Prospect-refuge patterns in Frank Lloyd Wright’s Prairie houses: Using isovist fields to examine the evidence

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It has been argued that the domestic works of Frank Lloyd Wright possess an innate phenomenological appeal that is a direct result of a particular spatial and visual pattern in Wright’s architecture. This argument, which is central to several architectural variants of prospect-refuge theory, suggests that a distinct spatio-visual system exists which directly shapes the way people move through and experience Wright’s architecture. This paper uses a computational technique, isovist field analysis, to search for prospect-refuge related spatio-visual patterns in paths through five of Frank Lloyd Wright’s canonical Prairie houses. The paper concludes that there is no clear evidence in these particular cases of the suggested pattern.

1. Introduction
The domestic designs of Frank Lloyd Wright, one of the 20th century’s most famous architects, have been repeatedly praised for their capacity to evoke positive experiential or phenomenological responses (Laseau and Tice, 1992; Lind, 1994; Hale, 2000; Hienz, 2006). For example, Robert Twombly (1979) observes that Wright’s Prairie houses elicit a ‘deeply felt’ attraction that is ‘strongly emotional and psychological’ (p.78). Multiple attempts have been made to explain these qualities using a range of theories including material ethics (Lin, 1991; Harries, 1997), spatial archetypes (Assefa, 2003) and genius loci (Norberg-Schulz, 1979; Hale, 2000). One of the more detailed and convincing arguments that explains the experience of Wright’s architecture is Grant Hildebrand’s (1991) application and refinement of prospect-refuge theory.

Prospect-refuge theory suggests that certain spatial and formal configurations, which provide a balanced combination of outlook and enclosure, respond to basic human psychological needs and thereby stimulate positive emotional reactions (Appleton, 1975; 1988). Hildebrand (1991) develops this theory to argue that Wright’s domestic architecture possesses a distinct spatial and formal pattern that is directly responsible for the strong emotional response felt by visitors. Moreover, through a detailed discursive and diagrammatic analysis of Wright’s architecture, Hildebrand describes a particular set of spatial and formal conditions that can be used to both explain and potentially replicate this subconscious human reaction. The formal and spatial features Hildebrand identifies could be broadly categorised in two ways: the first associated with the way a person passes through a house, from its entry to its living areas, and the second with the properties of the living area itself. For the first of these cases, the entry or approach path, Hildebrand provides detailed axonometric diagrams to identify the precise paths, through several of Wright’s houses, that he argues are significant.

Since its publication, Hildebrand’s variation of prospect-refuge theory has been widely adopted in architecture as both an analytical and a design strategy (Weston, 2002; Roberts, 2003; Unwin, 2010). However, despite its evocative qualities, there is little evidence confirming the validity of this interpretation of Wright’s architecture. Indeed, one of the foundational features of Hildebrand’s argument, that the combined visual and spatial properties of Wright’s houses are sufficiently similar as to constitute a distinct pattern, has never been tested.
The present research uses computational and mathematical means to test one critical facet of Hildebrand’s theory; the proposition that there are strong similarities between the spatio-visual properties of the approach paths found in Frank Lloyd Wright’s Prairie houses. The particular computational method that is used in this paper is isovist field analysis and the test case for this research is a set of five Prairie houses: the Henderson house (1901), Heurtley house (1902), Cheney house (1903), Evans house (1908) and Robie house (1910). Hildebrand describes and maps two of these in detail, and identifies the Heurtley house as the perfect example of his argument, and the remainder are covered in a more limited way.

The method used in this paper, isovist analysis, is concerned with the geometric and mathematical properties of the volume of space that is visible from a single, fixed location. Whereas many arguments about the relationship between space and vision, like Hildebrand’s, rely on qualitative propositions and poetic descriptions, the isovist method provides a quantitative approach to one particular facet of the experience of space. In the past, isovists have been used to provide insights into spatial cognition (Meilinger et al., 2009), way-finding (Conroy, 2001), social structure (Markhede and Koch, 2007) and spatial occupation (Ellard, 2009). Importantly in the present context, Stamps III (2005) suggests that some of the measures derived from isovist geometry appear to reflect the basic elements of prospect-refuge theory. However, further examination fails to identify an ideal set of measures for prospect-refuge conditions (Dawes and Ostwald, 2013). While previous studies of Wright’s domestic architecture have used mathematical and computational means to examine formal, geometric and stylistic similarities (Koning, 1981; Laseau and Tice, 1992; Ostwald and Vaughan, 2010; Vaughan and Ostwald, 2011), no previous study has investigated the spatio-visual experience of these houses using isovists.

