Why so much attention on daylighting now?

- Americans spend 95% of our lives inside of buildings!
- We need buildings that help keep us healthy
  - Exposure to natural patterns of light and darkness has been established as a key factor in circadian health
  - Access to daylight has been shown to be associated with better performance in schools and office buildings
  - Many green building standards encourage greater utilization of daylight in workplaces
The age of fluorescent lighting…
…resulted in windowless workplaces

- Buildings are cheaper without windows
  - Deeper "plates"
  - Fewer walls
  - Less heat loss and heat gain
- Windows create "distractions" for children & workers
  - And maintenance problems
  - And HVAC challenges
- Electric lighting and mechanical ventilation
  - engineered to maintain the "ideal" (static) environment…24/7

And we may all die of boredom...

Media attention to circadian health, 2015
Our ancestral pattern of light and dark

Port Hueneme Naval Facilities Offices

- Simple office daylighting … perfected as High Art
- In a simple, WWII navy bungalow

- sustainable
  - 60 yrs +
- reused
  - remodeled
- people care
  - high morale
- low energy
  (+ easy climate)
A well daylit space:
Balanced, subtle, dynamic

- “Daylight from two sides” = low glare illumination
- The electric lights are off 90% of the time (!)
  - we know, we monitored it...often at only 50 to 100 lux ambient

Where are the electric lights?
What is the role of the lighting designer in a daylit building?

Bilbao Airport
Calatrava, architect
Day- Night Transformations

- Paris is the “City of Lights” – at night
- Electric lights are for nighttime
  - and the dark seasons and the dark places…

Daylight Visual Quality

- Daylight Illumination
  - How much?
  - Where, and when?
- Glare & Privacy
- View
- Electric Lighting
  - How much?
  - Where, and when?
There’s much more to windows than just thermal performance….

Window Services:

1. Light
2. View
3. Air (ventilation)
4. Acoustic Control
5. Visual Privacy
6. Glare Control
7. Thermal Regulation
8. Display
Daylight Illumination

- **People rarely complain about “excessive daylight”**
  - Most importantly, the eye needs TIME to transition between very bright and very dim spaces
- **People complain about “glare”**
  - which means “I can’t quite see what I am interested in seeing”
  - Or “my eyes are getting tired”
- **People complain about “dim” spaces**
  - Which usually means “dull”
  - with lack of sparkle and lack of visual interest
    - Especially lack of view…

<table>
<thead>
<tr>
<th>Type 3: Classroom</th>
<th>smf10sp1</th>
<th>Shades 5%</th>
<th>VLT 30%</th>
<th>WWR 12%</th>
</tr>
</thead>
</table>

This is the only space (!) out of 61 that passed the new ASHRAE proposed criteria of WWR <30% and SHGC <25%

**Judged the worst of the lot**, with poor visual quality and no useful daylight

Facing northwest

Facing east

Jan. noon no blinds

Jan. noon with blinds
Type 3: Classroom  

Identical portable classroom to previous, but with tubular skylight added, resulting in much higher overall daylight illumination levels throughout. Occupants rated the visual quality higher, and also reported it had less glare and a better view!

Jan. noon no blinds  Jan. noon with blinds

New IES LM-83-12: spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)

- Annual simulation-based calculations of daylight availability
  - Accounts for weather dynamics, sunlight, blinds operation
‘Daylight’ versus ‘Sunlight’

- **Daylight**
  - Provides diffuse, even illumination
  - Enables electric lights to be turned off
- **Uncontrolled Sunlight**
  - Too bright
  - Too hot
  - Creates uncomfortable contrast
  - Can make a space appear darker by comparison

People do enjoy sunlight

- **When it is filtered and diffused**
  - Avoiding excessive brightness or heat
- **The designers’ challenge is:**
  - how to get the right balance inside our buildings?
If there is too much sun...

- You can pretend you are outdoors!

Windows need visual modulation

- The sun moves, and so do reflections off of cars and other buildings
- So, occupants need the ability to adjust view window treatments as conditions change
- What about unoccupied cubicles?
  - When blinds are left closed, all office occupants receive less daylight
Should designers assume windows will have blinds? YES!

- **Blinds, shade, and curtains are ubiquitous**
  - One field study showed that 93% of workplaces had some form of interior window controls

- **Occupants want to control:**
  - Privacy
  - Protection from a variety of (moving) glare sources
    - Sun, cars, puddles, other buildings
  - Brightness and intensity of views

Subtle changes in daylight patterns can have a big effect on occupant acceptance….

