Measuring environments for public displays: a Space Syntax approach

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Abstract
This paper reports on an on-going project, which is investigating the role that location plays in the visibility of information presented on a public display. Spatial measures are presented, derived from the architectural theory of Space Syntax. These are shown to relate to the memorability of words and images presented on different displays. Results show a complex pattern of interactions between the size and shape of spaces in which displays are situated and the memorability of different types of representations depicted. This approach offers a new way to consider the role of space in guiding and constraining interaction in real settings: a growing concern within HCI and Ubicomp.

Keywords
Ambient display, location, environment assessment, Space Syntax

ACM Classification Keywords
H5.2 [Information interfaces and presentation]: User Interfaces. -Theory and methods, Interaction styles

Introduction
The use of large digital displays in public spaces is a focus of much recent work in HCI and Ubicomp. Different public display designs have been studied in

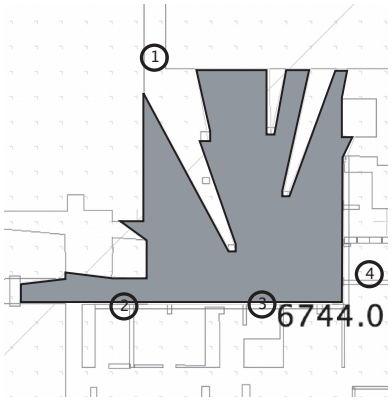

Figure 1: Isovist (grey) from location 2 in building

diverse contexts such as cafes [9], classrooms [2] and social events [1]. They can play a variety of roles, including representing contextually-relevant information, entertaining or trying to persuade [5].

While this work shows the potential of large display technologies to support practices such as community involvement, awareness and information provision, emerging work that has looked at the use of large displays outside a research context paints a more complex picture. Huang et al. [8] report on an study of large displays in natural settings, which found that passers-by rarely do more than glance at displays, and often don't look at them at all. Müller et al. [10] describe the phenomenon of display blindness: in situations where people expect uninteresting content like advertising to be displayed, they tend to ignore large screens in a similar way to web users blocking out banner adverts.

A second theme to emerge from Huang et al.'s work is the importance of display location: across a variety of contexts, passers-by typically attended to displays more if they were at eye-level rather than positioned above their head and also if they were positioned near to other objects in the environment that acted to catch their attention. This highlights the importance of attending to their physical context of use if designers hope to draw the attention of passers-by or lead them into interacting with a display [cf. 1]. If public displays are to be attended to in a variety of contexts, then it is important to maximise the likelihood that they will be visible to passers-by.

In this paper we draw upon the architectural theory of Space Syntax [7] to explore how objective measures of physical space might be used to position public displays to maximise their visibility and increase information pick-up. There is some precedence for the use of Space Syntax theory in research on public displays: Scupelli et al. [13] investigated the relationship between space and social relationships, using a display to encourage interaction between two groups within a hospital. We describe findings from on-going work that uses Space Syntax to position displays within a public space. We discuss its utility in predicting recognition of text and images displayed in different locations.

Background

Space Syntax theory uses mathematical descriptions of space and shows how empirically testable outcomes can be predicted for aspects of collective human behaviour in building and urban settings.

One area that has received attention in Space Syntax is the role that the layout of offices can play in the spontaneous interactions that occur between occupants. In studies by Hillier, Penn and co-workers [6, 12], the degree to which people were found to be "useful in their work" by colleagues was strongly correlated with the spatial structure of the building. In particular, the spatial integration of their location with the rest of the building predicted the number of people who would walk past, which in turn predicted the likelihood that they would be engaged in impromptu conversations.

Conroy [4] looked at second-order effects on the formation of spontaneous conversations after the effects of integration (i.e., numbers of passers-by), were removed. She produced data, which suggested that the shape of the space a static worker occupied

