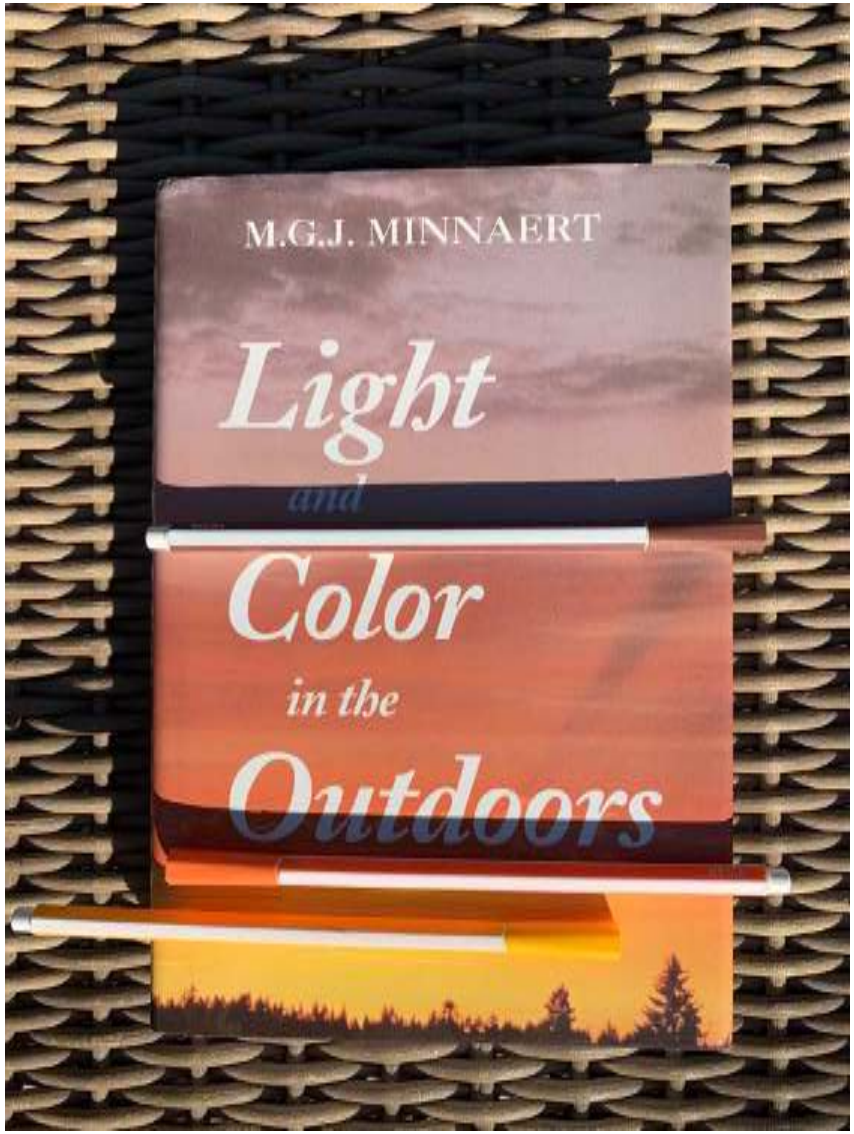
ECOLOGICAL OPTICS: LIGHT, MATERIAL AND APPEARANCE IN NATURAL ENVIRONMENTS

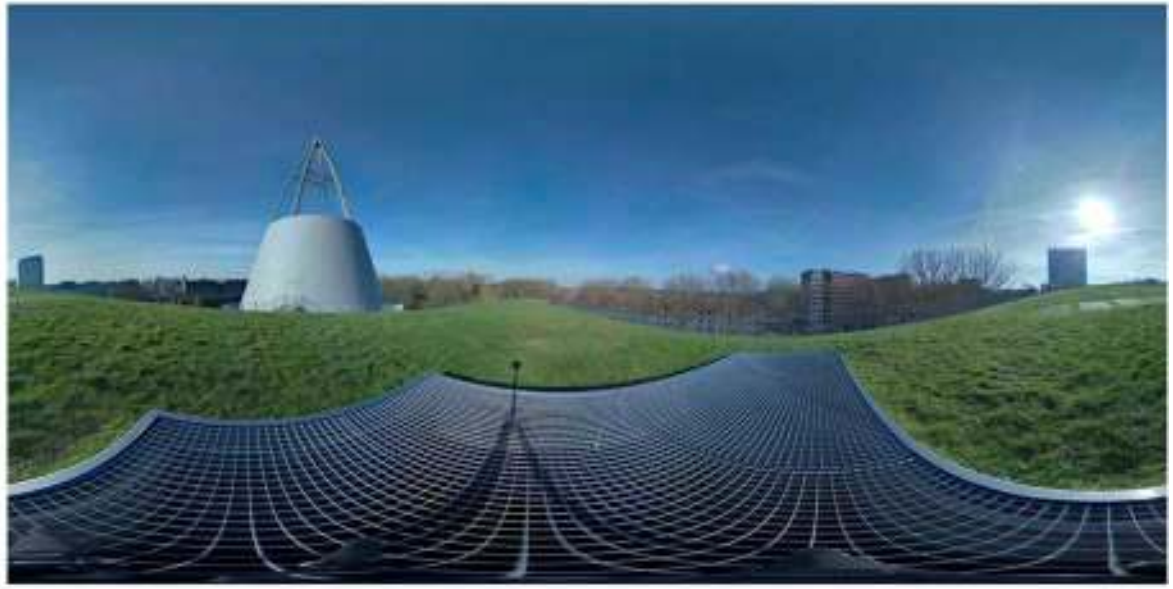
SYLVIA PONT

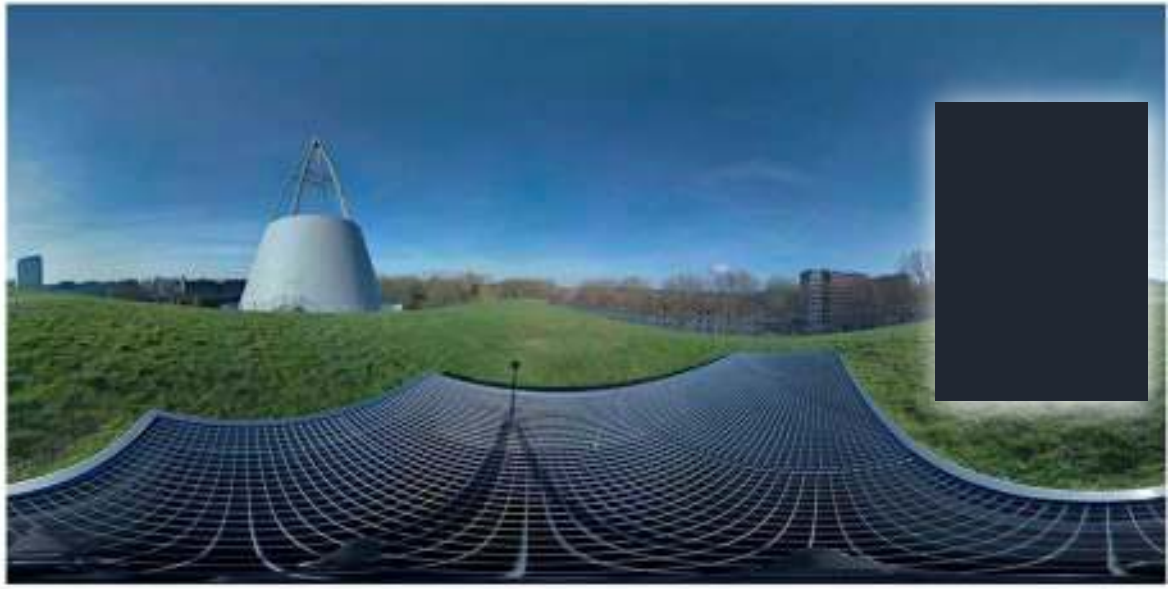
DESIGN FOR our future

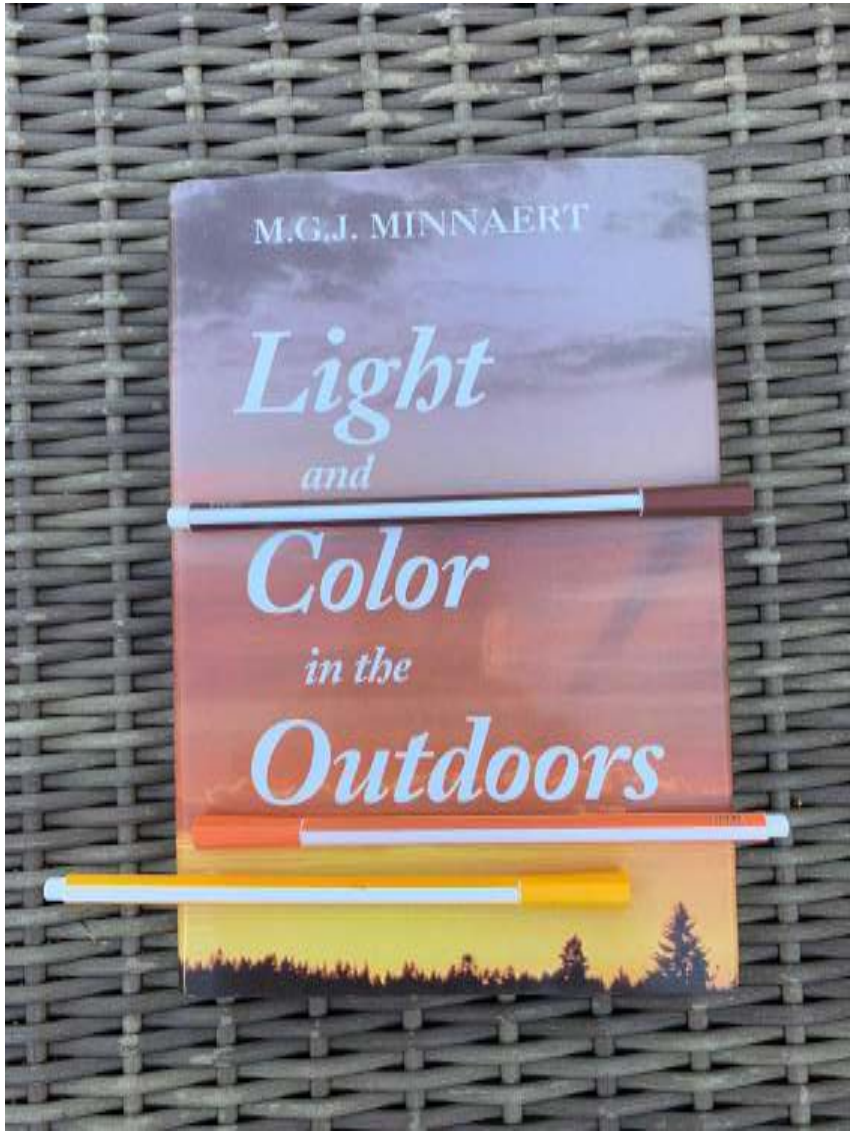
TU Delft

FACULTY OF INDUSTRIAL DESIGN ENGINEERING


M.G.J. MINNAERT
Light
and
Color
in the
Outdoors



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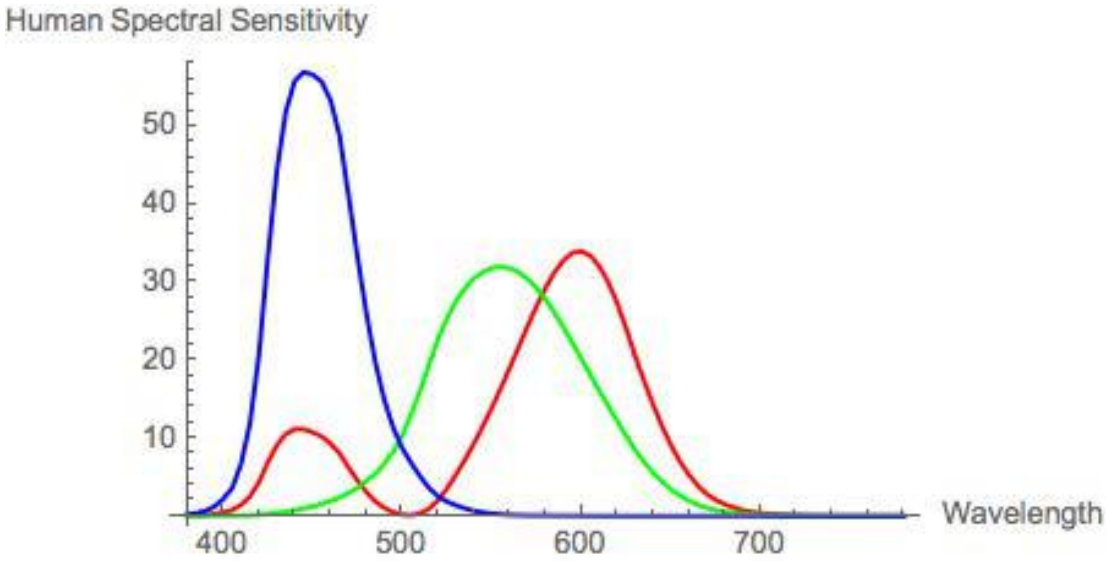
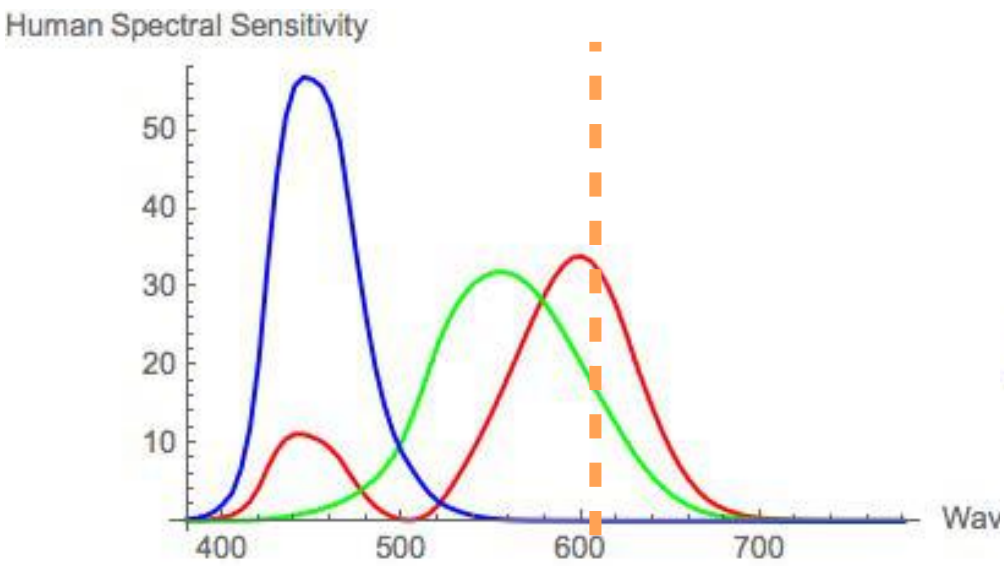

Human Spectral Sensitivity
50
40
30
20
10
400
500
600
700
