

# Lighting Assessments for Low Vision Clients: How Reliable Is the LuxIQ™?

Jonathan Jarry<sup>1</sup> ◆ Marie-Céline Lorenzini<sup>1</sup> ◆ Lorie St-Amour<sup>1</sup> ◆ William Seiple<sup>2</sup> ◆ Walter Wittich<sup>1</sup>

<sup>1</sup>School of Optometry, Université de Montréal, Montreal, Canada

<sup>2</sup>Lighthouse Guild, New York, New York



## LuxIQ™

A tool to simplify the prescription of lighting interventions in low-vision rehabilitation by easily evaluating subjective preferences.

The LuxIQ™ produces an adjustable light over reading material, the luminance and color temperature of which can be set by the client. These settings are used to suggest a lamp, light bulb, and reading distance based on a manufacturer-provided lookup table.

## INTRODUCTION

- The most common functional complaint of individuals with a visual impairment: difficulty reading (Brown et al., 2014, Ophthalmol).
- This is the most common motivation for patients with age-related macular degeneration (AMD) to seek rehabilitation (Owsley et al., 2009, Arch Ophthalmol).
- How to improve reading performance? Magnification and increased lighting levels (Essentials of Low Vision Practice, 1999).
- Determining the appropriate lighting intervention can be complex and time consuming (Perlmuter et al., 2013, Am J Occup Ther).
- The LuxIQ™ is a relatively new device intended to simplify the prescription of lighting interventions in low-vision rehabilitation.
- We assessed the LuxIQ™'s test-retest variability in normally sighted and visually impaired individuals by examining the variability of both luminance and color temperature measures.

## METHODS

### Calibration

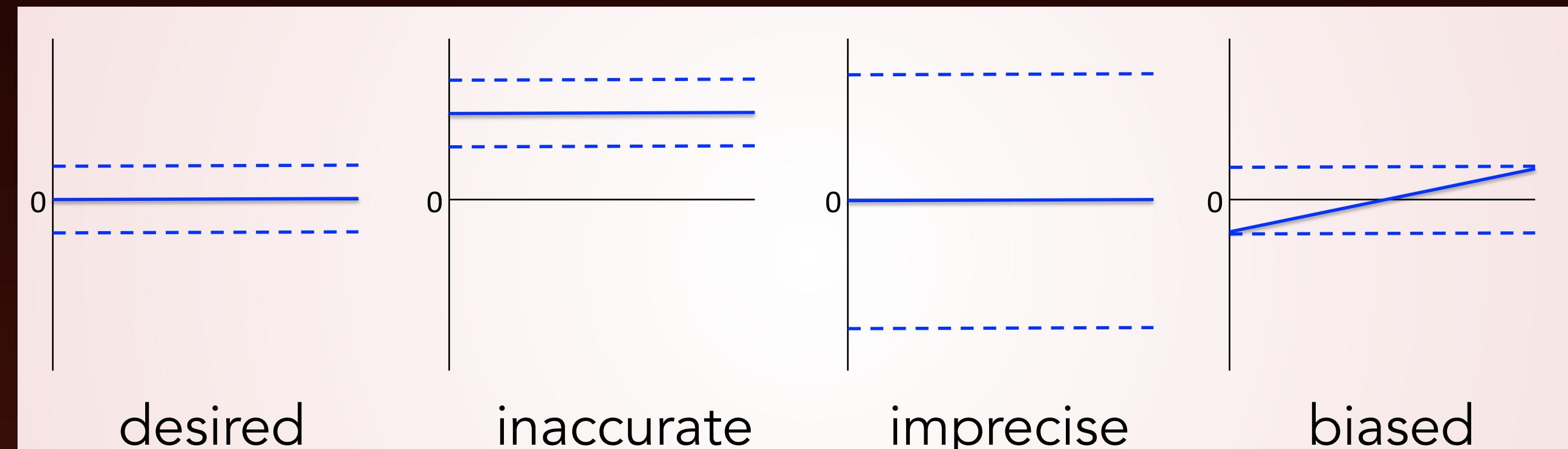
Luminance generated by the LuxIQ™ was measured by photometry in 500-lux increments.

