Prototype Device for Driving Suitability Tests in Sunglasses

Artur D. Loureiro and Liliane Ventura

Abstract

Wearing inadequate sunglasses while driving may lead to dangerous misunderstandings in objects and traffic lights recognition. Sunglasses standards propose transmittance requirements that sunglasses should fit to be classified as suitable for driving. Transmittance tests are time-consuming and laborious. Also, it requires a spectrophotometer and a skilled technician to be performed. The aim of this study was to develop and to build an easy-to-use, quick and accurate device for luminous and traffic lights transmittance tests which runs the tests by itself in a way anyone can operate it without any training. A microcontrolled prototype was developed and built using a white LED and a four-channel sensor combination. This combination generated luminous and traffic lights weighting functions similar to standard ones. Using our prototype and a gold standard (VARIAN Cary 5000 spectrophotometer), luminous transmittance and relative attenuation quotients for traffic lights were measured in 128 sunglasses lenses. Bland-Altman method was used to assess concordance between both measurement methods. The bias was insignificant for all measurement and the limits of agreement were broad for luminous transmittance and for relative attenuation quotient for blue light detection, and narrow for the others. Thus, within the predefined tolerance, prototype measurements are equivalent to gold standard ones for relative attenuation quotients for red, yellow and green light detection. Despite not all prototype measurements being equivalent to gold standard ones, results were accurate; only 5 from 128 lenses were defectively classified as to suitability for driving (2 for luminous transmittance, 1 for red light quotient and 2 for blue light quotient). Our prototype creates means to general public to assess characteristics of their own sunglasses including whether they are suitable for driving according brazilian and ISO standards.

Keywords

ABNT NBR ISO 12312-1 • ISO 12312 • Sunglasses
Luminous transmittance • Traffic lights transmittance
Transmittance measurement

1 Introduction

International standard ISO 12312-1:2013 defines requirements that sunglasses lenses must comply with in order to be suitable for driving [1].

Luminous transmittance, τ_V, and traffic lights signal transmittances, τ_{signal}, are calculated by Eq. (1) where $\tau_F(\lambda)$ is the lens spectral transmittance and $W(\lambda)$ is a known weighting function. Traffic lights signal transmittances are calculated for red, yellow, green and blue signals [1].

$$\tau = \frac{\int_{380}^{780} \tau_F(\lambda) \mathrm{W}(\lambda) \mathrm{d}\lambda}{\int_{380}^{780} W(\lambda)\, d\lambda} \tag{1}$$

The relative visual attenuation quotients for signal lights detection, Q_{signal}, are calculated using Eq. (2) and they are also calculated for red, yellow, green and blue signals [1].

$$Q_{signal} = \frac{\tau_{signal}}{\tau_V} \tag{2}$$

Sunglasses with dark lenses or that attenuate excessively traffic light signals are inappropriate for driving as they could lead to perilous misunderstandings [2, 3]. To be suitable for driving, sunglasses lenses must have luminous transmittance greater than 8% (0.08), red signal detection quotient greater or equal to 0.8 and yellow, green and blue ones greater or equal to 0.6.

A. D. Loureiro · L. Ventura (✉)
Ophthalmic Instrumentation Laboratory - LIO/Sao Carlos School of Engineering - EESC, University of Sao Paulo - USP, São Carlos, SP, Brazil
e-mail: lilianeventura@usp.br

L. Lhotska et al. (eds.), *World Congress on Medical Physics and Biomedical Engineering 2018*,
IFMBE Proceedings 68/3, https://doi.org/10.1007/978-981-10-9023-3_48

To certify compliance with the standard it is required a laborious, time-consuming test performed with a spectrophotometer by a skilled technician.

After long solar exposure, sunglasses lens transmittance may vary spectrally unpredictably [4]. Thus, even lenses approved in traffic lights tests need to be retested after years of use to assure that they are still suitable for driving.

The purpose of this study is to develop a portable device capable to perform transmittance measurements related to suitability for driving in a fast and automatic way.

2 Materials and Methods

Using a white LED and a four-channel sensor, four weighting functions were obtained.

These functions were linearly combined to produce weighting functions similar to standard ones for luminous transmittance and traffic lights transmittance (red, yellow, green and blue).

