Sara Stokes Patterson

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EDUCATION

09.2015 - 07.2020 **Ph.D. in Neuroscience**, University of Washington
Thesis: Structure and Function of S-Cone Opponent Circuits in the Primate Retina

08.2010 - 05.2014 **B.S. in Neuroscience**, Dickinson College
Honors in Neuroscience, Minor in Psychology

RESEARCH EXPERIENCE

08.2020 - present *Postdoctoral Fellow*, University of Rochester
Lab: Dr. David Williams, Center for Visual Science
Foveal ganglion cell structure and function in the living eye
Adaptive optics, calcium imaging and retrograde tracer injections

09.2016 - 07.2020 *Graduate Student*, University of Washington
Lab: Dr. Jay Neitz, Department of Ophthalmology
Structure and function of S-cone circuits in the primate retina
Single electrophysiology and serial electron microscopy

08.2014 - 08.2015 *Post-baccalaureate IRTA*, National Institutes of Health
Lab: Dr. Ralph Nelson, Neural Circuits Unit, NINDS
Zebrafish retinal development using ERG and confocal microscopy
Received NINDS Annual Symposium Poster Award, $1500 travel grant

11.2010 - 05.2014 *Research Assistant*, Dickinson College
Lab: Dr. Jonathan Page, Department of Psychology
Role of V1 in mental imagery with visual evoked potentials and EEG
Cognitive-behavioral training for PA State Police Academy

06.2013 - 08.2013 *Summer Intern*, National Institutes of Health, NINDS
Lab: Dr. Ralph Nelson, Neural Circuits Unit
Characterized photoreceptor function in transgenic zebrafish lines
Received NINDS Exceptional Summer Intern Award

TEACHING EXPERIENCE

Summer 2018 - 2020 *Mentor*, University of Washington
Supervised four high school students in serial EM research projects

Fall 2017 *Teaching Assistant*, University of Washington
NBIO 302: Introduction to Systems Neurobiology

Summer 2015 *Mentor*, National Institutes of Health
Supervised intern that won NINDS Exceptional Summer Intern Award

08.2013 - 05.2014 *Head Lab Assistant*, Dickinson College
Trained and supervised three new lab members in EEG and EMG

SERVICE

- *Center for Visual Science Executive Committee*, University of Rochester
- *Center for Visual Science Retreat Committee*, University of Rochester
- *Ophthalmology Summer Scholars Internship Program Mentor*, University of Washington
- *Neuroscience Seminar Committee*, University of Washington
- *Neuroscience Outreach Group*, University of Washington
- *Expand Your Horizons Mentor*, American Association of University Women
- *Neuroscience Student Representative*, Danish Institute for Study Abroad
- *Student Wellness Committee*, Dickinson College

OTHER TRAINING

- 06.2019 - Cold Spring Harbor Vision Course
- 08.2018 - Allen Institute Dynamic Brain Summer Course in Computational Neuroscience

FUNDING

- 06.2021-06.2023 - NRSA Postdoctoral Fellowship (F32-EY032318)
- 08.2020-06.2021 - Vision Training Grant (University of Rochester, T32-EY007125)
- 06.2018-06.2019 - Vision Training Grant (University of Washington, T32-EY007031)
- 06.2016-06.2017 - Neuroscience Training Grant (University of Washington, T32-NS099578)

AWARDS

- 09.2021 - Steadman Family Postdoctoral Prize for Interdisciplinary Research
- 07.2019 - Patmalnieks Award for Best Student Talk - International Color Vision Society
- 07.2019 - International Color Vision Society Travel Grant
- 05.2019 - Association for Research in Vision and Ophthalmology Travel Grant
- 09.2018 - Best Collaboration Award - Allen Institute Dynamic Brain Summer Course
- 05.2015 - NINDS Annual Symposium Post-bac Poster Award and Travel Grant
- 08.2014 - McAndrews Award for Outstanding Female Athlete
- 08.2013 - NINDS Exceptional Summer Intern Award
- 05.2013 - Psi Chi National Honor Society
- 05.2012 - Outstanding Research Poster Award, Dickinson Science Research Symposium
- 2011-4 - 4x USATF All-Academic, 2x NCAA All-American Honors
- 01.2011 - Alpha Lambda Delta Freshman Honor Society