### Participants

109 control subjects and 64 low-vision clients were recruited.

### Test-retest

Participants were seated at a table and an MNRead acuity chart was placed on an angled reading stand at a distance of 40 cm. The MNRead was chosen because of its high validity and reliability. The coefficient of repeatability of this test is  $\pm 0.05$  logMAR for reading acuity,  $\pm 0.12$  logMAR for critical print size and  $\pm 8.6$  words per minute for reading speed, and its previous use in low-vision reading assessment in patients with AMD and glaucoma. After participants chose a supra threshold sentence size they would find comfortable for extended binocular reading under ambient lighting conditions, a LuxIQ™ Light Exam System (Jasper Ridge, San Mateo, CA) was used to frame the sentence and measure preferences in luminance (lux) and color temperature (Kelvin), as indicated on the device. Participants were asked to adjust luminance themselves to a level they would find comfortable for extended binocular reading. The color temperature was fixed at an initial 6500K. Following setting the luminance value, they were then instructed to adjust the colour temperature according to preference. Participants were finally asked to readjust luminance as preferred given that the color temperature had changed, and both final values were noted. Please note that the units on the sliding lever were covered during the experiment, to not influence participants. Thirty minutes later, the same paragraph was chosen and participants were asked to repeat the same protocol.



## RESULTS

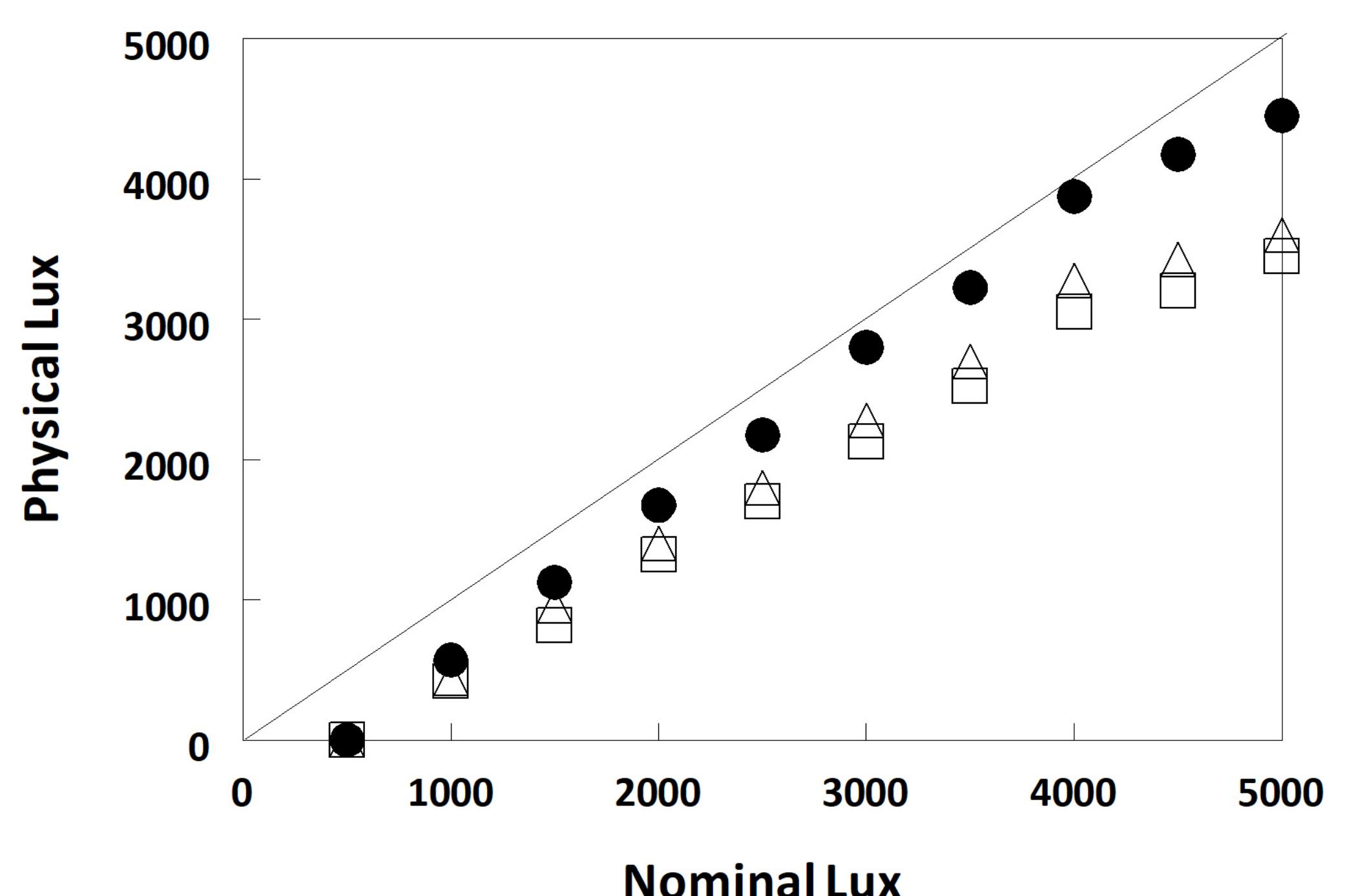


Fig. 1: Illuminance as measured by photometry is plotted against the lux value indicated on the LuxIQ™ slider scale. Measured values (ascending as descending) were generally at least 500 lux below the value indicated on the LuxIQ™ slider. Solid round = center position of photometry probe; triangle = left position; square = right position (in the plane of the reading material).

Table 1: Participant Characteristics as a Function of Comparison Group

	NORMALLY SIGHTED	VISUALLY IMPAIRED
n	109	64
Sex		
male	43	24
female	65	40
unknown	1	
Age (years)		
M	42	76
SD	17	18
range	18-85	27-99
Primary Diagnosis		
AMD		37
GL		5
other		22
Acuity (logMAR/Snellen)		
M	0.01 (20/20)	0.68 (20/96)
SD	0.10	0.38
min	-0.12 (20/15)	0.00 (20/20)
max	0.30 (20/40)	1.48 (20/604)
CS (logCS / % contrast)		
M	1.83 (1.4%)	1.16 (6.9%)
SD	0.11	0.32
min	1.32 (4.8%)	0.52 (30.2%)
max	1.91 (1.2%)	1.76 (1.7%)

Note: Three participants had a diagnosis of both age-related macular degeneration (AMD) and glaucoma (GL). They were both included in the "AMD" group, as this was their primary diagnosis.

