Light Mantle
Quantifying Daylight Perception in Edward Hopper’s Spaces

EMIL OSORIO-SCHMIED

The spaces represented in Edward Hopper's paintings are taken as a model by an academic project about light behavior in architecture, the goal of which is to develop a quantitative approach contrastable with the perception of natural light in such paintings. With the support of a physical model and a smartphone as measurement and verification instruments, the author tests the idea that it is possible to establish links between sensory registers and the performance of light in a certain precinct, using as a starting point the question posed by Hopper about the feasibility of light.

The scenes of daily life in the United States during the early decades of the twentieth century depicted in Edward Hopper's paintings often serve as references for various contemporary artistic expressions [1]. It is possible to recognize his influence in the sculptures of George Segal, the engravings of Edward Ruscha, the photography of Joel Meyerowitz and even in the film productions of Gustav Deutsch, among others. Within works like, for instance, Ruscha’s Standard Station or Meyerowitz's Hopper’s Window, compositional elements such as light, colors and perspectives tend to favor the perception of different atmospheres, similar to those of Hopper's artworks. For architecture as an artistic discipline, the projection of spaces using these compositional elements is suitable, but it is also acceptable to consider user perceptions in the form of a design statement, as Peter Zumthor [2] declares with regard to the work of Hopper. In this way, a building conveys, on the one hand, an explicit impression of space as imagined by its author and, on the other hand, phenomena that are only appreciable in physical form [3]. Also, a design concern such as natural lighting can determine the stimulation of particular sensory responses to a space [4]. These responses are defined as the recognition of the attributes of an enclosure, including its shape, openness and boundaries [5]. In Hopper's scenes, the incident light generates, among other effects, a distinction between the inside and outside environments, between human scale and nature [6]. Now, if these scenes were translated into tangible spaces, how could we quantify that incident light? What correspondence would this analysis have with our perceptions of the original image? My architecture students and I approach this discussion by way of a study of environmental performance in architecture. The main objective is to evaluate the levels of natural light in the interior spaces represented by Edward Hopper through instrumental monitoring of scale models, establishing a comparison between the perceptions attributed to the original scene and a literal reinterpretation of it.

PAINTING INSIGHTS

Studies with a similar approach in the analysis of paintings from an architectural scope address various types of sensory responses, for instance, the perception of perspectives [7], the recognition of geometrical shapes [8] and even the apparent light in historical scenes [9].

Likewise, we base the present work on the fact that it is possible to equate real levels of illumination with those registered in a model [10–12], as natural lighting performance conditions the acknowledgment of physical attributes within a space. Two relevant issues emerge from this assumption. The first refers to the perception of space, attributable to the incidence of light in various Hopper scenes. In this context, one of the observable facts is the contrast between the built and natural environment and, at the same time, between the intimate and public. In both cases, visible limits are determined by the management of lighting [13]. Among the effects related to the incidence of light is recognition of the attributes of an enclosure, including its color, shape and degree of openness. In the latter case, although the presence of windows indicates a relationship with the outside, in certain scenes the dimensions or omission of glass panels gives the impression that boundaries have dissolved [14]. Thus, the window, as an architectural element, takes on a substantial role in the perception of space, since it also admits a deliberate management of natural light [15].
However, the translation from painting to architectural space implies a change of condition, that is, the passage from the condition of a viewer to that of an inhabitant [16], where environmental phenomena are sensitive, but also quantifiable. For this reason, another consideration is how light performance is understood—in this case, by calculating the daylight factor in reinterpreted enclosures. This factor corresponds to the percentage of external illumination that encroaches upon an inner point, which is represented as a constant figure, i.e., independent of variations according to time or season. When calculating for several points in an enclosure, for example, an average value less than 2% indicates the perception of a dark space, with undefined attributes, where the supplement of permanent artificial lighting is necessary. On the other hand, a daylight factor equal to or greater than 5% implies an enclosure is perceived as illuminated, with strong contrasts and a marked presence of natural light [17] or even an excess of light [18]. Such an effect can be associated with location, quantity, shape, dimensions and glazing specifications. Similarly, the daylight factor increases when its calculation includes interior points close to the windows, since the levels of external illumination can sometimes significantly impact lighting even several meters beyond external borders [19].

