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Microarticle

New photochromic spectacle lenses improve glare discomfort and photostress recovery

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A B S T R A C T

Purpose: To investigate the influence of a new photochromic spectacle lens on glare discomfort (GD) and photostress recovery time (PRT) in normal healthy subjects. A subject-masked within-subject comparison was performed using the fully activated state of Transitions® Gen S^{TM} and clear control.
Methods: 30 participants ($M = 19.2 \pm 1.3$ years) were tested. GD was assessed both physically, by measuring palpebral fissure size, and subjectively, via a 5-point Likert scale. PRT was measured as the amount of time necessary to regain visual function after an intense (~15 % bleach) 5-second exposure to a broadband (emulated sunlight) light stressor.
Results: GD, measured both physically and subjectively was significantly reduced ($p < 0.001$) when participants viewed the stimulus through the test lens compared to the clear control lens. PRT was also significantly reduced when using the test lens ($p < 0.001$).
Conclusions: These data are consistent with past findings but show that they apply to a commonly used photochromic tint. The results highlight the potential of specialized lenses to enhance visual comfort and performance in varying lighting conditions.

1. Study compendious

One approach to dealing with frequent and extreme changes in brightness is assistive technologies such as photochromic lenses (ranging from contacts to spectacles). In this study, we assessed the ability of the Transitions® Gen S^{TM} photochromic spectacle lens to influence visual stress due to exposure to an intense, ecologically valid (emulated sunlight; CCT = 5532, chromaticity coordinates = X = 033, Y = 0.329), light-stress stimulus. Two major categories related to visual stress were assessed (for specifics regarding methods/procedures see Renzi-Hammond et al., 2022): photostress recovery (measured as photostress recovery time; PRT): the process by which the visual system recovers normal function after exposure to an intense light source and glare discomfort (GD) which is discomfort caused by an "unsuitable distribution or range of luminance, or by extreme contrasts" (CIE, 2019). PRT is mediated primarily through direct physiological mechanisms, such as photopigment regeneration and neuroadaptation. GD, in contrast, is more complex/subjective and, hence, like many pain-related phenomena, mediated by similarly complex mechanisms, ranging from low-level physiology to higher-level cognition. In this study, we hypothesized that viewing intense stimuli through the photochromic lens would improve PRT and reduce GD in a population of young, healthy viewers.

A total of 30 participants ($M = 19.17 \pm 1.26$ years) were recruited from the local population at the University of Georgia. Participants (83 % female, 73 % Caucasian) had 20:40 or better binocular best-corrected visual acuity (BCVA) and had no history of ocular disease. The study was approved by the Institutional Review Board of the University of Georgia and was conducted according to the tenets of the Declaration of Helsinki. All participants provided verbal and written informed consent prior to enrollment and participation. This was a prospective, randomized, patient-masked crossover design where visual function was tested using a visibly clear control lens compared to a filtering test lens. The absorbance of the test lens was fixed (see spectra in Renzi-Hammond & Hammond, 2016) but emulated a commercially available photochromic lens when fully activated (XTRActive Polarized Poly, FSV; Transitions Optical). The two lenses were placed in custom lens mounts and placed as the last lens in the optical system, rather than being worn as spectacles, to maintain the subject mask. Lens order was randomized between participants. All measurements were conducted binocularly.

GD was measured physically, as palpebral fissure size (this was done using high-resolution videography with biometric software), and subjectively, by asking participants to rate their discomfort on a 5-point Likert scale. To determine whether the test and control lenses were different for both GD and PRT, paired samples t-tests with one-tailed (directional) $p < 0.05$ were used. Physical discomfort, as quantified by

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the magnitude of the squint response, was significantly lower ($t = -6.51$, $p < 0.001$) in participants while viewing through the test lens ($M = 3.81 \pm 3.10$ mm squint) compared to viewing through the clear control lens ($M = 7.59 \pm 4.43$ mm squint). Participants also ranked the intensity of the light as significantly more comfortable ($t = -6.07$, $p < 0.001$) when viewed through the test lens ($M = 2.63 \pm 1.07$) compared to the clear control lens ($M = 3.80 \pm 0.89$).

PRT was measured as the amount of time needed to recover sight of a visual target after the target was occluded by a bright, broadband photostressor. PRT was significantly lower ($t = -3.97$, $p < 0.001$) when participants were exposed to the photostressor through the test lens ($M = 9.26 \pm 7.80$ s), compared to the control lens ($M = 15.43 \pm 13.56$ s). The mechanism that mediated these optical effects is likely straightforward; the absorption characteristics of the test filters were broadband and matched the spectra of the light source, hence, effective light attenuation leading to less discomfort and faster recovery.

Although the visual system can dynamically adjust sensitivity to match ambient conditions (e.g., when entering a dark room), the system is not perfect. Adjusting sensitivity takes time, especially as one gets older. Changing adaptive state was often sufficient for handling natural changes in sunlight which can create intense glare, particularly during specific times of the day and in certain geographic locations. Modern technologies, however, have changed the visual environment from that which the system evolved to cope. Now, the visual system must accommodate to much more rapid transitions in lighting environments based on artificial lighting, glare due to reflective materials (e.g., steel bumpers), headlights, digital displays, etc. One approach to dealing with such frequent and extreme changes in brightness is assistive technologies such as photochromic lenses. This study is consistent with previous results on photochromic contact lenses and spectacle lenses showing that strategic filtering of light can mitigate some of these adverse consequences.

2. Disclosures

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CRediT authorship contribution statement

Jacob B. Harth: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Billy R. Hammond:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Cameron J. Wysocky:** Project administration, Data curation. **Lisa M. Renzi-Hammond:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The research was funded by Transitions Optics. Billy Hammond has worked as a consultant for this company within the last three years.

Data availability

Data will be made available on request.

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