Wavelength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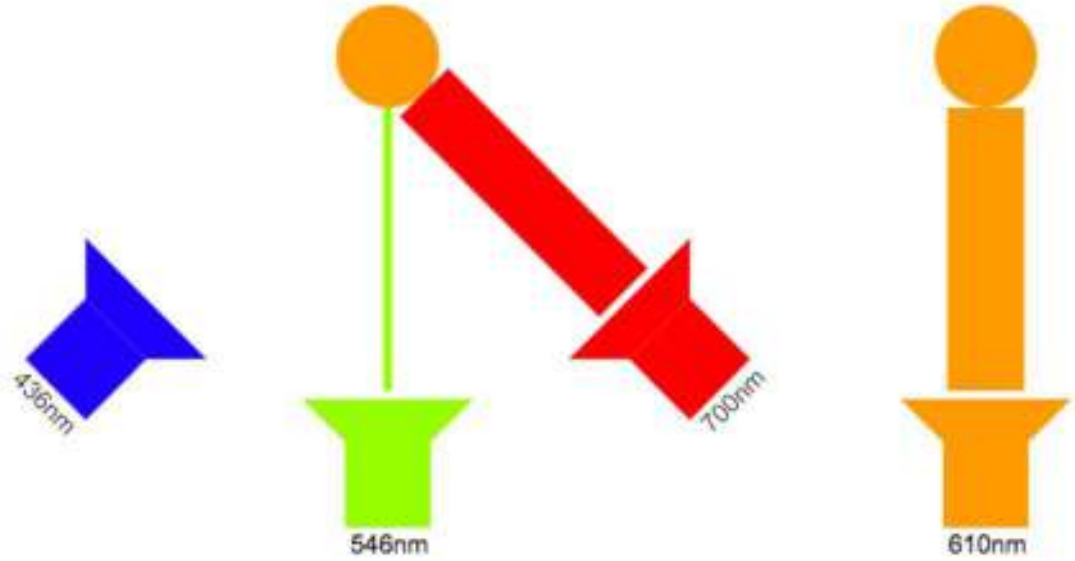
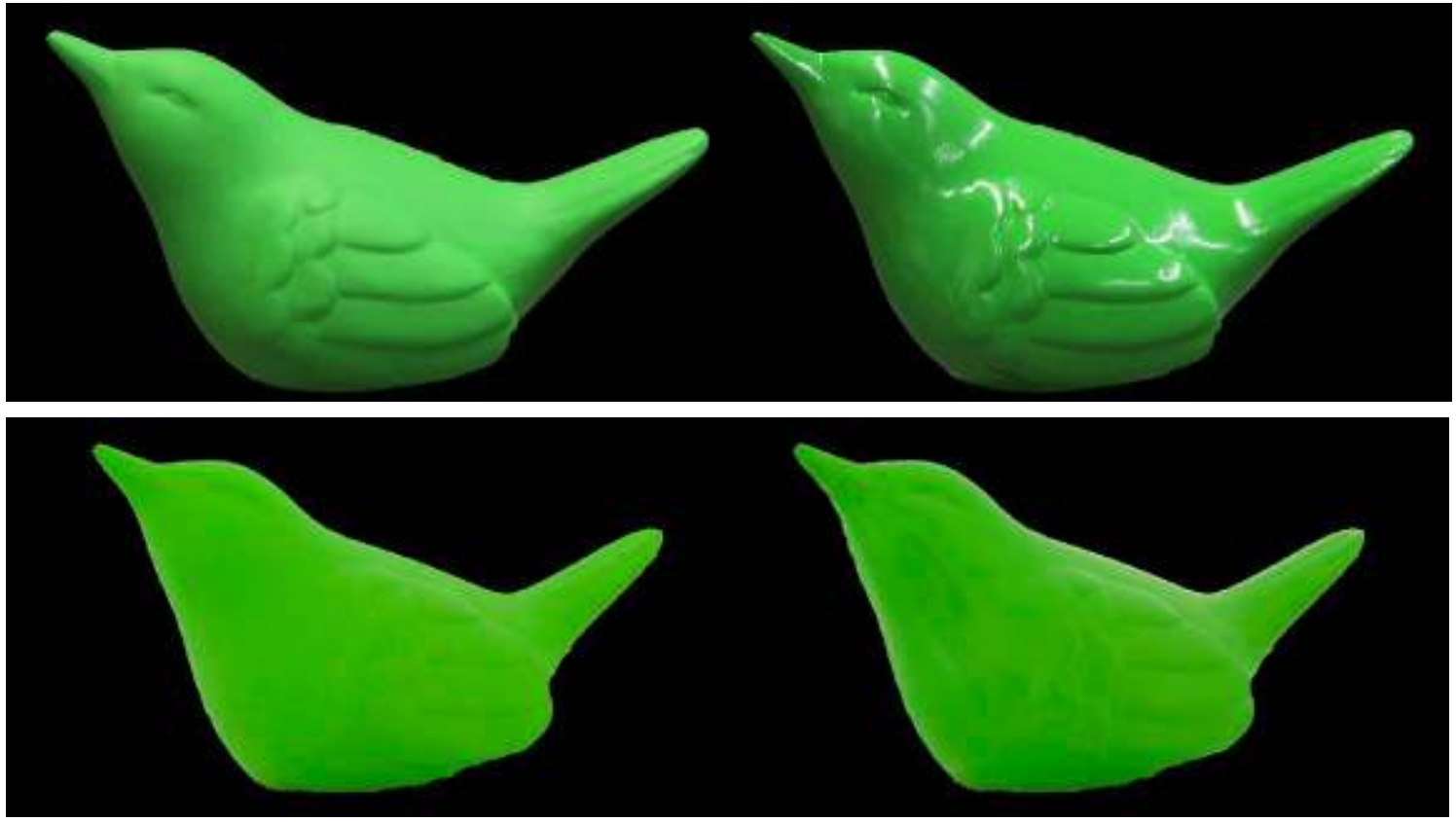
700
Wav


436nm
546nm
700nm
610nm

Colour metamerism

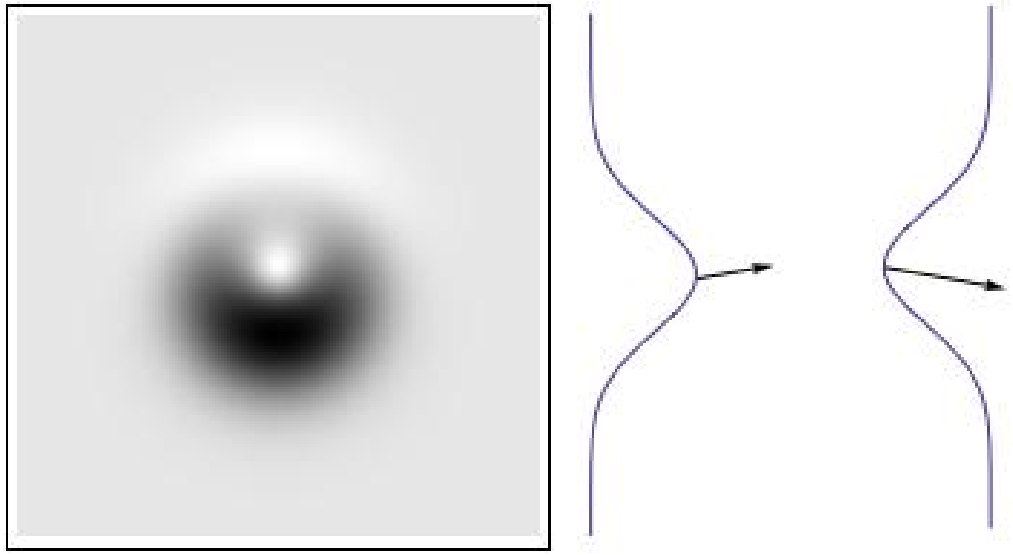
Colour metamerism

Material metamerism

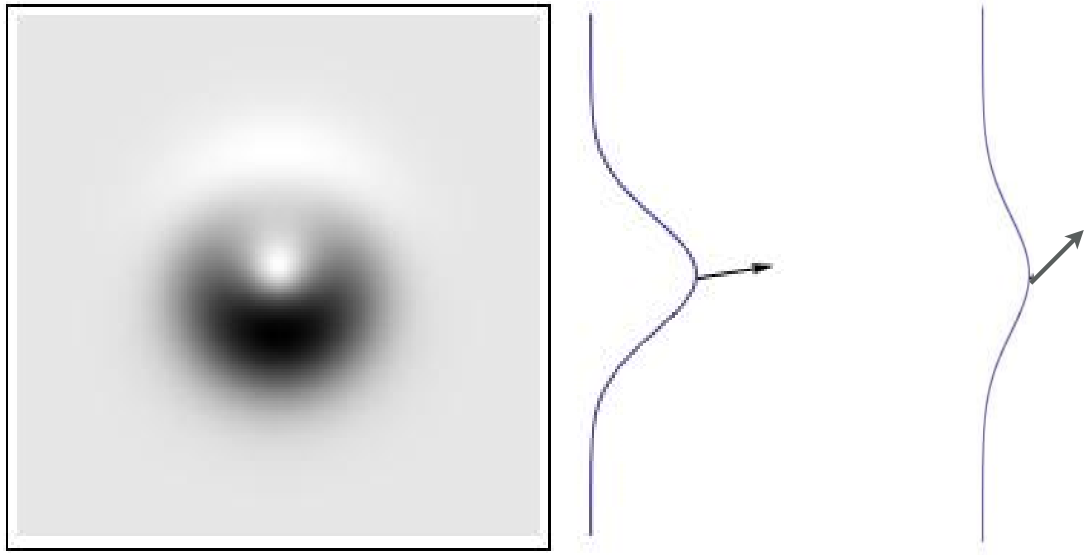


Zhang et al, JOV, 2016, 2018, 2019

Convex-concave ambiguity



Bas-relief ambiguity



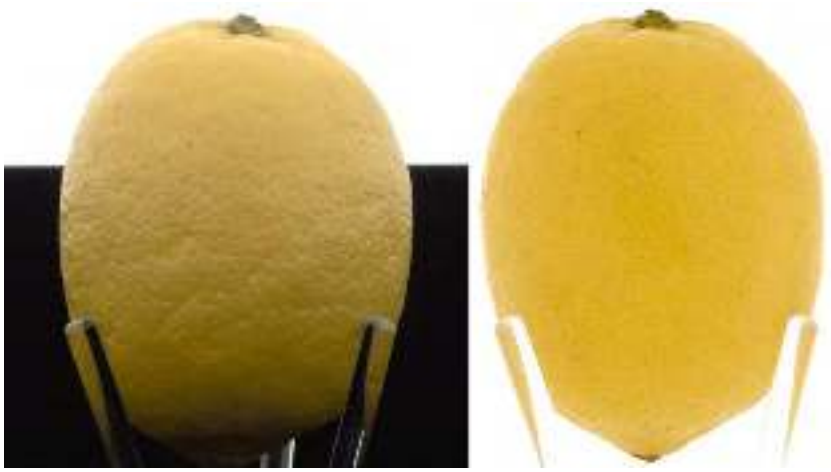
Belhumeur et al., CVPR 1997

Thus

-  Different colours, materials and shapes can look the same,

Each pair: same object (same shape, same material), different light

Dror et al., Journal of Vision, 2004.