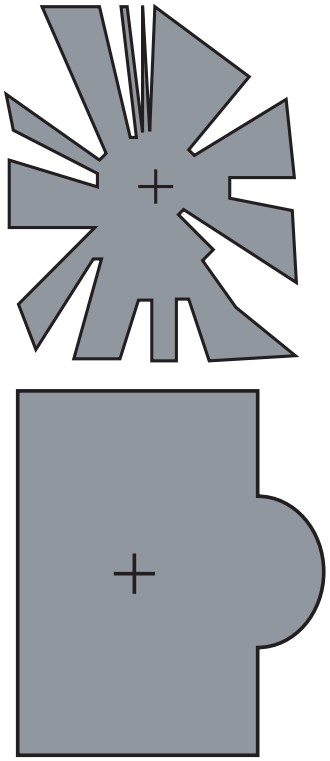

Figure 2 top: a spiky isovist (low APR); bottom: a more rounded isovist (high APR)

had an impact on whether they would be recruited into conversation. To measure the shape of the space, She used an isovist [3]: the horizontal polygon generated by considering how far an eye can see from 360 degrees around a point (e.g., the grey polygon in figure 1). Treating the 2D isovist as a polygon enables a number of values to be derived from it. These numbers are found to relate to our embodied perception of a space. A large isovist from a point, for example, implies a large visible area around a person and a small one implies a tight confined space. A salient measure is the Area-Perimeter ratio (APR) or 'spikiness' of the isovist.

$$\text{APR} = \text{Isovist Area} \div (\text{Isovist Perimeter})^2$$

The area-perimeter ratio might be thought of as a measure of the visual stability of a space. In a forest, where tree trunks are constantly blocking your view, perception of the stability of space is low due to the many occlusions, compared to standing in a large open room, even if the total visible area is the same. Thus, a spiky isovist is perceptually different to a round one (see figure 2). APR can range between 1/4π (a perfect circle) and 0 (a forest of infinitely thin lines). Those people recruited into a conversation were more likely to be located in non-spiky locations [4]. The explanation proposed for this finding was that if as an individual approaches a person their vision is constantly interrupted, then they might switch their focus onto someone more visible.

Our use of Space Syntax measures to position large displays was to predict that the relationship between the location of a display and the stability of its visibility would be similar to the relationship between the location of a seated individual and the stability of their visibility. We therefore predicted that information presented on a display with a large round isovist would be more salient than information presented on one in a small spiky isovist. We tested this prediction in the exploratory in-situ study described below.

Study design

Two hypotheses were derived for the study, based on the measures: 1. if a display can be seen from a large area, then information on that display will be more salient and therefore more likely to be remembered; and 2. if information is presented on a display in a location with a high APR (more round space) it will be more salient than information presented on one in a location with a low APR (more spiky space) as the visual stability of the information will be higher.

The study was conducted in the ecologically valid setting of the atrium of the Jennie Lee building at the Open University (see figure 1). Near the centre of the atrium is a spiral staircase serving both floors.

Using analytical software called Interstice (written by the first author), four locations within this single space were chosen (numbered 1-4 in figure 1). Two locations (1 and 3) had large visible isovist areas and two had small areas (2 and 4). Two spaces had high APR (3 and 4: more round spaces) and two had low APR (1 and 2: more spiky spaces). A projection screen was set up in each location together with four projectors with the same lumen brightness. Each screen was set up so that the same size of image was projected at the same height. Each projector ran a rolling series of four slides showing alternating pictures and words. Each image or word was changed every 10 minutes and they were projected over the length of the workday (08.30 –

17.30). In the two-week period prior to running the study, an attempt was made to reduce the novelty of the stimuli by showing a similar set of images and words, which were not used in the study. The words used were randomly selected from a highly memorable set [11] and the images were from a standard set with high cross-cultural recognition values [14]. A different set was presented on each of three full days. At the end of that period an email was send out to the occupants of the building inviting them to take part in an online questionnaire. This comprised a set of 75 words and 75 images. The participants' task was to identify which of the words and images they recognised as having been projected in the atrium over the previous three days. To encourage participation a prize was offered to the individual who correctly recognised the most items and two randomly selected smaller prizes were offered. 34 completed questionnaires were returned.

Analysis

For the initial analysis, each questionnaire respondent was given a recognition score for both words and images for each of the four locations by subtracting the number of false positives from the number of true positives. The effects of stimulus type (words or images), APR (high or low) and isovist area (large or small) on recognition memory were compared in a 2×2×2 repeated measures ANOVA.

Results

Neither of our starting hypotheses were supported by the analysis of the questionnaire responses. However, the findings did show that the visibility of content on the displays was related to Space Syntax measures through a series of interactions.

There was no significant main effect of stimulus type on the number of stimulus materials recognised by participants, $F(1, 32) = 2.69$, $p > 0.05$. Thus, looking at all of the locations together, recognition scores for words and images did not differ significantly. In contrast to our prediction, there was also no main effect of isovist area, $F(1, 32) = 1.52$, $p > 0.05$. Stimuli materials were therefore equally well recognised if they were displayed in a location visible from a large or a small isovist.

