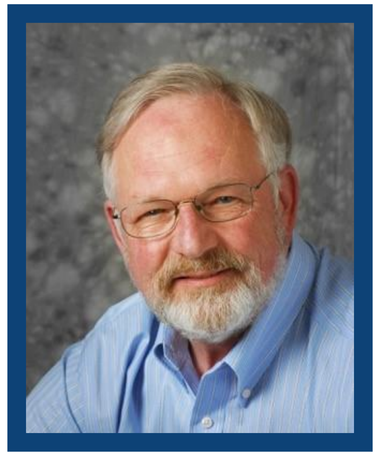
Lighting:

The Indispensable Low Vision Aid



Chairs:

Gregory Goodrich, PhD, FAAO

Peter Derksen, OD, FAAO

Dr. Goodrich is a research psychologist who has expertise in low vision research as well as brain injury-related vision loss. He was the lead researcher at the Western Blind Rehabilitation Center, VA Palo Alto Health Care System for 40 years and now is in private practice as a research consultant (Sea Bright, New Jersey, USA). His research has included studies of reading, mobility, technology, and rehabilitation strategies. In 2004 he began a series of studies which were the first to highlight vision loss in U.S. Service members who experienced vision loss following traumatic brain injury due to blasts and other causes. This work was recognized by the Department of Veterans Affairs with the Olin E. Teague Award. Dr. Goodrich has published well over 100 peer reviewed publications, as well as numerous other publications and book chapters. Professionally he has served on the Board and as President of the Association for Education and Rehabilitation of the Blind (AER) and was a founding member of the International Society for Low-vision Research and Rehabilitation (ISLRR). He is also the recipient of the ISLRR Tiresias award. Dr. Goodrich is also active as a reviewer for numerous journals and served as the guest editor for the special issue of *Optometry and Vision* Science on eye, vision, and brain injury (January 2017). His current research interests include seeking a better understanding of lighting for individuals with low vision and continuing work in low vision and brain injury-related vision loss.

Peter Derksen, OD, FAAO first became interested in low vision and binocular vision in 1980 as a student in optics. He is the third generation from a family that has been involved in optics and low vision. This year marks the 150th anniversary of his private practice. Peter is active in the American Academy of Optometry and was the first clinical diplomate in low vision from the Netherlands. He is an active board member in the Dutch Low Vision NUVO section and committee member in low vision of the OVN. He is involved in many projects studying low vision and clinical protocols. He has worked for 21 years at the Royal Visio in Apeldoorn conducting research and improving in low vision care. From 2004 – 2008 he collaborated on a bioptic driving study. From 2005-2007 he was involved in a pilot study on the impact of prescription glasses on ergonomic factors of dentists. Since 2008 he is has worked with the visually impaired athletic team of the Netherlands and NOC/NSF. He is also active with the International Paralympic Committee.

Symposium Abstract

Arguably lighting is the most prevalent and least understood aid vision rehabilitation professional's use. Instead of measuring the patient's lighting needs we often employ simple rules such as "more is better", although we do realize that factors such as glare are important considerations. In large part our lack of knowledge has corresponded to the limited options available in lighting devices and the absence of means to quantify lighting needs for the individual. A notable exception are light meters, however, we argue that these meters are limited in their specificity to the tasks patients want to do. That is, they measure light output rather than the light input patients may benefit from.

In this symposium we will present important information regarding light, light measurement, human perception of light, and how these variables relate to human visual performance. We briefly review existing literature on the lighting and low vision as well as more recent findings. Included will be research exploring the ability of current technology (LuxIQ) to quantify the lighting needs of individuals with low vison. Further, we will discuss the use of measurement to improve services to low vision individuals and how this can be incorporated into clinical practice. Additionally, we will discuss the potential use of the LuxIQ to explore the effects of tints on functional low vision performance at near and distance, and further explore its use as a measurement tool to assess the effectiveness of treatments for conditions such as dry eye.

The conclusion of the symposium will be a 10m question and answer session. Since we are presenting a novel technique we would like to use the final portion of the session to ensure that participants understand both the strengths and limitations of current lighting measurement to low vision, as well as, reinforce the need for continued research to more fully understand the potential of quantifying lighting to improve visual function for patients with low vision.

Presenter Abstracts

1. Light properties and the human response

Gregory L. Goodrich. Ph.D.

Light emitting diodes (LEDs) are revolutionizing the lighting industry. From automobile headlights to home appliances LEDs are becoming ubiquitous. And why not – they are inexpensive, readily mass produced, require little energy, and can be configured into arrays with varying intensity and hue. Importantly, they emit single frequencies of light so that by precisely combining them one can not only tailor light intensity (brightness and color temperature), but also virtually any hue within the human visual spectrum. Simply put it is feasible to create lighting conditions that optimize vision for any given task including tasks individuals with low vision want and need to perform. The problem, however, is determining what is "optimum" for a given individual.