The present paper commences with a brief background to isovist analysis and environmental preference theory; both of which have been extensively researched in the past, but have only rarely been connected (Franz et al., 2004; Wiener and Franz, 2005; Stamps III, 2005). The paper then posits a series of conditions which should be uncovered if Hildebrand’s theory is valid. Thereafter the paper describes the method that is used in the present research to analyse the spatio-visual characteristics of Hildebrand’s paths through the five houses. Using new computer models of these houses, an isovist field is generated for each and then four major properties derived from this model are compared. The results for each of the five houses are examined in detail, before the paper concludes with a discussion of evidence of the presence of a pattern in the spatio-visual experience of the houses.

The present research has several technical and theoretical limitations; the former of which are described in detail in the methods section of the paper. In the latter case, the theoretical limitations, it must be acknowledged that Wright’s houses possess many features that cannot be examined using isovists. For example, some of the key qualities of Wright’s houses have been traced to the presence of rich surface ornament, dramatic natural outlooks and prominent hearths. While past research has criticised the way in which Hildebrand has interpreted such features (Seamon, 1992), their impact is outside the scope of the present research. Moreover, prospect-refuge theory is fundamentally about human emotional or psychological reactions to environments, objects, forms and spaces. These reactions can be influenced by a wide range of personal factors including age, cultural background and education (Nasar, 1984; Kaplan and Herbert, 1988). These reactions are also contingent on particular tectonic, spatial and stylistic conditions (Stamps III, 2006). None of these can be considered using the present method, which is optimised for
examining one facet of Hildebrand’s version of prospect-refuge theory, the presence or absence of a spatio-visual pattern in the passage through Wright’s Prairie architecture.

2. Background to Isovist Analysis

The origins of isovist analysis can be traced to the ‘optic array’ model of thinking about sensory perception that arose from pioneering pilot training programs in the 1940s (Gibson, 1947). Spatio-visual research prior to that time was often focused on understanding perception through an analysis of the subtended angle of an object in the field of view; that is, the angle occupied by the object’s silhouette. In contrast, the optic array model holds that all light entering the eye carries valuable environmental information (Gibson, 1966; Gibson, 1979). Due to its origins in flight training, this model is ideal for examining the experience of movement through space and, significantly, several of Gibson’s (1979) examples are suggestive of the changing experience of a person following a path through a building. Michael Benedikt (1979) developed the concept of the optic array into the more geometrically defined isovist and, working with Larry Davis (Davis and Benedikt, 1979), provided a stable and repeatable method for isovist generation. Benedikt (1979) defined the isovist as ‘the set of all points visible from a single vantage point in space with respect to an environment’ (p.47). The method has since been optimised for computational analysis including the development of several statistical measures that are derived from the ‘ray’ properties used to generate the isovist (Batty, 2001; Christenson, 2010).

In its most basic form, constructing an isovist requires extending radial lines from an observation point to the surfaces of an environment, or a predefined view-length limit. These lines are drawn at a regular angular increment, often one degree, and the end of each line is linked to the ends of their immediate neighbours to form the isovist polygon. The isovist polygon perimeter will consist of surface edges, view limit edges, and occluding edges. Occluding edges extend beyond a surface vertex, such as beyond a window, and represent portions of the isovist perimeter beyond which objects are just out of sight (Figure 1).

Once the isovist polygon has been generated, a range of mathematical values can be derived from it that reflect, for example, the volume of space that is visible from the observation point, the furthest a person can see, or how much of their vision is constrained by surfaces. Past research has used this approach to examine the spatio-visual geometry of significant locations in buildings (Stavroulaki and Peponis, 2005; Markhede and Koch, 2007; Peponis and Bellal, 2010). Isovist analysis is also favoured for documenting the experiential properties of art galleries and the display of valued objects within a spatial structure dedicated to this task (Tzortzi, 2004; Peponis et al., 2004; Psarra, 2005, 2009; Zamani and Peponis, 2013). While some of these studies track occupants moving through a building, or finding their way around space, none examines and compares a systematically defined set of paths in the way proposed in the present paper. For example, circulation routes through a gallery may serve a variety of purposes although they are typically optimised for allowing a visitor to move from one display to the next without getting lost. In contrast, the present research considers paths that are less functional and are potentially more attuned to psychological or emotional needs.

