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RESPONSE TO LETTER

Effect of Illumination on Near Positive Fusional Vergence in Young Adults [Response to Letter]

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Dear editor

We thank Dr. Erdinest and Ms. Bura for their thoughtful letter and their keen interest in our recently published work, "Effect of Illumination on Near Positive Fusional Vergence in Young Adults".[1] We appreciate the opportunity to engage in this scholarly discussion and to further elaborate on the context and implications of our findings.

We read with great interest the perspective offered by Erdinest and Bura, which emphasizes the complex, multidimensional nature of light and its influence on human physiology.[2] They rightly highlight the critical role of correlated color temperature (CCT) and its interplay with illuminance in modulating cognitive functions such as mental workload, alertness, and stress.[3–5] We agree entirely that these non-visual, cognitive pathways are a vital component of overall human performance in illuminated environments and represent a crucial frontier in vision science and environmental ergonomics.

The primary objective of our study was to investigate a specific and underexplored relationship: the direct effect of varying illuminance intensity (lux) on the oculomotor function of near positive fusional vergence (PFV). Our methodological approach was deliberately designed to isolate this single variable. By controlling for factors like time-of-day and prior screen exposure, and by using a standardized white LED source, we sought to quantify the pure, direct impact of the amount of light on the blur, break, and recovery points of PFV. Our findings, which demonstrate a statistically significant and large-magnitude decrease in PFV parameters with increasing illuminance (eg, a 20.5% reduction in blur point from 50 to 150 lux), provide a clear and foundational data point.[1] This rigorous isolation of variables is a cornerstone of the scientific method. It allows for the establishment of causative relationships before introducing the complexity of interacting factors.

Erdinest and Bura correctly point out that our study did not account for the spectral composition (CCT) of the light source. This was a conscious and necessary methodological boundary. Introducing multiple CCTs would have conflated the effects of illuminance with those of wavelength, making it impossible to determine which variable was responsible for the observed changes in vergence. Our study answers the question, "If the color temperature is held constant, what is the effect of changing the light level?" The research cited by Erdinest and Bura begins to answer the subsequent, more complex question: "How do illuminance and color temperature interact to influence both visual function and cognitive state?"[2]

We believe these two lines of inquiry are not contradictory but are sequential and complementary. Our work establishes a baseline: higher illuminance, in isolation, places a greater demand on the vergence system, leading to reduced PFV amplitudes. The logical next step, as suggested by the correspondents, is to build upon this baseline. Future research should indeed employ a multi-factorial design to investigate how different CCTs (eg, warm 3000K vs cool 6500K) might modulate or interact with the illuminance-dependent PFV effects we documented. For instance, does a cooler, more alerting CCT at 500 lux mitigate or exacerbate the PFV reduction we observed at 150 lux? This is an excellent direction for further study.

It is also important to distinguish between the visual-motor outcome we measured (PFV) and the cognitive outcomes (alertness, mental workload) discussed in the letter. While undoubtedly linked in real-world tasks, they are governed by

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different physiological pathways, largely subcortical oculomotor control for PFV versus melanopsin-mediated non-image -forming responses for circadian alertness.[4] Furthermore, the illuminance-dependent PFV reduction we observed is likely mediated by well-known visual mechanisms, such as pupil miosis, which increases depth of field and alters accommodative-convergence dynamics. This physical, optical effect of illuminance on the visual system is distinct from the psychophysiological effects of CCT on alertness. A lighting condition that optimizes cognitive performance (eg, high illuminance, high CCT) may not be the same condition that optimizes the ease and sustainability of the oculomotor convergence required for near work. This potential dichotomy is of significant clinical and ergonomic importance. Our recommendation for "lower-to-moderate lighting" (50–100 lux) is specifically targeted at optimizing the motor component of binocular coordination and reducing vergence-driven visual fatigue during sustained near tasks. This advice can coexist with the understanding that for tasks that require high alertness, a different lighting regimen might be beneficial. This potential dichotomy highlights the need for task-specific lighting protocols, where the demands on the oculomotor system and cognitive state are balanced according to the primary activity.

In conclusion, we thank Erdinest and Bura for expanding the discussion around our work and for rightly emphasizing the multifaceted role of light. Our study provides a critical piece of the puzzle by definitively establishing the direct inhibitory effect of increasing illuminance on PFV. Their letter fittingly places this finding within the broader, and equally important, context of cognitive neuroscience and environmental design. We fully endorse their call for a multidimensional framework in future lighting research and look forward to studies that integrate illuminance, CCT, and cognitive metrics to develop more holistic and task-specific lighting recommendations for visual comfort, ocular health, and cognitive performance.

Disclosure

The authors report no conflicts of interest in this communication.

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