**METHODOLOGY**

In light of the above, the present study is organized in three stages. First, we reinterpret scenes from 14 paintings by Edward Hopper made between 1926 and 1965 (Table 1) through the construction of a physical model at 1:10 scale. These scenes not only show programmatic functions such as habitation, leisure or work but also contain a series of relationships between an enclosure and lighting conditions provided by the outside environment, whether rural or urban.

Each model considers a complete interior space as it appears in the original frame, including aspects such as proportion, use of color, estimated reflexivity of surfaces and the provision of openings. Some of the models depict a scene arguably located in a rural context; for example, in *Rooms by the Sea* (Color Plate A-a) two rooms, adjacent to a large outward space, are perceived, while *Western Motel* (Color Plate A-b) originally showed a road landscape in the background through the window of a dwelling. Considering images apparently located in urban scenarios, *Eleven A.M.* (Color Plate A-c) and *Hotel by a Railroad* (Color Plate A-d), among others, imply a single window connecting the living space with the external environment. However, there are certain scenes where the visual relationship with the outside decreases or is simply omitted, as in *Hotel Lobby* (Color Plate A-e) and *Office at Night* (Color Plate A-f); both cases demonstrate an exceptionally intuitive approach to lighting.

In the next stage, the specific objective is to calculate the daylight factor for the reinterpreted enclosures. We based this calculation on recording levels of natural lighting or illuminance, measured in lux, performed by instrumental monitoring of the work models (Fig. 1). We must note that we performed the evaluation outside, under conditions equivalent to a completely overcast sky, regardless of both orientation and shadow projection, according to the standards required for this type of observation [20]. Also, we measured illuminance with either the Galactica Luxmeter (iOS) or the Light Meter (Android) smartphone application, hence allowing instant visualization of data using the photometer built into most contemporary mobile devices. I chose both applications from a variety of available software after comparing their results to an analog lux meter.

**LIGHT MANTLE**

The final stage of the study contemplates the layout of a light mantle, that is, a three-dimensional grid that graphs the calculation of daylight factor, using the data obtained in the step described above. As seen in Fig. 2, the mantle rises from the floor of an enclosure, where each vector is a point corresponding to the measuring grid. The objective is to incorporate this representation as an instrument to analyze the phenomena associated with the incidence of natural lighting perceived in the Hopper scenes.

For example, for a permanent enclosure, as represented in *Eleven A.M.* (Fig. 2a), we expected an average factor above 1.5% [21]; however, most points on the light mantle of this scene are below that threshold. Additionally, we can confirm a perception regarding the powerful role of the singular window, in relation to the external light environment. This relationship is evidenced by the area of the grid with a visibly greater height, coinciding with the location of the window, while the remaining space rests at a relatively homogeneous, penumbral level.

With an average natural light factor higher than the latter case, but still below the 2% threshold needed to overcome a dim appearance, scenes such as *Woman in the Sun* (Fig. 2b), *New York Office* (Fig. 2c), *Western Motel* (Fig. 2d) and *Rooms by the Sea* (Fig. 2e) arise. Although the mantle of the latter work indicates a substantial incidence of light at the point of entry, this effect is soon diluted and gives way to a comparatively uniform level of illumination.