OPEN SOURCE SOFTWARE

- *SBFSEM-tools*: Data analysis and 3D visualization for serial electron microscopy
  - RRID: SCR_017350

PATENTS

- 17/612,061: “Systems, Methods, and Devices for Stimulating Circadian Rhythms”

PUBLICATIONS

12. **Patterson, S.S.**, Neitz, J., Neitz, M. (2021) S-cone circuits in the primate retina for non-image-forming vision. *Seminars in Cell and Developmental Biology*, In Press
11. Bordt, A.S., **Patterson, S.S.**, Girresch, R.J., Perez, D., Tseng, L., Anderson, J.R., Mazzaferri, M.A., Kuchenbecker, J.A., Gonzales-Rojas, R., Roland, A., Tang, C., Puller, C. Chuang, A.Z., Ogilvie, J.M., Neitz, J., Marshak, D.W. (2021) Synaptic inputs to broad thorny ganglion cells in macaque retina. *Journal of Comparative Neurology*, 529(11), 3098-3111
10. **Patterson, S.S.**, Mazzaferri, M.A., Bordt, A.S., Chang, J., Neitz, M., Neitz, J. (2020) Another Blue-ON ganglion cell in the primate retina. *Current Biology*, 30(23), R1409-1410
9. Neitz, A., Jiang, X., Kuchenbecker, J.A., Domdei, N., Harmening, W., Yan, H., Yeonan-Kim, J., **Patterson, S.S.**, Neitz, M., Neitz, J., Coates, D., Sabesan, R. (2020) The effect of cone spectral tomography on chromatic detection sensitivity. *Journal of the Optical Society of America A*, 37(4), A245-A255
8. **Patterson, S.S.**, Kuchenbecker, J. A., Anderson, J. R., Neitz, M., Neitz, J. (2020) A color vision circuit for non-image-forming vision in the primate retina. *Current Biology*, 30(7), 1269-1274
    - Rivera, A. & Huberman, A. (2020) Coloring time: A chromatic retinal circuit encodes sunrise and sunset for the brain. *Current Biology*, 30, R316-R318
7. **Patterson, S.S.***, Bordt, A.S.*, Girresch, R.J., Linehan, C.M., Bauss, J., Yeo, E., Perez, D., Tseng, L., Navuluri, S., Harris, N.B., Matthews, C., Anderson, J.R., Kuchenbecker, J.A., Manookin, M.B., Ogilvie, J.M., Neitz, J. and Marshak, D.W. (2019) Wide-field amacrine cell inputs to ON parasol ganglion cells in macaque retina. *Journal of Comparative Neurology*, 528(9), 1588-1598. **** co-first author***
6. **Patterson, S.S.**, Neitz, M., Neitz, J. (2019) Reconciling color vision models with midget ganglion cell receptive fields. *Frontiers in Neuroscience*, 13, 865
5. **Patterson, S.S.**, Kuchenbecker, J.A., Anderson, J.R., Bordt, A.S., Marshak, D.W., Neitz, M., Neitz, J. (2019) An S-cone circuit for edge detection in the primate retina. *Scientific Reports*, 9, 11913
4. Neitz, M., **Patterson, S.S.**, Neitz, J. (2019) Photopigment genes, cones and color: Disrupting the splicing code causes a diverse array of vision disorders. *Current Opinion in Behavioral Science*, 30, 60-66
3. Nelson, R.F., Balraj, A., Suresh, T., Torvund, M., **Patterson, S.S.** (2019) Strain variations in opsin peaks *in situ* during zebrafish development. *Visual Neuroscience*, 36, E010
2. Bordt, A.S., Perez, D., Tseng, L., Liu, W.S., Neitz, J., **Patterson, S.S.**, Famiglietti, E.V., Marshak, D.W. (2019) Synaptic inputs and connectivity of a sparsely branched ganglion cell in rabbit retina. *Visual Neuroscience*, 36, E004
1. Manookin, M.B., **Patterson, S.S.** & Linehan, C. (2018) Neural mechanisms mediating motion sensitivity in parasol ganglion cells of the primate retina. *Neuron*, 97, 1327–1340
    - Murphy-Baum, B.L. & Awatramani, G.B. (2018) An old neuron learns new tricks: Redefining motion processing in the primate retina. *Neuron*, 97, 1205-1207