- **Sunlight in field of view**
  - But not on work surface
  - Judged ‘preferred’

- **¼ turn of blinds**
  - Stripes on work surface
  - Judged ‘just disturbing’

Photos, © Mehlika Inanici & Kevin Van Den Wymelenberg
Dappled sunlight

- Magical moments

Capturing the movement of sunlight

- Enlivens a space
  San Francisco International Airport
Solar Moments

- Phoenix Central Library
  - Daily noon passage
  - Lighting the candles at Summer solstice
    - a library town party?

Redirect the sunlight, where it is useful...

- Inverted blinds, with concave surfaces facing ‘up’
  - act as miniature light selves
  - angle can be adjusted to optimize sun light redirected to the ceiling
  - should be highly reflective, but not specular
3 sunlight redirecting options

- Use upper window to redirect sunlight deeper into space
  - Keep treatments well above 'eye level', i.e. 7'6” minimum

- Lightshelf
  - The architectural solution

- Louvers
  - 3” specular louvers

- Optical Film
  - Nanostructures refract the light

Daylight Redirecting Film

- Micro replicated structure reflects light incident on the window surface towards the ceiling
- Redirects more than 2/3rds of all incident light upwards towards the ceiling
- Extends ‘daylight zone’ about 8’ into room for each 1’ of treated upper window
- Can be combined with other solar control films or blinds options

Image courtesy of 3M
Daylight Glare

- Everyone "knows it when they see it..."
  - But, as of yet, there are no good predictive tools/equations
    - There are about 12 equations, but none with field validity...
- Sunlight IS predictable – one, but not the only, cause of glare
  - A view of the solar orb is always too bright
    - Even through the darkest sunglasses!
  - Sun reflections and “patches” are often too bright
    - But sometimes welcome
- “Glare” is often a case of adaptation stress
  - The eye cannot adjust quickly enough: i.e. its a timing problem
    - Young and healthy eyes adapt faster than older or tired eyes
  - Glare = visual overload
    - The eye is the most energy intensive part of the body
    - Reduce effort, increase reward

Diffusing Glazing, when in Sunlight = GLARE

- All light...no information
- Like paving a wall with lensed luminaires!
  - (only even brighter)
The downside of translucent shades

- In sunlight, shades become a brightly glowing surface – and essentially opaque
- Increasing contrast, and putting other objects into silhouette

White shades – are transparent only in the shadow
Modulation: Transparent v Translucent

- Depends on the direction of light
  - Opaque when looking from light to dark
  - Transparent only when looking from darker to lighter

Fabric shades don’t block the sun!

- They just break it into little pieces
- 5% "openness" still allows plenty of "pin-pricks" of beam sunlight through
- Will still wash out projected images
- Will still cause discomfort glare for anyone in line of sight of the solar disk
- or a reflection of solar disk
Daylight, Glare and View: Lighting Design Implications

Photo: Mark Changazi, "Harnessed"

Copyright Lisa Heschong 2013
Which image is most troublesome?

The cognitive processing of images may thus have a greater impact on basic reflexes and other CNS-driven physiological functions than previously assumed.

From: Pupil responses to high-level image content
Your eye….is part of your brain….

The Berkeley Hills View—
Who cares about glare?
The New Whitney Art Museum in New York City

- Anchoring the southern end of the new Highline elevated linear park

Whitney Museum, NYC

- The VIEW is the main attraction
Does View Matter?

In our 2nd round daylighting productivity studies: View was the big winner!

- Call Center
  - +7% to +12%
  - Worker speed
- Desktop study
  - +10% to +25%
  - 3 mental acuity tests
  - Less fatigue
- Schools study
  - +7% to +30%
  - Faster math and reading learning
In the SMUD Desktop Study

- Those workers with the best views
  - Had fewest complaints
    - About temperature
    - About acoustics
    - About smells and air quality
    - About ergonomics
  - And fewest stress-based health issues, such as:
    - Headaches, neck and back aches
    - Eye fatigue, general fatigue

Is this productive?

