International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

CIE Research Strategy 2023-2027

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CIE President

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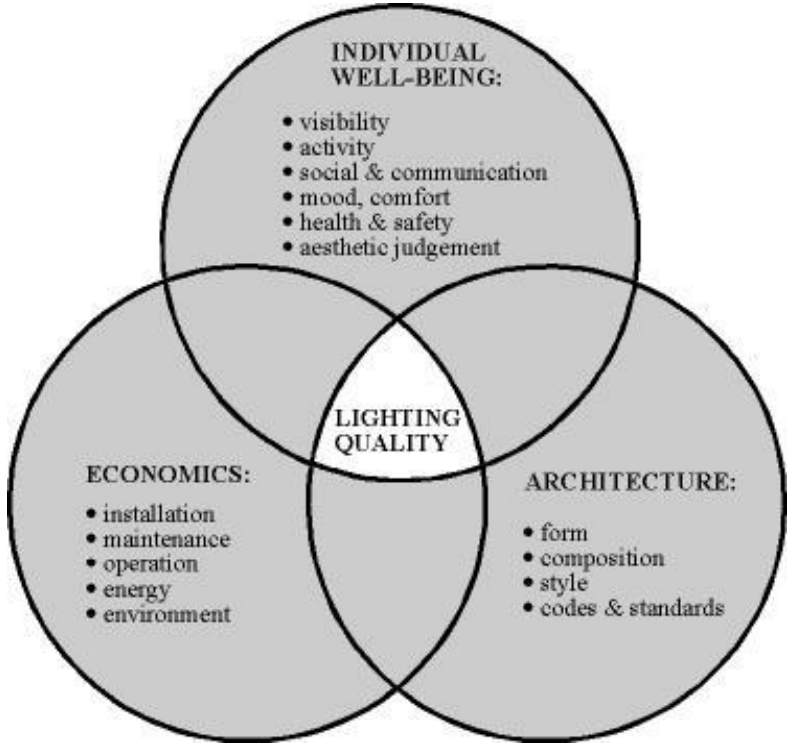
Our aim: lighting quality

lighting quality

degree of excellence to which the totality of lighting characteristics fulfils user needs and expectations or other applicable requirements

Note 1 to entry: The degree of excellence is not a quantitative measure but depends on the application area and covers individual end-user well-being, safety and public security, architecture and lit environment.



The proper light, at the proper time, in the proper place

Lighting matters!

Lighting knowledge can support 12 of the 17 UN Sustainable Development Goals (SDGs)

International Day of Light 2024 webinar:

SpotLIGHT on the UN Sustainable Development Goals

Why a Research Strategy?

CIE publications — Technical Notes, Technical Reports, and International Standards — rely on a scientific foundation.

One can scan the environment to see what might be on the horizon, what areas might need consensus documents… but can't form consensus when there is too little information.

The Research Strategy communicates to the global research community what the CIE needs from researchers – work that will lay the foundation for the next generation of CIE technical publications.

It provides the basis for the CIE to write letters of support to researchers when they seek funding for related research, conveying to funders the importance of the topic (CIE Research Support Letters).

CIE Research Strategy 2023-2027: Thematic Approach

1 **Overarching themes**

- 1.1. Digital transformation of metrology, science, and industry
- 1.2. Towards inclusive, equitable lighting

2 **Topical themes**

- 2.1. Advances in measurement & calibration
- 2.2. Integrative lighting for people
- 2.3. Ecologically respectful, high-quality exterior lighting
- 2.4. Fundamentals of photobiology for agriculture and aquaculture
- 2.5. Enabling the application of safe & beneficial optical radiation
- 2.6. Measuring, modelling, perceiving and reproducing colour