PREPRINTS

1. Bordt, A.S., **Patterson, S.S.**, Kuchenbecker, J.A., Mazzaferri, M.A., Yearick, J.N., Yang, E.R., Ogilvie, J.M., Neitz, J., Marshak, D.W. (2022) Synaptic inputs to displaced intrinsically photosensitive ganglion cells in macaque retina. *Research Square*, doi: 10.21203/rs.3.rs-1239828/v1
2. **Patterson, S.S.**, Bembry, B.N., Mazzaferri, M.A., Neitz, M., Neitz, J. (2021) Conserved Circuits for Direction Selectivity in the Primate Retina. *bioRxiv*, doi: 10.1101/2021.07.21.453225
3. **Patterson, S.S.**, Neitz, M., Neitz, J. (2019) The Spectral Sensitivity of the Neurons Mediating Black and White. *bioRxiv*, doi: 10.1101/829051

BOOK CHAPTERS

- Neitz, M., **Patterson, S.S.**, Neitz, J. (2020) The genetics of cone opsin based vision disorders. In: *The Senses: A Comprehensive Reference*, 2nd edition, Vol. 1, pg. 493-507

INVITED TALKS

10.14.2021	*OSA Fall Vision Meeting* The S-cone connectome of the primate retina
05.03.2021	*Association for Research in Vision and Ophthalmology* Conserved circuits for direction selectivity in the primate retina
12.11.2020	*AOIP Young Investigator Seminar Series* Form and function of S-cone circuits in the primate retina
05.07.2020	*Association for Research in Vision and Ophthalmology*, Baltimore, MD Direction selectivity in the primate retina (canceled due to COVID-19)
07.06.2019	*International Color Vision Society Meeting*, Riga, Latvia The neural basis for encoding black, white and hue sensations
04.28.2019	*Association for Research in Vision and Ophthalmology*, Vancouver, BC An S-cone amacrine sets the circadian clock at sunrise and sunset
04.10.2019	*Janelia Farm Color Vision: Circuits and Behavior*, Ashburn, VA A color vision circuit for circadian photoentrainment in the primate retina
05.07.2018	*Association for Research in Vision and Ophthalmology*, Honolulu, HI S-cone inputs to midget ganglion cells and their implications for color vision
10.14.2017	*OSA Fall Vision Meeting*, Washington, DC Differences between the S-OFF and L/M-OFF contacts inform the role of OFF midget bipolar cells in the perception of yellow

CONFERENCE ABSTRACTS

- Usamani, H., **Patterson, S.S.**, Giarmarco, M.M., Neitz, M., Neitz, J., Kuchenbecker, J.A. (2022) Electrophysiological evidence for GABA-mediated feed-forward as a major cone signal ON pathway. *Investigative Ophthalmology & Visual Science*
- Marshak, D.W., Bordt, A.S., **Patterson, S.S.**, Kuchenbecker, J.A., Neitz, J. (2022) OFF bipolar cell inputs to ipRGCs in macaque retina. *Investigative Ophthalmology & Visual Science*
- Mazzaferri, M., **Patterson, S.S.**, Bordt, A., Kuchenbecker, J.A., Rezeanu, D., Barborek, R., Puller, C., Neitz, M., Neitz, J. (2021) The stellate varicose amacrine cell is positioned to provide a second layer of inhibition specific to the primate midget system. *Investigative Ophthalmology & Visual Science*
- Neitz, J., **Patterson, S.S.**, Chang, J., Giebel, B.Q., Rieke-Wey, I., Neitz, M. (2020) Another blue-ON ganglion cell in the primate retina. *Investigative Ophthalmology & Visual Science*, 61(7), 2338
- Marshak, D.W., Bordt, A.S., **Patterson, S.S.**, Girresch, R., Puller, C., Ogilvie, J.M., Neitz, J. (2020) Synaptic inputs to broad thorny ganglion cells from macaque retina. *Investigative Ophthalmology & Visual Science*, 61(7), 5139
- Girresch, R., **Patterson, S.S.**, Bordt, A.S., Anderson, J.R., Kuchenbecker, J.A., Neitz, J., Marshak, D.W., Ogilvie, J.M. (2020) Synaptic input to parasol and smooth monostratified ganglion cells in central macaque retina. *Investigative Ophthalmology & Visual Science*, 61(7), 4625