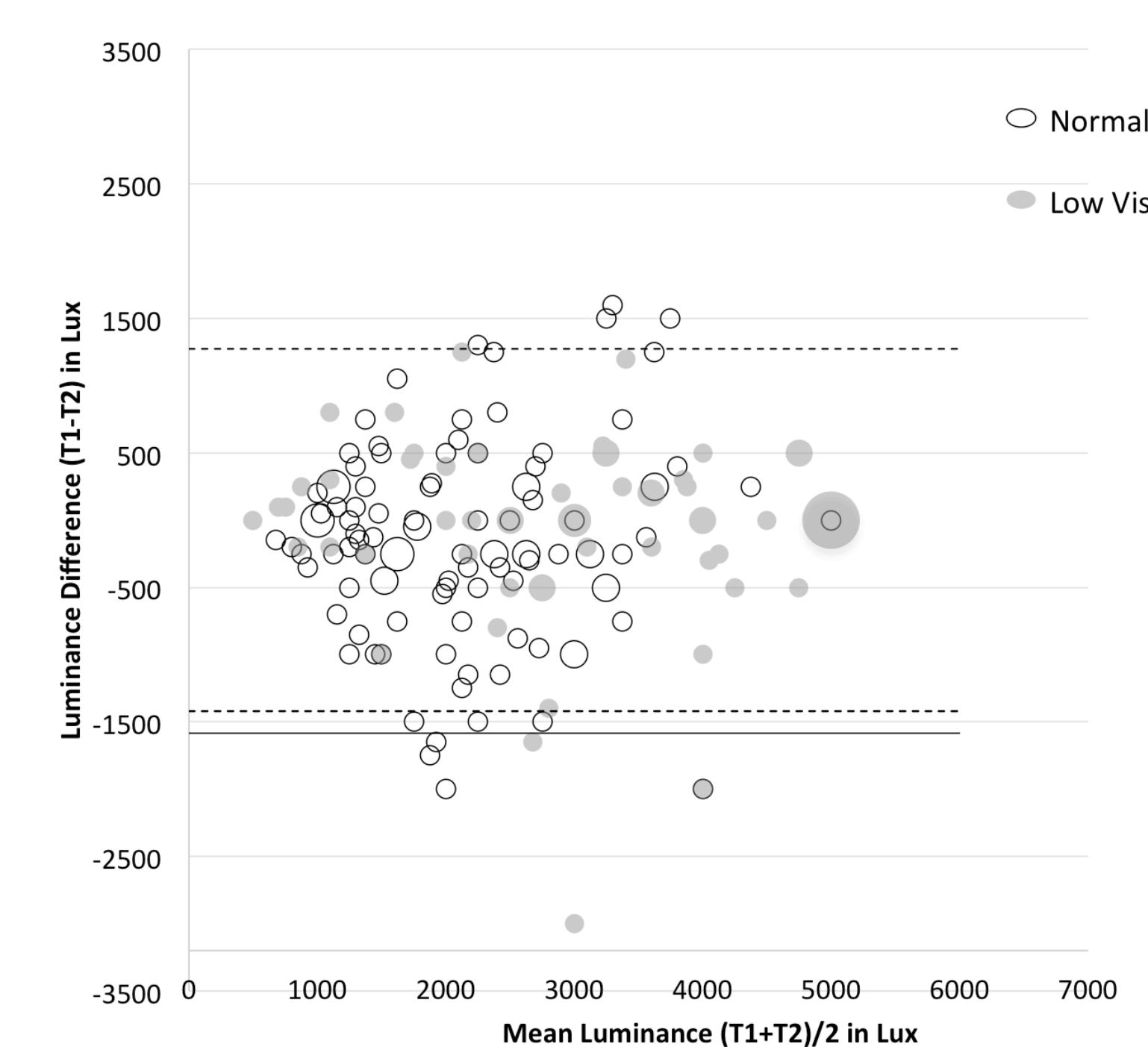


Fig. 2: Bland-Altman plot for illuminance differences (test - retest) plotted as a function of mean illuminance [(test + retest)/2] for participants with normal sight (open circles) or low vision (filled circles). Bubble size increases for overlapping data points (largest bubble n = 9), dotted lines represent the Limits of Agreement for participants with low vision, the solid line indicates the lower limit of agreement for normally sighted participants, the upper limit of the normally sighted subjects overlaps with that of the low vision group.