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**TABLE 1. Edward Hopper’s artworks selected for this study**

<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1926</td>
<td>Eleven A.M.</td>
</tr>
<tr>
<td>1929</td>
<td>Chop Suey</td>
</tr>
<tr>
<td>1938</td>
<td>Compartment C Car</td>
</tr>
<tr>
<td>1940</td>
<td>Office at Night</td>
</tr>
<tr>
<td>1943</td>
<td>Hotel Lobby</td>
</tr>
<tr>
<td>1951</td>
<td>Rooms by the Sea</td>
</tr>
<tr>
<td>1952</td>
<td>Hotel by a Railroad</td>
</tr>
<tr>
<td>1955</td>
<td>Morning Sun</td>
</tr>
<tr>
<td>1957</td>
<td>Western Motel</td>
</tr>
<tr>
<td>1958</td>
<td>Sunlight in a Cafeteria</td>
</tr>
<tr>
<td>1961</td>
<td>Woman in the Sun</td>
</tr>
<tr>
<td>1962</td>
<td>New York Office</td>
</tr>
<tr>
<td>1965</td>
<td>Chair Car</td>
</tr>
</tbody>
</table>

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Fig. 1. (a) Instrumental monitoring on a model based on Rooms by the Sea; (b) Daylight factor on the measuring grid proposed for Rooms by the Sea. (© Emil Osorio-Schmied)

Fig. 2. Light mantles for (a) Eleven A.M.; (b) Woman in the Sun; (c) New York Office; (d) Western Motel; (e) Rooms by the Sea; (f) Hotel by a Railroad; (g) Morning Sun; (h) Hotel Lobby; (i) Office at Night. (© Emil Osorio-Schmied)
The diagram confirms that the presence of the aperture closest to the position of the observer establishes a difference in the light and spatial perception of two adjacent enclosures. Meanwhile, regarding the mantle of scenes such as Hotel by a Railroad (Fig. 2f) and Morning Sun (Fig. 2g), we observe an irregular distribution of the natural light factor, which ratifies the sensation of a space whose limits are configured with shadows and light contrasts. This is not only associated with the opening of the window, but also with the reflection of light seen on the background wall.

However, considering that their average daylight factor is in the ideal range of 2% to 5%, it is possible to state that, despite their contrasts, the boundaries of space remain visible as long as natural light is available, as in the original scene. Finally, we find cases such as Hotel Lobby (Fig. 2h) and Office at Night (Fig. 2i) where an exceptional reinterpretation of natural lighting has been proposed. The latter mantle shows an incidence of light derived from the horizontal aperture above the level of the partition, which, combined with two other windows, evenly distributes a light factor of more than 5%, not only making it possible to perceive a naturally lit room, but also confirming the sensation of being in a place of high elevation, in proportion to its level dimensions.

CONCLUSIONS

We can now establish the feasibility of quantifying the incidental natural light depicted in the scenes of Edward Hopper’s paintings, through instrumental monitoring of tangible models of such scenes. Similarly, it is possible to establish a correspondence between perceptions gained through the original images and the associated understanding achieved by generating the light mantle. This perception deals with attributes of space related to their contours, openings and limits, which are affected by percentage of available light. Although this analysis is comparable to a digital simulation, from a certain point of view, working with a physical scaled model to perform parallel measurements of illumination, coupled with the opportunity to digitally construct a diagram representing the data obtained, allows a tangible approximation to the impressions given by the original scene, whether intentional, explicit or spontaneously perceived by a circumstantial observer. Then, considering the above as an instrumentalization of perception, one can also consider this as a methodology complementary to such fields as for example, design and criticism, linking perceptions with environmental behavior in architecture and specifically, with natural lighting.

Acknowledgments

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References and Notes

8. Foster [3].
13. Kranzfelder [1].
14. Renner [6].
15. Pallasmaa [4].
17. McMullan [10].
20. McNicholl and Lewis [19].
21. McMullan [10].

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COLOR PLATE B: LIGHT MANTLE: QUANTIFYING DAYLIGHT PERCEPTION IN EDWARD HOPPER’S SPACES

1/10 scale cardboard models based on Edward Hopper’s (a) Rooms by the Sea; (b) Western Motel; (c) Eleven A.M.; (d) Hotel by a Railroad; (e) Hotel Lobby; (f) Office at Night. (© Emil Osorio-Schmied) (See the article in this issue by Emil Osorio-Schmied.)