Pont, Utrecht Oranges database

PUUE


grazing
lighting
frontal
lighting
BEAUTY
IS IN THE EYE OF THE BEHOLDER

Thus

- Different colours, materials and shapes can look the same,
- And the same colours, materials and shapes can look different,
- Dependent on the lighting

- light influences how we perceive a space and objects / people in it,

- light influences how we perceive a space and objects / people in it,
- and the space and objects in it also influence the light (objectively and subjectively).
- So: this is about light, not lamps!

perception

design

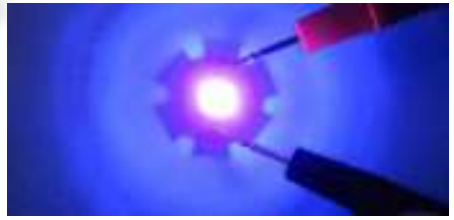
Lighting Design
elective 2016

synthesis

optics

Pont & Koenderink,
Applied Optics, 2003

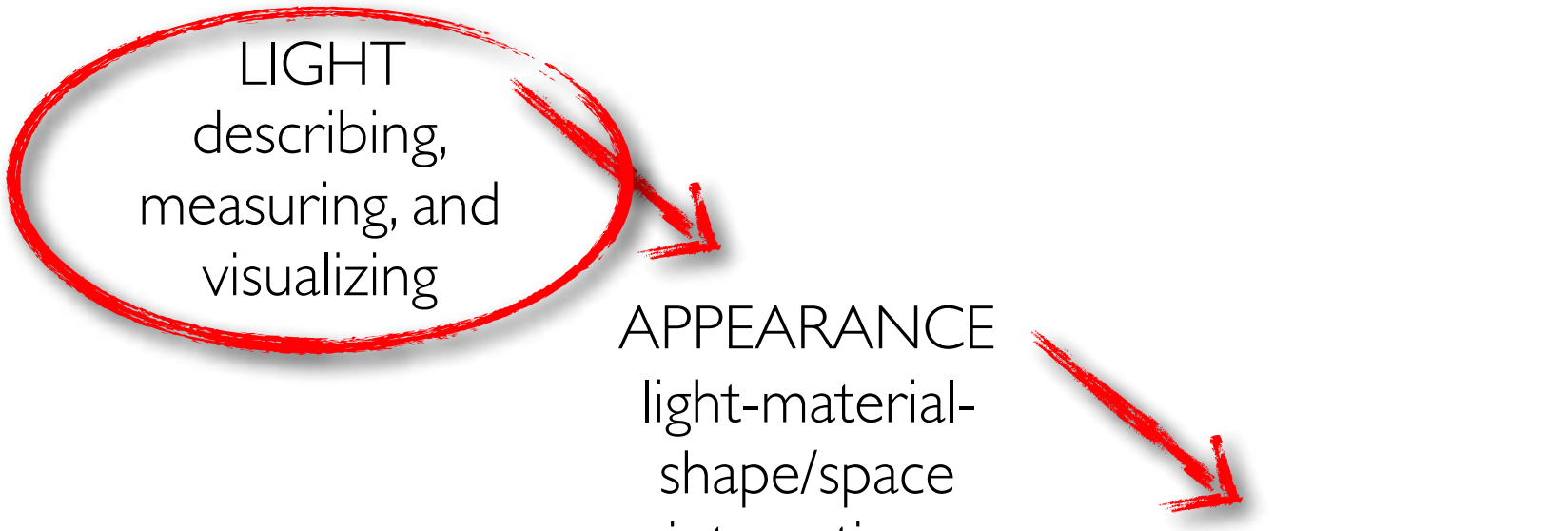
engineering



LIGHT
describing,
measuring, and
visualizing

APPEARANCE
light-material-
shape/space
interactions

EXPERIENCE
scientifically informed,
perception-based
lighting design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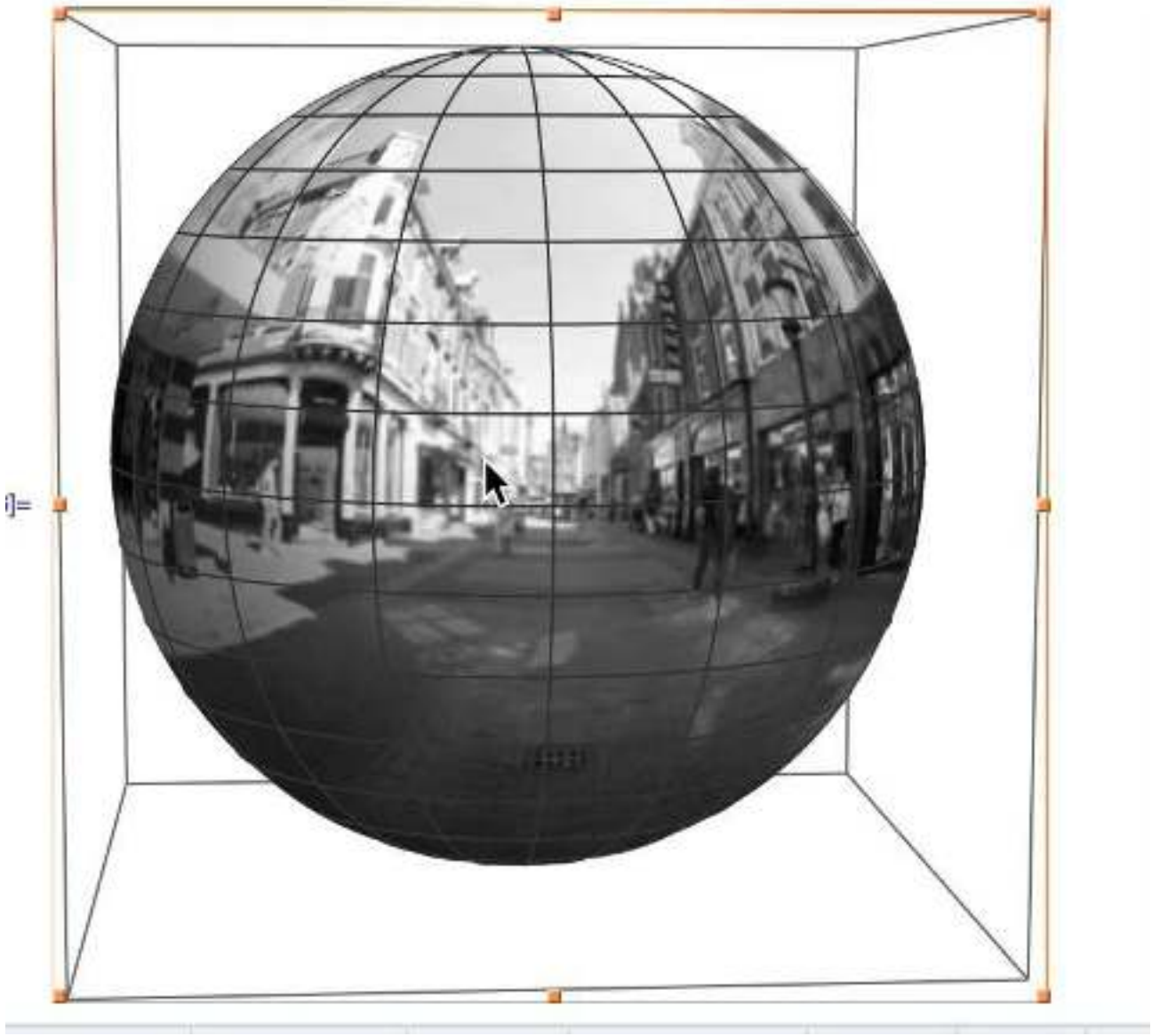


the light field

Gershun (1939):

the light traveling in every direction (θ,φ)

…

the light field

Gershun (1939):

the light traveling in every direction (θ,φ)
through any point (x,y,z) in space

the light field

Gershun (1939):

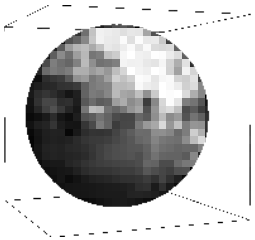
the light traveling in every direction (θ,φ) through any point (x,y,z) in space

2 dimensions

3 dimensions

5 dimensional function

Panoramic image / local light field



=

=

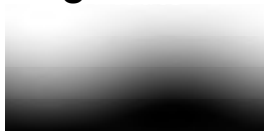
Spherical harmonics decomposition

Ambient

0th order component (monopole)

+

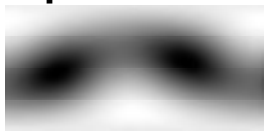
Light vector



1st order component (dipole)

+

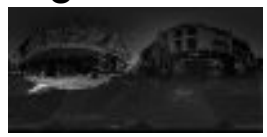
Squash tensor



2nd order component (quadrupole)

+

Light texture



sum of higher order components

Etcetera

Pont & te Pas, Perception, 2006
Pont & Koenderink, Perception & Psychophysics, 2007
te Pas & Pont, Proc. APGV, 2005
Koenderink et al., Perception, 2007
Mury et al, Applied Optics 2007, 2009
Pont, In: Handbook of Experimental Phenomenology, 2013
Xia et al., i-Perception, 2014
Barati et al., Lighting Research & Technology 2015
Xia et al., Journal of Vision, 2016
Van Assen et al., Journal of Vision 2016
Kartashova et al., Journal of Vision, 2016
Kartashova et al., SIGGRAPH Asia, 2016
Xia et al., Lighting Research & Technology 2016
Zhang et al., Journal of Vision 2016, 2018, 2019
Xia et al., i-Perception, 2017
Pont, SPIE HVEI 2018
Kartashova et al., ACM TAP 2019
Pont, Annual Reviews 2019

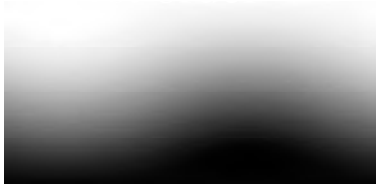
Perception

Design

Ambient | Focus | (Clamp) | Brilliance

Optics

+



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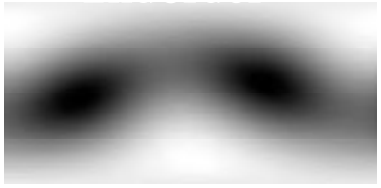


+

optic (objective) measurements

using HDR panoramic imaging

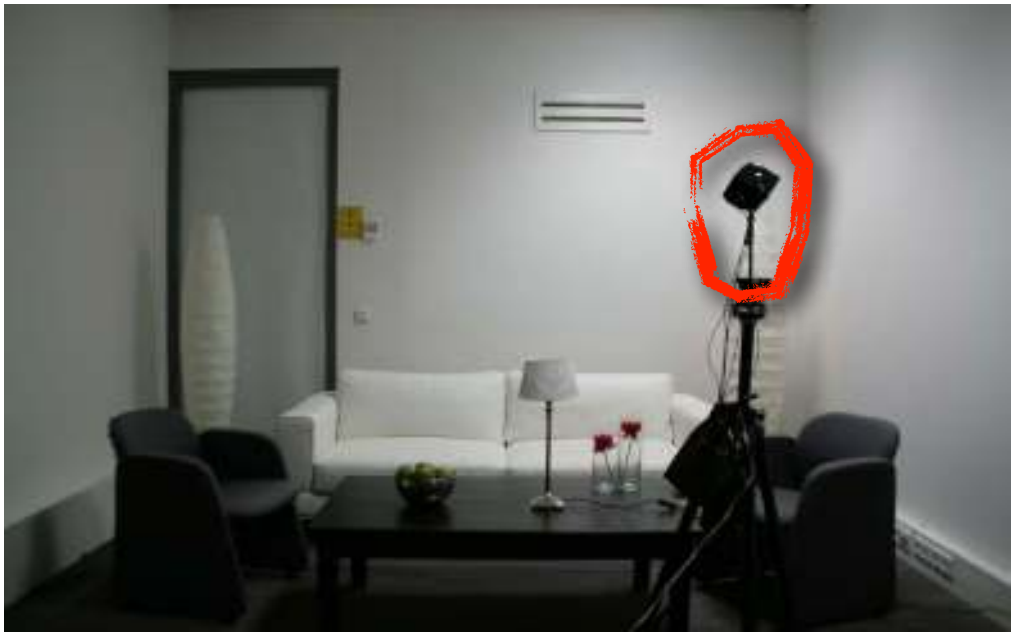
Mury et al., Applied Optics, 2007
Mury et al., Applied Optics, 2009

using a custom-built "plenopter"

using a partly custom-built cubic light meter

Xia et al., CIE 2015
Xia et al., Lighting Research & Technology, 2016

Optic (objective) measurements



Perception (subjective) measurements

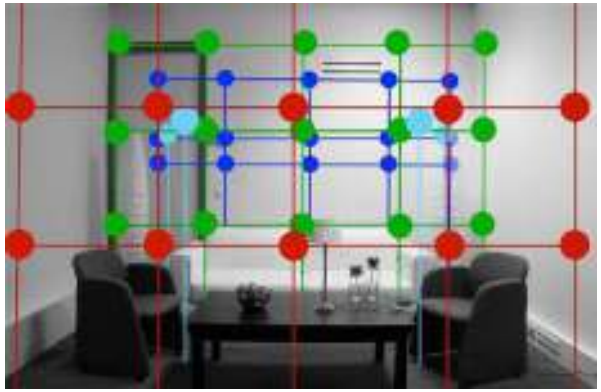
PHILIPS

Kartashova et al., Experiencing Light 2014
Kartashova et al., Journal of Vision, 2016

