ideas.

Keywords: design collaboration, external design representation, spatial and visual perception,

1 Introduction

Recent developments in virtual environments have the potential to bring significant changes in the way which design-related professionals collaborate and design. Although there is a variety of research on collaborative design that examines the way architects design and collaborate using traditional and/or digital media [1, 2], it is still not clear how different types of design environments affect architects' interaction with the design representation. The aim of the paper is to identify similarities and differences of interaction with the external design representation between co-located sketching and remote designing in different virtual environments. In this paper, we present two designers collaborating over four different design environments and report a comparison of those environments with face-to-face (FTF) collaboration, using protocol analysis [3].

The focus of the paper is on the design protocols (verbal and visual) in a collaborative design context, based on the assumption that interaction between team members requires effective communication through discourse and visual representations in the design environments. Collaborative designing involves communication and working together in order to jointly establish design goals, search through design problem spaces, determine design constraints and construct a design solution [4].

In design research, external design representations (sketches, models, diagrams) are recognized as having important roles in the design process [see 5 for the details, 6]. In particular, sketches comprise possible design solutions and also seem to be essential for recognizing conflicts and possibilities [see 7 for more detail on the experiment setting] as well as for revising and refining ideas, generating concepts and facilitating problem solving [5, 8]. Designers sketching in the early stages of a design process and the role of sketching in designing have been examined [borrowed from 9] showing the different roles sketches play in visuo-spatial reasoning and their connection to different aspects of the design process.

2 Studying design collaboration

In order to understand the changes in designers' behaviour, there is a need to have baseline data that characterises collaborative design activity without the technology, that is, co-located sketching. Then there is a need to gather the data to characterise and identify the changes that occur in design collaboration when the different technologies are introduced. With these ideas in mind, a series of experiments were conducted to investigate the impact of technology on design collaboration. The empirical data forms two groups: baseline study (co-located sketching) and comparison study (remote designing) [see 5, for more detail6]

2.1 Baseline study

In the baseline study, the aim is to understand the nature of the collaborative design process when the designers are using traditional materials: pen, paper, scale, etc. and without the digital systems for designing and communication, as shown in Fig. 1.

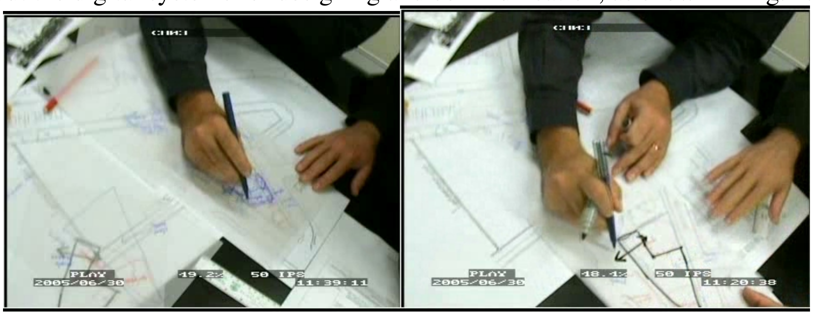

Fig. 1 The baseline study, face-to-face design session

In the baseline study (face-to-face design session, FTF), two architects are collaborating on a design task in co-located sketching in which they are working together around a table and develop a design representation using traditional materials (pen-paper). The designer's actions and communications are captured in the Digital Video Recording (DVR) system [10].

2.2 Comparison study

In the comparison study, the aim is to compare three collaborative design sessions with the baseline study (FTF): (1) FTF and remote sketching (RS), (2) FTF and 3D virtual world (3D), and (3) FTF and 3D virtual world with sketching (3DS). Fig. 2 shows the DVR views of the three experiments in which the architects are collaborating within the technology. The designers were located in the same room with a panel between them to simulate high bandwidth audio communication. The same architects were given different tasks of similar complexity in each setting. Similar to the baseline study, their actions and communication were recorded in the DVR system.

