Sean Linnaeus Barton
Ph.D. | Cognitive Scientist

Research scientist with a Ph.D. in Cognitive Science from Rensselaer Polytechnic Institute. Currently working at the U.S. Army Research Laboratory to investigate and develop adaptive computational systems. I am interested in the application of computational learning and artificial intelligence for improving human-computer interactions and solving real-world problems.

Overview

Education & Degrees

Cognitive Science	**M.S., Ph.D.**
Rensselaer Polytechnic Institute	*12/2014, 12/2017*
Psychology	**B.S.**
Arizona State University	*05/2011*

Research & Work Experience

Cognitive Scientist

U.S. Army Research Laboratory, Postdoctoral Fellow   *2018-Present*

Applied research in deep learning, online and reinforcement learning, and human-agent teaming for the purposes of developing intelligent computational systems to work with military personnel.

Research Assistant

Rensselaer Polytechnic Institute, Cognitive Science Department   *2011-2017*

Basic research in human perceptual-motor control. Extensive work with virtual reality, motion capture, and statistical analysis of large data sets in R, Python, and MatLab.

Technical Skills

Programming & Computation: (*Python, R, TensorFlow, Matlab, Git, C++*)
I have extensive experience working with high-level programming languages for the purposes of computational learning, algorithm development, scientific experimentation, data analysis, and data visualization.

Data Analysis & Visualization: (*R, Python, TensorBoard, Shiny, HTML*)
I am experienced with experimental design, statistical hypothesis testing, statistical modeling, and data visualization. I prefer using multiple analytical approaches, combining Frequentist, Bayesian, and graphical modes of reasoning to construct a comprehensive and convergent argument.

Writing & Communication: (*LaTeX, Jupyter Notebooks, RMarkdown, Microsoft Office, Adobe Illustrator*)
I have published a number of technical and academic papers in scientific journals, both as a primary author and a co-author. I also have designed a number of professional posters, presentations, and interactive data visualization applications for use at meetings and conferences.

Presentation & Teaching Experience: (*AAAI Symposia, SFN, VSS, SPIE, IHSED, IHSI, statistics lecturer*)
I have regularly given talks and presentations at professional and academic conferences over my career. I also have experience teaching students at the university level.

Select Publications

- Evaluating the Coordination of Agents in Multi-Agent Reinforcement Learning (2019)
- Measuring collaborative emergent behavior in multi-agent reinforcement learning (2018)
- Reinforcement learning framework for collaborative agents interacting with soldiers in dynamic military contexts (2018)
- Visual regulation of gait: Zeroing in on a solution to the complex terrain problem (2017)

Personal Profile

Research Interests

I am interested in what human cognition and behavior can teach us about adaptive and intelligent systems generally. Understanding human cognition is critical for not only better understanding how humans interact with a rich and dynamic world, but also for developing advanced technologies that can work alongside humans in a continuous and fluid manner. At the heart of human cognition are our perception, action, and learning capabilities, all of which can be understood by studying our behavior as we interact with our world. The creation of advanced and intelligent artificial systems can likewise be furthered by taking seriously the roles of perception, action, and learning in intelligent behavior. By creating systems that can behave and adapt in a human-like manner when interacting with the world, we take a step towards a computational intelligence that is naturally prepared to function alongside humans.

Career Interests

As a research scientist, my interests are in the development of novel concepts, ideas, and understanding in the realm of computational intelligence, human-level cognition, and intelligent behavior. However, I am also interested in transitioning such ideas into usable technology that can benefit society across a multitude of sectors. In technological fields the line between basic and applied research is increasingly blurred, and remaining on the cutting edge requires as much innovation and discovery as it does application development.

I am also interested in how the increasing amount of human data available throughout society can be used to make better and more informed decisions about our behaviors and needs. This information affords an unique opportunity to inform progress in technology, industry, and policy in unprecedented ways.

Personal Interests

I am a person driven by curiosity and creativity. I thrive on exploration and on sharing in the explorations of others. I love data-driven stories that reveal surprising patterns about our world, and I love beautiful visualizations of information that make you think about something in a way you never before considered. I enjoy hiking and backpacking, and I find some of my greatest peace when I immersed in the natural world. I like rock climbing but I'm afraid of heights (it's a work in progress). I love podcasts and I am passionate about coffee. I am ecstatic that personal home robots are available in my lifetime. I play the viola and I love being part of an orchestra, though I have never liked playing solo. I like to write, even after I've spent all day writing. I prefer story-driven video games and story-driven board games. Shared creativity is something I seek out in the people around me, and I love working with groups of people who are all passionate about the same thing and can talk about it for hours at length. I believe that our desires for knowledge and our desires to create are our greatest assets as humans.