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Overarching Themes

Digitalization of the CIE

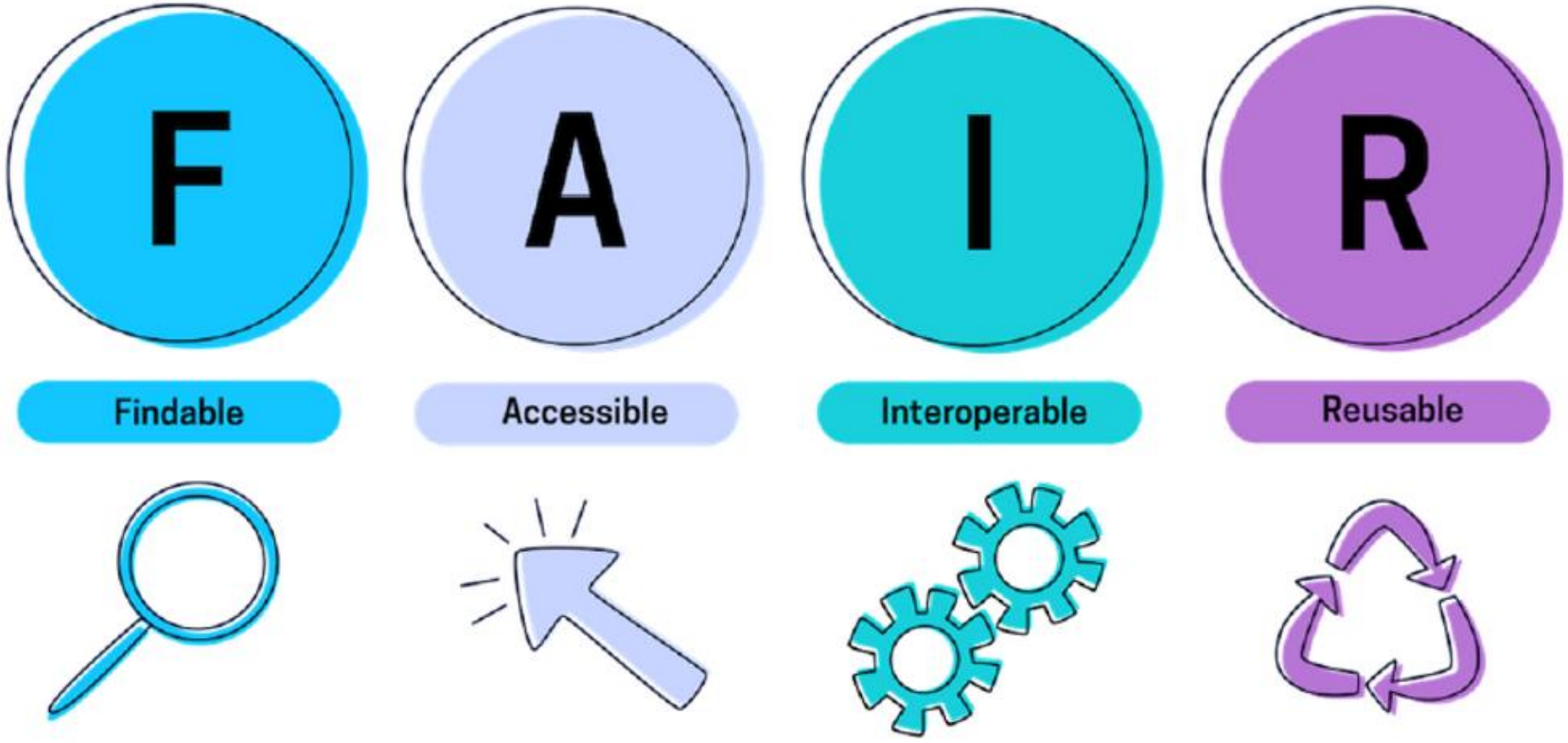
Free datasets now (and ongoing)

Metadata format

Joint Statement of Intent on the digital transformation in the international scientific and quality infrastructure

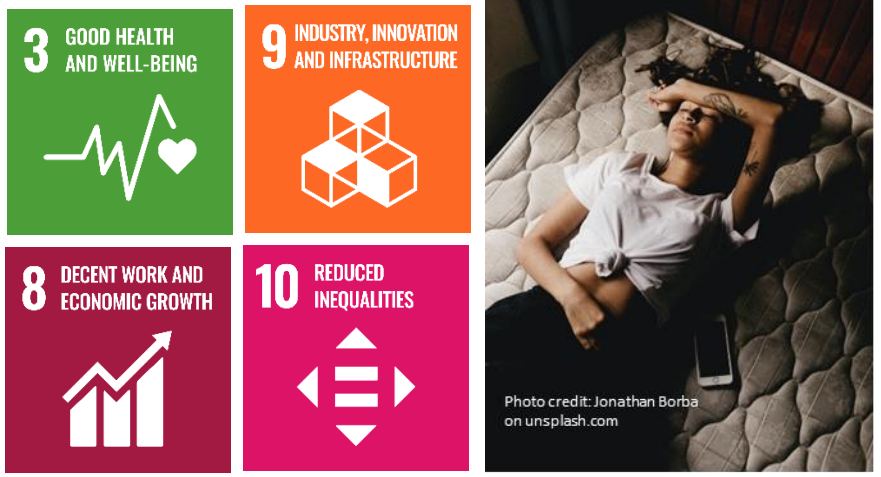
New research should encompass this approach