3 lighting conditions:

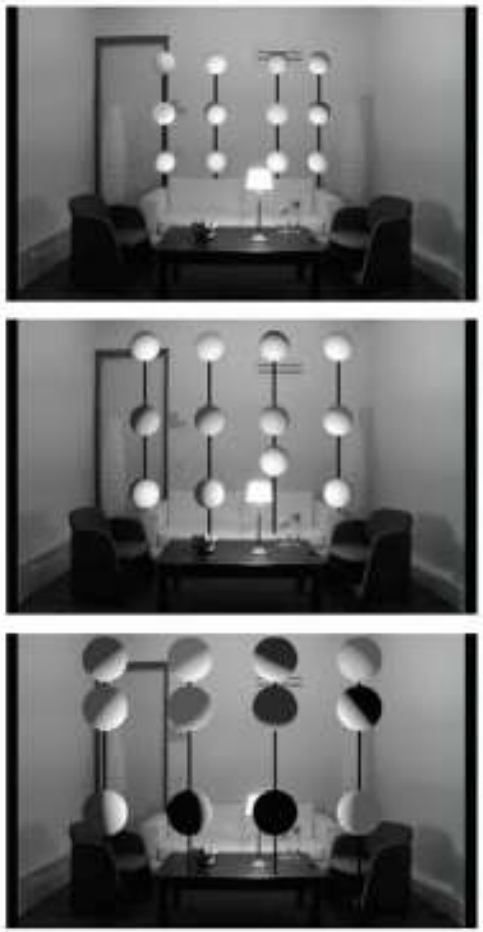


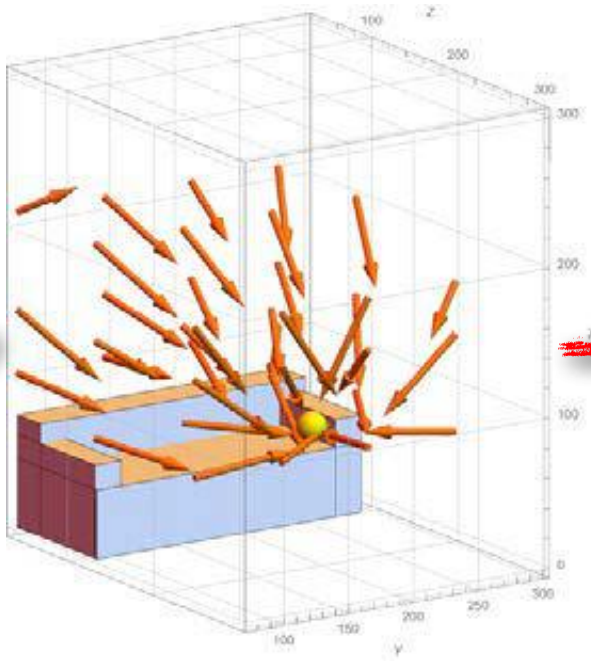
36 positions:

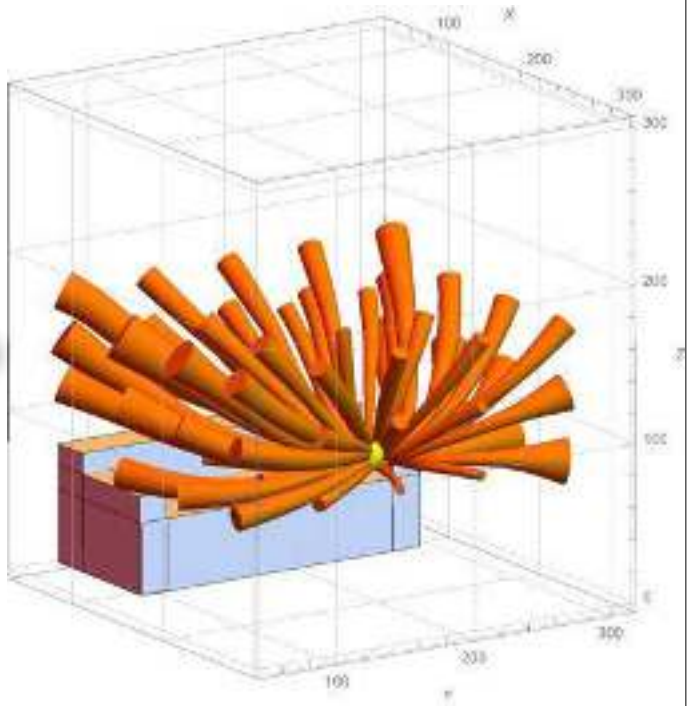


Optic (objective) measurements:
x 6 illuminance measurements
= 648 numbers

Perception (subjective) measurements:
4 parameters x 10 observers
= 4320 numbers

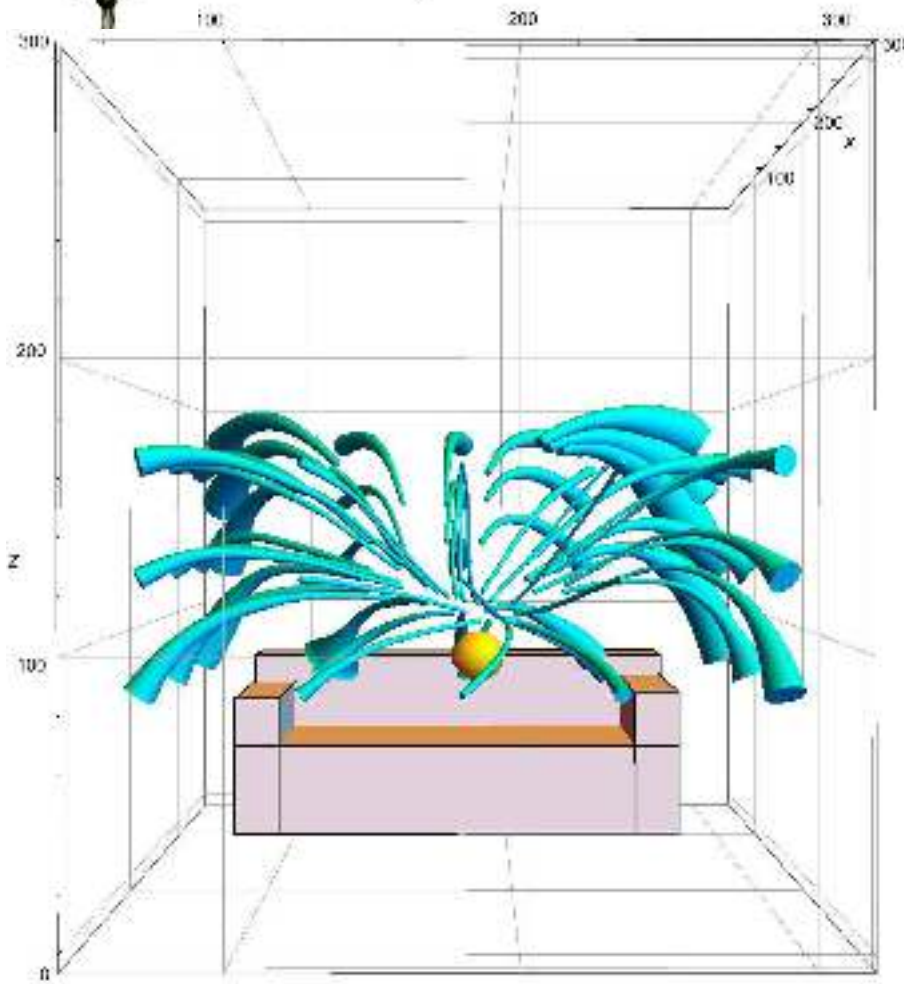




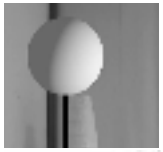


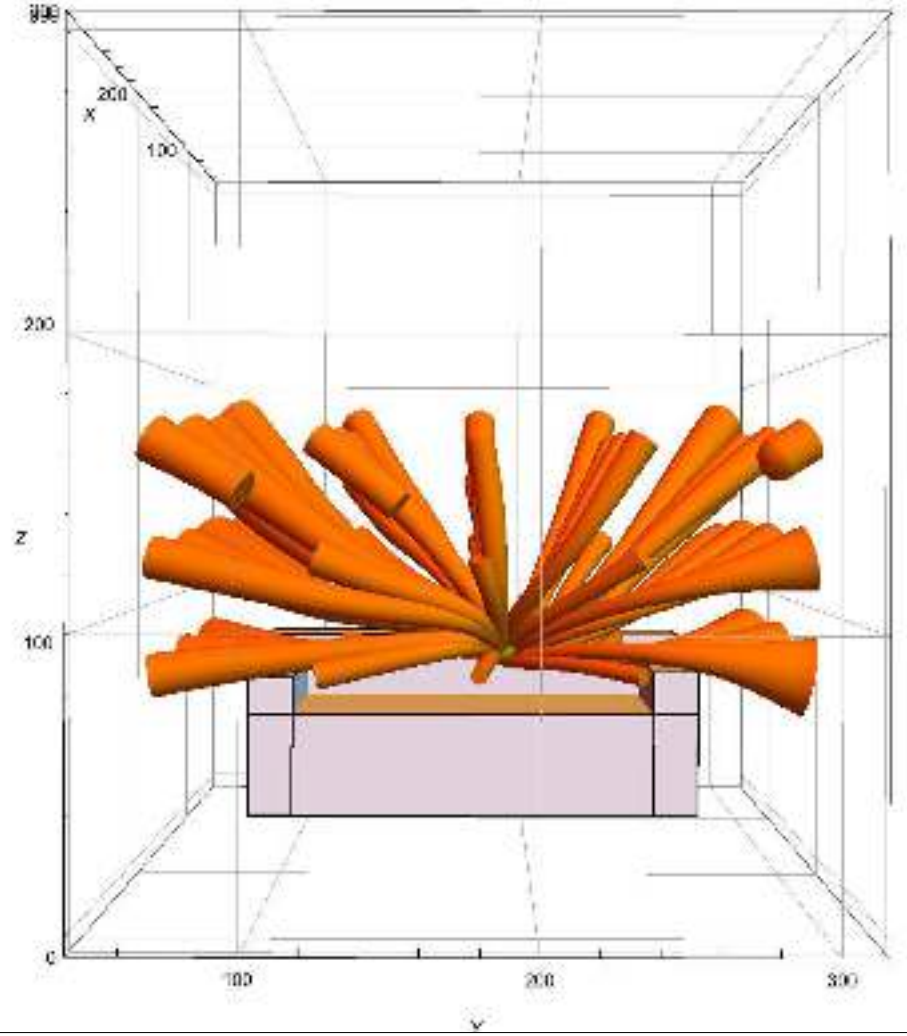
Kartashova et al., Experiencing Light 2014
Kartashova et al., Journal of Vision, 2016