Education

Doctorate of Philosophy   **Rensselaer Polytechnic Institute**
Cognitive Science   *Dec 2017*
Doctoral Dissertation: The Role of Vision and Biomechanics When Walking Over Rough Terrain

Master of Science   **Rensselaer Polytechnic Institute**
Cognitive Science   *Dec 2014*
Master's Thesis: Learning to Coordinate a Redundant Motor System: The Role of Postural Comfort

Bachelor of Science   **Arizona State University**
Psychology – Summa cum Laude, with Honors   *May 2011*
Honors Thesis: Organic Cation Transporter 3: A study of the potential behavioral role played by a novel monoamine transport protein in the response to acute stress

Research Experience

U.S. Army Research Laboratory   **Cognitive Scientist**
Postdoctoral Fellow – Computational & Information Sciences Directorate   *Jan 2018 – Present*

Current research investigates the role that deep reinforcement learning can play in the development of more effective human-agent teams. As our reliance on technology continues to grow, we require increasing intelligence and adaptability from computational systems. One way to achieve this to create systems that are capable of learning from human partners in real time. We leverage advances in computational learning to develop computational teammates that anticipate a human partner's needs and intentions within the context of continuous simulated tasks.

Details:

o Involved in organizing and maintaining several independent research directions
o Researching multi-agent teaming and applications through simulation experiments
o Conducting behavioral research in human-agent teaming
o Working on algorithm development for novel deep reinforcement learning applications
o Presenting research to military clients
o Presenting research at scientific conferences
o Writing academic papers and technical reports on research findings
o Implementing computational simulators for algorithm testing

Rensselaer Polytechnic Institute   **Research Assistant**
Perception and Action Lab   *Jan 2014 – Dec 2017*

Conducted research investigating the role of visual information during continuous walking over naturalistic terrains. This research aimed to understand how information about footholds and obstacles along the future path is used by humans to leverage the dynamics of the body for efficient and stable locomotor behavior. The paradigm utilized a full-body motion capture system and an immersive virtual environment to study total body motion in response to different information about the path being traversed.

Details:

o Conducted five experimental research projects under this paradigm.
o Currently helping develop paradigms for continuing research in the study of visual control of locomotion.
o Utilize motion capture and virtual reality to create naturalistic, interactive terrains as experimental stimuli.
o Developed custom Matlab and R pipelines for data analysis.
o Developing an experimental paradigm using augmented reality to project 3D terrains.

Rensselaer Polytechnic Institute   **Research Assistant**
Perception and Action Lab   *Aug 2011 – Dec 2014*

Conducted research to investigate how humans learn to exploit kinematic redundancy in the upper arm. Motor redundancy is critical for flexibility and adaptability in human motor control. I implemented the experimental paradigm within the Vizard virtual environment.

Details:

o Designed and implemented a novel experimental research project.
o Oversaw experimentation and data collection.
o Developed custom Matlab and R pipelines for data analysis.

Arizona State University   **Undergraduate Research Assistant**
Orchinik Lab   *Aug 2008 – May 2011*

Worked independently, and as part of a team, conducting research on the neuro-chemical pathways of the acute stress response in rat and frog animal models. Investigations focused specifically on *organic cation transporter 3* (OCT-3) and its action as a secondary serotonin uptake mechanism in the brain.

Details:

o Animal care and handling with Sprague-Dawley rat model.
o Surgical and chemical preparation of animal subjects for neural tissue analysis.
o Analysis of neural tissue using immunofluorescence.

Technical Skills

Programming

Python
Numpy, Scipy, Matplotlib, Pandas, PyMC, Jupyter Notebooks

I am experienced at programming in Python for experimentation and data analysis, utilizing both functional and object oriented programming. Frequently use Numpy, Scipy, Matplotlib, and Pandas. Familiar with PyMC for Monte Carlo simulation and Bayesian statistics. I have experience using IPython and JupyterNotebooks as well.

TensorFlow
DNN, CNN, LSTM, DQN, Actor-Critic, Keras

In my current research I work extensively with Tensorflow using existing libraries in novel applications, as well as developing novel algorithms or synthesizing new techniques when existing solutions are insufficient. My primary experience is in the realm of deep reinforcement learning, though I have a working knowledge of addressing deep learning problems in other domains (such as NLP or image classification). I primarily work with Tensorflow directly, though I am familiar and comfortable with the Keras wrapper syntax.

