Section II – Sponsor and Co-Sponsor Information

A. Research support available

Jonathan Samir Matthis, Sponsor

ACTIVE

R00-EY028229 (PI: Matthis)   07/2019 – 07/2022   1.0 Academic

NIH/NEI $249,000

RO1 EY05729-31 (PI - Hayhoe; co-I Ballard)   07/2019-07/2024   1.5 summer

NIH/NEI $249,000

NORTHEASTERN STARUP FUNDS   07/2019-07/2024 $505,228.00

B. Sponsor's/Co-Sponsor's Previous Fellows/Trainees

Sponsor's Previous Trainees

None

Co-Sponsor's Previous Trainees (Peter Bex)

Trainee Category	Number Supervised
Post Doctoral Associates	17
Pre Doctoral trainees	7

Co-Sponsor (Peter Bex) Example Trainees

Name	Category	Dates	Present organization	Present Position
Dr Ankoor Shah	Pre doc	96-98	Boston Children's Hospital; Harvard Medical School	Assistant Professor of Opthamology
Dr Michael Chiang	Post Doc	00-01	Oregon Health Sciences University	Knowles Professor of Ophthalmology and Medical Informatics and Clinical Epidemiology
Dr Sjoukje Loudon	Post Doc	07-08	Erasmus MC, University Medical Center, Rotterdam	Assistant Professor
Dr Christian Salgado	Post Doc	07-08	Pontifical Catholic University of Chile	Professor and Chair of Opthamology
Dr Mary Whitman	Post Doc	2013-2017	Boston Children's Hospital; Harvard Medical School	Instructor in Opthamology (Mentored K Grant)

Co-Sponsor's Previous Trainees (Dagmar Sternad)

Trainee Category	Number Supervised
Post Doctoral Associates	17
Pre Doctoral trainees	14

Co-Sponsor (Dagmar Sternad) Example Trainees

Name	Category	Dates	Present organization	Present Position
Kunlin Wei	Pre Doc	00-02	Peking University, China	Professor in Psychology
Masaki O. Abe	Post Doc	07-10	Hokkaido University, Japan	Associate Professor
Christopher J. Hasson	Post Doc	09-12	Department of Physical Therapy, Northeastern University	Assistant Professor
Hiromu Katsumata	Post Doc	97-02	Daito Bunka University, Tokyo, Japan	Professor
Se-Woong Park	Post Doc	14-19	University of Texas, San Antonio	Assistant Professor in Kinesiology, Health and Nutrition

C. Training Plan, Environment, Research Facilities

Training Plan

Trenton Wirth is completing his graduate training at Brown University under the supervision of Dr. Bill Warren, where is studying cognitive science with a focus in perception and action. Trenton's dissertation work focuses on the self-organization of human crowds, where the complex global patterns of crowd behavior are explained by the local, perceptual interactions between neighbors. In his study of human crowds, Trenton has gained extensive experience implementing psychophysically inspired experiments in large, walkable virtual environments where participants engage with tightly controlled displays of virtual crowds in various scenarios. Trenton uses his virtual reality experiments to improve and develop his labs behavioral dynamics model of human crowd behavior. This model is then used to simulate trial-by-trial predictions within the virtual reality studies. The model is additionally used to generalize to the simulation of real human crowd behavior. Trenton has experience analyzing rigid body motion capture data from real human swarms collected from large gymnasium-like motion capture spaces, where hypotheses tested in virtual crowds can be similarly tested in shorter experiments with many people. This three-pronged approach of empirical examination, model development and simulation, and the generalization to real world behavior is commonly referred to as the modelling cycle in the animal collective behavior literature. Trenton's experience implementing the modelling cycle in the study of human crowd behavior is a critical component of his training at Brown, and it is part of what he brings to the table in this proposal, applying the same intellectual rigor to the study of the visuo-locomotor system.