In his introduction to the symposium Dr. Goodrich will briefly review light and the human response to light. This will include terminology used to quantify light and important light properties (for example, the inverse square law) and human perceptual responses to light (for example, Steven's power law). This is necessary so that clinicians can understand the basic principles necessary to understand lighting for low vision clinical use and how the human visual system responds to changes in lighting. The human visual system normally tolerates large changes in ambient light. We see relatively well on both dark days (~1000 lux) and on very bright days (~100,000 lux) even though the two vary in magnitude by a factor of 100. In terms of color we normally see a spectrum of colors from 390 nm to 700nm. Newton named major points in this spectrum red, orange, yellow, green, blue, indigo, and violet. The visible spectrum is, as von Helmholtz hypothesized, perceived in the eye by only three distinct receptors: red, green, and blue.

Low vision patients generally do not have the same ability to perceive objects well across the range of brightness the normal eye does, and frequently their ability to perceive color is also attenuated. As a consequence the need to tailor lighting to the low vision patient becomes critical. Dr. Goodrich will present the LuxIQ (Jasper Ridge Inc.) which is designed to assess lighting needs for low vision individuals. He will present studies that assess the effect of "optimized" lighting, using the LuxIQ, to improve visual acuity in patients with low vision.

2. Luminance and color temperature preferences in normal and low vision

Marie-Celine Lorenzini

Purpose: Optimal lighting is an essential component of reading rehabilitation for older adults with age-related vision loss. The LuxIQ assessment tool provides a new opportunity for systematic evaluation of lighting needs; however, to date, this tool has not been evaluated for its ability to provide consistent and repeatable data. The goal of this study was to compare test and re-test data for luminance and color temperature preferences under controlled ambient lighting conditions as well as clinically realistic illumination, in both normally sighted and low vision participants.

Methods: Luminance intensity (Lux) and color temperature (Kelvin) preferences were assessed using the LuxIQ in 57 patients (ages 7-96, M =75, SD = 22) with low vision (VA 20/30-20/458) and 71 normally sighted participants (ages 19-84, M =40, SD = 18). The low vision data were collected under uncontrolled conditions, e.g., in the patients' homes, whereas the control data were obtained at 625 Lux ambient illumination. Participants were asked to adjust the intensity to the level they would find most comfortable while reading sentence on the MNRead, whereby color temperature was fixed. They then had to adjust the color temperature to their preferred level. Finally, they had to re-verify the intensity level. The entire procedure was repeated 30 minutes later.

Results: Using Bland-Altman plots, the 95% limits of agreement (LoA) of inter-test difference scores were calculated. For luminance intensity, the LoAs were -1735 to 1269 Lux and -temperature, the LoAs were -1545 to 1316 Kelvin and -1173 to 1194 Kelvin, for normally sighted and low vision patients, respectively. For luminance intensity, the LoAs were -1658 to 1370, -667 to 794 and -1315 to 951 Lux for AMD, glaucoma and other diagnostic categories, respectively. For colour temperature, the LoAs were -960 to 1265, -1196 to 923 and -1552 to 1153 Kelvin, respectively. The mean difference scores ranged from -233 to 153.

Conclusions: The range of differences between repeated measurements of luminance intensity was between 3500 and 4200 Lux and between 4000 and 3500 for temperature level, depending on the administration conditions and the clientele. However, test re-test variability is not similar across the 3 diagnostic groups; for luminance, this range was smaller for the patients with glaucoma (1000 Lux) than that for patients with DMLA and others pathologies (4200 and 2215 Lux, respectively). The size of the variability warrants further investigation to determine if controlled ambient illumination can improve the variability ranges. The next steps are to evaluate if measurement of variability is a good clinical indicator and if it is relevant to the functional abilities of low vision patients

3. Differences in reading thresholds and print size preferences across levels of illumination

Wittich, Walter [1, 2, 3], Jarry, Jonathan [1], Seiple, William [4], St.-Amour, Lorie [1]

1) School of Optometry, Université de Montréal, Montréal, Canada; 2) CRIR/Centre de réadaptation MAB-Mackay du CIUSSS du Centre-Ouest-de-l'Île-de-Montréal, Canada; 3) CRIR/Institut Nazareth et Louis-Braille du CISSS de la Montérégie-Centre, Longueuil, Canada; 4) Arlene Gordon Research Institute, New York, NY, USA

Introduction: Previous studies with normally sighted younger adults have indicated that visual acuity is reduced when lighting is decreased to very low levels. Moreover, comprehension and reading rate were not affected by increased illumination, and lighting preference did not appear to have an effect on reading performance. While increased light intensity or preferred lighting conditions do not have a big impact on the reading performance of normally sighted younger adults, they may make a difference to the abilities of older individuals. The present study set out to systematically examine reading acuities and preferred print sizes, under threshold and preferred retinal illumination conditions.