R
RStudio, RMarkdown, RShiny

Highly experienced at using R for statistical analysis and programming. I routinely use R, RMarkdown, and RNotebooks for analysis and research presentation. I am skilled at using GGPLOT2 for creating publication-worthy figures and tables. I am also experienced with using Shiny in R for development of web applications and statistical presentations in HTML5.

OpenAI Gym
Reinforcement Learning

Experienced with using OpenAI Gym for creating simulation environments for reinforcement learning problems. Utilizing OpenAI gym for research in reinforcement learning and human-agent teaming.

LaTex
Document typesetting

Highly experienced with LaTex. I use LaTex routinely for manuscript writing, either working directly in LaTex or using an interim word processor (like Scrivener) and compiling to LaTex for final document preparation.

Git
Github, GitLab, BitBucket, Atlassian

Routinely use Git-based version control services for collaborative work and source-code versioning. Comfortable with collaborative programming, project branching, merging, and documentation.

C++
Basic programming

Familiar with functional programming in C++. Utilized C++ for experiment design and simple virtual environment presentation. Worked with C++ as a network bridge between Vicon and Vizard.

Industry Software

Matlab
Programming, Simulink

I am experienced with Matlab programming. I developed custom pipelines for post-processing motion capture data and experiment data in Matlab, and use this pipeline to prepare data for analysis in R. I am experienced at generating figures with Matlab, and I am familiar with SimuLink.

Vicon
Nexus 1.8

Experienced with passive motion capture for the purposes of research and analysis, including data collection and post-processing for analysis in MatLab and R. Routinely calibrate and maintain motion capture hardware.

WorldViz
Vizard3, Vizard5

Experienced using Worldviz software to produce interactive virtual environments for experimental purposes. Worldviz is primarily scripted in Python, and utilizes proprietary libraries for event handling and stimulus presentation within an experimental context.

Other

Vector Graphics
Adobe Illustrator, Inkscape

I regularly use vector graphics programs such as Inkscape and Adobe Illustrator to make professional posters and conference presentations. I am experienced with vector graphic creation and to a lesser extent graphic design.

Teaching Experience

Research Methods and Statistics II   **Rensselaer Polytechnic Institute**
Graduate Teaching Assistant   *Jan-May 2017*

Helped to build a curriculum for a new course at Rensselaer Polytechnic Institute designed to teach students studying Psychology and Cognitive Science advanced topics in research methods and parametric statistics. This course was also designed to teach students to use R and RMarkdown to create documents that effectively communicate and defend research experiments.

Details:
- o Curriculum development
- o Assignment creation in RMarkdown
- o Lecturing
- o Grading student work and providing guidance through office hours

Perception and Action   **Rensselaer Polytechnic Institute**
Graduate Teaching Assistant   *Jan-May 2014*

Perception and Action is an advanced level course on the study of human perceptual and motor systems. I worked with students through office hours to help them develop a conceptual understanding of the advanced topics in this course, and assisted Dr. Brett Fajen with grading and lesson planning.

Details:
○ Grading
○ Student guidance through office hours

Sensation and Perception   **Rensselaer Polytechnic Institute**
Graduate Teaching Assistant   *Aug-Dec 2011, Aug-Dec 2012, Aug-Dec 2016*

An introductory course for students interested in psychophysical experimentation, Sensation and Perception is part of the core curriculum for the Cognitive Science department. I helped students through one-on-one meetings, graded assignments and tests, and instructed students on the use of Python to conduct simple psychometric experiments in class.

Details:
○ Grading
○ Student guidance through office hours
○ Python for experimentation

Published Work

Journal Publications & Proceedings

Published

○ Barton, S. L., Zaroukian, E., Asher, D. E., & Waytowich, N. R. (2019) Evaluating the Coordination of Agents in Multi-Agent Reinforcement Learning. In *International Conference on Intelligent Human Systems Integration, 2nd IHSI* (pp. 765-770). Springer, Cham.
○ Barton, S. L., Waytowich, N. R., Zaroukian, E., & Asher, D. E. (2018). Measuring collaborative emergent behavior in multi-agent reinforcement learning. In *International Conference on Human Systems Engineering and Design: Future Trends and Applications, 1st IHSED* (pp. 422-427). Springer, Cham.
○ Barton, S. L., & Asher, D. (2018). Reinforcement learning framework for collaborative agents interacting with soldiers in dynamic military contexts. In *Next-Generation Analyst VI* (Vol. 10653, p. 1065303). International Society for Optics and Photonics
○ Barton, S. L., Matthis, J. S., & Fajen, B. R. (2017). Visual regulation of gait: Zeroing in on a solution to the complex terrain problem. *Journal of Experimental Psychology: Human Perception and Performance*, 43(10), 1773.
○ Matthis, J. S., Barton, S. L., & Fajen, B. R. (2017). The critical phase for visual control of human walking over complex terrain. *Proceedings of the National Academy of Sciences*, 114(32), E6720-E6729.
○ Matthis, Jonathan Samir, Sean L Barton, and Brett R Fajen. "The Biomechanics of Walking Shape the Use of Visual Information during Locomotion over Complex Terrain." *Journal of Vision* 15, no. 3:10 (2015): 1–13.