FAIR Principles and Open Science

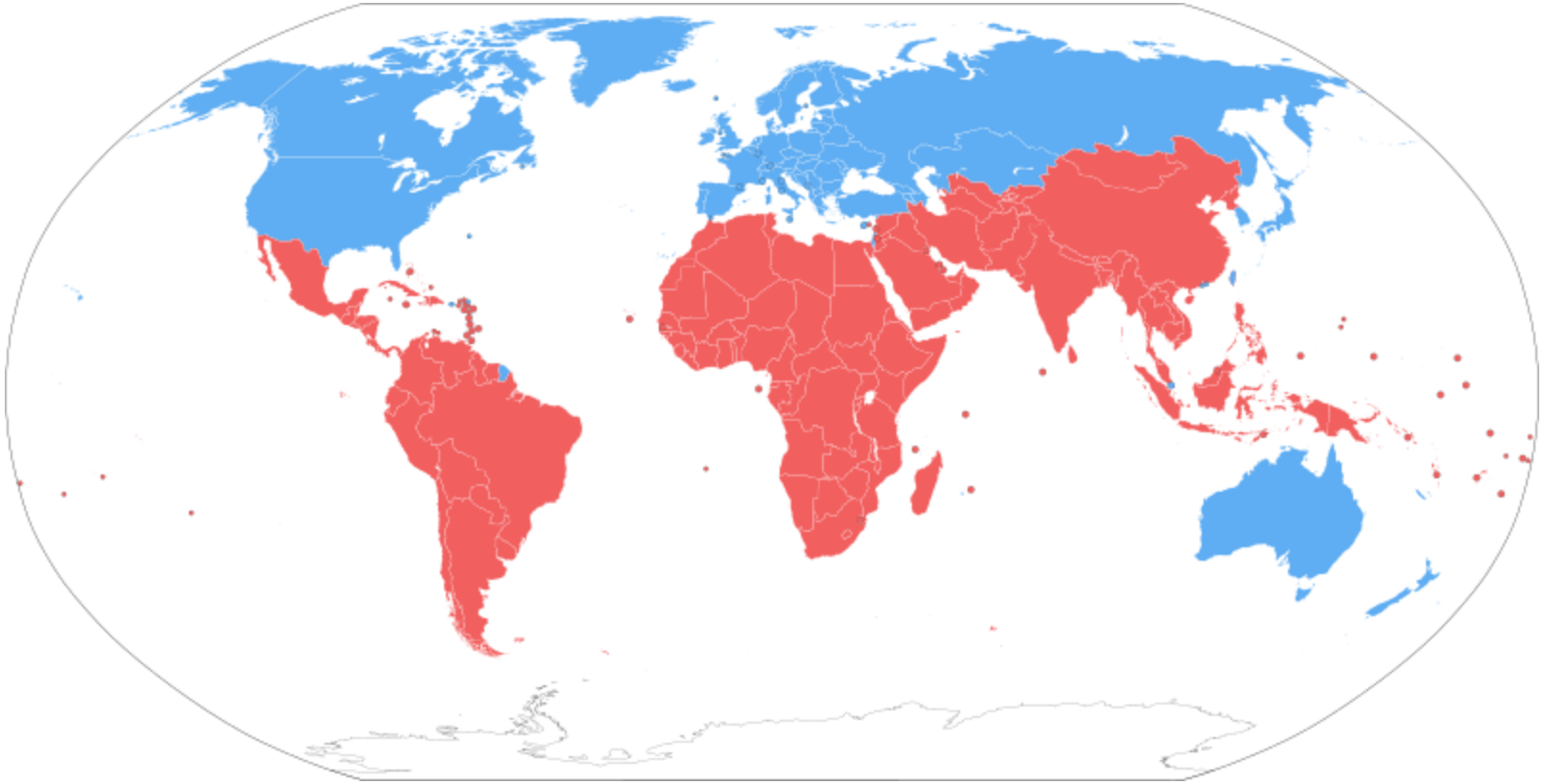


https://www.go-fair.org/fair-principles

Overarching theme: More inclusivity please!



Geographic inclusivity too, please!



https://commons.wikimedia.org/wiki/File:Global_North_and_Global_South.svg

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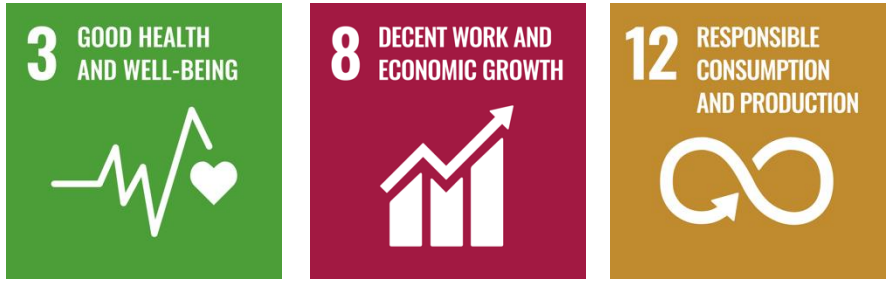
Topical Themes

Topical Theme 1:
Advances in measurement & calibration

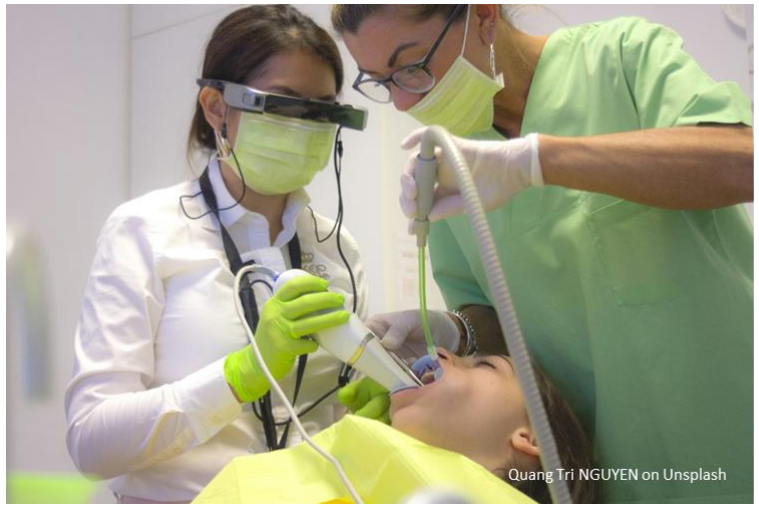
Target researchers: Physicists (especially metrologists), Electronics engineers (sensor and device developers)

Allied stakeholders: National metrology institutes, testing laboratories, instrument developers, many industrial sectors

Why is this important?



