BIOGRAPHICAL SKETCH

NAME: Walker, Laura L.

eRA COMMONS USER NAME: lrenninger

POSITION TITLE: Executive Director, Envision Research Institute

EDUCATION/TRAINING:

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
Massachusetts Institute of Technology Cambridge, MA	B.S.	06/1997	Chemical Engineering (Biomedical Engineering)
University of California Berkeley, CA	Ph.D.	12/2003	Vision Science
The Smith-Kettlewell Eye Research Institute San Francisco, CA	Postdoctoral	09/2005	Psychophysics

A. Personal Statement

My background is in psychophysics and computational modeling of vision with an emphasis on models of saccade and fixation behavior in healthy vision and in those with central field loss (primarily AMD). In addition to decreased visual acuity, central field loss necessitates a reassignment of fixation locus and thus the reference for oculomotor planning. With my first NSF CRCNS / NIH R01 award, I developed an information theoretic model to quantify fixation and saccade behavior. In addition to developing our understanding of eye movements, this model provides a tool for assessing the efficiency of eye movements in patient populations. With my most recent NIH R01, I examined the impact of oculomotor re-referencing on eye-hand coordination in central vision loss. This project entailed extensive data collection of visual field, eye and hand movements for many subjects (AMD, JMD and Controls) over several age decades.

In my role as founding Executive Director for the Envision Research Institute (ERI), my research and programmatic activities have greatly expanded to address issues in low vision and blindness rehabilitation, employment and accessibility. During the previous three years, I have put my energies into mentoring postdoctoral fellows and collaborating with faculty at Wichita State University in electrical engineering and computer science, human factors and biomedical engineering. We are working diligently to create research opportunities for young researchers that will have long term impact on research aimed at removing functional barriers for those who are blind or visually impaired. This includes basic research into visual functioning, but also rehabilitation and engineering research that establishes evidence-based interventions and technology. Results of these efforts are beginning to emerge, including an intervention to recover depth perception in AMD (first ERI postdoctoral fellow) and a wayfinding system for blind users (and others) in unfamiliar indoor spaces (WSU collaboration).

Succar, T., Ghahghaei, S., Fletcher, D. C., & **Walker**, L. (2016). Restoring Functional Stereopsis in AMD with Dichoptic Training. *Investigative Ophthalmology & Visual Science*, *57*(12), 5177-5177.

Cheraghi, S.A., Namboodiri, V., & **Walker**, L. (2017). GuideBeacon: Beacon-Based Indoor Wayfinding for the Blind, Visually Impaired, and Disoriented, *IEEE International Conference on Pervasive Computing (IEEE PerCom)*, Kona Island, Hawaii, USA, March 2017; to appear.

At ERI, we intend to establish evidence-based low vision rehabilitation to both improve current clinical practice and to increase awareness, access and referrals to rehabilitative care.

B. Positions and Honors

Positions and Employment

1993-1997 Cadet Engineer, Gas Division, Holyoke Gas and Electric Department, MA
1995-1997 Research Assistant, Massachusetts Institute of Technology, Cambridge, MA
1997 Summer Intern, Focal Interventional Therapeutics, Lexington, MA
1997-1998 Process Engineer, Inhale Therapeutic Systems, San Carlos, CA
1998-2001 Independent Contractor / Software Developer, Walker Consulting Services, Albany, CA
1998-2003 Graduate Researcher, Computer Vision & Human Visual Perception, UC, Berkeley, CA
1999-2002 Graduate Instructor, Computer Science & Vision Science, UC, Berkeley, CA
2003-2005 Post-doctoral Fellow, The Smith-Kettlewell Eye Research Institute, San Francisco, CA
2006-2007 Research Associate, The Smith-Kettlewell Eye Research Institute, San Francisco, CA
2008-2016 Associate Scientist, The Smith-Kettlewell Eye Research Institute, San Francisco, CA
2014- Executive Director, Envision Research Institute, Wichita, KS
2016- Adjunct Research Scientist, Regional Institute on Aging, Wichita State University, Wichita, KS

Awards and Honors

1991-1992 SummerMath Scholarship, Mount Holyoke College, MA
1993 Holyoke High School Valedictorian, MA
1993-1997 Cadet Engineering Scholarship, Holyoke Gas and Electric Department, MA
1993-1997 R.C. Byrd Scholarship
1998-2001 NIH Trainee Fellowship
2002 Vision Sciences Society Student Award
2003-2005 Ruth L. Kirchstein NRSA Fellow
2006-2011 NIH LRP Recipient
2016 "Exceptional Reviewer" designation, Journal of Vision