For an analysis of the visual and spatial properties of a complete building, or a path through space, an isovist field is commonly needed (Ostwald and Dawes, 2013). An isovist field is the set of all isovists, generated from a defined spread of locations (typically a grid of points) in a building. This approach allows researchers to plot the changing spatio-visual properties of the building as a scalar map or to sequentially chart the measured values
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as a graph. While the three dimensional analysis of individual isovists is gradually becoming viable (Yang et al., 2007; Morello and Ratti, 2009), isovist field analysis using two dimensional data is more widely accepted and it is the method used in the present paper.

3. Background to prospect-refuge theory
Habitat theory suggests that animals, including humans, are biologically motivated to seek environmental conditions that are conducive to their survival (Appleton, 1975). Environmental and spatial psychologists have also demonstrated that humans are drawn to intuitively, unconsciously and virtually instantaneously appraise spaces for characteristics or qualities that support these conditions (Kaplan and Kaplan, 1983; Kaplan and Kaplan, 1989; Kaplan 1987). However, despite evidence of genetic predisposition, research also suggests that environmental ‘preference is a complex amalgam of factors, with innate preferences forming a foundation which is then overlain by both socio-cultural and personal experience factors’ (Falk and Balling, 2009, p.489). In order to examine and explain the complex impact of these factors, Appleton (1975) proposed prospect-refuge theory.

Prospect-refuge theory conceptualises environments that are conducive to survival in terms of the predator and prey. The central idea being that, in order for a predator to hunt successfully it

Figure 1:
(a) Radial lines traced from observation point. Occluding radials shown as solid lines, Radial lines shown dotted.
(b) Isovist polygon defined by surfaces and occluding radials.
must be able to track its prey while remaining hidden. Conversely, hunted species require similar environmental conditions: the ability to identify and avoid predators while remaining hidden. Thus, ‘prospect’ in Appleton’s (1975) theory refers to an ‘unimpeded opportunity to see’ (p.73) and ‘refuge’ to ‘an opportunity to hide’ (ibid.) and, in the right combination, these two spatial properties define an environment that is conducive to survival and thereby yields environmentally derived pleasure. In its architectural variant, Hildebrand (1991; 1999) argues that Wright’s living rooms provide a perfect mix of outlook and enclosure – an ideal space for survival at the end of complex approach path. Twombly (1979) similarly argues that Wright’s Prairie houses elicit a positive emotional response by ‘emphasising in literal and symbolic ways, the security, privacy [and] shelter [that …] people found important in a period of […] conflict’ (p.78).

As acceptance of prospect-refuge theory grew, additional measures derived from research into environmental preference began to be connected to it. Probably the most persuasive of these additions have been complexity and mystery. Scott (1993) states that ‘complexity refers to the amount of visual information offered by an environment’ (p.25) and Kaplan (1988) identifies that a ‘scene high in mystery is one in which [a person] could learn more if [they] were to proceed farther into the scene’ (p.50). In a sense, complexity and mystery are closely related to what might be called the ‘discoverability’ of a space. Hildebrand (1991) incorporates and partially merges these characteristics in his analysis of Wright’s work, arguing that the path from the entry to the living room is an integral part of the psychological experience of architecture because it evokes a sense of mystery and complexity that draws a person though a staged process of discovery.

One of the traditional challenges for prospect-refuge theory is that past quantitative research has been largely focussed on psychological testing, rather than on a concomitant analysis of the properties of the environment itself. This is because many aspects of prospect-refuge theory rely on the interpretation of environmental symbols. For example, a dark forest in a distant view may evoke a sense of fear, while a waterfall, in exactly the same location and filling exactly the same volume of space, may evoke a sense of excitement. In order to overcome this problem Kaplan (1987) proposes that the primary features of an environment should be extracted ‘to construct a rough conceptual model of the three-dimensional space represented by the scene’ (p.22). In this way, for a reasonable analysis to occur, the environment should be converted into a pure geometric system that is devoid of complex symbolic or semiotic connotations. In the present research, the geometry of Wright’s architecture is well defined and therefore an ideal case for analysis using geometric, mathematical and computational means.