Topical Theme 1:
Advances in measurement & calibration



Continuous-spectrum LED sources with UV and NIR range for spectroradiometer calibration.

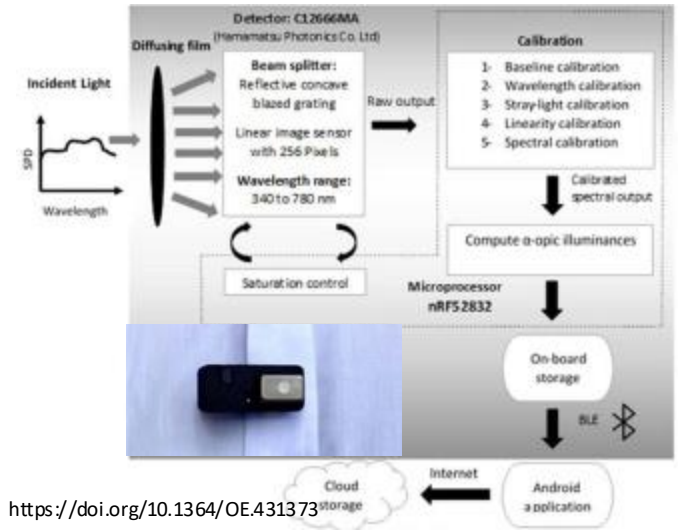
Measurement procedures for new devices including heads-up displays, augmented and virtual reality headsets

Machine-readable calibration certificates that can be implemented in complex control and building automation systems

Topical Theme 1:
Advances in measurement & calibration

Support for researchers in other theme areas, including:

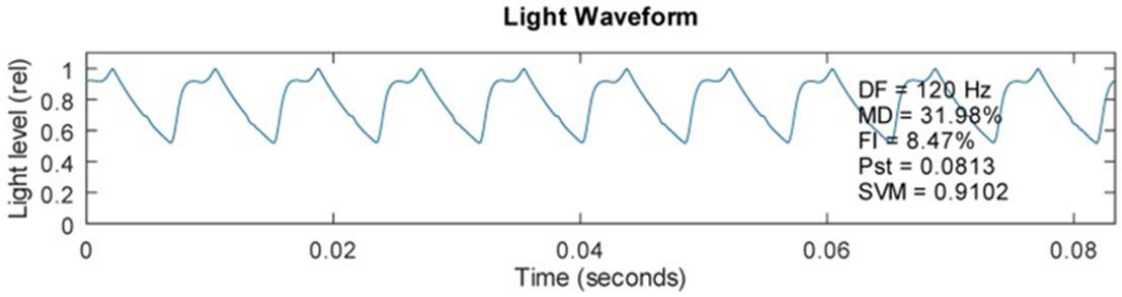
- Dosimeters for personal exposure to optical radiation from UV to IR



https://doi.org/10.1364/OE.431373

Source: https://journals.sagepub.com/doi/10.1177/14771535221147140

- Accurate devices and reference sources for temporal light modulation measurements



Topical theme 2: Integrative lighting for people

Integrative lighting: lighting integrating both visual and non-visual effects, and producing physiological and/or psychological benefits upon humans

Full range of psychological and physiological effects of light and optical radiation

- Necessary daily light-dark pattern, intensity, spectrum, duration, timing
- Understand causes of visual discomfort and visual disability, and how to avoid both while delivering the light part of the daily pattern
- Beauty and its effects on well-being

Topical theme 2: Integrative lighting for people

Target researchers: Psychologists, physiologists, medical professionals, together with lighting professionals (lighting designers, architects, illuminating engineers...), lighting & controls industry, and building scientists

Allied stakeholders: Regulators, public health professionals, labour unions, business community, lighting industry, individuals

