#135

USING SPACE SYNTAX APPROACH TO ASSESS SIGNS' LOCATIONS FOR IMPROVING WAYFINDING IN AN EDUCATIONAL SETTING

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ABSTRACT

Purpose: This study looks at the utility of Space Syntax measures for analysing signs for improved noticeability and usability. It identifies spatial properties of signs locations that positively influence users' capacity to find their destinations in an educational setting.

Hypothesis: In this study, we contend that different spatial properties of signs' locations, as measured using space syntax, will show consistent correlations of different strengths with the number of times people report seeing signs and using them in a wayfinding task.

Research design: The independent variables of the study include the spatial properties of the locations of signs measured on building plans using the VGA and Isovists techniques of space syntax. The dependent variables are the number of times people reported seeing specific signs and using them in a wayfinding task. This data was collected using pre-established observation protocols.

Findings: Using correlation analysis, the study concludes different effects of space syntax measurements on the number of times users see and use signs in their wayfinding tasks. The findings of the study demonstrate the usefulness of applying the space syntax approach to help designers when placing signs in educational settings.

KEYWORDS

Space Syntax, Signage, Wayfinding, Assessment Tool, Educational Settings

1. INTRODUCTION

It has been demonstrated in previous studies that the signage system plays an important role during first-time users' wayfinding experience because they provide directional information that is explicitly available in the environment (Holscher, Buchner, Brosamle, Meilinger, & Strube, 2007; Rousek & Hallbeck, 2011; Vilar, Rebelo, Noriega, Teles, & Mayhorn, 2015) (Conroy, 2001; Vilar, Rebelo, & Noriega, 2012). Using signs in a wayfinding task is not a random process, because it follows the psychological patterns of visual perception that guide an individual to use some signs more than others (Vilar, Rebelo, & Noriega, 2014). Under such circumstances, it can be difficult to predict whether the designs of a particular signboard or its location render the best usability that support users' navigation or simply add to the visual clutter in the environment. The current study focuses on answering this question. Specifically, it assesses the relationship between signboards use and the spatial properties of their locations. It targets the impact of signs' visibility on individuals' capacity to view and use them while finding a destination.

The study applies Space Syntax techniques – Isovists and Visibility Graph Analysis (VGA) – in order to imitate, as closely as possible, the visual field of signs and their visual relationships. Using Space Syntax techniques, the study will be able to identify and measure the possible role of specific spatial features of signs' locations that are associated with their use. The study combines behavioural data collected from the site of investigation using behavioural tracking protocol. Thirty-two participants volunteered for the study. A prior approval for the use of human subjects in this research project was required and received from the Office of Research Compliance Institutional Review of the University of Kansas.

1.1. INSIGHTS FROM THE LITERATURE ON SIGNBOARD DESIGNS

Although enhancing signage design and planning can provide an accessible and cost-effective means for supporting way-finders in unfamiliar environments, there is little evidence-based information available to guide architects in designing buildings to promote signage' noticeability and usability (Buechner, Wiener, & Hölscher, 2012; Rousek & Hallbeck, 2011; Tzeng & Huang, 2009). Designers usually develop their expertise by applying standard guidelines and knowledge about best-practices in particular environments to come up with ideal solution (Buechner et al., 2012). However, this traditional approach may not always work, because some environments are architecturally and geometrically complex and might have a high amount of movements. In addition, different user groups with different goals or motivations may have to be served.

Some previous studies have focused on changing the physical qualities of signboards by changing the size, colour, font and shape, and on changing interior finishes of the existing building to attract potential users (Lomperski, 1997; Rousek & Hallbeck, 2011; Stempler, 2013). While these studies have identified several local features of signboards that might influence their use, they fail to acknowledge that signage use is a supporting activity of purposeful travel and is influenced by the way people understand and move through buildings. This suggests that signboard use is not only determined by the physical qualities of signs, but also by the relationship between signage and the spatial characteristics of their locations within a building environment. Thus, the spatial properties of signs' locations can be considered as a main potential determinant of signboards use during individual's movement within a building.

Therefore, we employed two of Space Syntax techniques – Isovists analysis and visibility graph analysis (VGA) – in order to identify (1) the visual fields of signs and (2) their visual relationships with all other interior spaces in the building.

