Fitch on Vision in Architecture

Nevertheless, the visual experience of architecture remains the dominant one, above all for the architect himself. The tendency to base important design decisions on narrowly visual criteria seems to have steadily increased ...

… the more apt is the architect to rely largely or wholly upon visually acquired data, divorced from its matrix of multidimensional sensual reality.

James Marston Fitch

emphasis added
The Human Eye

- Retina
- Iris
- Macula (Fovea)
- Cornea
- Optic Nerve
- Lens
- Vitreous

Functions of Eye Components

- collect
- process
- transmit

- RODS and CONES
- light reception and energy translation (radiation to nerve signal)
- focusing muscles
- signal transmission
- aperture (opening) control
- primary focusing
- protection and some focusing
Response of the Eye to Light

**Energy**
The eye does not respond equally to all wavelengths of light; it is most sensitive in the mid wavelengths (green), less sensitive in the violet realm, and even less sensitive in the red. *For an equal amount of energy, a green light will provide a greater visual response than a red light.* Watt-for-watt, a light source that produces mostly yellow/orange/red light will be less visually effective than one producing mostly green and blue light.

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**Rods**
Provide no perception of color response even though they are active across a range of wavelengths; are generally more sensitive to light than cones; rod peak sensitivity is at 510 nm; rods are concentrated at the periphery of the retina; rods are more sensitive to motion than cones.
The Eye’s Response to Light

Cones

Provide color response perceptions; three cone types are postulated – blue, green, and red; cones are generally less sensitive to light than rods; cone peak sensitivity is at 555 nm; cones are concentrated near the fovea.

Response of the Eye to Light

There are three “realms” of vision, based upon the luminance (“brightness”) of the scene being viewed:

- **Scotopic vision**
  - Occurs under low luminances: the rods are active and the cones are inactive; this results in grey-scale vision (with no colors); a typical exterior nighttime situation

- **Mesopic vision**
  - Transition between scotopic and photopic; not a great place to hang out (visual-comfort-wise)

- **Photopic vision**
  - Occurs under higher luminances: the cones are active (color vision is available); this is the typical architectural lighting condition
Response of the Eye to Light

→ Lowest detectable (not necessarily useful)
  luminance (with rods) = 0.001 cd/m²
→ Highest detectable (not necessarily safe)
  luminance (with cones) = 1,000,000 cd/m²

This is a huge range (making the eye a truly marvelous tool)

<table>
<thead>
<tr>
<th>Table 12.5 Commonly Experienced Brightness Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidewalk on a dark night: 0.0093</td>
</tr>
<tr>
<td>Sidewalk in moonlight: 0.003</td>
</tr>
<tr>
<td>Sidewalk under a dim streetlight: 0.03</td>
</tr>
<tr>
<td>Book illuminated by a candle: 0.3</td>
</tr>
<tr>
<td>Wall in an office: 3</td>
</tr>
<tr>
<td>Well-illuminated drafting table: 30</td>
</tr>
<tr>
<td>Sidewalk on a cloudy day: 300</td>
</tr>
<tr>
<td>Fresh snow on a sunny day: 3,000</td>
</tr>
<tr>
<td>500-watt incandescent lamp: 30,000</td>
</tr>
</tbody>
</table>

*For S.L. (cd/ft² m²) = (cd/lux ft²) × 11

Key Visual Phenomena

Adaptation

→ A process whereby the sensitivity of the eye (to light) adjusts to match the environment
  • Partly a result of pupil changes (physical)
  • Substantially a result of retinal changes (chemical)
→ Light-adaptation (going from dark to light) is a jolting experience, but fairly quick … takes about 1 minute
→ Dark-adaptation (going from light to dark) is slow, very slow … takes up to 30 minutes
→ There are architectural implications to adaptation, relative to comfort and safety—adaptation temporarily reduces visibility

color-adaptation also occurs
Key Visual Phenomena

**Accommodation**
- A process whereby the eye adjusts focus to suit the scene (in order to deal with distant versus near vision demands)
- The shape of the lens changes (via muscle tension) to adjust focus (versus a change in focal length for a camera)
- The muscles are relaxed for distant viewing and tensed for near viewing; “eye strain” is related to muscle overuse caused by extensive work on close-up tasks
- There are architectural implications to accommodation (for example, LEED-BD&C gives a credit for “views”—views allow the eye to relax)