4. Evidence for a Pattern

Hildebrand (1991) proposes that, in his early Prairie house plans, Wright developed a particular spatial ‘configuration to a canonical state’ (p.19). This so-called ‘Wright pattern’ (ibid.) comprises 13 elements, of which 10 are consistently present in all of the Prairie houses, and all 13 in the Heurtley house. However, several of these elements are not, as previously noted, related to combinations of spatial and visual characteristics. For example, deep eaves, low ceilings, and horizontal exterior massing are all features that could be measured, but they are not within the scope of the present research. Similarly, the relationship between an elevated exterior terrace and a prominent distant view is also difficult to analyse in any consistent way. However, many of the other characteristics of the Wright pattern are explicitly concerned with the combined visual and spatial experience of the path through the house. If
then, in these limited terms, the Wright pattern does exist, the following results might be anticipated from a detailed study of the Prairie houses.

- A gradual shift from being refuge-dominant (smaller, enclosed spaces) to being more balanced in terms of prospect and refuge (larger spaces, more outlook). In the present paper, isovist area (see discussion in the ‘results’ section) is used to assess this part of the pattern.

- A gradual increase in mystery and complexity experienced while moving along the ‘circuitous path’ (Hildebrand 1991, p.25). At the end of the path, mystery and complexity should reach a peak value because the major space is framed by peripheral ‘interior views to contiguous spaces seen beyond architectural screening devices’ (ibid.). In the present paper, occluded length (see discussion in the ‘results’ section) is used to assess this part of the pattern.

- A visitor will be drawn along the path by the combined phenomenal power of space, form and vision. There is presumed to be both ‘visual pull’ and spatial ‘force’ along the path, much of which is caused by ‘glimpses of major spaces’ (ibid., p.75). In the present paper, two values, drift direction and drift magnitude (see discussion in the ‘results’ section) are used to assess this part of the pattern.

5. Method
The isovist fields used in this paper were generated from floor plans derived from new three-dimensional AD models which were prepared in accordance with Wright’s final construction drawings (Futagawa and Pfeiffer, 1987). The floor plans of these houses were analysed in UCL Depthmap (version 10.14.00b) (Turner, 2004) using a grid resolution of 100mm. All of the houses were analysed simultaneously by placing scaled drawings of each in a single file. Each floor plan depicts a horizontal slice through the building at a height of 1.65 meters above the ground or floor level. This height allows for views over some fixed elements, such as the bookcases in the Cheney house, but not others, such as the Robie house fireplace. The 1.65m height approximates the eye level of Wright, who had a habit of calibrating the vertical dimension of his designs to his own body (Hildebrand, 1991).

The scale of the 100mm isovist grid coupled with the size of the buildings resulted in over 200,000 observation locations being generated, with each one providing 11 useful measures; a set of results which is too great to report in a paper. The data presented in this research is therefore limited to that associated with points located along the centreline of the paths at 500mm increments, approximating the length of Wright’s step. The choice of 500 mm increments also reduces the amount of manual data processing required to identify measures from observation points along the paths, while retaining an accurate depiction of the spatial experience.

The five paths chosen for analysis each commence from the front door and trace the shortest route to the living room fireplace, before continuing to the centre of the living room; a location identified by drawing a diagonal line between the room’s corners. If a person must pass through the centre of the living room prior to reaching the hearth, the final step is not included. Hildebrand explicitly maps multiple paths according to these rules and implies that the path must not commence from the servant’s entrance and it must avoid service areas, such as kitchens. Furthermore, in accordance with Hildebrand’s diagrams and analysis, all of the paths follow straight lines of movement with 90-degree turns.

Due to unreliable and inconsistent information about the surrounding context, the primary analysis is limited to habitable space. Therefore, the method treats all external windows as opaque, and all external doors, and doors to dedicated storage areas,
as opaque and closed. Storage and service areas forming an access route to other habitable spaces are assumed to possess open doors, while all timber screens are treated as solid, opaque elements. Multi-level buildings present a particular challenge for isovist field analysis due to the complexity of linking floors across levels in UCL Depthmap. In order to solve this problem, the creation of modified sections of floor plans, focused on the stair and immediately visible spaces were required for several houses. This procedure takes advantage of the fact that isovist analysis measures only the local properties of the plans. Each 500mm step along the path yields a discrete set of measures of the isovist polygon. Any portions of the floor plan that do not define the shape of the polygon are irrelevant to that position on the path. Therefore, between steps along the path it is possible to substitute portions of one plan, for example the ground floor, for portions of another plan, such as the first floor. This proce-

**Figure 2:**
Example of hybrid floor plan construction for multi-floor isovist analysis.
procedure allowed for the documentation of a seamless transition of isovist measures between separate levels but excludes the use of global measures (such as visual integration) which are more difficult to reliably generate using these methods.