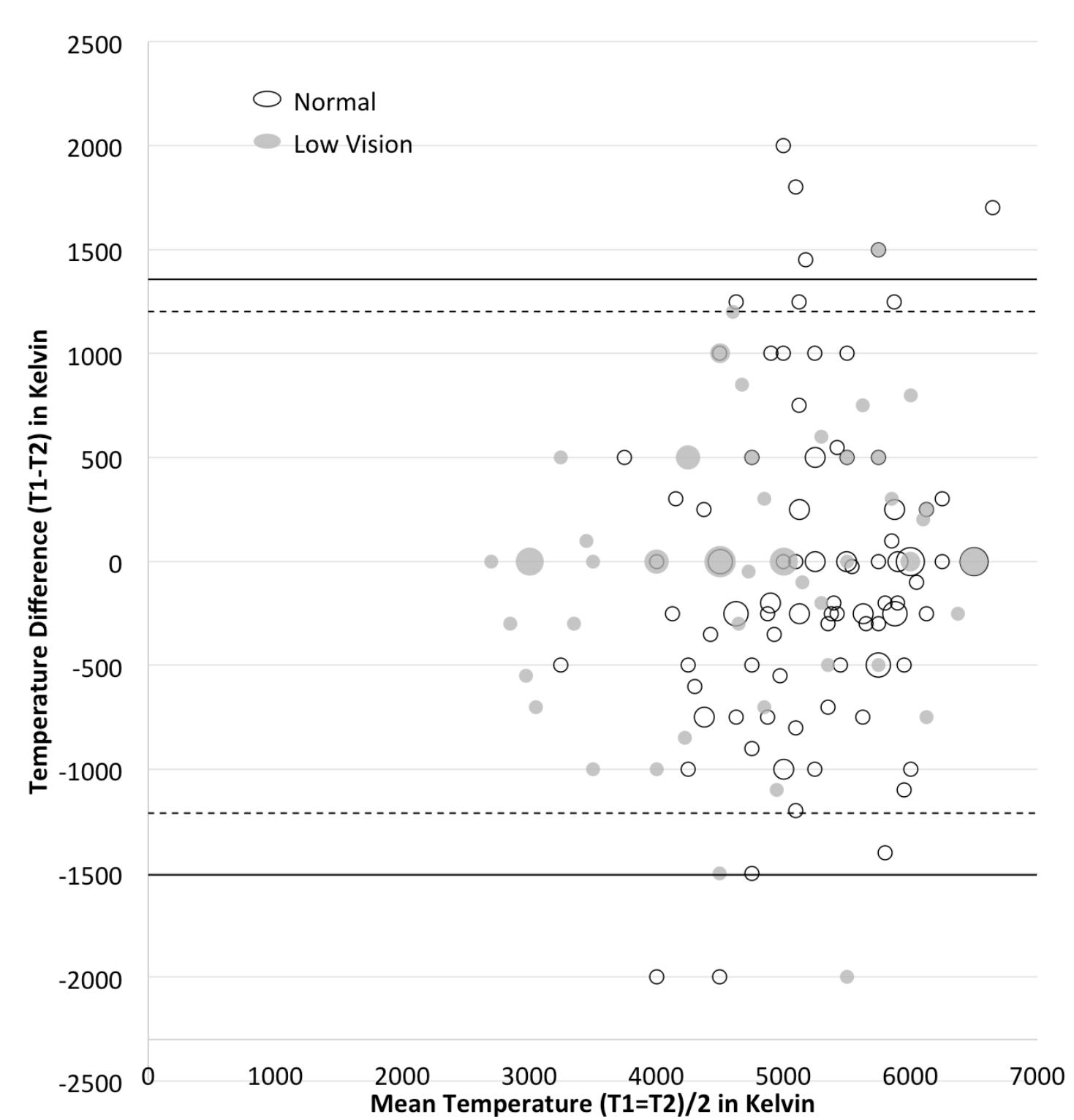


Fig. 3: Bland-Altman plot for color temperature differences (test - retest) plotted as a function of mean temperature [(test + retest)/2] for participants with normal sight (open circles) and low vision (filled circles). Bubble size increases for overlapping data points (largest bubble n = 6), dotted lines represent the Limits of Agreement for participants with low vision, the solid lines indicate the limit of agreement for normally sighted participants.

## CONCLUSION

- Calibration: we found deviations commonly associated with LED lights.
- Accuracy (doseness between measurement and true value): the LuxIQ™ performed well, with both luminance and temperature differences centred on zero for all participant groups.
- Bias (tendency of measures to systematically shift in one direction from the true value): measurement variability was unaffected by luminance or temperature level, making it equally interpretable for all participants at all lighting levels.
- Precision (closeness between measurements): our study provides evidence that the LuxIQ may be too imprecise for clinical use, as both luminance and temperature test-retest measurements were spread over a large range ( $> 2,700$  lux and  $> 2,400$ K, respectively), regardless of vision status.
- Variability in precision is explainable by subject's own psychophysical judgement. We have recently published data showing that reading speeds are relatively unaffected by illuminance once photopic levels (i.e. daylight) are reached (Seiple, 2018, Am J Occup Ther).

### Acknowledgements:

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