Combining wearable eye-tracking with 4π light-field measurements: towards controlling all bottom-up and top-down factors driving overt attention during real-world tasks

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Introduction
For improvement of office space design, we intend to capture the full (4π) light-field of an office space, while measuring gaze, head direction, body position, blink rate, and pupil size along with task performance and subjective well-being during a variety of office tasks. Besides the immediate application aspects this will allow for the first time to have full control over task and visual input in a fully unconstrained real-world setting.

In the study reported here, 52 participants performed office tasks that varied in the tools used (phone, computer, paper) as well as in their mental load - input, output, reflection and interaction - and were recorded under various experimentally controlled lighting conditions and outside views. We analyze gaze allocation during these tasks, with a particular emphasis on the distinct roles of eye and head, as well as on the effects of discomfort glare.

Real-world Setup
Our measurement facilities are located in Freiburg (South Germany) on top of the four-storey ISE main office building, the test room measures 3.5 x 6 x 3 meter and can be fully rotated around 360°. Glazed façade specs: color-neutral, double glazing, Tvis = 0.54, U-value = 1.1 W/m²K, g-value = 0.28.

For daylight control, the rooms are equipped with Venetian blinds, roller blinds and foil. A meteorological station on the roof of the test rooms records the global, total and diffuse illuminance [lux], as well as the global horizontal irradiance [W/m²].

Paradigm
Here, 2 different views were chosen as independent, within-subject variable, all independent of the weather. The experimental design further includes two independent, within-subject variables, namely work conditions and outside views. We analyze gaze allocation during these tasks, with a particular emphasis on the distinct roles of eye and head, as well as on the effects of discomfort glare.

Eye to Gaze Coordinates transformed by Head Orientation
A mobile eye-tracker equipped with an inertia measurement unit (IMU) records eye-in-head plus rotating and translative head movements and a scene video. Integration in quaternion formalism of calibrated rotation velocities yields head orientations time series, whose room referencing is applied by measuring a few scene-camera images. Eye-in-head angles are rotated for room referencing by the sideward’s head tilt and then superposed straightforward with head in room orientations into room referenced gaze directions.

Detailed method’s link: https://www.dropbox.com/s/5dxl8vswa6t/biameasurementswbf.pdf
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Results
Distributions of Eye-in-Head, Head-in-Room and Gaze-in-Room orientation (horizontal and vertical angles). Grand mean, N=52. Data are separated by the independent variables office task (4 rows) and task support (3 columns). Eye-, head- and gaze distributions are scaled equally.

Conclusions
We find that eye and head are fundamentally differently affected by view as well as depending on mental activity and task conditions, even for the reading task. Surprisingly, gaze allocation is not dominated by eye movements, but for some tasks head movements, which are not typically assessed in standard laboratory experiments of attention deployment, play a dominant role.

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