Neuroendocrine

BRIEFING

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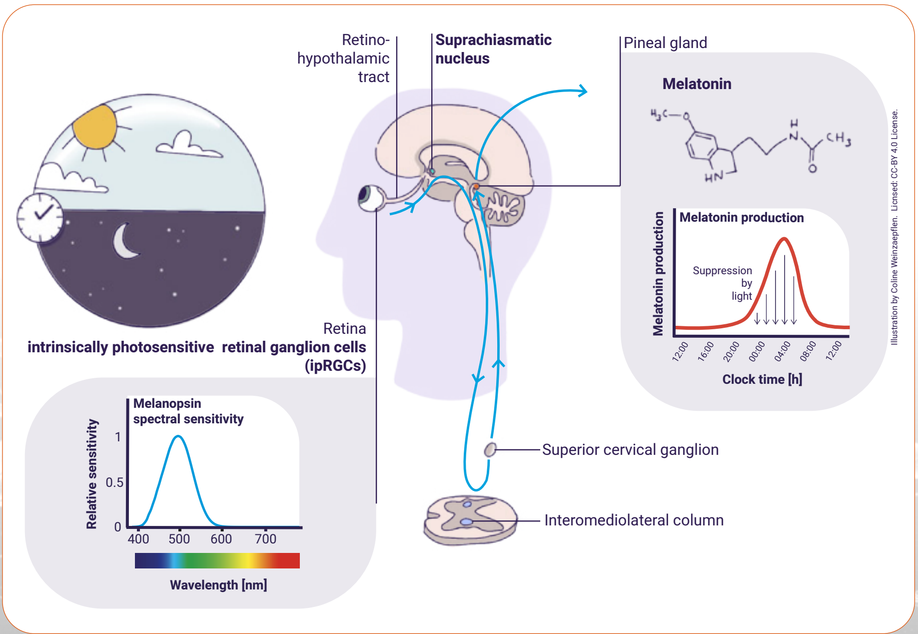
SUMMARY

In addition to enabling us to see the colourful and detailed world around us, light profoundly impacts our brains and bodies – exposure to light in the evening and at night suppresses the production of melatonin and disrupts our circadian rhythm, which can have negative consequences on physical and mental health. To offset these adverse effects of mistimed light, daylight exposure may be beneficial.

Seeing the light: beneficial impacts on neuroendocrine physiology?

Melanopsin – the link between sensing light and suppressed melatonin production

Melatonin is the "sleep hormone" secreted by the pineal gland in a 24 hour or circadian rhythm. It is not produced during our typical daytime hours and starts to be secreted a few hours before our habitual bedtime, with peak secretion occurring during the night. We have known for some time that exposure to light in the evening and at night suppresses the production of melatonin, which can have negative effects on our health. The melatonin-suppressing effects of light are mediated by the retina, the layer of cells in the back of the eye. In the 1990s, the discovery of the photopigment, melanopsin expressed in cells of the retina called the intrinsically photosensitive retinal ganglion cells (ipRGCs), challenged the long-held belief that the rods and cones were the only light-sensing elements in the human eye. Melanopsin is sensitive to short-wavelength (blue) light, with a peak sensitivity at wavelengths around 480 nm. It converts light into neural impulses that are then sent to a brain structure called the suprachiasmatic nucleus (SCN), our circadian pacemaker or our brain's "body clock". Studies have demonstrated that melatonin suppression cannot be easily explained by the rods and cones. Instead, activation of the melanopsin



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photopigment is the best predictor for melatonin suppression and other non-visual effects of light, including the shifting of circadian phase by light. Rods and cones may still play a role, as they are wired to the ipRGCs, but melanopsin appears to be the primary driver.

The protective effects of light

As with most biological phenomena, the interaction between the environment and our physiology is more complex than it at first seems. In the case of melatonin suppression, overwhelming evidence demonstrates that the light we are exposed to during the day affects how sensitive we are to light in the evening and at night. A bright day can make our melatonin production less vulnerable to being disrupted by wrongly timed light exposure in the evening or night. This fundamental insight has clear implications for how we use daylight – the most abundant and freely available source of bright light – for example, in architectural lighting design. Importantly, it also provides a clear imperative for adapting our behaviour – we should maximise the time we spend outdoors, and when indoors during the day, ensure rooms are brightly illuminated to fully exploit the beneficial effects of natural daytime light.

"A bright day can make our melatonin production less vulnerable to being disrupted by wrongly timed light exposure"

We are all different when it comes to light

The question *"Is the red that I see the same as the red that you see?"* has a long history in philosophy and visual perception research. A similar question recently emerged when it comes to the non-visual effects of light. In 2019, researchers at Monash University found that people's responses to evening light vary greatly. Volunteers were exposed to a range of different light intensities – from dim, twilight-like light to bright light – and their melatonin secretion was measured in the evening. The study found that, in terms of melatonin suppression, the most sensitive individuals are around 60 times more sensitive to light than the least sensitive individuals. Currently, we do not know why or what drives these differences. While the researchers controlled for daytime light exposure, which could affect evening light sensitivity, we know that other things could also be at play. For example, there may be genetic differences in the melanopsin photopigment, which make people more or less sensitive. More research is necessary to disentangle the factors underlying these considerable individual differences.

Which light is best for us?

The notion that light can be harnessed to promote health and well-being is an attractive one. The lighting industry has embraced this idea and a few years ago minted a new buzzword for lighting that is somewhat 'tuned' to human biological needs: 'human-centric lighting'. Buzzwords aside, a group of international experts recently published recommendations regarding light exposure: they proposed a minimum of 250 lux during daytime hours, a maximum of 10 lux during the evening, and a maximum of 1 lux during the night to promote optimal physical and mental health and performance. In addition, it is also important to keep light exposure pattern consistent between days. These guidelines are a starting point from which to adapt both our environment and behaviour in a way that harnesses the beneficial aspects of light on neuroendocrine function.

Still in the dark

While melatonin suppression is a non-visual function that can be measured in the laboratory, it is not a proxy for all non-visual effects of light. Indeed, there is convincing evidence that circadian phase shifts can happen in the absence of acute melatonin suppression. While laboratory studies can tease apart how melatonin production responds to different wavelengths of light, these artificial light exposures are generally not representative of the actual light exposure we receive. An open area of research is how different aspects of light, including the temporal pattern and spatial geometry, affect melatonin suppression. More research is needed to understand the neural pathways underlying these two non-visual functions, how they interact, and how laboratory findings can be translated into practice and policy to improve human health.

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