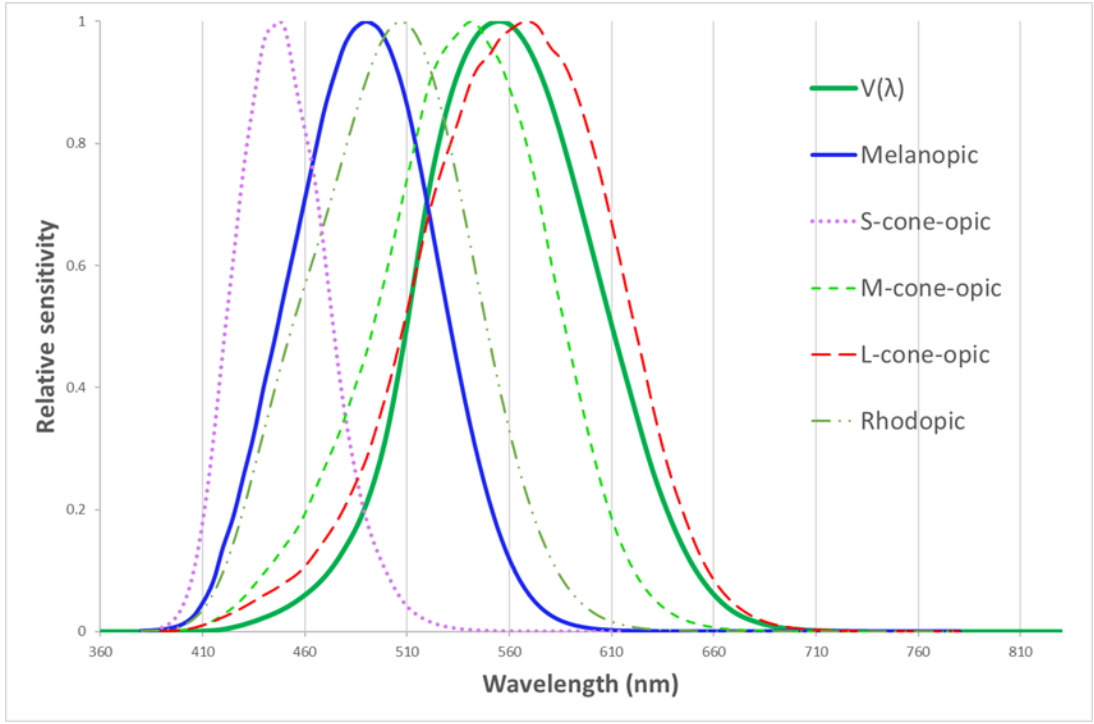
Why is this important?

Integrative lighting fundamentals

CIE S026: 2018 established SI-compliant quantities for assessing light exposures for the full range of physiological and psychological effects of light, especially those mediated by ipRGCs.

... but we now know there are at least 5 subtypes of ipRGC – What is the function of each? Are there other action spectra?

... and there are projections of ipRGCs to many brain regions, and much to learn about how these connections influence physiology and behaviour.



Proper light at the proper time – in a sustainable delivery

CIE Position Statement on Integrative Lighting, August 2024 affirmed Manchester II recommendations for daily light-dark rhythm (Brown et al. 2022), and described where more information is needed, including...

- more diverse population (children, older people, health conditions, lifestyles...)
- how to deliver a higher daily light exposure without glare and respecting energy use limits
- daylighting and controls integration with building systems to deliver suitable conditions


Photo © National Research Council of Canada. Used by permission.


Annie Spratt on Unsplash


JP Valery on Unsplash

Topical Theme 3: Ecologically respectful, high-quality exterior lighting

Target researchers: Physiologists, biologists, psychologists, medical professionals, astronomers, together with lighting professionals (illuminating engineers, landscape lighting designers...)

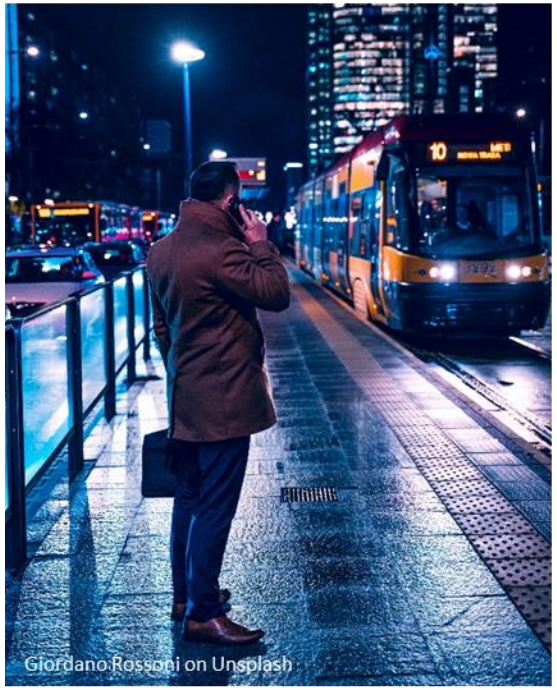
Allied stakeholders: Local and national officials, advocacy groups, business community, lighting industry, individuals

Why is this important?

Obtrusive light

Safety and security for all:

- Find the balance between roadway & community safety with energy & interior intrusions
- Building interiors as a source of obtrusive outdoor light



Anthropogenic light at night

Understand ecological consequences and prevent most

- new measurement quantities and units – action spectra for insects, birds, animals
- establish limits


NASA


rage on Unsplash

Topical Theme 4: Fundamentals of photobiology for agriculture and aquaculture

Target researchers: Botanists, zoologists, agricultural scientists, together with lighting professionals

Allied stakeholders: Local and national officials, business community, lighting industry

Why is this important?