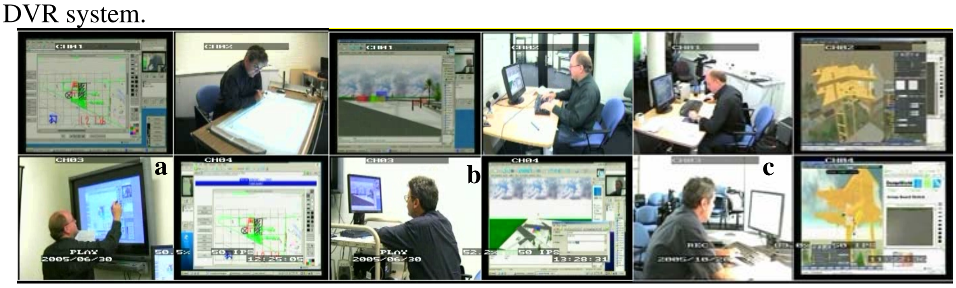

Fig. 2 The Comparison study, two designers collaborating within three different collaborative virtual environments: (a) RS-Groupboard, (b) 3D-Active Worlds, (c) 3DS-DesignWorld

In the remote sketching (RS) session, the architects used a shared whiteboard application (Groupboard) and digital pen interfaces (Mimio and SmartBoard), as illustrated in Fig. 2a. Mimio and SmartBoard were digital touch systems allowing the designers to use the digital pen as a mouse and to write in digital ink on the screen.
In the 3D virtual world (3D) session, the architects design in Active Worlds using a typical desktop system with mouse, keyboard and a monitor, as shown in Fig. 2b.
In the 3D virtual world with sketching (3DS) session, the architects used a prototype system, DesignWorld[1] which included a 3D virtual world augmented with a number of web-based communication and design tools, as shown in Fig. 2c (see [7], for details of the experiments, training sessions and DesignWorld).

3 Method

Protocol analysis, which was first adopted by Eastman (1968) to study design cognition, has been used as a research technique. We examine the protocols by using a coding scheme, interaction with the design representation, which includes the verbalisation and the visualisation of the external design representations (verbal-visual design protocols) to communicate the design ideas with her/himself and/or to others. The interaction with the design representation coding scheme captures: (1) how architects create the external design representation, (2) how they approach construction of the design representation, (3) how they use visual information and

[1] This prototype was developed as part of a CRC Construction for Innovation project.

how they inspect/interact with the interface/tools, given materials and the representation, and (4) what visuo-spatial features of the representation they focus on while they are developing the design solution, as shown in Table 1.

Table 1 The first level of the interaction with the design representation coding scheme

Interaction with design representation	DESCRIPTIONS	Types of data Verbal & Visual
Realisation	Looks at discussions and actions about concretisations of design ideas: (1) Realisation action: create – write – continue – delete and (2) Realisation process: modelling – describe – decision (adapted from [7, 11]).	
Agents Actions	Looks at actions that are related to designers' engagements with the surrounding space: onTools – onElements - gesture	
Perceptual focus	Looks at discussions and actions that are related to visual features/form articulation and spatial relationships of the design elements: spatial relationships: alignment, arrangement, egocentric, allocentric - object/entity: size, form, surface.	
Design Space	Looks at discussions that are related to dimensions of design space: 2D-3D	
Representation Mode	Looks at actions that are related to the types of representation used: 2D-3D (adapted from [12])	
Collaboration mode	Looks at actions that are related to shared representation activities: meeting – individual (borrowed from [13]).	

The design protocols are divided into smaller units. This process is called segmentation. The data of the study consist of a continuous stream of video and audio that has two sources, the designers 1 (Greg) and designer 2 (Lee). Similar to Maher et al. [7], each design session is segmented twice: (1) reflecting Greg's design actions and intentions, and (2) reflecting Lee's design actions and intentions. Consequently, the two major segmentation rules, which are the utterances-based segmentation method [11] and the actions-and-intentions based segmentation method [14], are combined in this study.

4 Results

The duration percentages of each action category are examined to measure the similarities and differences of designers' behaviour in each design session. Fig. 3 shows the duration percentages of the designers' realisation actions comparing the baseline study with the virtual environments. As shown in Fig. 3a, in the baseline study, the duration percentages of the create and the write actions are higher, when the designers spent time on writing down the areas and listing the requirements, and drew the design solution. In the RS session, there is an overall increase in the duration percentages of the realisation actions, in that the duration percentages of the create action are higher, compared to the baseline study, as shown in Fig. 3a. The 3D and the 3DS sessions show different trends of the realisation actions, compared to the baseline study. The duration percentages of the continue element action is significantly high, followed by the create element and the write action categories in the 3D modelling environments, as shown in Fig. 3b and c. This also consisted of a cycle of actions such as move/rotate/transfer/group, etc., as pointed out by Maher et al. [7]. Thus the "continue" action consists of a series of actions that require a continuing attention on the particular object.