Methods: We recorded threshold reading acuities (logMAR), preferred reading print sizes (M units), threshold as well as preferred retinal illuminance levels for reading (td/trolands) on 82 healthy observers, ranging in age from 19-85 (M = 41, SD = 18), using the LuxIQ and the MNRead.

Results: Threshold acuities and preferred print sizes for reading were identical when being measured under actual as well as simulated room illumination using the LuxIQ. Threshold acuity improved statistically significantly by an average of 0.08 logMAR units, when illumination was increased by an average of 0.75 log td, $p < .001$. However, there was no statistical relationship between the change in luminance level and the increase in acuity level $r^2 = 0.07$. Preferred print size was 0.51 logMAR larger than at thresholds, $p < .001$. None of these findings were related to age.

Conclusion: In our participants, threshold acuity improved when increasing illumination. This increase was .08 logMAR units and was observed across all age groups. Whether this improvement is clinically meaningful needs to be further assessed, specifically in patients with reduced visual ability. Interestingly, participants' preferred illumination level at preferred print size was lower than their illumination requirements at threshold, indicating that too much light may interfere with comfort, such as would be the case under glare conditions.

Funding: Funded by a New Initiatives Grant from the *Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain*

4. Defining light intensity, color temperature and colored filters in practice

Peter Dirksen, O.D.

Light is one of the most important tools in working with low vision patients of all ages. Good lighting improves magnification and helps address contrast needs. For many visually impaired persons (VIP) lighting may be the difference between seeing or not seeing an object. Glare from light sources, if not controlled, may make the VIP functionally blind.

In the clinic and during examinations it is often a struggle to find out what lighting really helps the VIP. Often this is a lengthy and cumbersome trial and error process. About two years ago we began using the LuxIQ which allows us to do a good lighting assessment in 10 minutes or less. The VIP can define what lighting works best for them and the data from the LuxIQ allows us to prescribe suitable lamps for the specific task. This complements the range of bulbs and lamps available in our clinic and allows us to advise clients on how to enhance their own workspace. For those VIPs interested in color contrast we can also use the LuxIQ to demonstrate a range of colors from ~500 nm to ~650 nm. In our practice we begin the lighting portion of the examination by looking at light intensity (Lux), then color temperature (Kelvin), and, if desired, colored filters for indoor or outdoor use.

5. Opening doors to selecting tinted lenses

Peter Borden, Ph.D.

We conducted a study to determine the hue that optimized perceived acuity. The results, reported elsewhere in this Conference, suggest non-white background hues, especially with added green, can improve perceived near visual performance, and properly chosen tinted lenses may improve near visual performance over clear lenses. The spread of chosen hues suggests the need to measure an individual's best hue before making a recommendation.

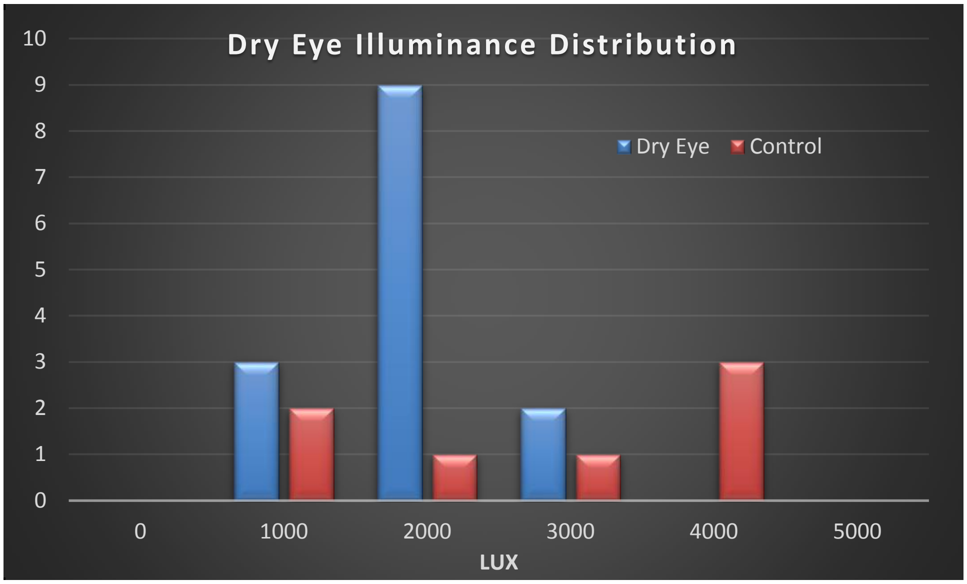
To accommodate this need, we discuss novel work to determine color preference and development of clinical methods to determine and recommend an individual's optimum tints. This facilitates selection of individually optimized commercially available tinted lenses.