We measured 128 sunglasses lenses with our device and a gold standard (VARIAN Cary 5000 spectrophotometer). By Bland-Altman method, we assess concordance between both measurement methods. For luminous transmittance values, it was adopted 0.5 and 6% as values above which bias absolute value is significant and 95% limits of agreement amplitude, wide, respectively. For traffic lights visual attenuation quotient values, 0.1 and 0.4, respectively.

All calculations were performed using the free software GNU Octave v.4.0.0 [5].

3 Results and Discussion

The five weighting functions (for luminous, red, yellow, green and blue light transmittances) we obtained by sensor-LED combination were plotted overlapped with respective standard ones and they are shown in Figs. 1, 2, 3, 4 and 5.

From the 128 measured sunglasses lenses, 19 have luminous transmittance inferior to 8% and for theses, signal detection quotients were not measured.

3.1 Luminous Transmittance Measurement

Mean-difference Tukey plot for 128 sunglasses luminous transmittance values obtained using our prototype and a gold standard is presented in Fig. 6. Two lenses were classified in wrong categories. The difference between methods tends to rise with the average. The greatest absolute error, the bias and the 95% limits of agreement are 12.939%, −0.4994% and [−7.0984%; 6.0996%], respectively.

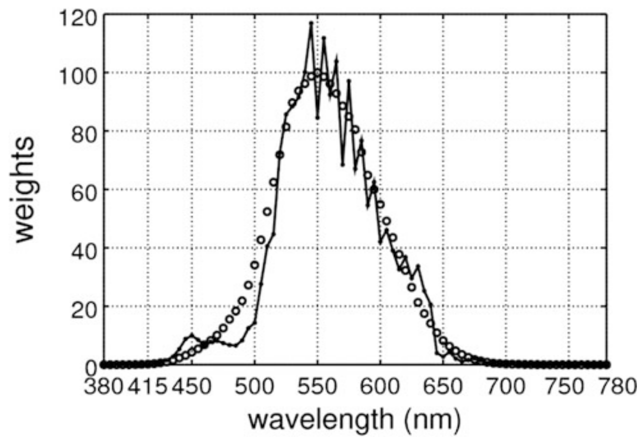

Fig. 1 Our weighting function (continuous line) and the standard one (empty circles) for luminous transmittance

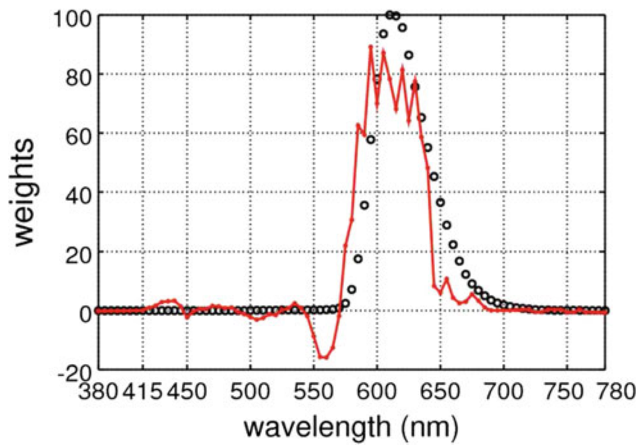

Fig. 2 Our weighting function (continuous line) and the standard one (empty circles) for red signal transmittance (Color figure online)

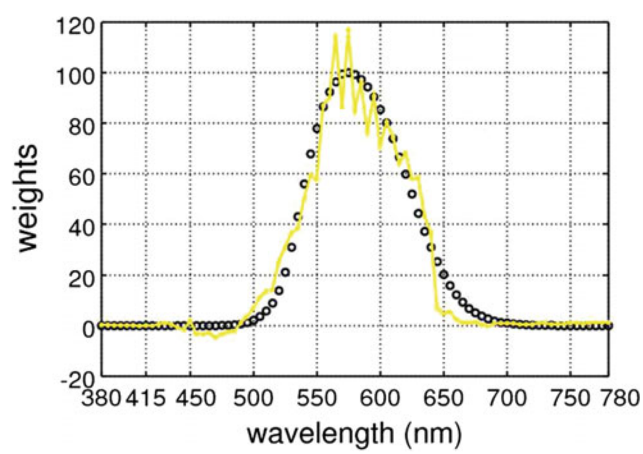

Fig. 3 Our weighting function (continuous line) and the standard one (empty circles) for yellow signal transmittance (Color figure online)

Bias is not significant and 95% limits of agreement interval is wide. Consequently, within the predefined tolerance, our method is not equivalent to gold standard one for luminous transmittance measurement.