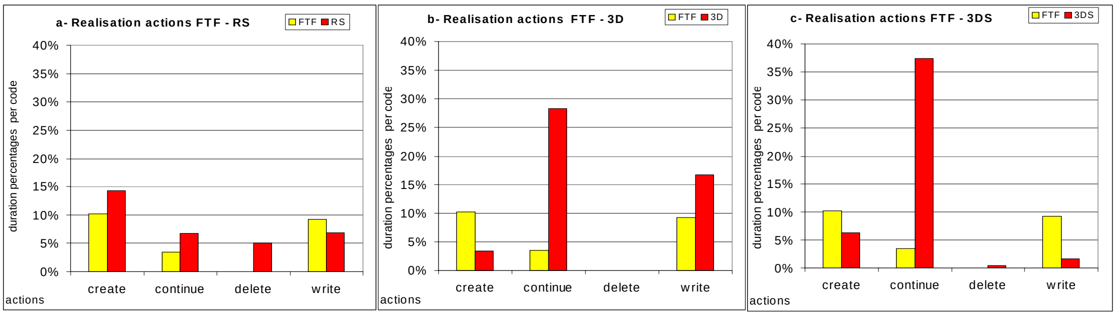

Fig. 3 The duration percentages of the realisation actions: (a) FTF and RS, (b) FTF and 3D, and (c) FTF and 3DS

Fig. 4 shows the duration percentages of the perceptual focus actions of the designers comparing the baseline study with the virtual environments. The duration percentages of the object/entity action are higher in the baseline study, as shown in Fig. 4a. The RS session shows a similar trend, with a drop in the duration percentages, as shown in Fig. 4a. In the 3D and 3DS sessions, there is an increase in the duration percentages of the spatial relationships actions, compared to the baseline study, as illustrated in Fig. 4b and c.

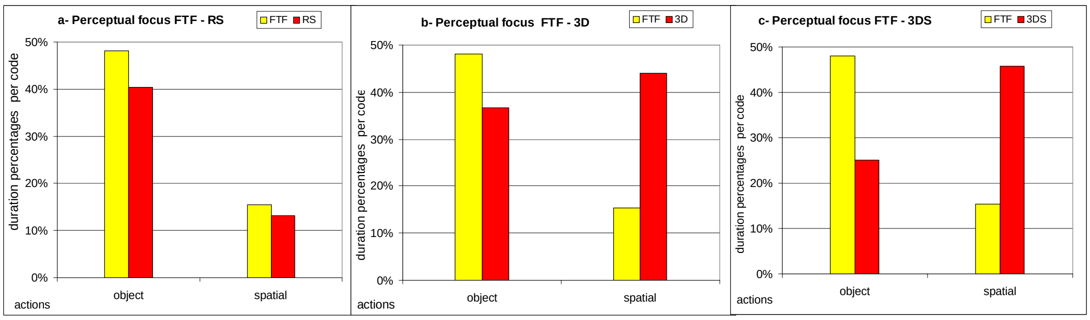

Fig. 4 The duration percentages of the perceptual focus actions: (a) FTF and RS, (b) FTF and 3D, and (c) FTF and 3DS

The durations of the spatial relationships actions are investigated in order to understand what kind of spatial features the designers focused on. Table 1 shows the duration percentages of the spatial relationships actions in all the design sessions. In the baseline study, the time spent on the spatial features of the design representation was limited (the highest percentage is 7.2%, for the arrangement actions), as shown in Table 1. We observed that the architects focused more on the alignment action (spatial adjacency of the design objects) in the 3DS sessions (30.9%), and focused more on the arrangement action (how the objects should come together) in the 3D session (12%). The duration percentages of the allocentric referencing are high in the baseline study. There is an increase in the duration percentages of the allocentric and the egocentric actions in the 3D virtual worlds, compared to the baseline study, as shown in Table . The highest percentages of the actions are shaded in grey, as shown in Table .