Agriculture and aquaculture

Action spectra, new quantities needed to quantify exposures for plants & animals


National Cold Water Marine Aquaculture Center: Orono, ME


Photo by Richard T on Unsplash


Photo by Zoe Schaeffer on Unsplash


Photo by Christine Elisay on Unsplash

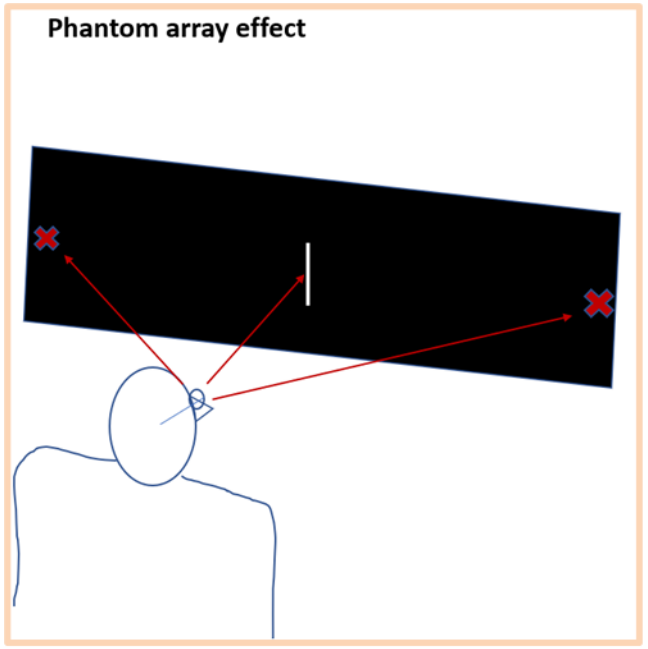
Topical theme 5: Enabling the application of safe & beneficial optical radiation

Target researchers: Physicists, psychologists, physiologists, medical professionals, together with lighting professionals (lighting designers, architects, illuminating engineers...) and relevant industry professionals

Allied stakeholders: Regulators, public health professionals, labour unions, business community, lighting industry, individuals

Why is this important?

Safe optical radiation: Limits to TLM?



Temporal light modulation causes changes to brain activity, perception, eye movements, cognition, and well-being.

For example, the phantom array effect occurs when the eye is making large saccades, because of spatially separated retinal images.

- Evidence shows it can occur across a frequency range from 80 Hz to 11,000 Hz (with large individual differences).
- Peak sensitivity usually at 600 Hz
- Emerging evidence of associated adverse health effects

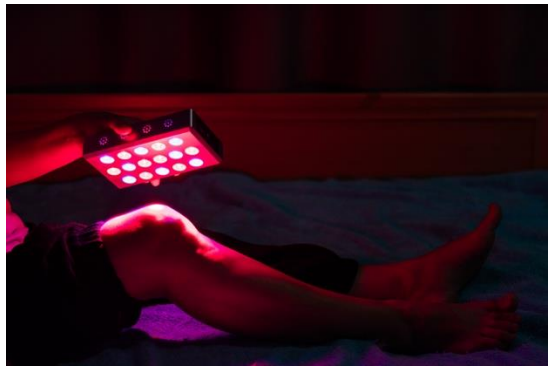
New quantities are needed that can predict the TLM conditions that influence cognitive and well-being effects, and further investigation of existing quantities for visual perception effects.

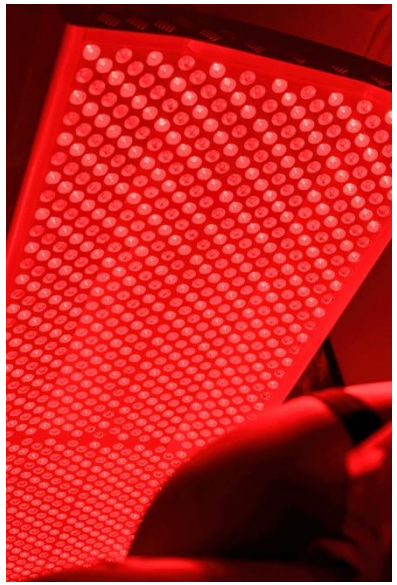
Establishment of limit values for those quantities

Safe & beneficial: Near-infrared radiation

Therapeutic uses of long wavelengths currently include:

- Pain relief
- Skin healing
- PTSD

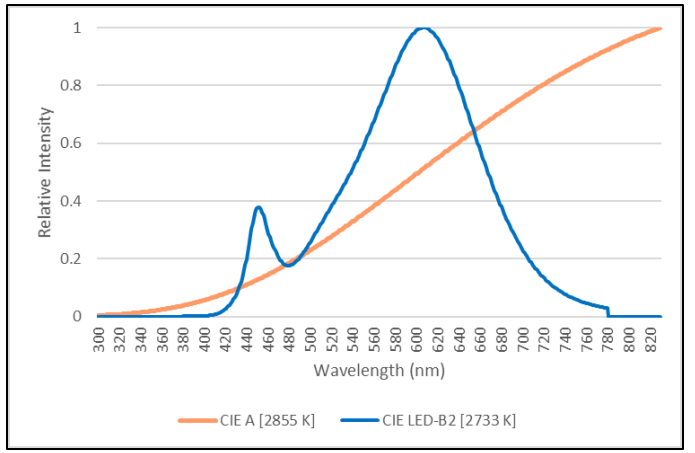




Interior LED lighting systems mostly lack near infra-red (NIR)

Low-e window coatings exclude NIR

Incandescent lamps emitted a lot of NIR



Could there be value in adding NIR to interior lighting systems?