In Press

○ Barton, S. L., Waytowich, N. R., & Asher, D. E. (2018). Coordination-driven learning in multi-agent problem spaces. To appear in *Reports on the 2018 AAAI Fall Symposium. arXiv preprint arXiv:1809.04918.*
○ Asher, D. E., Zaroukian, E., & Barton, S. L. (2018). Adapting the Predator-Prey Game Theoretic Environment to Army Tactical Edge Scenarios with Computational Multiagent Systems. To appear in *International Command and Control Research and Technology Symposium, 23rd ICCRTS. arXiv preprint arXiv:1807.05806.*

Conference Presentations

Talks

- Fajen, B., Barton, S., & Steinmetz, S. (2018). The visual control of walking over terrain with multiple raised obstacles. *Journal of Vision*, 18(10), 181-181.
- Barton, S., Matthis, J., Hinojosa, E., Brion, D., & Fajen, B. (2016). Biomechanical and visual constraints on rapid adjustments to foot placement during continuous locomotion. *Journal of Vision*, 16(12), 767-767.
- Barton, Sean L., Jonathan S. Matthis, Evelyn Hinojosa, Dylan Brion, and Brett R. Fajen. "Visual Control of Foot Placement during Continuous Locomotion over Complex Terrain." *Dynamic Walking*, 2016.
- Fajen, Brett R., Sean L. Barton, Jonathan S. Matthis."Which regions of the ground surface do humans need to see to control walking over complex terrain?". Program No. 374.04. 2015 Neuroscience Meeting Planner. Washington, DC: Society for Neuroscience, 2015. Online.

Poster Presentations

- Barton, Sean L., Scott Steinmetz, Jonathan S. Matthis, Brett R. Fajen. "Active versus passive perceptual control of locomotion: The preference for ballistic movements during walking." Program No. 808.28/DP05 (Dynamic Poster). 2016 Neuroscience Meeting Planner. San Diego, CA: Society for Neuroscience, 2016. Online.
- Zhao, Ye, Jonathan S. Matthis, Sean L. Barton, Mary Hayhoe, and Luis Sentis. "Exploring Visually Guided Locomotion over Complex Terrain: A Phase-Space Planning Method." *Dynamic Walking*, 2016.
- Barton, Sean L., Jonathan S. Matthis, Brett R. Fajen. "Dynamics inherent to bipedal locomotion constrain active control of foot placement". Program No. 519.18/U7. 2015 Neuroscience Meeting Planner. Washington, DC: Society for Neuroscience, 2015. Online.
- Barton, Sean L., Jonathan S. Matthis, and Brett R. Fajen. "The Contributions of Active and Passive Modes of Control during Walking over Complex Terrain." *Journal of Vision* 15, no. 2 (2015). doi:10.1167/15.12.1324.
- Barton, Sean L., Jonathan S. Matthis, and Brett R. Fajen. "Walkers Use Visual Information about Distance between Target Footholds to Initialize the Upcoming Step." *Dynamic Walking*, 2015.
- Fajen, B. R, Sean L. Barton, and Jonathan S. Matthis. "Visual Information for the Control of Walking over Complex Terrain." *Journal of Vision* 15, no. 12 (2015).
- Matthis, Jonathan, Sean Barton, and Brett Fajen. "Visual Control of Precise Foot Placement When Walking over Complex Terrain." *Journal of Vision* 13, no. 9 (July 2, 2013): 121–121. doi:10.1167/13.9.121.
- Matthis, Jonathan, Sean Barton, and Brett Fajen. "The Critical Period for the Visual Control of Foot Placement in Complex Terrain Occurs in the Preceding Step." *Journal of Vision* 14, no. 10 (August 3, 2014): 3–3. doi:10.1167/14.10.3.