Table 1. The durations of the perceptual focus on the spatial relationships action (second and percentages of the total elapsed time)

Sec - %	FTF		RS		3D		3DS	
alignment	105.44	2.9%	95.07	2.6%	742	20.6%	1113.54	30.9%
arrangement	258.24	7.2%	129.26	3.6%	444.47	12.3%	339.03	9.4%
egocentric	18.47	0.5%	110.3	3.1%	94	2.6%	81.4	2.3%
allocentric	170.57	4.7%	133.17	3.7%	280.54	7.8%	206.3	5.7%

4 Conclusions

First, we conclude that the two sketching sessions show a similar trend, that the realisation actions of the design representation are based on the “create” and the “write” actions. In contrast, in 3D modelling environments, the realisation actions of the design model were based on the “continue” action. Second, analysis of the protocol shows that the type of presentation has an effect on designers’ perceptual focus on the spatial properties of the design solution: (1) the designers focused more on the visual features of the design, which are size, form, colour and materials, while sketching, and (2) the designers focused on the spatial relationship of the design objects, which are spatial adjacency, arrangements, position, etc., while 3D modelling. Third, our analysis showed that there was an increase in the designers’ referencing (egocentric and allocentric) in 3D virtual worlds, and they tended to position themselves outside the design representation in sketching. In contrast, some actions that are related to interaction with the surrounding design space were different between the both sketching environments. For example, while they were engaging more with the problem space and the solution space in the baseline study, the same designers engaged more with the tools and interface of the applications in the RS session. Different interaction behaviour was also observed in both 3D modelling environments. For example, in the 3D session, the designers engaged more with the tools and interface of the applications. On the other hand, in the 3DS session, similar to the baseline study, the designers engaged more with the visual analysis of the design solution whereby they inspected the model by flying over and walking through it.

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What about People, Do They Matter? Insights on the Impact of People's Presence in the Built Environment

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Abstract. The identification of spatial properties responsible for influencing pedestrian navigation in non-familiar environments has been the focus of social scientists' research. Two findings from this were put together in this paper: First, the fact that people seem to follow global properties of configuration while navigating in complex buildings and urban environments; second, several indications that the presence of other people in the urban environment might influence the way an observer interprets and stores information about it. These lead this research to focus on – the presence of people. A questionnaire was made to investigate the impact of this to an observer in non-familiar urban environments. Results suggest that people are seen as an affordance of the environment, then acting as a feature considered on route choice. This finding has implications both in spatial cognition and navigation processes, thus being relevant to architecture in two different ways: conception/presentation and building use.

Keywords: Environmental Cognition, Wayfinding, Space Syntax, Natural Movement, Affordances, Awareness, Human Models, Complex Buildings.

1 Introduction

Pedestrian navigation in built environments has been a research focus of social scientists for at least forty years. Trying to identify spatial properties responsible for influencing this has been the main goal. Two findings from this line of research are assembled and explored in this paper. First, some research findings have pointed to the relevance of people in buildings and in the urban environment as possible interference in the way an observer perceives and stores information about the environment (Appleyard, 1970; Beaumont et al., 1984; Evans et al., 1982). Second, Peponis suggested that people seem to follow global properties of configuration while exploring a building (Peponis et al., 1990).

The implications of these possibilities are far reaching and its exploration may help to the comprehension of route choice behaviour in complex buildings and in the urban environment, and potentially to the understanding of how individual behaviour creates global patterns of movement. This means insights both to the Man-Environment and Individual-Social paradigms. Also, considering the importance of people to the understanding of environments, the space of graphics (Tversky, 2003) (namely architectural and urban representations) may benefit from this knowledge. These lead this research to focus on local properties of space which are simultaneously a consequence of configuration, and which has been recognised as a relevant feature of the urban environment – the presence of people.

Sociologists and psychologists give many possible explanations to the importance of social interaction. These are suspected to be the cause of such importance given to the presence of other people while navigating. However, it is not the intention of this research to deeply investigate this, for now the aim is to check if this is the case. From these considerations, three questions emerged, and a questionnaire was conducted in order to answer them.

2 The Questionnaire

A questionnaire was made in order to explore the relationship between the individual and other humans in non-familiar environments. The questions to answer were: first, are people sensible to the presence of other people in the public space? Second, in case they are, is it to the point that the density of people may have influence on route decision? Third, what do people seem to associate to the presence of different densities? These questions were addressed by showing three pictures of a virtual street populated with different densities of people and ten questions were asked.

The sample consists of 275 respondents of 29 countries. 168 female (61%) and 107 male (39%).