1.2 THE SPATIAL PROPERTIES OF SIGNS' LOCATIONS

1.2.1. SIGNS' VISUAL FIELD:

The visual field addresses the extent to which a sign can be seen from other interior spaces within the building or what is called visibility catchment area VCA of a sign (Xie et al., 2007). Space Syntax techniques provide means for analysing the visual field though incorporating the concept of isovist. The isovist, as proposed by Benedikt (1979) is a 2D polygon representing the amount of space that is visible from a particular vantage point. A large isovist area from a point, for example, implies a large volume around this point and a small one implies a tight confined space that is visible from the point. Once the 2D isovist polygon is created, it is possible to derive a number of quantitative measures of its geometry, which include area, perimeter, occlusivity, compactness, and drift. Area is the amount of visible space. Perimeter is the total length of an isovist's boundaries defined by building surfaces. Occlusivity is the total length of an isovist's boundaries that is not visible or is not defined by building surfaces. Compactness is a measure of isovist complexity. Drift measures the deviation of the sign from the centre of the isovist polygon which entices an individual to orient him/herself in this direction to gain the largest possible view (Dawes & Ostwald, 2014).

1.2.2. VISUAL ACCESSIBILITY:

Visual accessibility is related to the visual relations between signs and other spaces. Visibility graph analysis (VGA) is a Space Syntax technique developed by Turner and his colleagues (A. Turner, Doxa, O'sullivan, & Penn, 2001) to assess how visible any point in the spatial configuration is from any other point. VGA incorporates different quantitative measures, which include; Connectivity, Integration, and Entropy. (1) Connectivity quantifies the local visual relationship between each space and its immediate neighbours. Higher connectivity values would ensure better visual permeability between the space in which a sign is located and other surrounding spaces. (2) Integration value is an important measure of local and global visual permeability. Researchers indicate the higher integration values a space (e.g., the visual field from a sign's location) correspond with better permeability and accessibility of this space (Beck, 2009; Hillier, 2007; Hölscher, Brösamle, & Vrachliotis, 2012). (3) Entropy is a measure of physical disorder, where high entropy values represent a lack of order in the sense that the relationship between the parts and the whole of the spatial structure is not systematic (Hillier, 2007). Entropy also reflects concepts of diversity and spatial differences (Stamps III, 2002). Bhatia, Chalup, and Ostwald (2012) propose that higher Entropy values for a point located in a space reveals high uniqueness of that space, as compared to other spaces within the entire layout.

1.3 RESEARCH HYPOTHESIS

In this paper, we examine the relationship between the number of signage use (dependent variable) and different spatial features (independent variables), identified quantitatively using space syntax analysis. The study tests the following null hypotheses:

H1: The visibility of a sign measured by the properties of a sign isovist is unrelated to sign use.

H2: The visibility relations between a sign and other spaces within the building are unrelated to signs use.

2. RESEARCH DESIGN

The diagram in Figure (1) below presents the research process, which consists of three stages (1) collecting data about signs' usage from the field; (2) floor plan analysis using Space Syntax; and (3) conducting statistical analysis to examine the relationship between the dependent variable and independent variables.

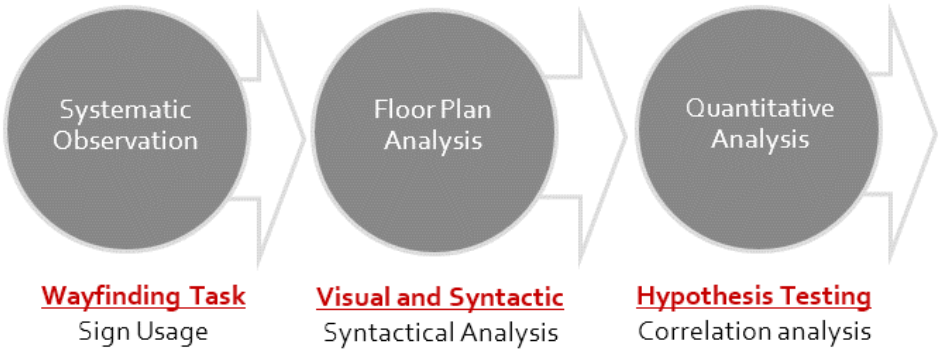

Figure 1 - Research Process

2.1 PARTICIPANTS OF THE STUDY

32 participants between the ages of 19 and 53 years volunteered for the study. 16 of participants were female and 16 were male. All of participants are first-time user who did not visit the KU's Edwards campus before the study.

2.2 THE STUDY SITE

The study was conducted in the University of Kansas Edwards Campus in Overland Park, Kansas, USA. The Campus consists of three buildings, Regents Center, Regnier Hall, and Business, Engineering, Science, and Technology Building (BEST). The buildings are connected together at the ground level (Figure 2). Both buildings, Regnier and BEST, have a simple linear layout with one corridor and a set of spaces arranged along the corridor. In contrast, Regents has a relatively more complex layout that consists of one path and two other corridors branching out from this path. In general, campus first-time users rely on asking the information desk to get directions and less on using wayfinding aids such as signs or maps, which increases the burden on staff and information desk.