We have developed an extensive database of commercially available lenses. Each was characterized using a standard method described in this talk, in which the color response of each filter was matched to that of the LuxIQ™ system. The talk will show how the database can be used with a look-up table to find optimized tinted lenses.

In practice, practitioners place the LuxIQ over a standard eye chart or scene representing an activity. Using a slider built into the system, people sweep through color space to select a hue providing their perceived comfort and acuity. The practitioner recommends or prescribes a filter from the tinted lens

A tool and standard methods now enable practitioners to simulate an individual's optimum tint prior to ordering tinted lenses. The tint-simulation method described opens the door to selecting tinted lenses from a wide range of available filters and tints. Questions for future investigation will be proposed, including measurement of actual versus perceived acuity gain, the effect of eye strain on color preference, and optimization for both indoor and outdoor scenarios.

Another novel use of the device is its use as means to assess the effectiveness of treatment for dry eye. I will present data from a study in progress utilizing the LuxIQ to guage treatment effect in reducing light sensitivity. The graph below shows illuminance distribution for 14 subjects with dry eye and 7 controls not reporting dry eye. Mean illuminance is 1750±753 lux, vs. 2643±1435 lux for the controls ($p=0.21$). Other data shows a linear correlation of $r^2=0.91$ to the conventional tear break-up time test when in both eyes have break-up time < 5 seconds. Study results will be presented by Dr. H. Fishman at ARVO, 2017.



Appendix: Presenter Bios

1. **Marie-Céline Lorenzini ;** University of Montreal

Marie-Céline Lorenzini is a PhD student in *Vision Science-Vision Impairment Option* in the Wittich Lab at the School of Optometry at the University of Montreal, Canada. Her thesis deals with the integration of new optical technologies in patients with low vision.

She studied in orthoptics and obtained a master in *Handicaps sensoriels et cognitifs* at the University Claude Bernard of Lyon 1, France. She practiced as an orthoptist in the department of ophtalmology in the *Centre Hospitalier Universitaire* of Nîmes, France.

She initiated and was principal investigator of a hospital research project, retained by the French Ministry of Health in December 2014 : a three-year project on the evaluation of a virtual reality module in the rehabilitation and visual rehabilitation of visually impaired patients: A randomized controlled monocentric trial with blind evaluator, CHU Nimes, France, and Institut ARAMAV, France. She was a member of the Care Research Committee in CHU of nîmes, France.

2. **Walter Wittich, Ph.D. ; University of Montreal**

Dr. Walter Wittich is an Assistant Professor at the School of Optometry at the University of Montreal, Canada, with a Junior Career Award from the Fonds de recherche du Québec – Santé (chercheur boursier junior 1), with focus on the rehabilitation of older adults with combined vision and hearing loss. He is resident researcher at both the CRIR/Centre de réadaptation MAB-Mackay du CIUSSS du Centre-Ouest-de-l'Île-de-Montréal and the CRIR/Institut Nazareth et Louis-Braille du CISSS de la Montérégie-Centre. Coming from a background in age-related vision loss, he now conducts research in dual sensory impairment and acquired deaf-blindness. His research domains include basic sensory science, as well as medical, psychosocial, and rehabilitation approaches to sensory loss. He is a Fellow of the American Academy of Optometry, is Quebec's first Certified Low Vision Therapist and is the inaugural chair of the Deafblind International Research Network, leading a team of 5 researchers from 4 continents in their efforts to facilitate networking and knowledge translation in deafblindness research. His has published over 40 peer-reviewed journal articles and his research is funded by the Canadian Institutes of Health Research, the Alzheimer Society, the Canadian Consortium on Neurodegeneration in Aging, as well as several provincial agencies and industry collaborators.

3. **Peter Borden, Ph.D**.; Jasper Ridge Inc., Menlo Park, CA

Dr. Peter Borden is President of Jasper Ridge Inc, where he develops tools for assessing lighting and color to optimize visual perfromance. He has Ph.D. and MS degrees in Applied Physics from Stanford and BS degrees in Physics and EE from MIT. He has 80 publications, 70 patents.