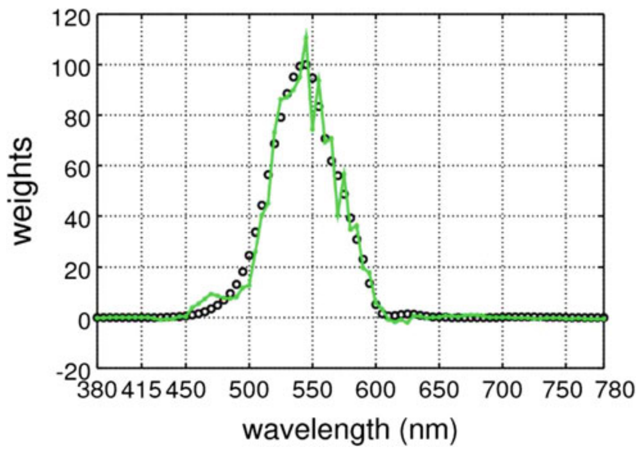

Fig. 4 Our weighting function (continuous line) and the standard one (empty circles) for green signal transmittance (Color figure online)

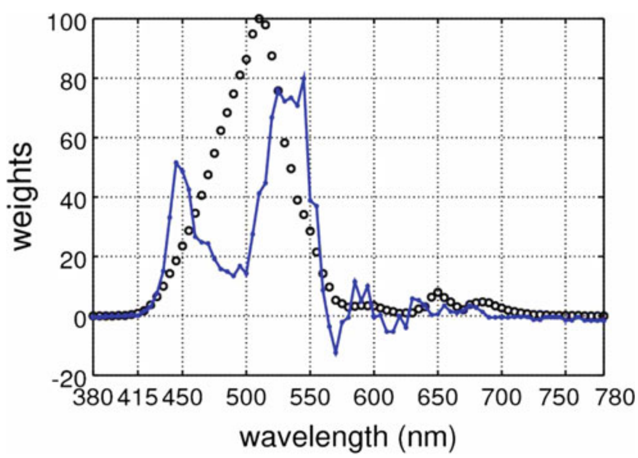

Fig. 5 Our weighting function (continuous line) and the standard one (empty circles) for blue signal transmittance (Color figure online)

3.2 Red Signal Detection Quotient Measurement

Mean-difference Tukey plot for 109 sunglasses red signal detection quotient values obtained using our prototype and a gold standard is presented in Fig. 7. One lens was wrongly classified as to suitability for driving (Qred $\geq$ 0.8). The greatest absolute error, the bias and the 95% limits of agreement are 0.268, 0.0536 and [−0.1415; 0.2487], respectively.

Bias is not significant and 95% limits of agreement interval is narrow. Consequently, within the predefined tolerance, our method is equivalent to gold standard one for red signal detection quotient measurement.

3.3 Yellow Signal Detection Quotient Measurement

Mean-difference Tukey plot for 109 sunglasses yellow signal detection quotient values obtained using our prototype and a gold standard is presented in Fig. 8. All lenses were correctly classified as to suitability for driving (Qyellow $\geq$ 0.6). Prototype measures tend to be inferior to gold standard ones. The greatest absolute error, the bias and the 95% limits of agreement are 0.256, 0.0909 and [−0.0406; 0.2223], respectively.

Bias is not significant and 95% limits of agreement interval is narrow. Consequently, within the predefined tolerance, our method is equivalent to gold standard one for yellow signal detection quotient measurement.