The signage system in the campus consists of three types; orientation signage, direction signage, and identification signage. Each type provides information for the visitor when moves further into the building. Orientation signage offer visitors an overview of their surroundings in the form of comprehensive site maps and directories. Direction signage constitute basic information about the circulation system, where it directs users between different spaces by displaying graphic prompts, such as symbols, and arrows. Identification signage explains the name of certain destinations or places.

The signs were about 25cm-35cm wide, and were mounted on the wall at eye-level. The signage system problems result from the fact that (1) some of signs are not placed at key decision points, which makes it particularly difficult to navigate through the buildings. (2) Room numbering scheme become confusing when moving between buildings. And (3) the maps, which contained a 2D birds eye view of the building, are not aligned with the building, so that the top of the map does not correspond to "ahead"' in the building. These main issues create confusing environment for first-time users and make them more dependent on asking other people for directions.

2.3. WAYFINDING TASK PROCEDURE

Upon arrival for the study, participants indicated consent to participate and were read task requirements by the researcher. The key requirement for participants was to find a specific destination inside the campus buildings. There were three wayfinding routes as shown in Figure (2). Each participant was randomly assigned to a specific route. There was no time limit for completing the task. After a participant reached her destination, the participant was asked to identify the signs she used while walking to the destination.

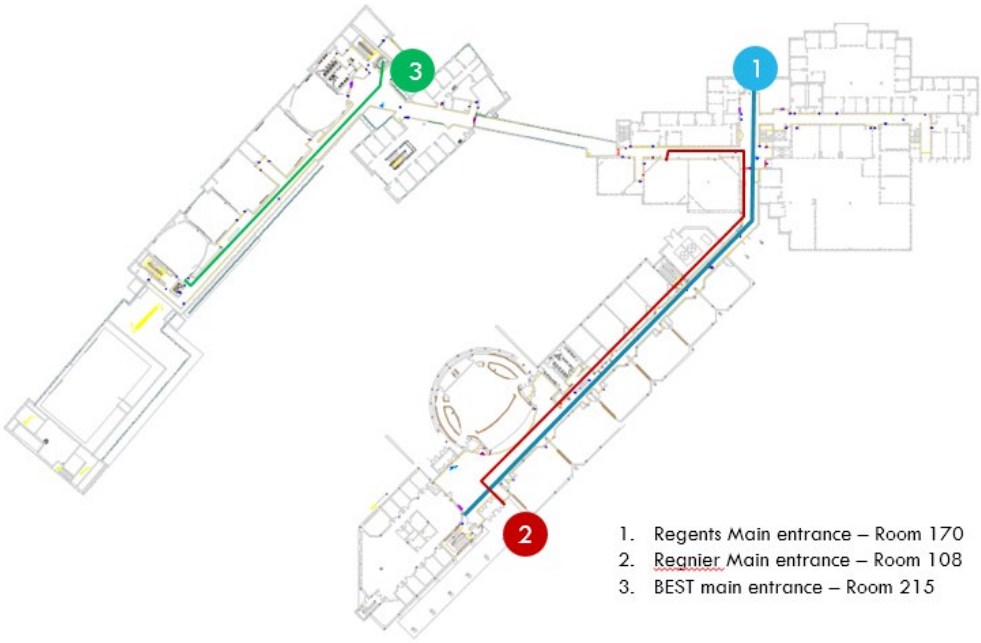

Figure 2 - Wayfinding Routes in the Building

Geographic information system (GIS) was used to locate the signs on buildings' layouts. Maps in Figure (3) show the distribution of signs' usage based on different routes. The large circles indicate high usage and small circles indicate low usage.

Figure 3 - The Distribution of Signboards' Usage on the Three Routes

2.4. FLOOR PLAN ANALYSIS

Floor-plan analysis gives an understanding about the layout of the setting, which is needed to develop a visual and perceptual relationship between signs and different spaces in the environment. In this research, we perform two types of Space Syntax Methods; Visibility Graph Analysis and Isovist using UCL Depthmap software (Turner, 2010). Of the measures produced by Depthmap, the following Isovist- and Visibility- based variables were picked as independent variables in the study:

- Isovist-based variables (geometric):

  Area and Perimeter

  Drift (Angle)

  Occlusivity

  Compactness

- Visibility-based variables (topological):

  Integration (global and local with a radius of 3)

  Connectivity

  Entropy (global)

2.5. STATISTICAL ANALYSIS

Statistical analysis using SPSS 20 (SPSS, 2013) showed correlations of different strengths among the independent variables with the number of times participants report seeing signs and using them in wayfinding. The findings are explained in detail below.