Beneficial lighting: Myopia prevention

Myopia, or nearsightedness, increases the risk of vision loss through retinal detachment, dense cataract, and glaucoma (among others)

Reviews converge on low light exposure at developmentally critical points as one cause

Light source spectrum might have an influence

Light treatments in development, but effective mechanisms unclear

Implications, if any, for electric lighting remain unclear

Increased daylight exposure another potential resolution

Beneficial and safe: Health protection

UVR for disinfection and sanitation

- Device characterization – quantities
- Basis for safe use in occupied interiors

UVR doses for beneficial health effects?

- Evidence for low-dose UV-A exposure benefits for mental health and blood pressure
- Evidence for regular low doses of UV-B for vitamin D synthesis
- Careful consideration of balance of risks and benefits

Topical Theme 6: Measuring, modelling, perceiving and reproducing colour

Target researchers: Psychologists, physicists, technology developers, together with lighting professionals (lighting designers, architects, illuminating engineers...)

Allied stakeholders: Regulators, manufacturers, lighting and display industries, individuals

Why is this important?

Colour science

Cone-fundamental-based photometry?

- See CIE 254:2024 A roadmap toward basing CIE colorimetry on cone fundamentals
- Research Forum RF-05: Implementation of CIE 2006 Cone Fundamentals in Photometric and Colorimetric Measurements (Convenor: Tony Bergen [AU])

Advances in ocular physiology and their possible implications for colour vision:

- ipRGC interactions with visual perception?
- inter-individual variability and observer metamerism — implications for inequality

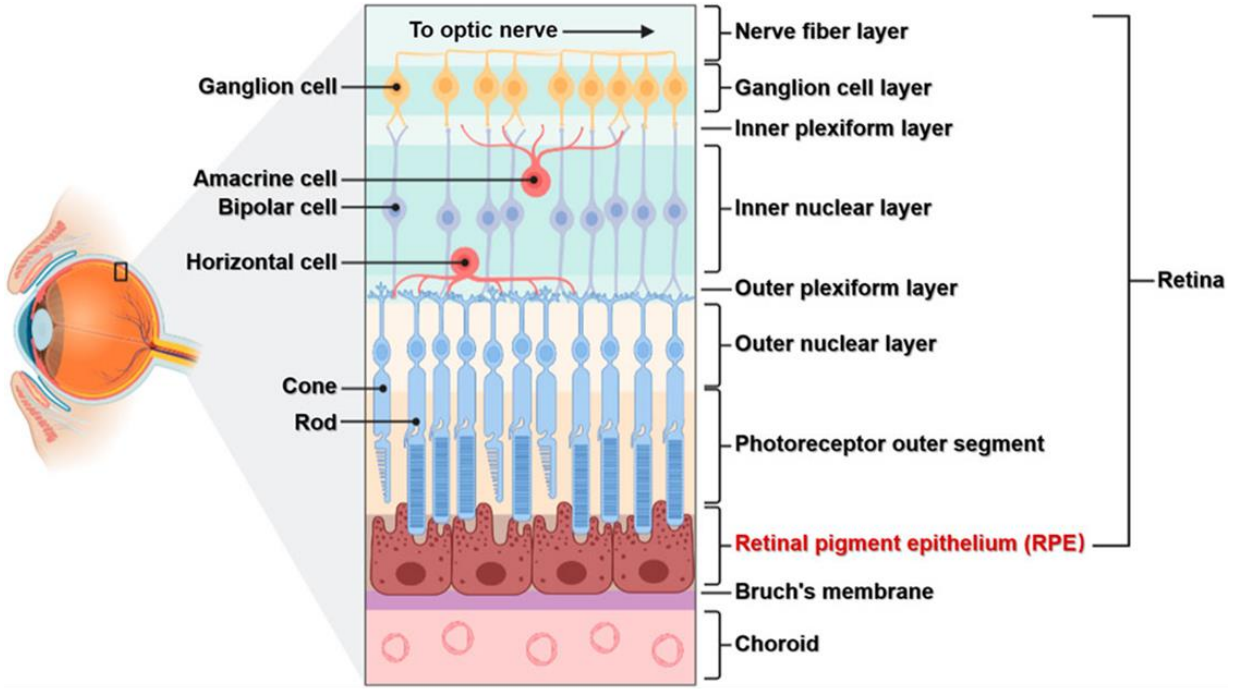
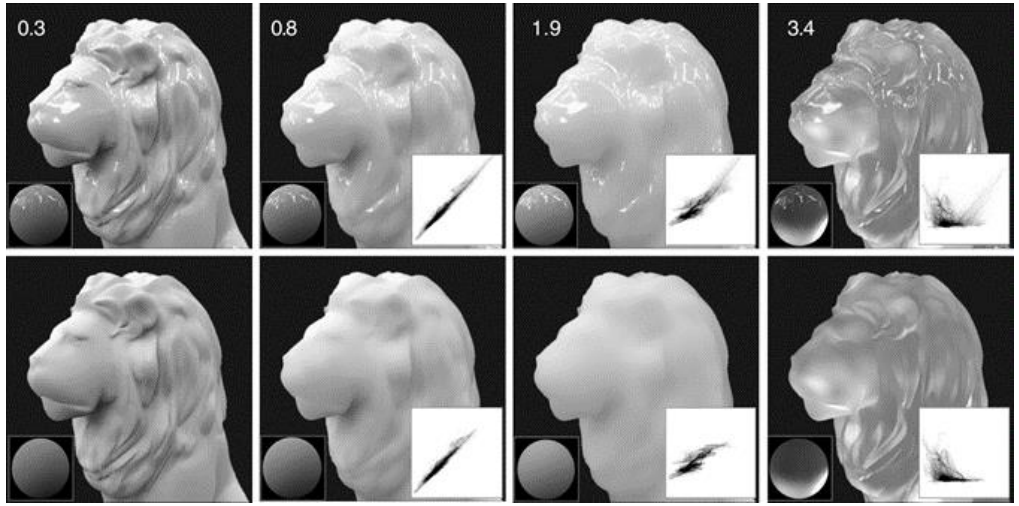