**Acuity**
- A measure of the ability of the eye to detect detail
- Historically acuity has been the driving force behind US illuminance recommendations (design guidelines)
- Acuity is a function of:
  - Size of object (relative size)
  - Time available to view object
  - Condition of eye (health, age, …)
  - Luminance of target
  - Contrast at target
  
  which of these are “architectural”?
Key Visual Phenomena

**Glare**
- A *negative* visual sensation resulting from excessive brightness or excessive contrast in the field of view
- *Always* a negative sensation (there is no “good” glare)
- Since it is a qualitative sensation (an individual’s opinion), glare cannot be measured with equipment (nor can “glare” be transmitted, reflected, admitted)
- Glare can be categorized →
  - By degree of impact on a person: as *blinding*, *disability*, or *discomfort glare*
  - By relationship of brightness source to the eye: as *direct* or *reflected glare*

Key Visual Phenomena

**Sparkle**
- A *positive* visual sensation resulting from high brightness or high contrast in the field of view
- The difference between sparkle and glare is in the eye (and the brain) of the beholder
- Too much (or inappropriate) sparkle can become glare
The Visual Process

Light flows from some source
Is received by eye and retina
Is converted to nerve signals

Nerve signals received by brain
Signals converted to meaning

The Visual Process

involves the qualitative interpretation of quantitative phenomena

can be radically different and very personal;
statistically predictable

broadly similar;
physically predictable
Visual Process

receive versus perceive

^^ great, good, or OK building facades? >>

what we “see” is influenced by experiences, expectations, peer pressure, culture, biases, perhaps by an inherent sense of appropriateness

Reviewing Key Terminology

ILLUMINANCE
Density of light falling on a surface
Cannot be seen directly, yet is a key design variable (often the only quantitative lighting design criterion)

lux (lumens/square meter) is the SI unit

footcandle (lumens/square foot) is the I-P unit

conversion \( \rightarrow \) fc (10.76) = lux
Reviewing Terminology

**LUMINANCE**

Density of light leaving a surface
Can be seen directly, *should* be an important design consideration (but luminance is seldom a design criterion)

candela/square meter is the SI unit

footlambert is the I-P unit

conversion \( \rightarrow fL \ (3.43) = \text{cd/sq m} \)

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Relating Illuminance, Luminance, and Reflectance
(for an opaque surface)

**LUMINANCE** = (ILLUMINANCE) \( \times \) (reflectance)

\[ L_{\text{luminance}} = \left( E_{\text{illuminance}} \right) \left( \rho_{\text{reflectance}} \right) / (\pi \ \text{pi}) \]

in SI units (\( L = \text{cd/m}^2 \), \( E = \text{lux} \), \( \rho = \text{decimal value} \))

\[ L = (E) \ (\rho) \]

in I-P units (\( L = \text{fL} \), \( E = \text{fc} \), \( \rho = \text{decimal value} \))
Reviewing Terminology

**LUMEN**
The basic measure of the quantity of light

A fundamental unit (on same “level” as the second or meter)

[same in SI and I-P]

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**LUMINOUS EFFICACY**

= light output / energy input

units are → lumens/watt

[same in SI and I-P]

for this lamp … \( \frac{420}{50} = 8.4 \)

[a very low value … an inefficient lamp]
Reviewing Terminology

**LUMINOUS INTENSITY**

Quantity of light leaving a source in a given direction

**candela** [same in SI and I-P]
[lumen / steradian]

is a designer interested in the light output going here or here or here?

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**Key Properties of a Light Source**

- Energy input (electricity or solar radiation)
- Luminous output (total light produced)
- Luminous intensity (directional light output)
- Luminous efficacy (energy efficiency)
- Color characteristics
Key Properties of a **Lighted Object**

- **Illuminance**
  - function of the spatial and luminous environment
  - (illuminance *is independent* of the object)
- **Luminance**
  - function of environment and object
  - is perceived as brightness
- **Color**

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**Daylight vis-à-vis Electric Light**

*light is light once it’s produced; the production, however, is *very* important to the environment* and, to be fair … all light is not the same when it comes to color (next topic)
Light Beyond Vision

There is increasing concern for the effects of light (and lighting) on humans beyond the visual aspects discussed above. The Well Building Standard, for example, encourages the use of lighting that enhances melanopic response.

A recent *LD+A* article (The Case for Circadian Correct Lighting," 2015) advised: “Expose normal populations to high-levels of blue-rich light near 460 nm in the morning through early afternoon, and eliminate these shorter wavelengths and reduce light levels in the late-afternoon. After 10 p.m., total darkness is ideal – or if this is not practical – very low levels of warmer red-rich light. Even an incandescent lamp can disrupt the circadian cycle if it is too bright.”

The human eye’s response to melanopic radiation differs from its visual response; this has implications for selection of light sources.

http://agi32.com/blog/tag/circadian-based-lighting/