- [Image of a comic strip showing office workers with various complaints and comments about their work environment.]
Qualities of ‘good’ views

- **Coherent, Informative Images**
  - Something interesting to look at – people, nature, fractal images
  - No annoyance: with obscured images, grids, moiré patterns

- **Natural Solar Spectrum**
  - Circadian stimulus appropriate to hour, place and season

- **Distance**
  - Eye health and development requires constant refocusing

- **Natural Rhythmic Movement**
  - Random patterns retain interest – water, traffic, shadows, clouds

- **The ‘Biophilia Hypothesis’**
  - Sum: Animals, birds, fish, growing plants, clouds, landscapes
Standard Abrasives, 1995
New plant, built to recover from 1989 Earthquake in San Fernando Valley

- Real work
- Real views
- Real daylight

What is an adequate view?
LEED View Assessment

- Angular size of view
Simulated Views: SkyFactory, a Kansas corp

- Helpful?
- Creepy?

Window coverings circa 2015

Window coverings & Attachments

Help Me Choose Compare Coverings Understanding Window Coverings Purchasing Glossary

Compare (choose up to 5)

Interior
- Interior panel
- Interior solar screen
- Cellular shade
- Louvered blind
- Drapery/Curtain
- Pleated shade
- Applied film
- Interior roller shade
- Window quilt
- Interior louvered shutter
- Sheer shade
- Roman shade

Exterior
- Exterior storm
- Exterior roller shade
- Retractable awning
- Exterior louvered shutter
- Exterior solar screen
- Fixed awning
- Roller shutter

Show what’s best for my windows using: These 2 Coverings.

Lisa Heschong, copyright 2015
19 Product Categories + Automation + counting...

Show what's best for my windows using: These 3 Coverings

Features | Applied Size | Cellular shades | Interior sunscreen shutter | Fixed security | Roller shutter
---|---|---|---|---|---
Thermal | | | | | |
Insulation | | | | | |
Alightness | | | | | |
Solar Heat Control | | | | | |
Winter Comfort | | | | | |
Summer Comfort | | | | | |
Condensation Resistance | | | | | |
Ventilation | | | | | |
Visual | | | | | |
View | | | | | |
Visible Transmittance (VT) | | | | | |
Daylighting Control | | | | | |
Glare Control | | | | | |
Privacy | | | | | |
Functional | | | | | |
Puerto Window Protection | | | | | |
Egress | | | | | |
Security | | | | | |
Smoke Control | | | | | |
Sound Absorption | | | | | |
Installation & Durability | | | | | |
Durability and Service Life | | | | | |
Window Coverings circa 2020:

- AERC
  - Attachments Energy Rating Council
    - Residential product label in 2017
    - Commercial database in 2018
  - Heating performance ✓
  - Cooling performance ✓
  - Daylight, view, glare performance ??

Have faith in daylight

- Use photocontrols!
- Save energy…
  - help the planet
Solar Moments

- Phoenix Central Library
  - Electric lighting is supplementary
  - Where, and when, needed...


- Highly automated system
  - Blinds and overhead lights
  - Blinds re-commissioned to only close 2/3 way
    - Better daylight savings
    - Less claustrophobia
    - More occupant satisfaction

- According to Glen Hughes, manager of the NY Times automated blinds project:
  - The better the view, the more frequently occupants manually opened blinds
  - Allowing 2” of sunlight at base of window helped relieve the claustrophobia of closed shades
  - And greatly improved the daylight energy savings!
Micro inverted blinds, embedded inside double glazing –
Alder Creek Middle School, Truckee, CA

- south facing classrooms have little shading
- all windows have micro-blinds integrated into double pane glass
  - allowing for easy cleaning, ventilation, dust-free optics, protected from little hands

Inverted blinds in south facing windows
Redirect sunlight

- Upper blinds redirect sunlight to ceiling (note bright ceiling)
  Middle and lower blinds adjusted for local control for view, glare, privacy
  Note luminaire parallel to windows, turned off
Scandinavian Design

- A little bit of sunlight sets the stage

Scandinavian Design

- Reflect the light on perpendicular surfaces
Display windows that work

- Roseville, California

Why Daylighting?
Because:
- It’s good for people
- It’s good for the planet

Thank you for your interest!

lisa@lheschong.com
This film is based on simultaneous time-lapse photography and studies the differences in the geographical orientation and the light of the sun, in a room in Denmark at 55° 6' N, 12° 5' W latitude

...and its impact on us as human beings

Lisa Heschong, School of Architecture, of Circadian Light

Carlo Volf, PhD

Copenhagen, Denmark

https://youtu.be/USYwmkFjHMA?

Intro: 38 sec to 2:28 seconds
Seasonal comparison: 3:30 to