- **Patterson, S.S.**, Kuchenbecker, J.A., Anderson, J.R., Neitz, M., Neitz, J. (2019) An S-cone amacrine cell in the primate retina sets the circadian clock at sunrise and sunset. *Investigative Ophthalmology & Visual Science*, 60(9), 1373.
- Girresch, R., **Patterson, S.S.**, Bordt, A.S., Anderson, J.R., Kuchenbecker, J.A., Ogilvie, J., Neitz, J., Manookin, M.B., Marshak, D.W. (2019) Parasol and smooth monostratified retinal ganglion cells of the primate retina. *Investigative Ophthalmology & Vision Science*, 60(9), 5274
- Kuchenbecker, J.A., **Patterson, S.S.**, Neitz, M., Neitz, J. (2019) The role of video display viewing in myopia. *Investigative Ophthalmology & Vision Science*, 60(9), 4267
- **Patterson, S.S.**, Kuchenbecker, J.A., Doebley, A., Neitz, M., Neitz, J. (2018) The normal human visual system extracts about 1% of the hues possible from the L, M and S cones compared to a perfect hue encoder. *Journal of Vision*, 19(8), 81
- Kuchenbecker, J.A., **Patterson, S.S.**, Neitz, M., Neitz, J., Manookin, M.B. (2018) Spectral density curves of the human lens inaccurate due to increased Rayleigh scatter in post mortem eyes. *Journal of Vision*, 19(8)
- Neitz, A., Jiang, X., Kuchenbecker, J.A., **Patterson, S.S.**, Doebley, A., Neitz, M., Neitz, J., Sabesan, R. (2018) High acuity vision corrected for chromatic and achromatic aberrations is associated with color discrimination without red-green or blue-yellow sensations. *Journal of Vision*, 19(8), 12
- **Patterson, S.S.**, Kuchenbecker, J.A., Anderson, J.R., Linehan, C.L., Neitz, J. (2018) S-cone inputs to midget retinal ganglion cells and their implications for color vision. *Investigative Ophthalmology & Vision Science*, 59(9), 5691
- Nelson, R., Balraj, A., Suresh, T., Torvund, M., **Patterson, S.S.** (2018) A computational method for determining opsin peak absorbance wavelengths from zebrafish PIII ERG responses. *Investigative Ophthalmology & Vision Science*, 59(9), 600
- Kuchenbecker, J.A., **Patterson, S.S.**, Neitz, M., Neitz, J. (2018) Studying S-cone inputs to hue perception using a DLP based projector integrated with a spectrally tunable light source. *Investigative Ophthalmology & Vision Science*, 59(9), 4050
- Neitz, A., Jiang, X., **Patterson, S.S.**, Doebley, A., Neitz, M., Neitz, J., Sabesan, R. (2018) Color detection without hue perception. *Investigative Ophthalmology & Vision Science*, 59(9), 5962
- **Patterson, S.S.**, Kuchenbecker, J.A., Anderson, J.R., Neitz, M., Neitz, J., Manookin, M.B. (2017) Differences between S-OFF and L/M-OFF contacts inform the role of OFF midget bipolar cells in the perception of yellow. *Investigative Ophthalmology & Vision Science*, 17(15), 15
- Kuchenbecker, J.A., **Patterson, S.S.**, Neitz, M., Neitz, J. (2017) Best of both worlds? A Maxwellian view visual stimulator incorporating a DLP spatiotemporal light driver with a programmable tunable spectrum source for studying human color vision. *Journal of Vision*, 17(15), 45
- **Patterson, S.S.**, Yoshimatsu, T., Suresh, T., Nelson, R.F. (2016) The role of thyroid hormone receptor β2 (trβ2) in development of photoreceptor opsin and bipolar cell connectivity. *Investigative Ophthalmology & Vision Science*, 57(12)
- Kuchenbecker, J.A., **Patterson, S.S.**, Manookin, M.B., Buhr, E., Neitz, M., Neitz, J. (2016) An ex vivo electroretinogram to study spectral mechanisms and cone pathways in the retina. *Investigative Ophthalmology & Vision Science*, 57(12)
- **Patterson, S.S.**, Suresh, T., Yoshimatsu, T., Nelson, R.F. (2015) Development of cone opsin expression in a transgenic line with crx-driven trβ2 expression. Society for Neuroscience Annual Meeting
- **Patterson, S.S.**, Nelson, R.F. (2015) Spectral properties of a zebrafish transgenic with L-opsin expression in all cone types. *Investigative Ophthalmology & Vision Science*, 56(7), 994
- Nelson, R.F., Abraham, R.R., **Patterson, S.S.**, Syrykowski, J.L., Li, L., Burgess, H.A., Connaughton, V.P. (2014) Zebrafish transgenic reports musashi1 (msi1) in retinal neurons. *Investigative Ophthalmology &*