Physical light field

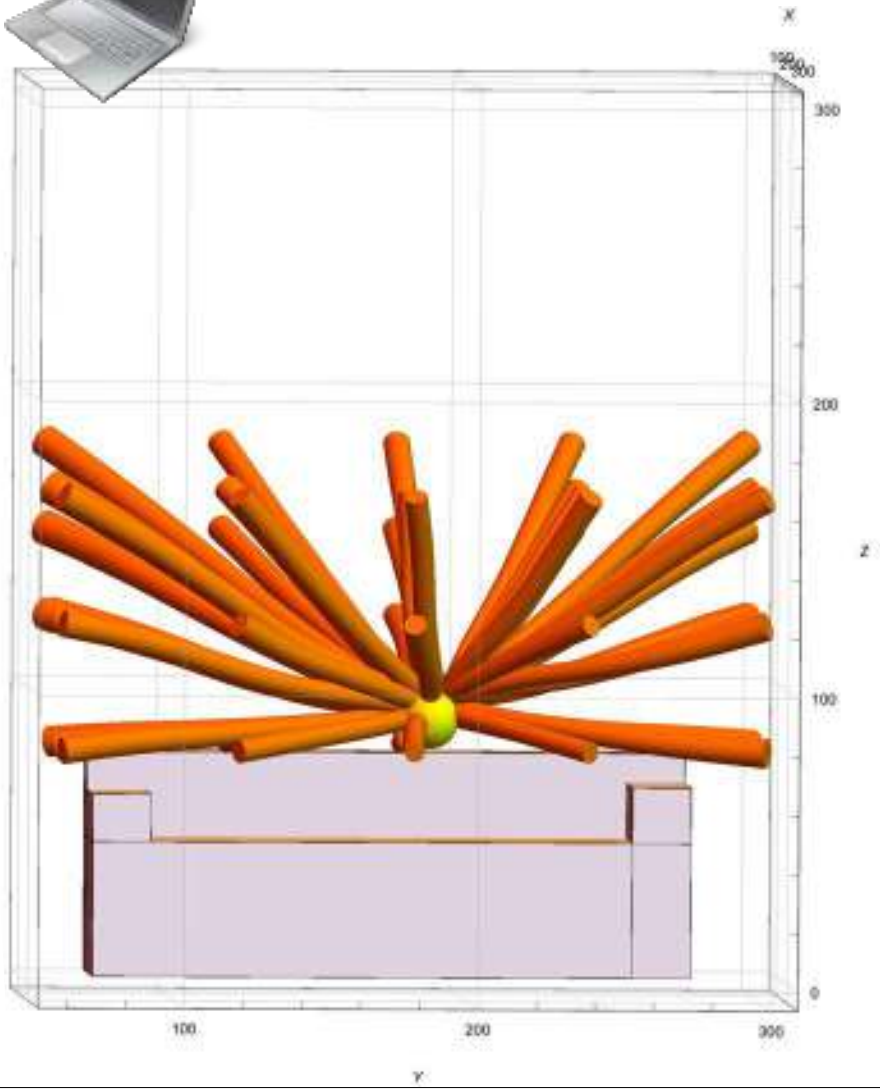


Visual light field

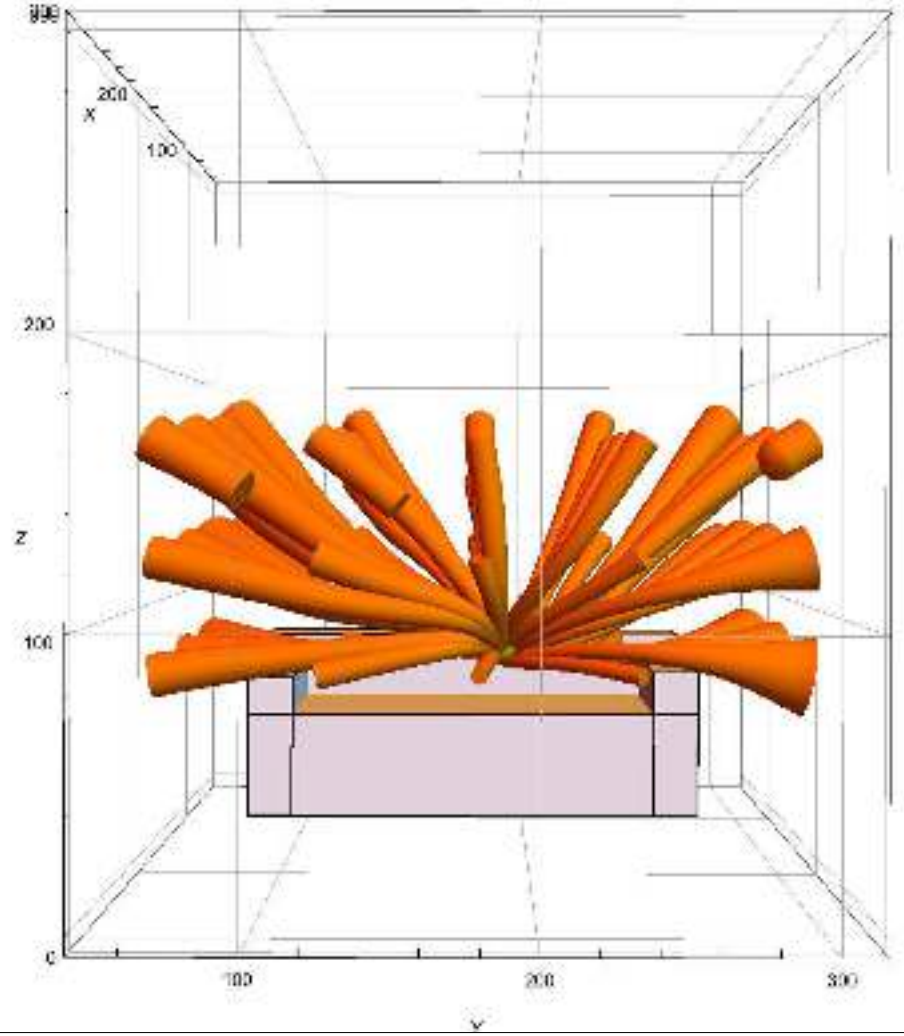




MODEL

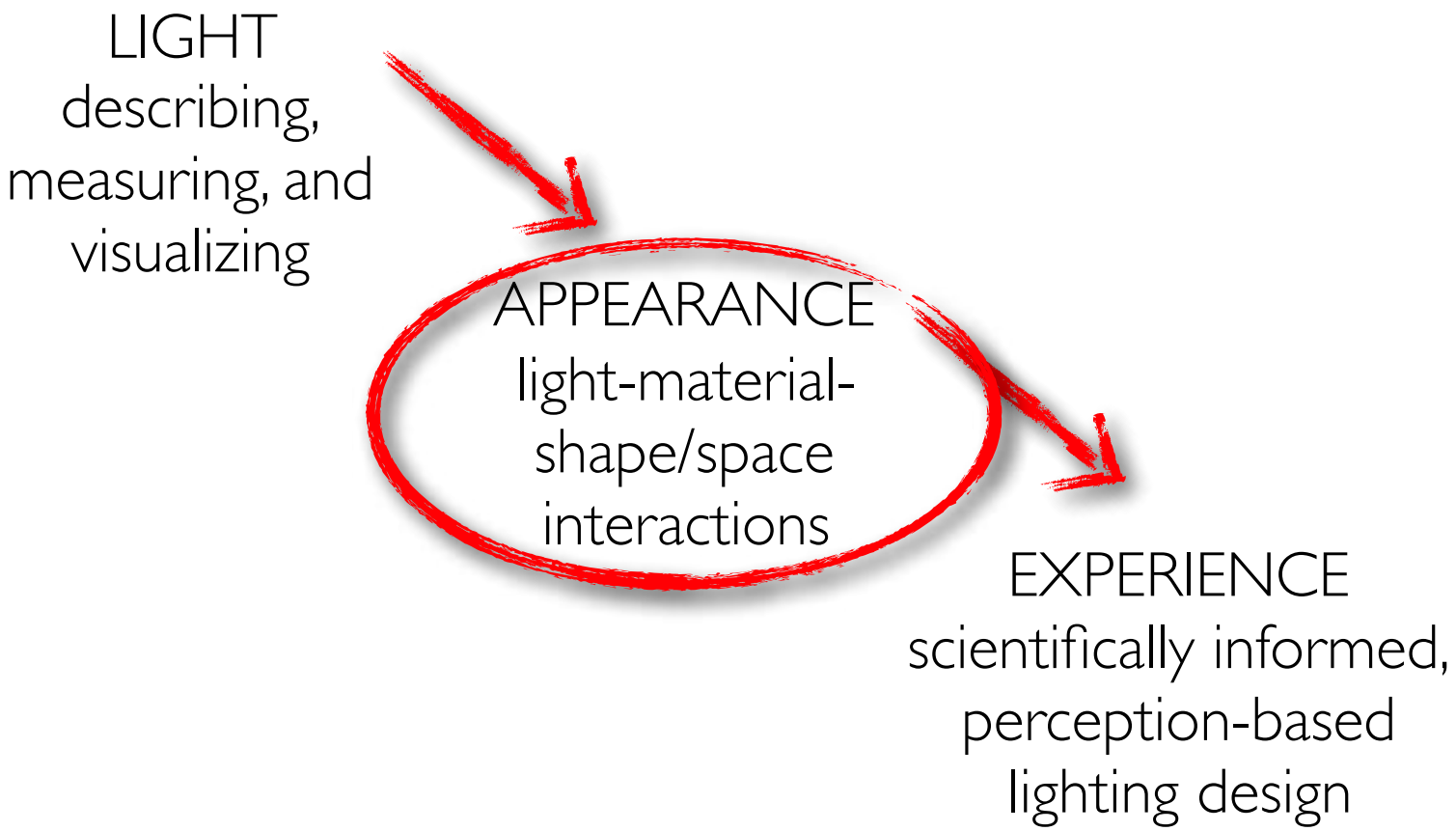


Visual light field

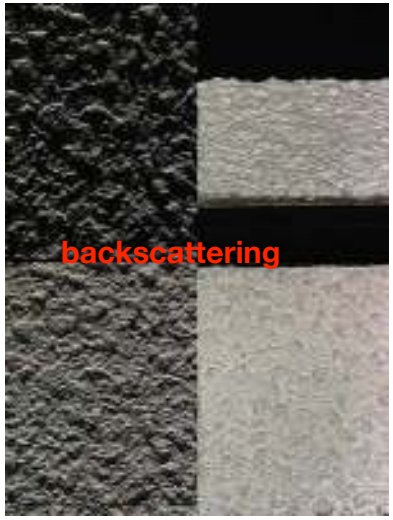


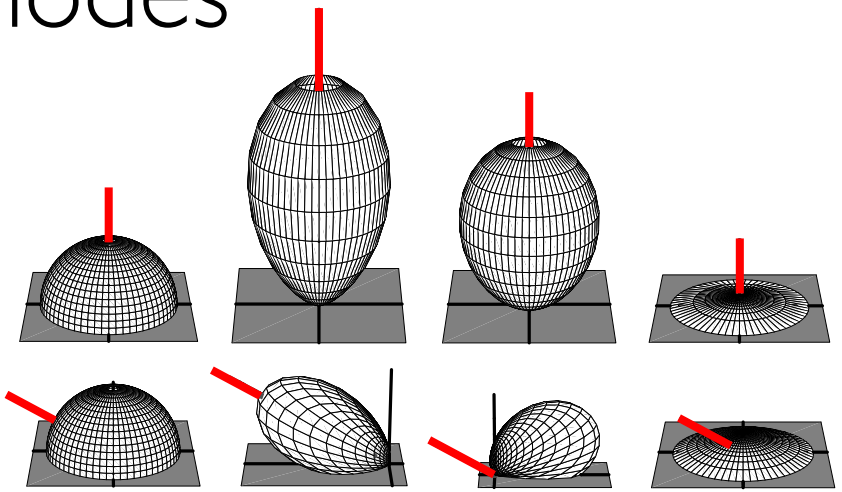
LIGHT

- Light in a space can be described, measured and visualized,
- optically (objective) and visually (subjective).
- Supporting a novel approach in lighting design that is focused on appearance instead of plane illuminations.
- In which we can safely neglect subtle variations in the light field structure.