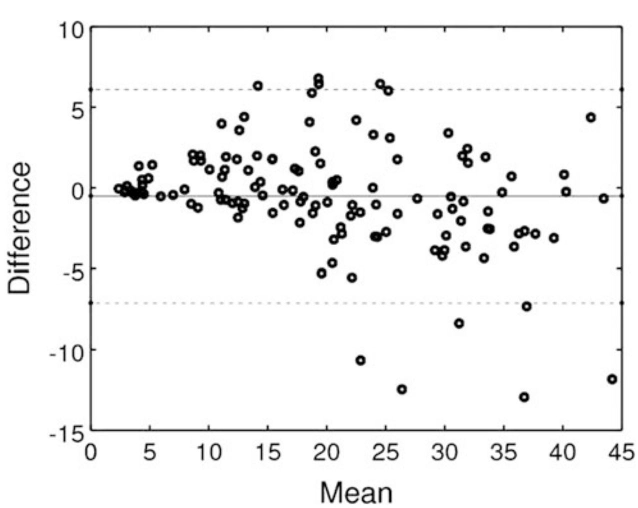

Fig. 6 Mean-difference Tukey plot for luminous transmittance measures in 128 sunglasses lenses

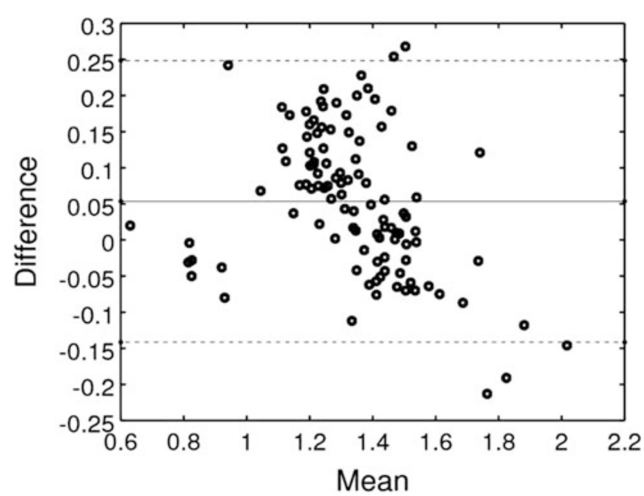

Fig. 7 Mean-difference Tukey plot for red signal detection quotient measures in 109 sunglasses lenses

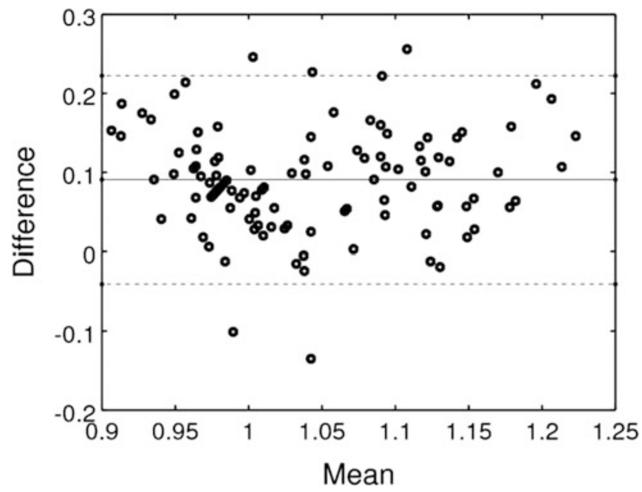

Fig. 8 Mean-difference Tukey plot for yellow signal detection quotient measures in 109 sunglasses lenses

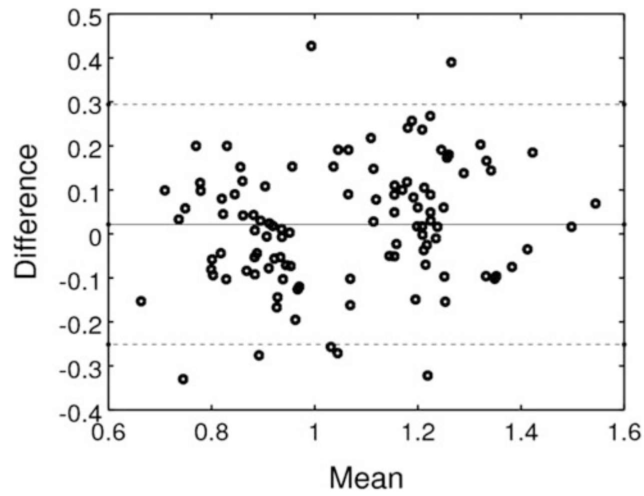

Fig. 10 Mean-difference Tukey plot for blue signal detection quotient measures in 109 sunglasses lenses