As an example of this method of constructing isovists across levels, consider the path through the Robie house (Figure 2). At the start of the path, isovist measures are derived from the standard ground floor plan (Plan A) until a point where the fireplace is no longer visible and the viewer is close to the turn in the path towards the base of the stairs. At this point the isovist will yield identical properties if constructed on either Plan A or a hybrid Plan B, which includes the base of the stairs. From this position along the path to the top of the first run of stairs, isovist properties are only extracted from Plan B as this depicts the ground floor and the staircase. The top of the first run of stairs (isovist on Plan B) is the final position from which the entire ground floor is visible; advancing 500mm along the path (to the isovist on Plan C) brings the first floor into view, while hiding portions of the ground floor, requiring a hybrid plan to depict the space visible on both levels. Advancing another 500mm along the path (isovist on Plan D) will hide the ground floor completely from view; isovist properties are now derived only from the first floor plan.

Because the paths through Wright’s buildings are considered a continuous spatial experience, from initial entry to arrival at the centre of the living area, they allow for the creation of graphs depicting the changing isovist data from every step along the path. In the reporting of these results, the data points are logged sequentially such that the horizontal axis of each graph in this paper represents the distance the observer has travelled along the path. The left side of the graph corresponds to the front door and the right hand side to the end of the path in the living room. Presentation of the data in this manner, as opposed to being tabulated, allows for a more intuitive understanding of the spatio-visual characteristics of the building.

While an isovist analysis of the external spaces surrounding each house is outside the scope of the present research, Hildebrand argues that the exterior paths (or driveways) that must be taken to reach the front door are also significant. Thus, these routes are also recorded in the present research and a simple discussion of path length and number and direction of turns is provided.

6. Results

Isovist field analysis produces 11 useful measures of the spatio-visual geometry present at each step along the selected path. While there is debate about the precise spatial qualities that each measure represents (Stamps III, 2005), the four most significant measures, in terms of their capacity to directly represent prospect-refuge characteristics, are isovist area, occluded length, drift magnitude and drift direction (Dawes and Ostwald, 2013).

- **Isovist area** is the volume of space visible from a particular location. It provides a close correlation to the measure of prospect (large areas) and to a lesser degree, refuge (small areas). The visible area also reflects the potential volume of visual information available, and thus the potential complexity of the view.

- **Occluded length** is the portion of the isovist perimeter representing the obscured or hidden parts of the building - a property that relates closely to the concept of mystery and, to a lesser extent, complexity (Kaplan, 1987).

- **Drift magnitude** is the distance between the viewer’s location and the centre of the isovist polygon. This measure describes the strength of the visual pull; or ‘force of movement’ (Hoffman, 1995, p.X) that draws a visitor through Wright’s architecture.
• Drift direction is the angle of a line connecting the observation point to the centre of the isovist polygon and measures the direction of the visual ‘pull’. This measure directly reflects Hildebrand’s (1991) notion of being drawn through space and the concept that Hoffman (1995, p.X) labels as the ‘visual dynamic’ in Wright’s architecture.

These four measures, when considered in combination, can be used to confirm or challenge Hildebrand’s suggestion that Wright’s paths follow a discernible, prospect-refuge related, spatio-visual pattern. Two charts per house document these four measures. In the first of these, the Y-axis records isovist area and occluded length, with the former measured in square metres and the latter in metres. The second chart for each house records drift magnitude, in meters, and drift direction, as the angular difference between the direction of travel and the direction of visual pull. As such, a result of +90 degrees represents a visual pull perpendicular and to the left hand side of the direction of travel. A result of -170 degrees represents a visual pull to the right hand side that is almost opposite to the direction of travel. A drift magnitude of less than two metres could be regarded as being barely noticeable, lengths of between two and five metres are noticeable and will draw the eye, and anything over five could be considered as significant. The X-axis, in both types of chart, records progress along a path from the front door to the centre of the living room in 500mm increments. Specific important locations along the path are also keyed to an axonometric diagram of each house, and to a description of the ‘experience’ of a person attuned to the properties of the isovists. In this description, to better allow for comparison with past claims about the impact of Wright’s architecture, the words ‘prospect’, ‘mystery’ and ‘pull’ are generally used in place of their mathematical counterparts. Therefore, this description offers a mathematically informed version of the type of phenomenological account that is common in Wrightian scholarship.