Fig. 1 from Yang, S., Zhou, J., & Li, D. (2021). Functions and diseases of the retinal pigment epithelium. *Frontiers in Pharmacology, 12*, 727870. https://doi.org/10.3389/fphar.2021.727870.

Material characterization



Source: Figure 3 in Motoyoshi, I. (2010). Highlight–shading relationship as a cue for the perception of translucent and transparent materials. *Journal of Vision, 10*(9):6. https://doi.org/10.1167/10.9.6

Measurement methods for visual appearance parameters

- Gloss, translucency, texture, sparkly, whiteness
- Broader range of influx/efflux angles needed
- See CIE 175:2006

3D printing needs a metrology system for nonuniform 3D objects

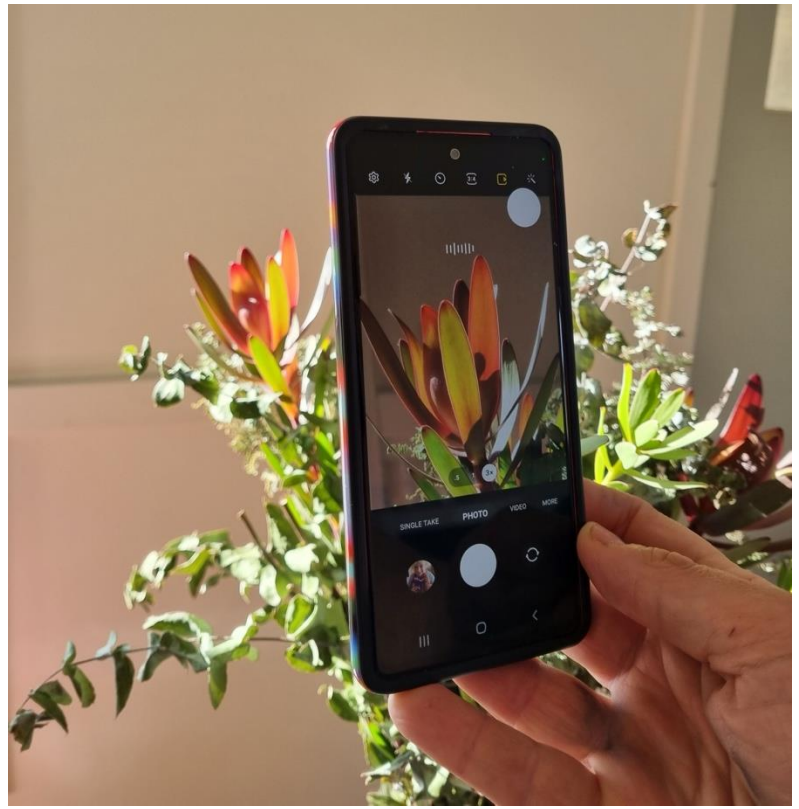
- 3D shape, local texture, properties affecting visual appearance
- Measurement instruments, protocols, artefacts for calibration

Image technologies

Translation of colour from object → imaging device → display

Real colour gamuts of scenes and images

Visual appearance information for AR, VR, XR devices



Multi-sensory stimulation immersive VR rehabilitation training platform

How to fulfil the CIE Research Strategy

Visit https://cie.co.at/research-strategy to read the details!

Funding bodies:

Develop funding calls to target these themes

Break down barriers to multi-disciplinary work

Researchers:

Pick a topic!

Find collaborators and allies to work with

Request a Research Support letter to include with your funding submission

SDG 17: Partnerships for the goals

At this intersection of disciplines and society, transdisciplinary research will be key

International Science Council

THE EARTH-HUMANITY COALITION

2024 • 2033
International Decade of Sciences for Sustainable Development

Our vision for the future

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