Trenton's passion for perception and action as well as his intuition for how to navigate interdisciplinary spaces (spanning animal collective behavior and vision science) has led him to arrange a post-doctoral position with me in the Human Movement Neuroscience Lab at Northeastern University starting in the Fall of 2020. Trenton plans to take his knowledge of how to investigate complex perception and action systems and apply it to the study of the visuo-locomotor system, with specific interest in how visual search for footholds is shaped by the influence of biomechanical information during locomotion. Trenton already brings a deep understanding of experimental design in walkable virtual spaces. His empirical intuition proved instrumental in designing the experiments for this proposal. His understanding of complex perception and action systems has also influenced his desire to receive training in measuring visuo-locomotor behavior in natural environments. With my guidance, alongside his selected co-sponsor experts in vision science (Dr. Peter Bex) and motor control (Dr. Dagmar Sternad), Trenton will receive the comprehensive training he needs to successfully achieve the aims proposed.

To guide Trenton in his transition from a senior graduate student to an independent interdisciplinary scientist, we have assessed his abilities with respect to five different skill areas 1. Scientific scholarship, 2. Research methodologies, 3. Communication skills, 4. Mentorship and teaching, 5. Scientific professional service. In the preparation for this grant, Trenton, the co-sponsors, and I have identified specific goals for Trenton's training with respect to two pertinent domains of research: A. Visual Neuroscience and B. Biomechanics. As a part of his mentoring plan, the four of us will meet twice a year and discuss Trenton's progress and provide feedback for development. In these meetings, Trenton will express his long-term career goals, recent accomplishments, and plans for the next six months. The co-sponsors and I will advise and support Trenton in establishing realistic and achievable goals in this time frame.

Scientific Scholarship. A critical component of this mentoring plan is developing Trenton's interdisciplinary expertise. Trenton's already versatile training in perception and action has prepared him with a deep understanding of coarse perception and action behaviors (full rigid body motion capture and measurement of head turns and body trajectory), and it is the aim of this mentoring plan to develop his expertise in both perception (visual neuroscience; *Training Objective 1*) and action (motor neuroscience; *Training Objective 2*) such that he can develop his expertise in *fine* perception and action research (eye tracking and measurement of full body kinematics). Given that both visual and motor neuroscience are relatively new to Trenton's scientific training, he will receive instruction and reading material from the co-sponsors in each of their respective fields, and audit courses to develop his expertise of visual and motor neuroscience. With Dr. Peter Bex – an expert in visual neuroscience – and Dr. Dagmar Sternad – an expert in motor neuroscience – Trenton will receive world class training on each side of his interdisciplinary journey, bringing them both together in our lab space conducting scientific research of the visuo-locomotor system of the highest quality.

Research Methodologies. Trenton will receive specific instruction from me on the implementation of binocular mobile eye trackers in both indoor laboratory spaces as well as unconstrained, natural outdoor environments. This training will include tutelage in the proper placement and orientation of the camera in order to get viable images of the eye. Trent will learn to practice on himself, as well as other members of the lab. He will also receive training in the proper calibration of an eye tracker (using various standard and non-standard methods). In the process of this training, he will gain familiarity with computational video analysis techniques (using Matlab and Python versions of the Open Computer Vision (OpenCV) toolbox. This familiarity will allow him to understand the inner workings of his eye trackers. He will also be encouraged to develop his own eye tracking methodologies, when appropriate.

		Developing -> Independent				
	Skill	**1**	**2**	**3**	**4**	**5**
Scientific Scholarship	Perception & Action				▓	
	Visual Neuroscience		▓			
	Motor Control		▓			
Research Methodology	Experimental design in virtual reality				▓	
	Eye Tracking	▓				
	Motion Capture		▓			
Communication Skills	Data Visualization				▓	
	Oral Presentation			▓		
	Manuscript Preparation		▓			
Teaching and Mentoring	College-level class teaching		▓			
	Mentoring Students in Research		▓			
Professional Service	Responsible Conduct of Research			▓		
	Academic Service		▓			
	Peer Reviewing	▓				

As part of this training, Trent will also gain experience in full-body biomechanical analysis of human movement. Although Trent has worked with motion capture before, he has not yet learned how to analyze full-body kinematic (mocap) and kinetic (force plate) data to investigate low-level mechanical aspects of human movement, such as the joint torques that facilitate movement through the world.