Professional Activities

1998- Member, Optical Society of America (OSA)
1998- Member, Association for Researchers in Vision and Ophthalmology (ARVO)
2001- Member, Vision Sciences Society (VSS)
2007-2015 NSF Review Panel and Ad-Hoc Reviewer
2009-2014 Session Organizer and Moderator, Envision Conference
2010-2012 Vice Chair of the Applications Technical Group of the OSA, Vision and Color Division
2012-2014 Chair of the Applications Technical Group of the OSA, Vision and Color Division
2012-2014 Veteran's Administration RR&D Grant Reviewer
2014- Low Vision Research Group (LVRG) Organizer at ARVO
2015- Review Editor, Frontiers in Human Neuroscience
2016- NIH SBIR Reviewer
2016- Biomedical Engineering Advisory Board, Wichita State University
2017- Research for Preventing Blindness Grant Review Committee

Ad-Hoc Journal Reviewer: *Perception; Vision Research; Journal of Vision; Journal of Neuroscience; Journal of the Optical Society of America; Transactions in Applied Perception; IEEE Transactions on Pattern Analysis and Machine Intelligence; Journal of Experimental Psychology: Human Perception and Performance; Canadian Journal of Ophthalmology; Frontiers in Human Neuroscience; Optometry and Vision Science; Investigative Ophthalmology and Visual Science; Neuroscience*

Invited Lectures

"Applying Information Models to Explore Eye Movement Behavior in Patients with Central Field Loss". Redwood Center for Theoretical Neuroscience, April, 2009.

"Quantifying Fixation Selection Efficiency in Age-Related Macular Degeneration". 'Envision' Conference, San Antonio, TX; September 2009.

"Uncertainty Reduction as a Theory for Fixation Selection". OSA Vision Meeting, University of Washington, Seattle, WA; September 2009.
"Information Model for Measuring Eye Movements". HSI NASA Brown Bag Presentation, Mountain View, CA; November, 2009.
"Fixation stability and its implications for low vision rehabilitation". School of Optometry, University of Montreal, Montreal, Quebec; March, 2010.
"How optimal are human fixation selection strategies?". European Conference on Eye Movements, Marseille, France; August, 2011.
"Inefficiency of Eye Movements in Central Field Loss". University of Alabama Birmingham, Vision Science Research Center's Visiting Scholars Program; December 2012.
"Mis-alignment of eye and hand reference frames in AMD" Gordon Research Conference on Eye Movements, Easton, MA; July 2013.
"Eye-Hand Coordination in Patients with Macular Degeneration: Current Research". Envision University Low Vision Grand Rounds, Wichita, KS; January 2014.
"Revolutionizing Low Vision Rehabilitation Research". VisionServe Alliance Fall Conference, San Antonio, TX; November 2016.
"Eye movements in low vision rehabilitation." Periopsia Seminar Series. University of Houston, College of Optometry. Houston, TX; December 2016.

C. Contributions to Science

1. Computational Model of Scene Gist Recognition

   Landmark work in scene recognition marveled at human capacity to recognize a scene in a single glance. My graduate work in this area has been highly cited in computational and behavioral work since its publication in 2004. A simple model of V1-like filters is used to process scene image into texture elements (textons) which are then classified into categories. Model performance is equivalent to human recognition performance with 30-50ms viewing time, offering a possible explanation for how the human brain is capable of quickly grasping the gist of a scene with a very brief glance. Link to model code: https://www.dropbox.com/sh/abxocqfse4av3f9/AAAlfEGonSV26y9kzFSePGH3a?dl=0

   a. **Renninger** LW, Malik J. When is scene recognition just texture recognition? *Vision Research.* 2004; **44**: 2301-11. PMID: 15208015.