Henderson House (1901)
The Henderson house in Elmhurst, Illinois, represents an early prototype of the Prairie style. The house exhibits a number of Hildebrand’s list of characteristic Wrightian phenomenological features, but fewer than are found in some later works. In this instance the living, dining and reception areas share a raised ceiling and occluded length, with the former measured in square metres and the latter in metres. The external approach path to the house follows a straight line from the street, passing under the wide eaves of the hipped roof and rising to the terrace and front door. This terrace functions as a traditional porch, unlike those in the other Prairie houses, which Wright often isolated from the approach path. The route into and through the house is complicated by a pair of dogleg manoeuvres that are required to pass through the front door and entry hall. Once inside, the route to the centre of the living room requires only three direction changes (Figure 3).

The data derived from the Henderson house show that upon emerging from the entry hall (A), the visitor experiences a minor but sudden increase in prospect (Figure 4) and an intense visual pull directing attention left and toward the living room (Figure 5). Proceeding along the path toward the living room threshold (B), both prospect and mystery indicators gradually rise as more of the house is both revealed and suggested. The most mysterious position coincides with a low visual pull, the centre of attention and the intersection of paths leading to the living room, kitchen and entry. Prospect is highest only after crossing the threshold to enter the living room (B), where prospect, mystery and visual pull decrease as the hearth is passed (C), and the visitor moves toward the centre of the room. Along almost the entire length of this path, the drift offset
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Figure 3:
Henderson house, axonometric showing movement path.

Figure 4:
Henderson house, isovist area and occlusivity.
is less than 90 degrees, indicating that visual pull is drawing the occupant toward the living room. The only exception occurs where the visitor finally reaches the centre of the living room and a visual pull of negligible strength directs attention back to the hearth. High visual pull at the start of the path, coupled with increasing levels of information and mystery suggest that the experience of the Henderson house is that of a journey of discovery; albeit a minor one. Upon reaching the living room centre, further movement yields little additional information and the low levels of visual pull and mystery discourage such movement.

**Heurtley house (1902)**
The Heurtley house in Oak Park is the first of the Prairie houses to display all 13 of Hildebrand’s major prospect-refuge features. This design departs from contemporary planning conventions by locating the living and dining rooms on the first floor in order to capture elevated views of the neighbourhood. The external approach path to the house shows the early signs of deliberate complexity through the inclusion of two, redundant, 90-degree turns. Internally the route is even more complex; three 90-degree turns separate the front door and the base of the stairs, two further turns are encountered while ascending the stairs and two more before reaching the hearth. A final turn is required to reach the centre of the living room (Figure 6).

Like the Henderson house, entry to the Heurtley house is via an enclosed hall that obscures the rest of the building. The isovist field data (Figures 7 and 8) demonstrate that as the occupant moves beyond this point (A), both prospect and mystery rise until reaching the stairs (B), where both values suddenly fall again as vision is restricted. Walking toward the stairs also requires the occupant to move away from the playroom, resisting the strongest visual pull experienced along the path. Visual pull remains directed behind the occupant while ascending the stairs. It is only after reaching the landing (C) that...
prospect and mystery values rise again. This corresponds to a sharp increase in visual pull, drawing the occupant toward the living and dining rooms (D). Prospect continues to increase in steps while approaching the living room centre and mystery peaks immediately before reaching the hearth (E). Along the latter part of this route, visual pull directs attention toward the dining room, living room, and finally back to the dining room. Once more, the living room centre is the location of highest prospect; however, this is coupled with a significant degree of mystery and mild visual pull toward the dining room, suggesting that this is a more dynamic space than the living room of the Henderson house.
Cheney House (1903)
In the Cheney house, Wright offers a deliberately complicated approach path. Hildebrand (1991) argues that in this design ‘the glass and overhangs may suggest penetrability, but the house protects its actual access through ambiguity (the dual walkways), masking (the screening of view from the street), and convolution’ (p.38). Traversing the correct exterior entry path requires a person to ascend several groups of stairs, and two unnecessary 90-degree turns (Figure 9, locations marked 1 and 2 in the axonometric diagram of the movement path).
This elaborate exterior route leads the occupant to the entry of the house and, once inside, another turn (A) is all that separates the entrance from the living room threshold (B), the hearth (C) and the centre of the room (Figure 9). The absence of a second story in the house allowed Wright to raise the ceilings of the library, living and dining rooms, and the hearth is again opposite a glazed wall. The bookcases defining the living room and adjacent to the fireplace, approximately 1.5m tall, are not high enough to obscure the view of an occupant of Wright’s stature.