LIGHT
describing,
measuring, and
visualizing
APPEARANCE
light-material-
shape/space
interactions
EXPERIENCE
scientifically informed,
perception-based
lighting design

Ecological optics of natural materials; canonical modes





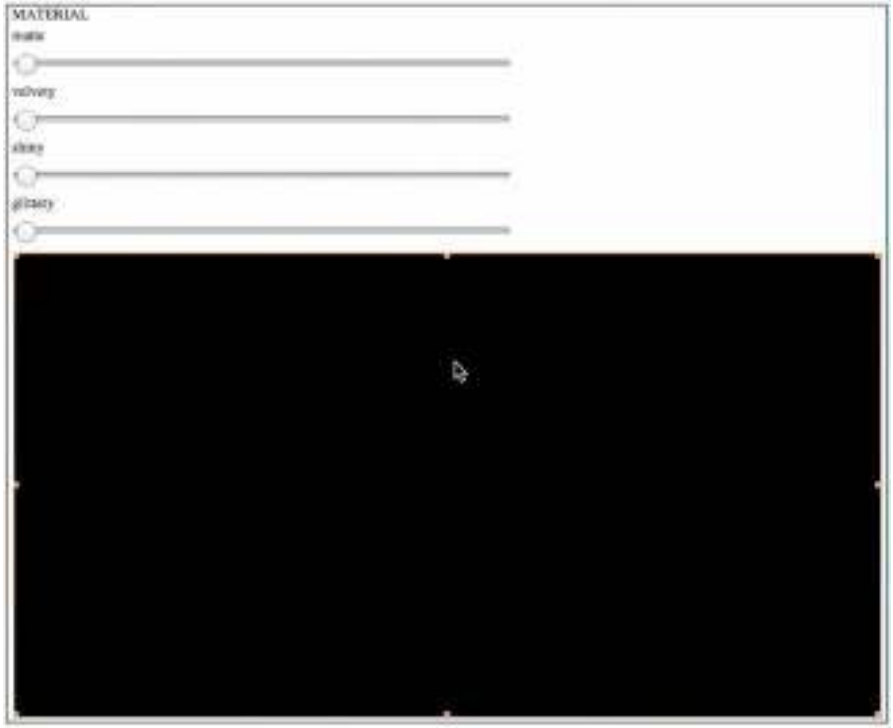
diffuse / back- / forward / asperity scattering

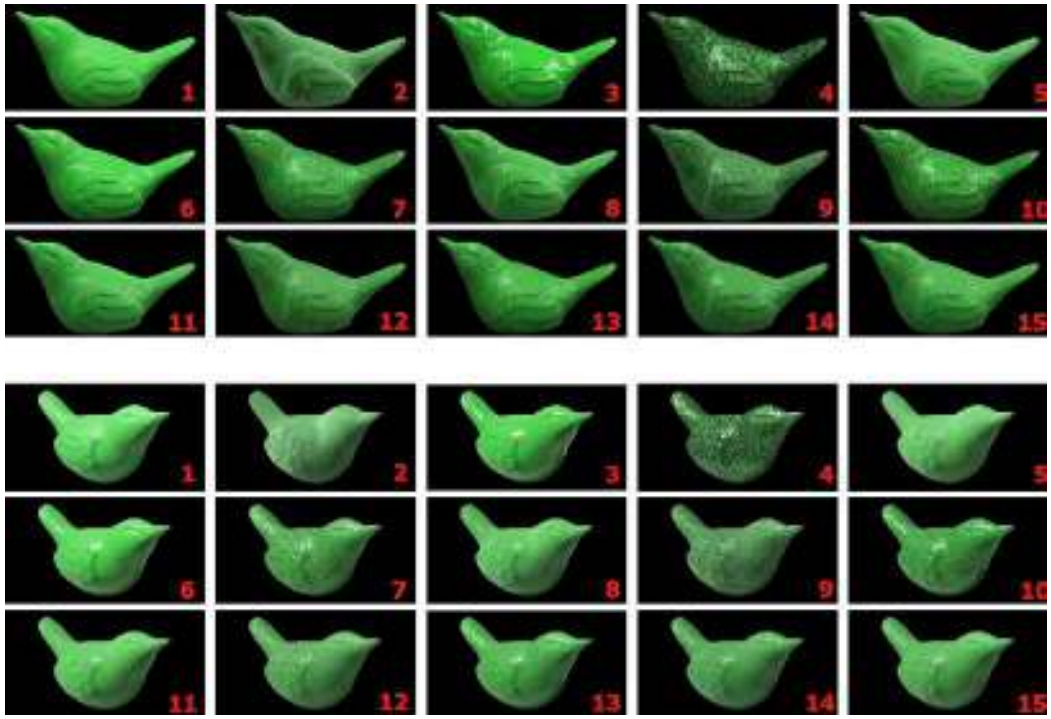
Koenderink & Pont, International Journal for Computational Vision and Biomechanics, 2008

Pont & Koenderink, Computer Vision and Image Understanding, 2005

Pont & Koenderink, Journal of the Optical Society of America A, 2002

Mixing canonical material modes





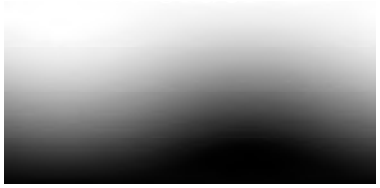
Perception

Design

Ambient | Focus | (Clamp) | Brilliance

Optics

+



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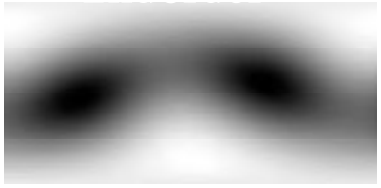

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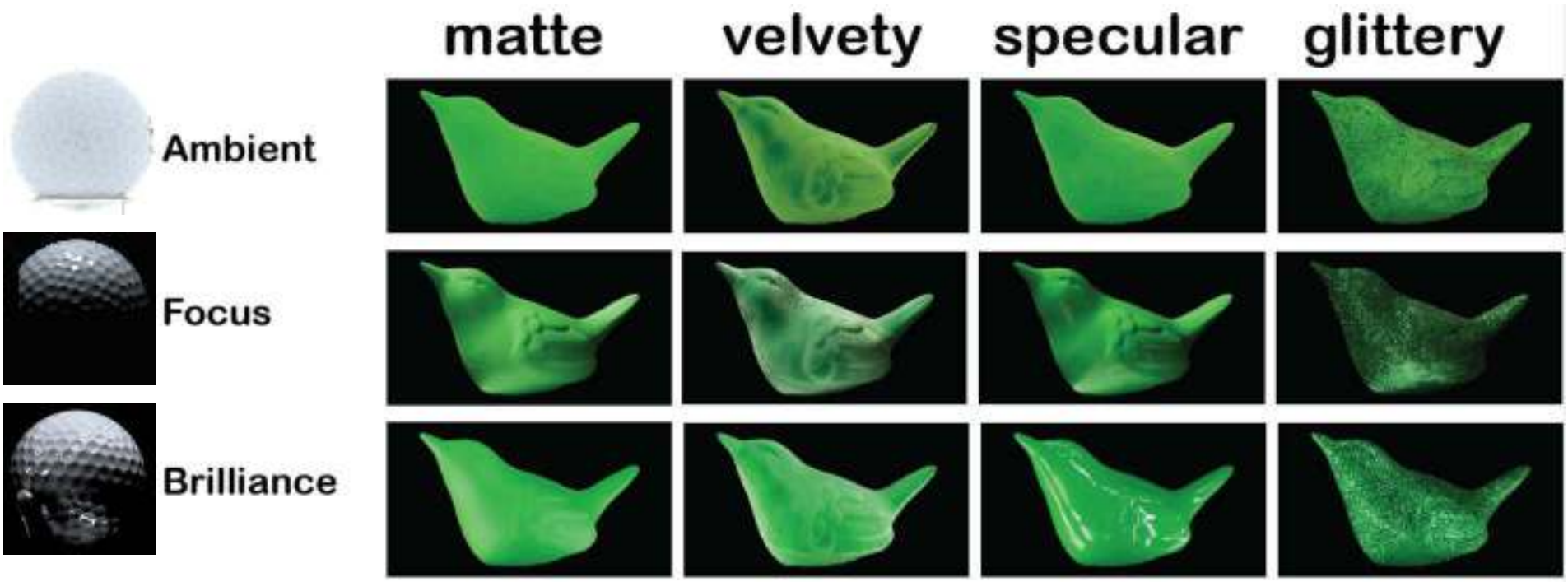
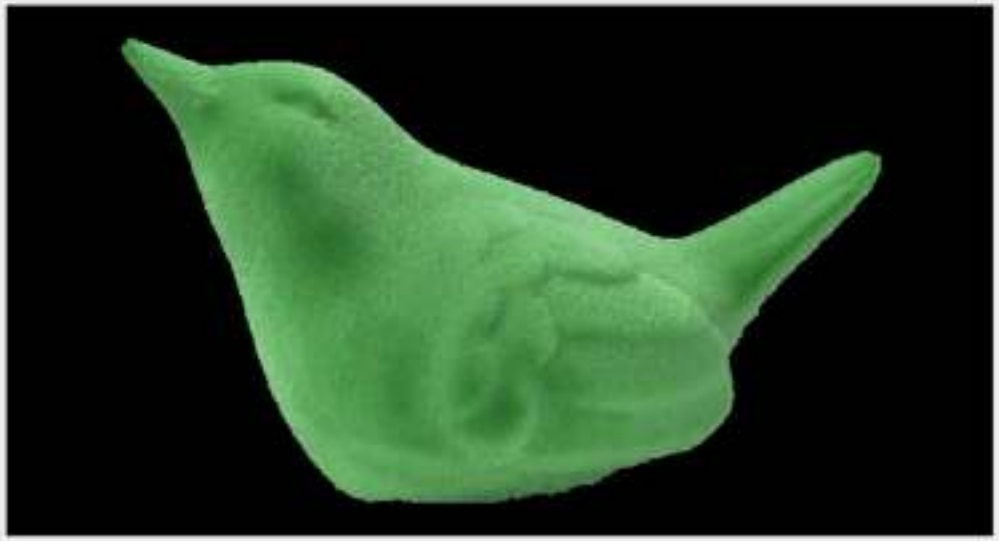
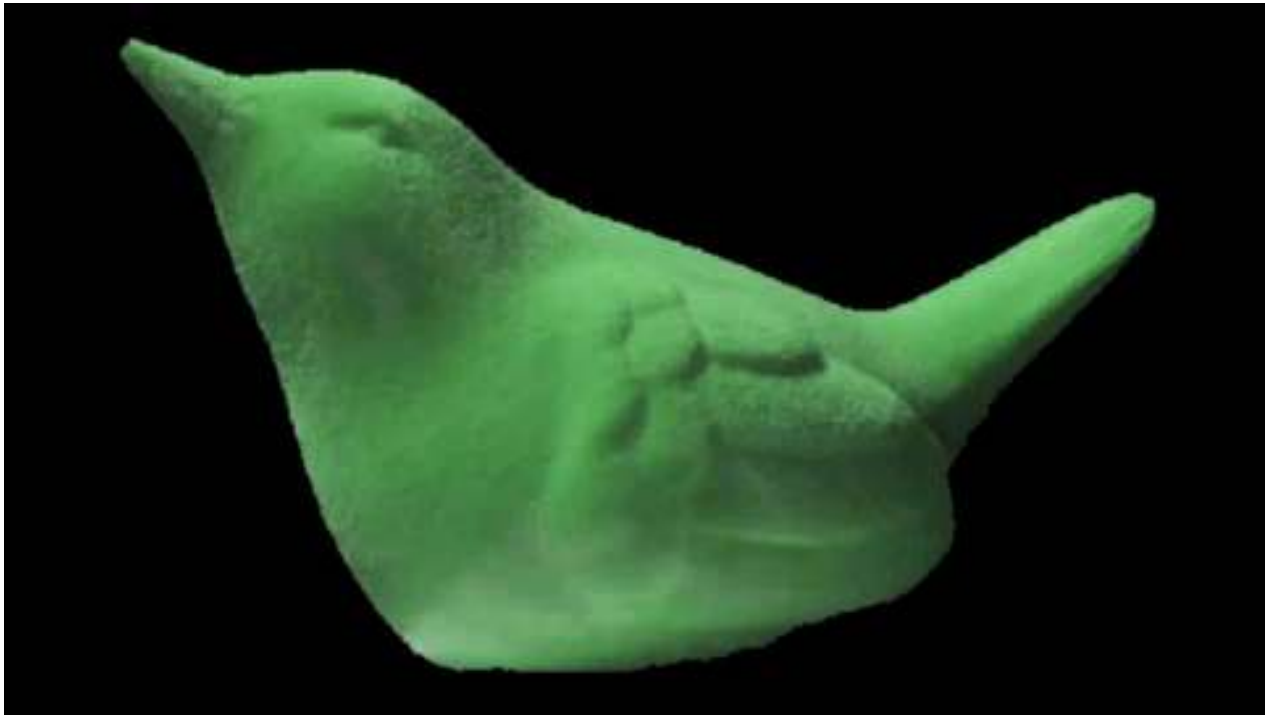