2. Information Theory of Eye Movements

   Since the time of Yarbus, there has been a fascination predicting where someone will look when viewing an image. Now classic work of Itti & Koch put forth early models of the visual system to identify salient locations in an image. These models do not take the task of the organism into account, which profoundly affects the chosen fixation locations. Instead, following the work of Legge for predicting eye movements in reading, I developed a model that predicts eye movements during a shape recognition task. This work began at the end of my PhD and was further developed during my postdoctoral training under the advisement of Drs. Verghese and Coughlan. It has since been applied to examine the efficiency of fixation selection in maculopathy patients. Shortly after its publication, Najemnik and Geisler released a model for predicting optimal search based on similar principles. In these models, the eye moves to gather task-relevant information, inhibition-of-return is implicit (we need not return to areas that no longer have useful information), and the acuity decline of the sensor away from the fovea (or visibility) can be modeled or measured directly to predict idiosyncrasies in fixational behavior. My later work applies these same principles to examining saccade properties (amplitude, latency and direction) in addition to fixation selection. Extensions of these models have since been applied to searching for multiple targets (e.g. Verghese) and as a theoretical basis for approaching eye movement training for low vision rehabilitation in maculopathy patients.

   a. **Renninger** LW, Coughlan JM, Verghese P, Malik J. An information maximization model of eye movements. *Advances in Neural Information Processing Systems* 2005; **17**: 1121-8. PMID: 16175670.

b. **Renninger** LW, Verghese P, Coughlan JM. Where to look next? Eye movements reduce local uncertainty. *Journal of Vision* 2007; **7**(3): 6, 1-17. PMID: 17461684.

3. Functional Impact of Scotoma on Daily Activities

   Application of the information theory of eye movements led us to examine the discrepancies that evolve in maculopathy patients. Their sensors are damaged, eye movements are misdirected, and eye-hand reference frames do not fully re-align to the preferred retinal locus. The majority of research on eye movements and PRLs has worried over improving reading performance for these individuals. Little theoretically motivated research has been conducted into the more general area of active vision for maculopathy, and I anticpate that my research will inform practical application for low vision rehabilitation that eases difficulty with activities of daily living for this population.

   a. **Renninger** LW & Ma-Wyatt A (2011). Recalibration of eye and hand reference frames in age-related macular degeneration. *Journal of Vision,* **11**(11): 954.
   b. **Renninger** LW, Ma-Wyatt A & Fletcher, DC (2012). Misdirected saccades with the PRL lead to reach delays in age-related macular degeneration. *Invest Ophthalmol Vis Sci.* **53**:4393.
   c. Sullivan, B., & **Walker**, L. (2015). Comparing the fixational and functional preferred retinal location in a pointing task. *Vision research*, *116*, 68-79. PMCID: PMC4726983.
   d. Downes, K., **Walker**, L. L., & Fletcher, D. C. (2015). SKread predicts handwriting performance in patients with low vision. *Canadian Journal of Ophthalmology/Journal Canadien d'Ophtalmologie*, *50*(3), 225-229. PMID: 26040223.

4. Assessing Scotoma Interference in Maculopathy Patients

   Of particular concern in working with maculopathy patients is understanding how their central field loss (scotoma) interferes with eye movement planning. This contribution is a close complement to the preceding work in functional impairments. Working closely with Dr. Fletcher, a leading ophthalmologist in low vision rehabilitation, we are developing tools to better quantify and diagnose the role that scotoma play in the impairment.

   a. Fletcher DC, **Renninger** LW. Acuity Alone Does Not Indicate the Extent of Macular Disease. *Retinal Physician* 2009; **6**(3): 64-6. http://www.retinalphysician.com/articleviewer.aspx?articleID=102901
   b. Fletcher DC, Schuchard, RA & **Renninger** LW (2012). Patient awareness of binocular central scotoma in AMD. *Optometry & Vision Science,* **89**(9):1395-1398. PMID: 22863789.
   c. MacKeben M, Nair UKW, **Walker** LL, Fletcher DC (2015). Random word recognition chart helps scotoma assessment in low vision. *Optometry & Vision Science 92*(4), 421–428. http://doi.org/10.1097/OPX.0000000000000548. PMCID: PMC4376273.