2.1 Results

The first question intended to answer: do people consider the same physical (inanimate set) populated with different densities of people as different environments? This question is based on the assumption that in case a difference is reported, being the human presence the only difference, people not only actually see people, but get from them enough information so as to consider the environment as different. The answers clearly point towards the difference.

In question 6, people were asked to choose the street they would follow on the context of a common exploratory situation. The text was: "Imagine you are just out of the hotel in a city which you are visiting for the first time. You will start exploring the surroundings. Which way would you take? Would you follow street *a*, *b* or *c*?" Moreover, the results allowed people to say that "they have no idea", and for those who choose a street, the level of confidence was explored by giving to each street, the possibility of choosing the expressions: "I *think* I would follow street…", or "I am *sure* I would follow street…". In answer to this question 64% of the sample choose street *c* (the most populated. Being *a* the less populated). From these, 57% showed a limited level of confidence by choosing: I *think*, but 43% (28% of the total) showed extra confidence by choosing: I am *sure*. 3% of the total answered that *they had no idea*. The answer to this question stresses out the meaning of the previous one, emphasizing that people are sensible to the presence of other people to the point that they can feel the same physical set as different when populated by different densities of people, but also that they show a clear preference for more crowded spaces (in non familiar places).

This evidence becomes even more conspicuous when one looks at the 20% of the respondents who choose *I think street b* (the second less populated). Because cumulative answers to street *a* only account for 10%, the 20% *I think street b* is seen as from people who were probably tempted to choose street *c*, but maybe found it too crowded (especially due to the absence of *I sure b*). Even people who choose street *a*, they are choosing it, so, they feel the difference. Anyway, the purpose of this question was not to evaluate preferences in street density population, but simply to detect if people's density may have influence on route choice. It apparently does.

In questions 7, 8 and 9 people were asked to choose from one list of commercial activities the ones they would expect to find in each street. This question tried to investigate what people see in the environmental difference they report. One possibility was thought to be that they could see more diversity in terms of destinations, commercial types were used to test this. What is in stake is not to test what kind of shop fit where. What really matters here is that overall scores show that people identify more types of commercial activities in more populated streets. The results show a clear tendency of people to associate more diversity of commerce to more populated streets. Street *a* has a mean of 2.23 types of commerce, street *b* of 3.20 while street *c* has 4.42.

Despite all the evidence that people are sensitive to the presence of other people in the urban environment, that it may influence route choice in non familiar places and that they apparently associate more commercial diversity to more people, the reasons to choose a certain street is not conclusive. In question 10, people were asked to rank from 1 to 5 the features they took in account when they made the route choice in question 6. This was the only question which imply that people bring to conscience and justify a previous choice. The unambiguousness of choice showed in previous answers is absent to the answer to what made them make that choice.

3 Implications of the Findings to Environment and Behaviour Theories

Consequences of these findings have an impact on established theories on urban collective movement and individual behaviour; namely help to explain the links between individual cognition and collective patterns and between man and environment.

The author suggests in this paper that people are seen by other people as affordances (Gibson, 1986). In this case, a very special kind because apart from affordances as security, potential for interaction, for help, etc, some results of this questionnaire (as the answer to question 5) suggest that we recognise ourselves in others and recognise their actions as potentially our own and see 'second hand' affordances in their presence. In other words, the suggestion is that we see the presence of other people as a sign of the existence of affordances; implying that some kind of positive correlation exists between the two.

The fact that people seem to follow global patterns of configuration before they get to know it, as suggested by Peponis (Peponis et al., 1990), may find here an explanation. People do not know the configuration, but they may perceive signs of it by comparing people's density in different spaces. It is not clear if they read the presence of people as configurational properties of the setting, or as local signs of diversity, safety, or something else; however, what are these features (including configurational properties) if not affordances?

Whatever the case, what are the implications of the fact that people recognise differences in environments in function to the density of present people? And that, at least to a certain point, they tend to choose the most populated ones?

The answer for this lies in the way one uses this information while exploring an environment.

3.1 The Process of Getting to Know an Environment

The expression 'familiar environment' is often used in literature to refer to a space or set of spaces which the individual knows. To refer to the opposite idea the term 'non-familiar' is used. However, it is often forgotten that an environment which we refer to as being familiar implies that it has been non-familiar in the past. This calls attention to the one-way process of getting to know an environment. If there is a process, its understanding lies on the understanding of its rules. So, what are the consequences of the application of the rule suggested by the questionnaire, that people tend to be attracted by people? The recall of the process reshapes the question: what are the implications of the systematic application of this rule? The author suggests a look at it in through: the Individual-Social.