3.4 Green Signal Detection Quotient Measurement

Mean-difference Tukey plot for 109 sunglasses green signal detection quotient values obtained using our prototype and a gold standard is presented in Fig. 9. All lenses were correctly classified as to suitability for driving (Qgreen $\geq$ 0.6). Prototype measures tend to be greater to gold standard ones. The greatest absolute error, the bias and the 95% limits of agreement are 0.159, −0.0523 and [−0.1377; 0.0330], respectively.

Bias is not significant and 95% limits of agreement interval is narrow. Consequently, within the predefined tolerance, our method is equivalent to gold standard one for green signal detection quotient measurement.

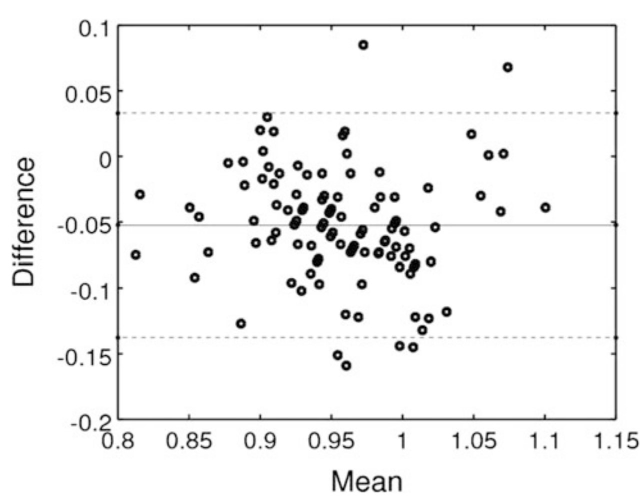

Fig. 9 Mean-difference Tukey plot for green signal detection quotient measures in 109 sunglasses lenses

3.5 Blue Signal Detection Quotient Measurement

Mean-difference Tukey plot for 109 sunglasses blue signal detection quotient values obtained using our prototype and a gold standard is presented in Fig. 10. Two lenses were wrongly classified as to suitability for driving (Qblue 0.6). The greatest absolute error, the bias and the 95% limits of agreement are 0.427, 0.0216 and [−0.2512; 0.2944], respectively.

Bias is not significant and 95% limits of agreement interval is wide. Consequently, within the predefined tolerance, our method is not equivalent to gold standard one for blue signal detection quotient measurement.

4 Conclusion

The proposed method for luminous and traffic lights measurements in sunglasses lenses uses simple components and provides accurate results.

Within the predefined tolerance, prototype measurements are equivalent to gold standard ones for relative attenuation quotients for red, yellow and green light detection.

From 128 measured lenses, only 5 were incorrectly classified as to suitability for driving; 2 for luminous transmittance measure errors; 1 for Qred measure error and 2 for Qblue measure errors.

Our device aims to provide to people a mean to obtain informations about their own sunglasses and the importance to use suitable sunglasses while driving.

Acknowledment The authors declare no conflict of interest.The authors acknowledge ABIOPTICA, CNPq (130755/2015-0) and FAPESP (2014/16838-0).

References

1. International Organization for Standardization. Eye and face protection - sunglasses and related eyewear Part 1: sunglasses for general use. Geneva: ISO 12312-1:2013; (2013).
2. Dain, S. J., "Sunglasses and sunglass standards," Clin Exp Optom, 86(2), 77–90 (2003).
3. Hovis, J. K., "When yellow lights look red: tinted sunglasses on the railroads," Optom Vis Sci, 88(2), 327–333, (2011).
4. Loureiro, A D; Gomes, L M; Ventura, L. Transmittance Variations Analysis in Sunglasses Lenses Post Sun Exposure. Journal of Physics. Conference Series (Online), v. 733, p. 012028, (2016).
5. John W. Eaton, David Bateman, Søren Hauberg, Rik Wehbring (2015). GNU Octave version 4.0.0 manual: a high-level interactive language for numerical computations, available online at: http://www.gnu.org/software/octave/doc/interpreter/.