The Cheney house possesses the shortest of all the internal paths in this study and the most elaborate external path. The isovist analysis shows that a person moving toward the living room experiences steadily increasing levels of prospect (Figure 10). In contrast, mystery tends to decrease from the beginning of the dogleg (A) until reaching a position halfway between the living room threshold
(B) and the hearth (C). This peak corresponds to a glimpsed view of the fifth bedroom over the bookcase adjacent to the fire. Mystery then declines until the occupant approaches the living room centre. Visual pull is high and forward close to the front door, drawing the occupant past the library and toward the living room (Figure 11). The direction of visual pull remains fixed on the centre of the living room except when crossing the threshold to this room (B); here, the direction of pull aligns with the direction of travel. The end of the path offers high prospect and mystery, with little visual pull suggesting an experience that is more static than that of the Heurtley house and with more mystery than the Henderson house.
Evans house (1908)
Wright designed the Evans residence as a ‘fireproof house for $5000’ (MacCormac, 2005, p.143). The house sits atop a low hill and its approach is via a simple journey up a long driveway (Figure 12, path location marked 1 in the axonometric) to the carport. Here, under the protection of the roof (Figure 12, location 2), a single 90-degree turn and a flight of stairs bring a visitor to the front door. Inside the entry, with its dropped ceiling, the living room and dining room form a semi-continuous space with the fireplace located at the centre of the house, again opposite glazing. A single turn (B) takes the occupant to the hearth and thereafter one additional turn (C) is needed to reach the centre of the room (Figure 12).

Entry to the Evans house is via a semi-enclosed foyer where visual pull directs a person’s attention to the living room, then toward the kitchen hall as this gradually enters into view. The first appearance of...
of this corridor (A) causes a spike in mystery and contributes to the rapid increase in prospect that peaks at the living room threshold (B) (Figure 13). Upon entering the living room, visual pull focuses attention on the centre of the living room while prospect decreases near the hearth (C). Like the Henderson house, visual pull decreases until the occupant steps past the centre of the visible area, pulling attention behind the visitor, but with negligible strength (Figure 14). The living room centre is very much like that of the Henderson house, offering high prospect and little mystery or visual pull to encourage further movement.
Robie house (1910)
The Robie house exterior approach is relatively straightforward, and like that of the Evans house, likely due to the exigencies of vehicular access. However, unlike the Evans house, the internal path of the Robie house is complex (Figure 15). It commences with a long straight path linking the main entrance to the stairs. Thereafter the stairs form a vertical transition, spiralling up through 360 degrees to the first floor to cross the lower level path. A further straight path leads to the living room, where another turn is required to reach its centre, before a final turn is taken to approach the hearth. There is no direct route from the stairs to the hearth, so the occupant must move through the centre of the living room to reach it (this is the reverse of the pattern in the other four houses). Interestingly, this path through the Robie house makes exclusive use of left hand turns.

When entering the Robie house, the isovist data suggests that the occupant immediately experiences an extraordinarily high, and thereafter quickly diminishing visual pull, drawing one to the base of the stairs (A) and past the point of maximum prospect. Mystery remains stable until the occupant

Figure 15:
Robie house, axonometric showing movement path.

Interior path - end point
Exterior path - start point
reaches the stairs, before dropping dramatically (Figures 16 and 17). Ascending the stairs requires the person to move away from the centre of visible space, causing a rearward visual pull of increasing strength until capturing a final glimpse of the lower level while traversing the landing (B). The constrained experience of the stairs causes both prospect and mystery to fall sharply, until emerging onto the first floor (C). At the top of the stairs, the strength of visual pull (left bias) is negligible while suggesting a relatively neutral decision point with a high degree of prospect. This prospect diminishes through the living room threshold (D), increasing as the living room enters sight and before views...
back down the hall are obscured, after turning (E) toward the living room centre (F). Here visual pull reaches its lowest level and moving toward the hearth requires resisting an increasing pull toward the centre of the living room. Again, the centre of the living room provides high prospect and little mystery or visual pull to encourage further movement.