Vision Science, 55(13), 2369

- Vitrano, D., Emery, A.C., **Patterson, S.S.**, Page, J.W. (2013) Imagine that! Comparing brain responses to imagining and perceiving novel stimuli. *Journal of Cognitive Neuroscience*, 264

CONFERENCE PRESENTATIONS

- **Patterson, S.S.**, Neitz, M., Neitz, J. "The neural substrates encoding black, white and hue sensations.", International Color Vision Society, July 2019
  - Received Latvijas Universitātes Patmalnieks Award
- Sabesan, R., Neitz, A., Jiang, X., Kuchenbecker, J., **Patterson, S.S.**, Neitz, M., Neitz, J., Coates, D. "Effect of cone spectral tomography on achromatic and chromatic detection sensitivity", International Color Vision Society Meeting, July 2019
- **Patterson, S.S.**, Kuchenbecker, J.A., Doebley, A., Neitz, M., Neitz, J. "The human visual system extracts about 1% of the hues possible compared to a perfect hue encoder", Gained In Translation Meeting, September 2018
- Estrada, M., **Patterson, S.S.**, Linehan, C.M., Neitz, M., Neitz, J. "Amacrine cell inputs to the S-cone pathway", Gained In Translation Meeting, September 2018
- **Patterson, S.S.**, Kuchenbecker, J.A., Manookin, M.B., Neitz, M., Neitz, J. (2018) "Spatial, spectral and directional information in the small bistratified ganglion cell", FASEB Retinal Physiology and Visual Neurobiology, July 2018
- **Patterson, S.S**, Neitz, M., Neitz, J., Manookin, M.B. "Midget ganglion cell circuits for achromatic and hue sensations.", Gained in Translation Meeting, September 2016
- **Patterson, S.S.**, Kuchenbecker, J., Neitz, M., Neitz, J., Manookin, M. "Subtypes of midget retinal ganglion cell in primate retina and their roles in color vision", FASEB Retinal Physiology and Visual Neurobiology, July 2016
- **Patterson, S.S.**, Nelson, R.F. "Spectral properties of a zebrafish transgenic with L-opsin expression in all cone types" NINDS Annual Research Symposium, May 2015
  - Received NINDS Post-baccalaureate Poster Award
- **Patterson, S.S.**, Cohen, P.M., Strykowski, J.L., Burgess, H.A., Nelson, R.F. "Effects of Musashi1 in Zebrafish Retinal Development: Disruption of UV Cone Mosaic and ERG Sensitivity" National Institutes of Health Summer Poster Day, August 2013
  - Received NINDS Outstanding Summer Intern Award
- **Patterson, S.S.** "Blue color vision as a measure of dopamine levels among ADHD subtypes", Dickinson College 29th Annual Science Research Symposium, May 2014
  - Received Departmental Honors in Neuroscience
- Gregory, K.A., Ludman, T., Liu, K.X., **Patterson, S.S**, Page, J.W. "Context and rapid discrimination" Dickinson College 29th Annual Science Research Symposium, May 2014
- **Patterson, S.S.** "Using synesthesia to study the role of color opponent process pathways in mental imagery" Dickinson College Independent Psychology Research Symposium, December 2013
- Kylus, J., Norato, G., **Patterson, S.S.** "Developing algorithms to detect pain with EEG." Dickinson College 27th Annual Science Research Symposium, December 2012
  - Received Outstanding Research Poster Award