Trent's training in eye tracking and full-body motion capture will come together as he learns to integrate these two data types to re-construct subjects' body-relative gaze behavior in the activities described in Aims 1 and 2. He will perform this integration under the guidance of Dr Matthis, using techniques developed in his lab. The lab based experiments in Aims 1 and 2 will provide the applicant with the skills and background he will need to complete the more technically difficult outdoor research activities described in Aim 3. Again, these activities will take place under the guidance of Dr Matthis, and will involve extensive self-testing prior to the recruitment of non-lab research participants.

Communication Skills. Trenton's eclectic intellectual background combines theory from vision science, animal collective behavior, and behavioral dynamics. This has led him to present his research to a wide variety of audiences: over the past five years Trenton has presented four times at the Vision Sciences Society conference (three posters and one talk), a poster presentation at the Institute for Computational and Experimental Research in Mathematics conference, and a co-authored book chapter describing crowd dynamics and their study to an audience of safety engineers. In his training at Northeastern, we will continue to develop Trenton's oral communication skills where he will present first author oral presentations at a variety of conferences (VSS, AMAM, SFN, Dynamic Walking, & SicB) where he can simultaneously grow his understanding of visual neuroscience (*Training Objective 1*) and motor neuroscience (*Training Objective 2*). Additionally, the proposed research will also serve as an opportunity to prepare at least three first author manuscripts, where he will receive the guidance from myself and the co-sponsors, who all together have experience and success at communicating scientific findings in visual neuroscience, motor neuroscience, and the visual control of locomotion.

Mentorship and Teaching. Another critical component of Trenton's training will be providing him opportunities to mentor junior scientists. As an early post-doctoral associate of the Human Movement Neuroscience Lab, Trenton will have the opportunity to mentor, manage, and assist in the hiring of undergraduate research assistants and co-op students from the highly regarded Northeastern University co-op program. In the preparation for this proposal, Trenton has already attended virtual lab meetings and scheduled his own virtual lab meetings with current co-op students, guiding them through the process of establishing the Augmented Reality environment for psychophysical experimentation. Additionally, as the only other scientist in the lab, Trenton's insight and mentorship will be invaluable in the education and scientific shaping of incoming graduate students. Finally, Trenton will have the opportunity to guest lecture on perception and action (his primary expertise) in relevant sections within my courses. In general, Trent will be involved with the development of the teaching syllabus of the classes that I teach, in order to provide him with the experience he will need in his future career as an educator.

Professional Service. Further development of professional skills is the final area of focus. As a student supported for three years from his PhD advisors' grants from the National Science Foundation, Trenton has received regular training in the Responsible Conduct of Research. In this time, he has learned a great deal about research ethics with respect to human subjects, data management, scientific reporting, intellectual property, and healthy mentor-mentee relationships. Having already established a high value and respect for RCR in universities, Trenton will seek out RCR workshops offered at Northeastern in line with NIH principles, and additionally use this as an opportunity to remain on top of the best practices for mentors and mentees. Additionally, Trenton will be encouraged to engage and assist in the organizations of the many journal clubs and seminar meetings organized at Northeastern, such as Dr. Peter Bex's journal club in Vision Science, and Dr. Dagmar Sternad's Boston-renowned Boston Action Club, hosted at Northeastern. Finally, this proposal will open the door for Trenton to gain experience in peer review of scientific manuscripts, as the sponsor will invite him to contribute toward peer review requests that he and the lab receives.