Hypothesis 1: Sign's Isovist and Use

The correlation coefficients in Table (1) show no correlation between the area, perimeter, occlusivity, or the compactness of Isovists, and the total number of signs that are seen or used by participants. Correlation coefficients also show that the Isovist Drift Angle of signs had a correlation with the total number of signs that are seen or used by participants. The correlation is weak and negative (Pearson r = 0.344; P value = 0.007). This finding suggests that in wayfinding situations, signs with smaller drifts from the centre of the isovist polygon may have more usage.

Variable	Person r	r^2
Isovist_Area	0.190	0.0361
Isovist_Perimeter	0.159	**0.025**
Isovist_Drift_Angle	**-0.344****	0.118
Isovist_Occlusivity	**0.197**	0.039
Isovist_Compactness	**-0.178**	0.032

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 1 - Correlations of Sign's Isovist and Signs Use

Partly supporting the null hypothesis 1, different features represent signs' visual fields have weak and insignificant effects on signs' usage. Only Drift angle explained about 11.8% of signboards usage. It also found that signs with low drift angle are mostly located in parts of the building that form a small alcove or niche in the walls as shown in Figure (4) below.

Figure 4 - Isovist Visual Drifts.

Hypothesis 2: Sign's Visual Accessibility and Signs Use

The correlation coefficients in Table (2) show no correlation among connectivity, global and local integration values (R3) and the total number of signs seen or used by participants. The correlation coefficients also show that signs' visual entropy had a weak positive correlation with the total number of signs that are seen or used by participants, which yields a Pearson r equal 0.331 (P value = 0.005). This finding suggests that in wayfinding situations, environments with high entropy, where the relationship between the parts and the whole spatial structure is not systematic, would increase the use of signs. Put simply, in a disorderly environment people tend to depend more on signs for wayfinding.

Variable	Person r	r^2
Connectivity	0.093	**0.008**
Visual_Entropy	**0.331****	0.109
Visual_Integration_Rn	**-0.018**	0.036
Visual_Integration_R3	**0.181**	0.033

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2 - Correlations of Sign's Visual Accessibility and Signs Use

Partly supporting the null hypothesis 2, different spatial visibility features have weak and mostly insignificant effects on signs' usage. However, the measure of spatial differences and spatial disorder show better relationship with signs usage than other visual accessibility measures (connectivity and integration). Similar to the previous finding, it is found that most signs with high usability and high entropy located in spaces that segregated from the whole building structure such as alcoves as shown in Figure (5) below.

Figure 5 - Visual Entropy.

3. CONCLUSIONS

Focusing on micro-scale, building design and signage guidelines often prescribe requirements for signs legibility such as the size, height, viewing distance, and location of the signs in order to facilitate wayfinding in buildings. Designers use these guidelines, along with other environmental factors such as the presence of possible visual and physical obstructions, the location of entries and exits, and the directions from which users would approach the building for specific functions, to identify the optimum locations for signs in the environment. However, building design and signage guidelines do not always guarantee the optimum locations of signs using wayfinding strategies that would improve user awareness and satisfaction. That is because the macro-scale environmental information on accessibility, visibility, and complexity of the environment are often not included in these guidelines. Designers need both micro- and macro-scale information and better tools to evaluate signs' performance and identify appropriate locations in relation to the information to improve circulation and wayfinding, especially for the first-time users of buildings. Therefore, some of space syntax techniques were employed here as a tool to investigate if the spatial and visual configurational qualities of the environment could affect signs' noticeability and visibility. The findings of the research provide evidence indicating the usefulness of the space syntax approach in assessing sign usage. According to this study, at least two measurements, visual entropy and signs' isovist drift, help explain sign use behaviours in our case study.