matte
velvety
specular
glittery
Ambient
Focus
Brilliance

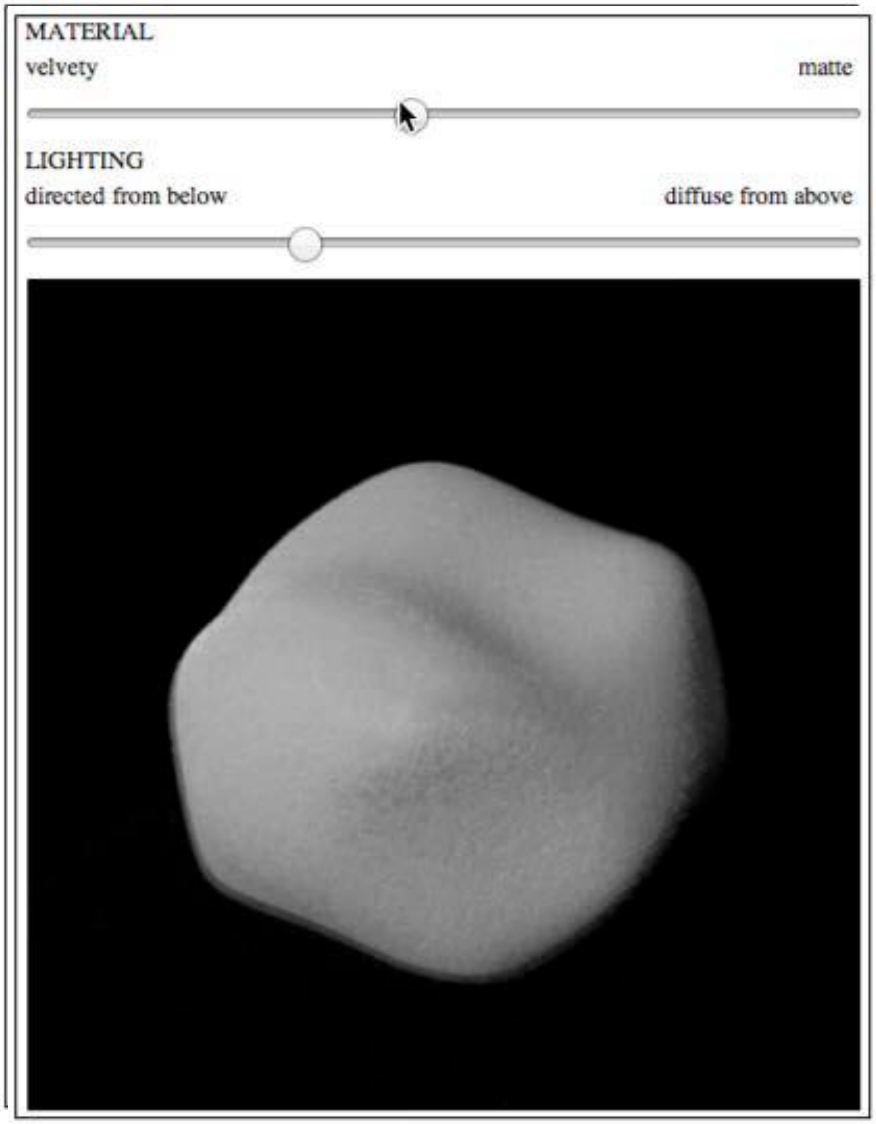


same material-mixture, only lighting varies



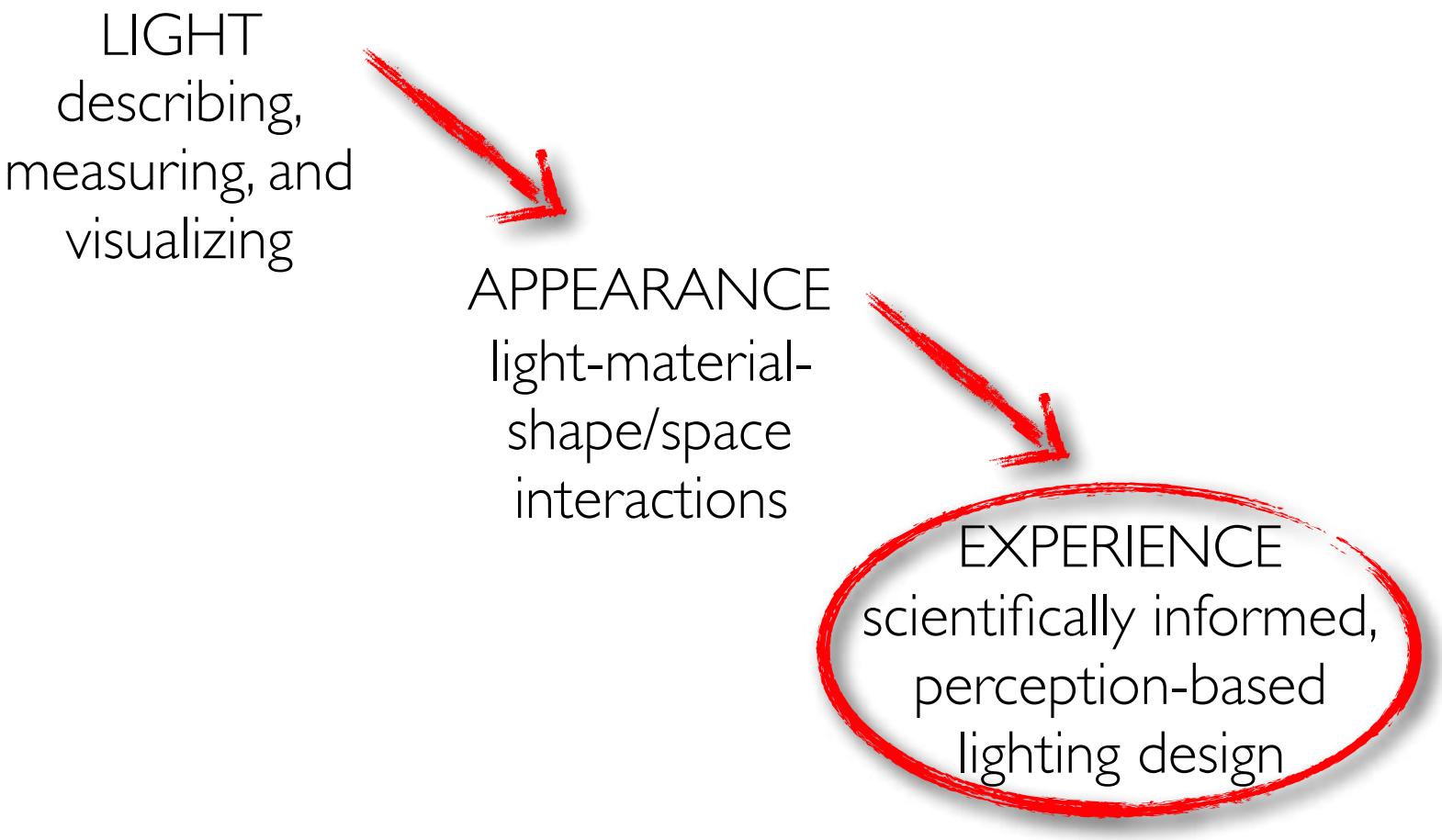
Zhang et al, JOV, 2016, 2018, 2019

- lighting systematically influences material perception
- in a material dependent manner
- Asymmetric confounds between lighting and material


MATERIAL
velvety
matte
LIGHTING
directed from below
diffuse from above

APPEARANCE

- is the result of a complex interplay between light, material and shape.
- It can be studied *and varied* systematically via canonical modes,
- resulting in insights into visual effects that we can predict.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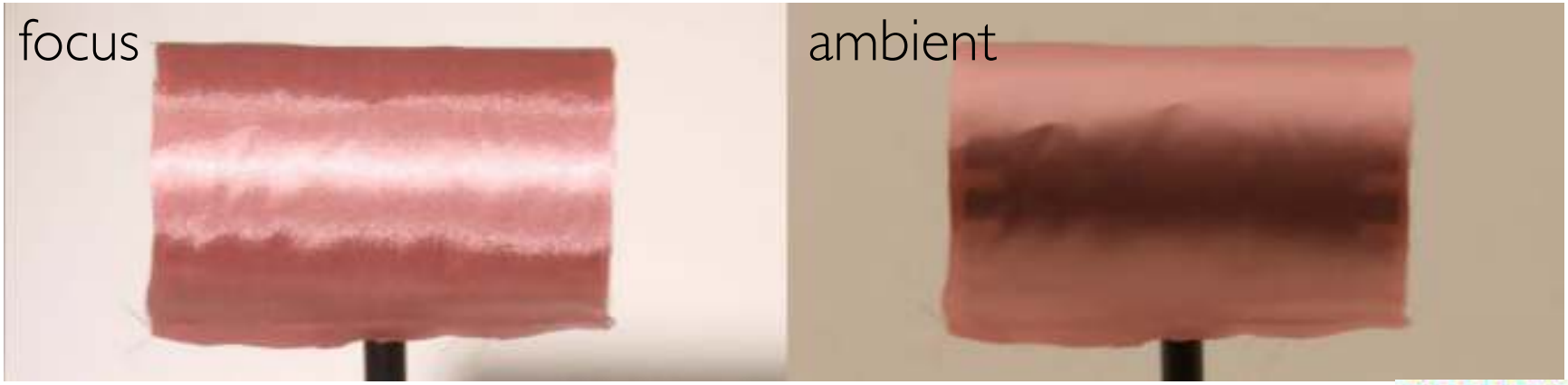
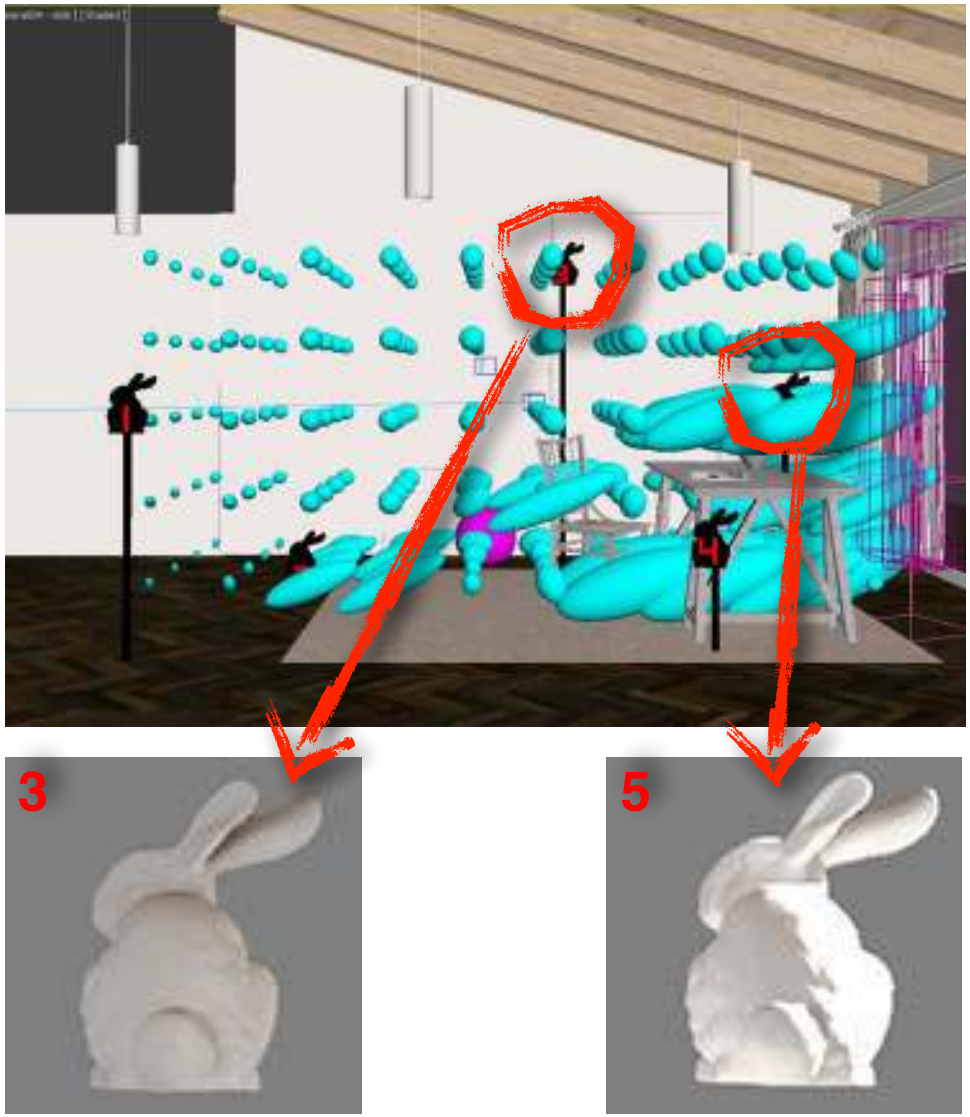