5. Pupil Dilation For Target Detection

   With the recent ubiquity of infrared eye trackers, there has been interest in harnessing the information available in the pupil response. As part of a larger project for DARPA, funded through UC Berkeley, I helped to program and synchronize EEG and eye tracking equipment to detect biological responses for rapid target detection (specifically threat targets). The first was a classification of the pupil response, which instead of constricting during the light response, actually dilates upon recognition of a target presentation. This citation was one of the most highly cited the year of its publication, leading the wave of interest in studying the pupil response as a biomarker of cognitive functioning.

   a. Privitera CM, **Renninger** LW, Carney T, Klein S, Aguilar M. (2010). Pupil dilation during visual target detection. *Journal of Vision,* **10**(10):3. PMID: 20884468.

complete list of published work available on Google Scholar

D. Research Support

<u>Completed Research Support</u> (12 completed research grants)

Chandna (PI) 01/01/16 – 12/31/16
The Smith-Kettlewell Eye Research Institute
"Eye Movements During Fusion Recovery in Strabismus"
The goal of the project is to characterize and classify recovery eye movement patterns for the diagnosis and clinical treatment recommendation for strabismus surgery.
Role: co-PI

R01 EY022156-01 **Renninger** (PI) 12/01/12 – 11/30/16
NIH/NEI
"Reaching with Central Field Loss"
The goal of this proposal is to quantify reaching deficits due to vision loss in individuals with central field loss associated with age-related macular degeneration (AMD).
Role: PI

5R01EY022394-03 Verghese (PI) 05/01/12 – 04/30/16
NIH/NEI
"Recovery of Stereopsis in Age-Related Macular Degeneration"
The goal of this project is to examine the potential for stereopsis in individuals with AMD, by investigating the relation between stereoacuity and the positions of the fixation loci in the two eyes.
Role: Scientist

1 R01 EY018004-06 **Renninger** (PI) 04/01/10 – 03/31/14
NIH/NEI
"CRCNS: Where to Look Next? Modeling Eye Movements in Normal and Impaired Vision"
The goal of this proposal is to gain a better understanding of the information processing and decision strategies that underlie eye movement planning in both the normal and diseased state.
Role: PI

Kuykendall (PI) 07/01/08 – 07/31/12
NSF
"3D Lithography of Thick Photopolymers for Imaging and Photonic Crystal Waveguides"
The goal of the project is to develop a lightweight, headmounted image delivery and capture system. The system will have the ability to image the retina and deliver gaze-contingent stimuli. Low vision applications include use as a visual aid and as an "all-in-one" vision testing and rehabilitation training system.
Role: PI on sub-contract

Renninger (PI) 01/01/11 – 12/31/11
The Smith-Kettlewell Eye Research Institute
"Binocular Coordination in Age Related Maculopathy"
Determine alignment of monocular PRLs and scotomas for different binocular viewing distances. Testing stereopsis and testing of the binocular fields. How does the visual system deal with non-corresonding PRLs?
Role: PI

3 R01 EY018004-03S1 Renninger (PI) 09/01/09 – 08/31/11
NIH/NEI
"CRCNS: Where to Look Next? Modeling Eye Movements in Normal and Impaired Vision"
The goal of this ARRA supplement is to build a distributed computing cluster for neural model development.
Role: PI

Renninger (PI) 01/01/10 – 12/31/10

The Smith-Kettlewell Eye Research Institute
“Reaching with Central Field Loss”
Pilot funds to establish collaboration with Dr. Anna Ma-Wyatt (University of Adelaide) and collect data for grant submission on eye-hand coordination in AMD patients.
Role: PI

1 R01 EY018004-01 Renninger (PI) 09/01/06 – 07/31/10
NIH/NEI
“CRCNS: Where to Look Next? Modeling Eye Movements in Normal and Impaired Vision”
The goal of this proposal is to gain a better understanding of the information processing and decision strategies that underlie eye movement planning in both the normal and diseased state.
Role: PI

Renninger (PI) 01/01/09 – 12/31/09
The Smith-Kettlewell Eye Research Institute
“Binocular Field Mapping for Low Vision Rehabilitation”
The goal of the project is to develop eye-tracking methods for mapping binocular field loss in maculopathy patients.
Role: PI

Renninger (PI) 01/01/09 – 12/31/09
Pacific Vision Foundation
“Binocular Field Testing”
The goal of this project is to develop, evaluate and validate three new tools for binocular field mapping. Special emphasize is placed on the evaluation of PC-based software tools that are inexpensive and accessible to the low vision rehabilitation community.
Role: PI

Verghese (PI) 01/01/06 – 05/31/08
Pacific Vision Foundation
“Optimal Eye Movement Strategies for AMD Rehabilitation”
The goal of this project is to measure the residual vision and eye scanning patterns of individuals with age-related macular degeneration (AMD) using a scanning laser ophthalmoscope. A large format display system for testing AMD patients will also be developed.
Role: Co-PI