The Robie house has a similar vertical transition to the Heurtley house; however, unlike the Heurtley, the Robie utilises visual pull and prospect to deliver the occupant directly to the stairs. The stairs remain a significant transition point after which visual pull remains centred on the staircase, providing no guidance and confusing the journey. It is only upon entering the living room, a threshold of several steps, that visual pull again begins to direct the visitor forward to the centre of the room. In summary, the journey through the Robie house is one of strong guidance through the lower level and weak guidance through the upper floor.

7. Discussion

When the data developed from the isovist field analysis for each house is compared, there are few, if any, clear trends. Moreover, those instances where trends could be said to occur, can readily be explained as by-products of the way in which Hildebrand constructed his paths; a process replicated in this paper.

Starting with prospect related spatio-visual measures, four of the houses possess a lower level of prospect at the point of entry and a higher level at the centre of the living room (Figure 18). While this result superficially supports the existence of Hildebrand’s pattern, this trend would be anticipated in any family house large enough to have a separate entry and living area. In essence, any route that starts in a smaller space and ends in a larger one is likely to show an increase in prospect over the journey. Therefore, this result could readily be explained as an artefact of Hildebrand’s method and not as something specific to Wright’s architecture.

There is no overarching pattern in the results for mystery found in the five paths. Staircase zones tend to possess the lowest prospect and the least mystery because such tight spaces not only restrict vision, but also restrict a sense (suggested through occlusivity) of what lies just out of sight. The paths

Figure 18:
Linear trend lines (‘least squares’ method) of the isovist area values of each house. Solid lines show the relative length of each path, dotted lines represent a continuation of the trend beyond the end of a path.
through the Robie and Cheney houses commence with high levels of mystery, while this value is low at the entry of the remaining houses (Figure 19). The Robie, Heurtley and Henderson houses show minor peaks in mystery corresponding to the threshold of the living room but few other similarities exist. Mystery is also low at the end of the journey through the Robie, Henderson and Evans houses, but high at a similar location in the Cheney and Heurtley houses. Thus, only the results of two of the five houses conform to the anticipated pattern.

The results for drift offset display a seemingly higher degree of correlation between the houses. For example, the Henderson, Cheney and Evans houses all have paths that are dominated by forward visual pull, as does the path through the Robie house, if its staircase and a few other minor spatial disjunctions are ignored. Ironically, the exception to this rule, the Heurtley house, is the one that Hildebrand argues most fully represents the Wrightian pattern. The Heurtley house has many instances where the drift offset is over 90 degrees, meaning the visual pull is against the direction of travel. Furthermore, as was the case with the prospect data, it might be expected that any large house would have a strong drift from the smallest to the largest spaces; a methodological anomaly that could account for the suggestion of a drift offset pattern in the data. The final critical measure, drift magnitude, has a low level of correspondence across the houses, with a minor tendency to peak at or near the entrance and thereafter dropping along the length of the path. Staircases again cause these values to fluctuate, spiking in the Robie house and falling in the Heurtley. Therefore, the final anticipated result for the existence of the Wright pattern is also, on balance, not reflected in the data.

8. Conclusion
In the specific case of Hildebrand’s reading of Wright’s Prairie houses, and based on a detailed analysis of five major works from this set, there are insufficient similarities to support the claim that there are any underlying spatio-visual patterns. Two of the four measures suggest a minor level of correlation with the results anticipated in the Wright pattern, but these are readily explained in other ways. The other two results neither support the existence of the Wright pattern, nor demonstrate any consistency between the houses.

Despite these results, it must be acknowledged that the key spatial experience of Wright’s architecture may exist primarily in the third dimension and simply cannot be captured using two-dimensional
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isovists. Hildebrand even argues that Wright’s manipulation of ceiling height may have a strong impact on the prospect-refuge characteristics of the architecture. However, within the limits of the present method, this research demonstrates that, in terms of the four primary mathematical determinants of prospect-refuge qualities in architecture, there is no evidence for a foundational pattern in five of Wright’s most important Prairie house designs.

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References