Barati et al., Lighting Research and Technology, 2015

PHILIPS

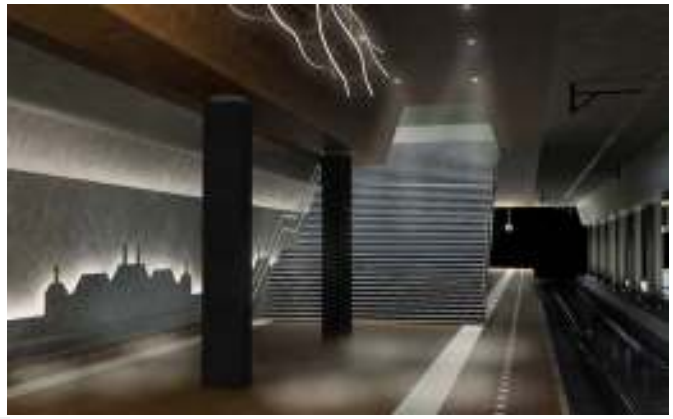


Kartashova et al, SIGGRAPH Asia 2016

Lighting design elective

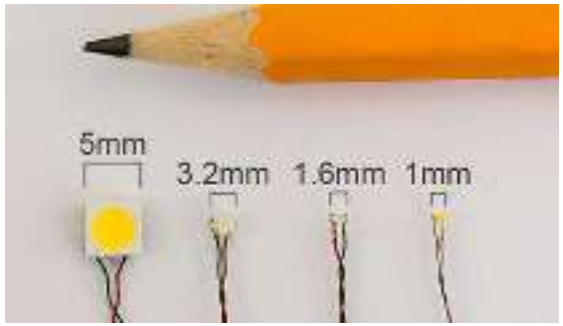
ARUP

ipv Delft



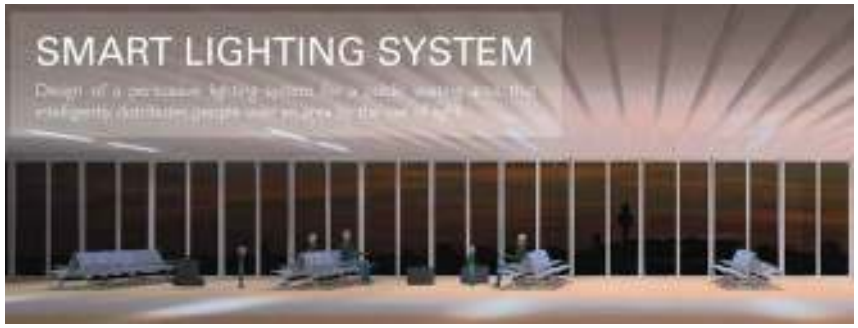
Deerns

LED's



http://www.true2scale.com/miniature-3v-led-lighting/

smart environments



Sander Fennema

Deerns

internet of light

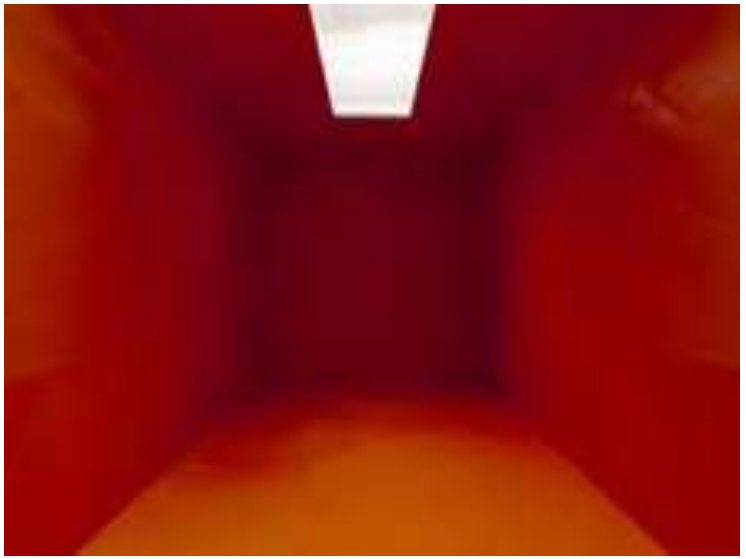
Marijn de Smit

PHILIPS

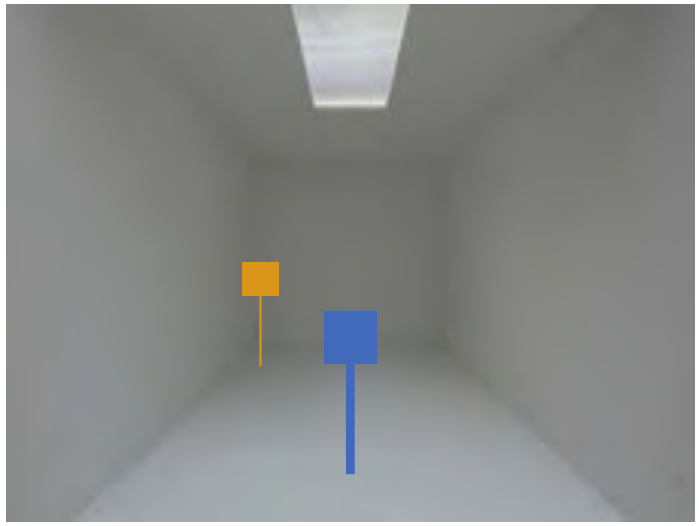
EXPERIENCE

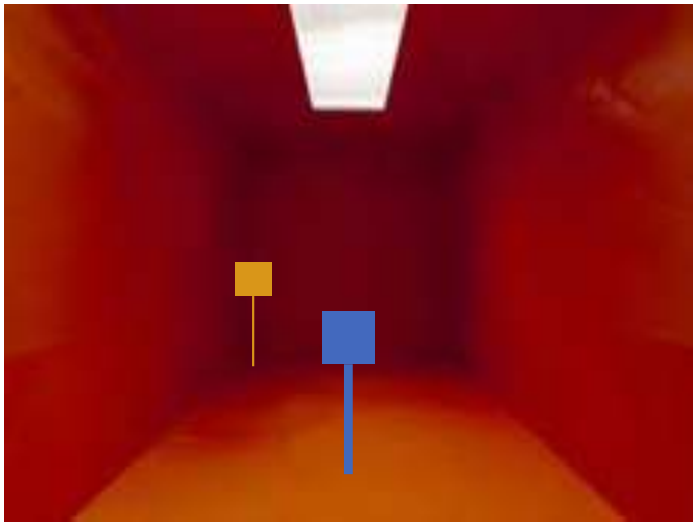
- via scientifically informed,
- perceptually intelligent design,
- of tools for lighting design, lighting products, and lighting plans.

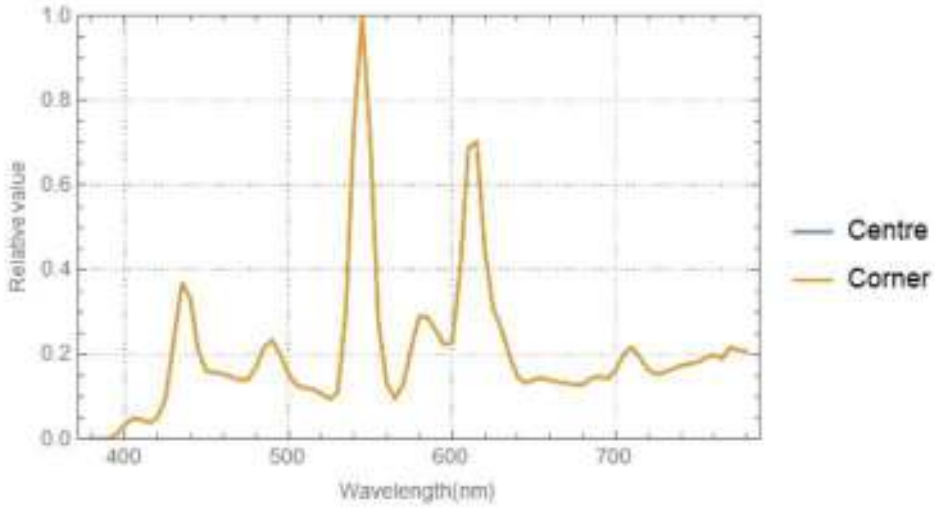
Chromatic effects of interreflections

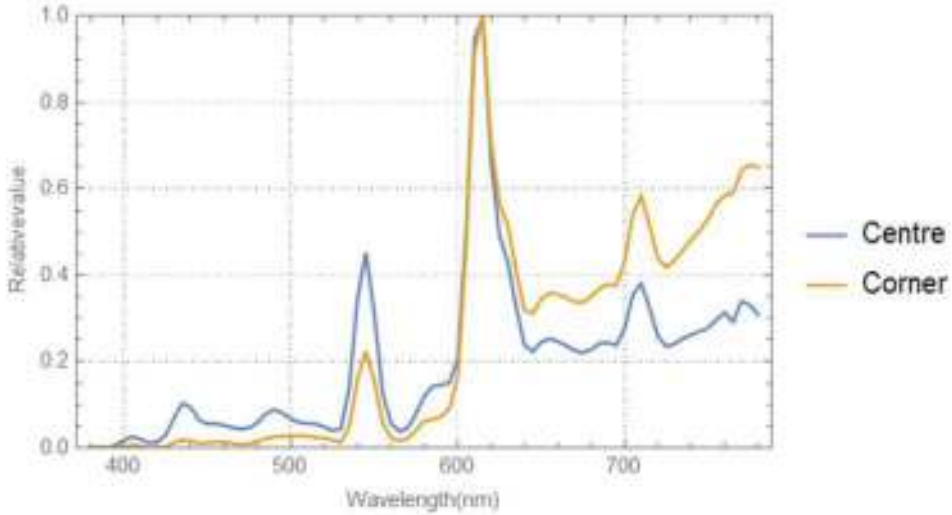


Yu et al., DyViTo & in prep. 2019

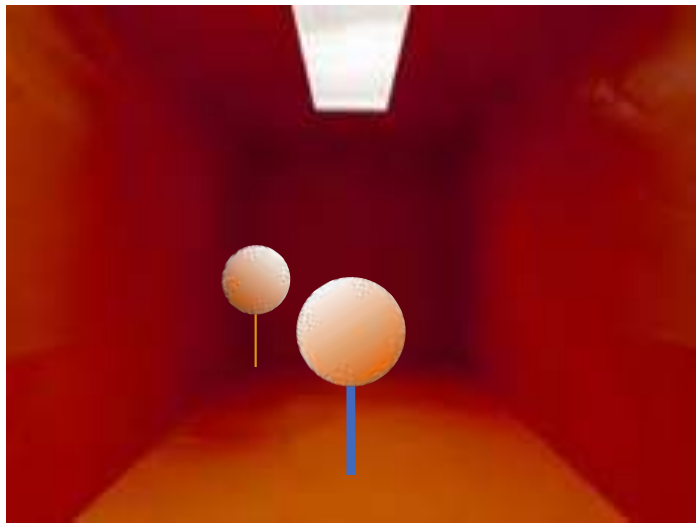








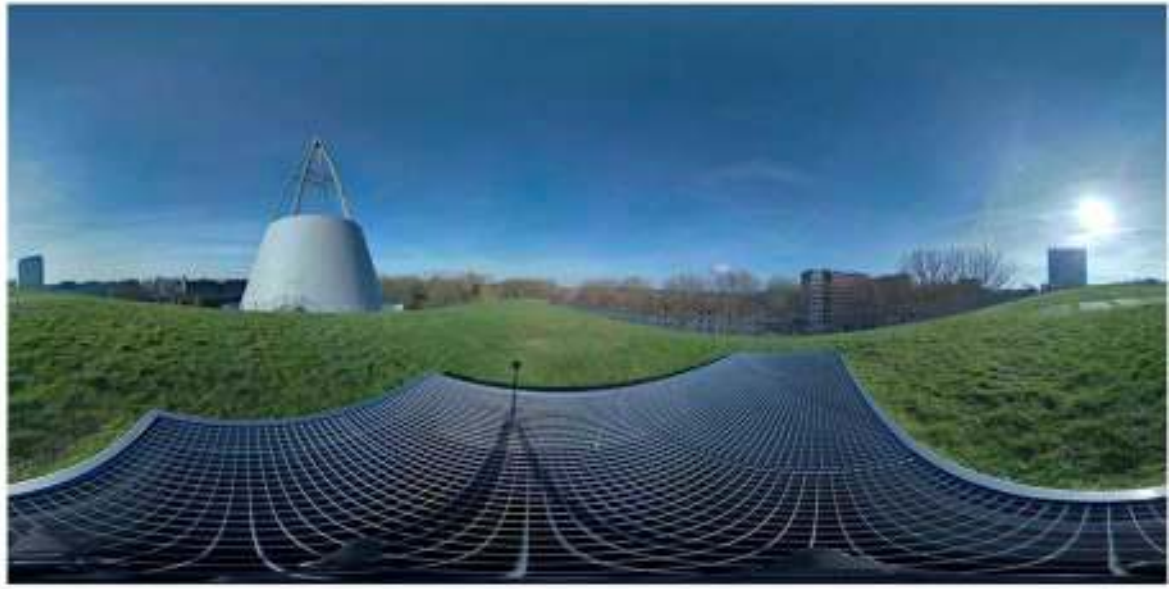
Yu et al., DyViTo & in prep. 2019



optic (objective) measurements

?

perception (subjective) measurements



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