3.2 Implications to the Individual-Social Paradigm

If one considers for a moment that each urban environment is always new for each one of us at some point in time, the situation portrayed by the presented experiment will apply to each one of us in each environment that we know. The implications of this suggest that we all get to know environments by using most populated spaces first. These being the ones we first use, it is reasonable to accept they are going to be the first ones to be stored in our memory. It is so logical that they are the ones we use in the next day because they are what we know. The need or will to go to other places will obviously widen our knowledge and allow us to store more information (although the tendency when exploring new ways should be the same of using more populated streets). This being the process of environmental knowledge acquirement and storage, it is logical to expect that the more populated streets are more used, more present in our journeys, and naturally more present in our mental environmental storage device. One of the findings which deployed this research, that higher densities of people around buildings reinforce the memory of those buildings (Appleyard, 1970; Evans et al., 1982) reinforces this argument. It is then reasonable to expect the more populated streets to be more important in our mental scheme not only for being more used, as for being more populated. This shows a multiplier effect of people density and so its importance.

Another phenomenon may join this in the cases where natural movement theory (Hillier et al., 1993) applies. The most accessible streets being the most populated, another multiplier effect takes place. This is of particular importance because, over time, it may lead to people finding those streets useful in terms of access and this may, again, reinforce their presence in our mental environmental storage device. Also, in this case, the absence of exploring other routes will diminish the lack of options and by doing that reinforce the use of the known ones, keeping them 'central' in our mind, and life. Here a clear connection about the individual and the collective behaviour emerges. In one person's point of view a certain space is more attractive than another and, as just explained, the use of it leads to repetition. This repetition over time creates an individual pattern which could be irrelevant in terms of the collective pattern. However, the individual pattern is deeply anchored in the presence of other people, or in other words it is bound to the collective pattern. The principle seems to be based on a cycle where people attract more people. Questionnaire results however also point to a possible pervasive effect of this, suggesting that in a certain point people may find some places too crowded and using instead the next less populated.

Haq also considers the hypothesis of a cycle where "Configuration creates movement, which in turn promotes an understanding of the configurational properties. This then contribute to more accurate movement and wayfinding."(Haq et al., 2003). This idea may well be right but it still does not explain how people are attracted to configurationally relevant spaces in the first place. In the present paper the suggestion is that configuration is 'empowered' by individual cognition which attracts people to where other people already are. Haq also mentions the process of knowledge acquirement suggesting that the local properties of connectivity is more meaningful than integration in the early phase of contact with a new environment and that afterwards individuals follow the space syntax measure of integration (Haq et al., 2003). This may be the case, but to state that imply more direct analysis on the impact of the measure of connectivity on people's behaviour. However, this is an important reminder which leads to the fact that rules may change within the process of learning, claiming extra attention to the process, where knowledge seem to bound and influence rules relative weight.

Another rule was identified in 2003. Dalton shows that people knowing the direction they have to take to their destination, tend to follow it, choosing the streets which imply the smaller deviation from it (Dalton, 2003). Note that the existence of Dalton's rule concerning directions is not a contradiction to the one suggested here. Several rules may coexist, however further work is needed in order to understand their relative weight.

4 Conclusion

If an idea of configuration in its own right is built in our mind as we experience it, many may be the environmental signs we read in order to build it. This paper shows evidence that the presence of people may be one of them. Both by influencing the way people move as well as one's mental representations of environments, the presence of people seem to be very powerful in influencing both the way space is perceived and the way it is used. This being true to exploratory behaviour, is significant to the way people use large spaces as complex building or urban environments, and its multiplier effect should be considered in urban design strategies.

The suggestion is that we learn the environment by own experience but we rely on others' experiences in order to make it more effective.

Additionally, this evidence claims attention to the way architects and urban designers populate drawings and models. If people are so influenced by the presence of other people in environments, this means that they rely on the first to perceive the latter, this may imply that the wrong use of human models in architectural representations may be counter productive, but the adequate use may empower understanding.

These conclusions suggest both the importance of visibility of populated spaces in environments as 'natural signage', and the importance of the correct use of human models in architectural representations, both in final representations and in conception stages.

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