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The Human Response To Variations In Natural Illumination

Natural illumination varies over space and time, from moment to moment as the weather changes, from dawn to dusk in the course of a day, and across seasons and habitats.

Over millennia, natural illumination and its variations have shaped the workings of the human brain, influencing visual perception and entraining biological rhythms. Understanding how humans respond to these complex changes in natural illumination, both visual and non-visually, is important both for understanding the structure and function of the brain and for controlling and designing artificial environments. In this session, we will examine different methods, datasets and findings that feed into that understanding.

Accurate measurements of the spectral, spatial and temporal variations in natural illumination provide the foundation; one example we will discuss is the Delft-Newcastle dataset of light-field measurements. These measurements, taken on individual days under different weather conditions, show that variations in daylight exhibit a characteristic tripartite pattern: with illumination chromaticity ("colour") changing fastest in the early morning and late evening at the lowest light levels, and remaining relatively stable during the day, as the light level rises and falls smoothly. From these measurements, we have also extracted the directional and diffuse components of natural illumination, which differ in both their spectral and temporal properties and in their activation of light receptors in the eye. Using a different method in a laboratory "lightroom", we have simulated such changes in natural illumination and measured the human ability to perceive these, as well as the ability to maintain a constant color perception of objects under these changes. The former shows that most natural illumination changes are too slow to be directly detected; the latter shows that object color constancy is best under illumination changes directed towards rather than away from neutral chromaticities. In other studies, we and others have measured changes in non-visual behaviour under changing illumination, finding that, for example, the effects of varying spectra on mood and alertness depend on the time of day as well as illumination chromaticity.

One speculative conclusion from these findings is that the human visual brain dampens sensitivity to the largest natural changes in illumination in order to maintain object colour constancy. Non-visual mechanisms appear tuned to chromaticity changes at dawn and dusk, and hence are critical for syncing the circadian clock with environmental conditions. The latter might also feed long-term memory of illumination conditions as well as subjective experiences of the illumination atmosphere. The results suggest ways to modulate artificial lighting environments to preserve visual perception while maximising impact on the non-visual system.