Signs' isovist drift provides a way to define the visual field of a sign and its direction or orientation in a behavioural setting. Therefore, using this information the designer can locate the signs in the layout of the building to improve a sign's visibility in relation to user movements and the directions of user movements. Visual entropy is another measurement that designers can consider when placing signs within the built environment. Entropy is a measure of disorder in the environment, developed based on the information theory of Shannon (1949).Instead of measuring information content, space syntax's entropy measures the complexity of spatial structure of buildings. When entropy is zero, the sequence of information in the building is perfectly ordered. As entropy increases, the sequence of information becomes increasingly disordered in the building. As shown in Figure (6) below, a more complex layout would generate high entropy values such as layout (1), where the average value of visual entropy is 0.80. In contrast, a less complex layout would have low entropy values such as layout (2) (average entropy = 0.51). Making any new alterations in the buildings' layout such as setbacks in the walls Increases the complexity of the building layout and would make visual information more disorderly, thus affecting how the information can be accessed. As shown in figure (6) below,

in layouts (3) and (4) the setbacks in the wall create new spaces in the building layouts, and increases the entropy values. The average entropy values for layout (3) and layout (4) are 0.85 and 0.57 respectively, which are higher than that for layout (1) and (2). The new spaces in layouts (3) and (4) have high entropy values as well, indicating that access to information in these spaces may not be easy or direct. Therefore, designers may consider placing signs in a manner that would help access these highly entropic spaces.

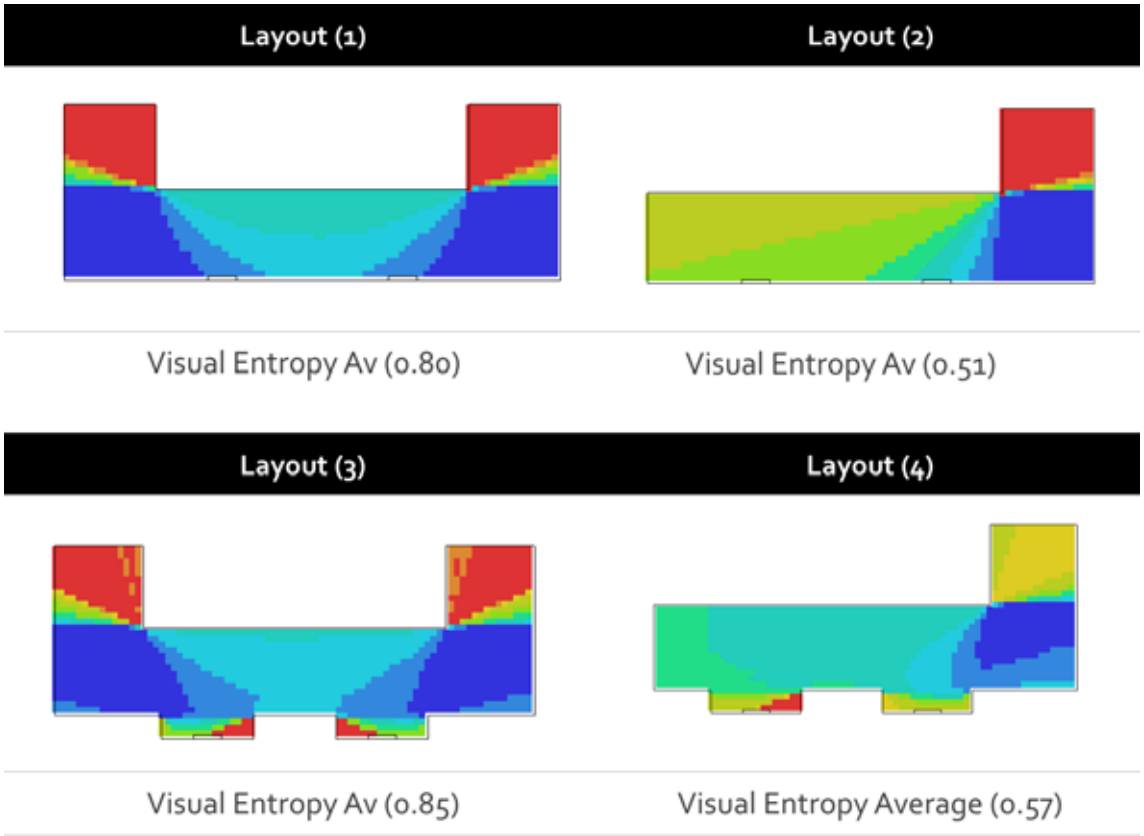

Figure 6 - Visual Entropy Comparison

The results of this research suggest how we can reliably evaluate between the locations of signs in the building layout and demonstrate how we can improve way finding signage systems using space syntax techniques. This is important, because wayfinding performance and experience are affected by both macro- and micro-scale environmental features. Each yields distinctive perspective on wayfinding, and both are needed to gain a more complete understanding of wayfinding. So far, with the exception of space syntax studies, most wayfinding studies have focused on micro-scale environmental features. Using space syntax techniques, this study illustrates how the signage systems of a building or a building complex can be described using both macro- and microscale configurational features of the environment for signage design and evaluation purposes.

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