There was however, a main effect of APR on recognition scores, $F(1, 32) = 4.25$, $p < 0.05$. In contrast to our predictions, recognition scores were higher for stimuli presented in the low APR (spiky) spaces than for those presented in the high APR (more rounded) spaces.

A significant interaction was found between stimulus type and isovist area, $F(1, 32) = 4.09$, $p < 0.05$. A simple effects analysis indicated that for the large isovist areas, images were recognised better than words ($p < 0.05$), whereas for the small isovist areas, words were recognised better than images ($p<0.05$).

Another significant interaction was found between stimulus types and APR, $F(1, 32) = 4.11$, $p < 0.05$. A simple effects analysis indicated no difference in recognition scores between words and images in spiky spaces ($p > 0.05$), but a significantly higher recognition score for words than for images in round spaces ($p < 0.05$). Words were recognised equally well in both spiky and round spaces, whereas images were recognised significantly better in spiky than in round spaces ($p < 0.05$).

An interaction between isovist size and APR approached significance, $F(1, 32) = 3.01$, $p = 0.09$ with the overall advantage of spiky spaces over round spaces tending to be greater in large than in small isovist areas.

Finally, a significant interaction was found between stimulus type × isovist area × APR, $F(1, 32) = 4.07$, $p < 0.05$. Simple effects analysis indicated that for more round isovists, recognition scores were better for words than for images ($p < 0.05$) irrespective of the size of the isovist ($p > 0.05$). For the spiky isovists however, recognition scores for images were marginally significantly greater than for words in large spaces ($p = 0.07$), whereas recognition scores for words were greater than for images in small spaces ($p < 0.05$). In the large spiky isovist, recognition of images was higher than those for words ($p < 0.05$), whereas for the small spiky isovist, words were recognized marginally significantly more often than images ($p = 0.08$).

Discussion

The analysis of data derived from our exploratory study appears to partially contradict our initial hypotheses. However, it does demonstrate the utility of Space Syntax measures for predicting the salience of different representations of information presented on displays in different locations.

Having a display in a large or small space did not appear to have an overall effect on whether information on that display is noticed. This might lead to the suspicion that display placement has no effect on how salient a display is. However, we also found effects of Area Perimeter Ratio on the recognition scores. This result is an apparent inversion of previous findings relating to the APR of an isovist (that passers-by notice people more in lower APR locations than in higher, more rounded ones). This might suggest that in this case, people were more actively interrogating perceptually complex environments and therefore noticing more visually interrupted displays. An alternative explanation that we will investigate in future work is that asymmetries in the movement patterns and directions of flow through the atrium may have created an asymmetry in the locations observed.

One surprising outcome of the experiment was that people appeared to have no greater overall recognition for images than for words. However, there was a considerable divergence between the recognition of words and images depending upon the space they were displayed in. If this finding extends to other situations, then it would have a number of research and design implications. Firstly, it appears that if one has a large space then pictures may be more salient and if one has a small space then words. Equally, if one has to display images it would be best to choose a spiky space over a round one. Secondly, it suggests that round and spiky spaces should not be treated as equivalent when testing the efficacy of a display. Future work will explore the extent to which these findings extend to other contexts, such as the shopping centres, train stations and campuses described by Huang [8].

The kinds of displays experimented with in this study were both flat and embedded into the background; different mechanisms may therefore be at play in their relative salience to those at play in Space Syntax research focusing on (three-dimensional) people. Other kinds of information displays such as physical installations might exhibit differing effects. While our results are non-intuitive it does suggest that spatial

analysis tools show potential in choosing the optimal location for displays showing different kinds of representation.

Conclusions and future work

Our hypothesis in this exploratory in-situ study was that the relationship between space and visibility for a display would be similar to that for a person. Thus, we predicted that displays located in isovists with both a large area and high area perimeter ratio would most salient. However, visible area was found not to be of primary importance and the effects of area perimeter ratio appears to work in the opposite way to that predicted. A complex pattern of interactions was discovered indicating relationships between the content presented on displays, the size of the visible area and its shape. We are currently planning a series of more controlled laboratory studies to investigate the extent to which these findings will generalise to new contexts and hold when we control more tightly for factors such as spatial integration, and direction and path of movement through space.

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