Environment

The sponsor is a new professor at Northeastern and is still building his lab. As such, the applicant will have ample opportunity to see what life is like for a new PI and gain valuable hands-on experience in the establishing a new lab. In addition, the applicant will work closely with the two co-sponsors, each of whom are established leaders in their respective fields and have vibrant and diverse labs of their own. The applicant's

experience working with PIs at various career stages will provide valuable training in preparation for his own career as an independent researcher.

Research Facilities

All experimental studies with healthy human subjects will take place in the so-called BIG lab shared by Dr Jonathan Matthis and Josh Stefanik located in Richards Hall at Northeastern University. Housed in Richards Hall on Northeastern's main campus, the Action Lab has an approximate space of over 3,100 sqft dedicated to the study of full-body human movement. This lab has state-of-the-art 31-camera Qualisys motion capture system providing over 140m^2 of usable full-body capture volume within a 7.6m x 18.5m area, 5 AMTI 400600 force plates, and a FLOAT multi-directional active bodyweight support system, a Bertec instrumented spilt treadmill, several Pupil Labs mobile eye trackers and a Delsys wireless EMG system. The labspace also includes a lockable exam room that be used for confidential conversations and secure storage of sensitive documents.

Northeastern University offers formal training in responsible conduct of research, grant preparation, manuscript preparation and provides training for effective methods for giving research and teaching seminars. Trent will be encouraged to attend these courses as part of her tenure at Northeastern University. Trent will have no mandatory teaching requirements and she will have no clinic commitments. However, he will be encouraged to give occasional lectures, seminars and tutorials for graduate and undergraduate students. Trent will also be encouraged to participate in the seminars organized by the two co-sponsors - The Northeastern Vision Club (Bex) and the Boston Action Club (Sternad)

D. Number of Fellows / Trainees to be Supervised During the Fellowship

Counts (Including Applicant)	Sponsor's Current Trainees	Co-Sponsor's Current Trainees
Post Doctoral Accociates	0	5
Pre Doctoral Trainees	0	9

E. Applicant's Qualifications and Potential for a Research Career

Trenton Wirth has great potential as a perception and action scientist. He is a brilliant experimentalist who has leveraged his training at Brown University to develop a deep understanding of complex systems, emboldening his research endeavors to address difficult questions that others might shy away from. Trenton has a deep intuition for the connectedness of perception and action as *one* system, this intuition stems back to his education as an undergraduate student at the University of Cincinnati. His intuition for perception and action makes him well suited to tackle the difficult interdisciplinary work of pulling the threads between visual and motor neuroscience. On top of his intuition and his expertise in experimental design, it is his passion for this subject that drives him toward success. Trenton communicates this enthusiasm in the classroom, having received high ratings from his teaching assistant reviews from both students and professors. Additionally, and perhaps most importantly, Trenton has demonstrated that he is a kind and thoughtful mentor to undergraduate students and junior graduate students within his department at Brown.

Trenton has achieved a great deal in his time at Brown University and will be defending his doctoral thesis two months after this proposal has been submitted. In his time at Brown, Trenton has mastered skills in experimental design for large scale virtual and real world environments, behavioral dynamical modeling, and the simulation of perception and action behaviors – all of which will be invaluable to him in his career as a perception and action scientist. As an ABD graduate student, Trenton has an impressive history in scientific communication, having presented four posters and one first author talk at two different conferences, as well as one co-authored book chapter publication, where he communicated his methodological expertise in the study of crowd behavior to an engineering audience. Trenton's ambitious ideas and creative spirit have been recognized through financial award. Trenton's final year of graduate school has been supported by the Link Foundation Modeling Simulation and Training Fellowship. In 2018, Trenton and his lab were one of the three winning teams in the Brown University Hyundai Visionary Challenge, where he and his lab mates were awarded for their design of a research program to study the perceptual control of flying cars.

Trenton's career interests, however, are much more grounded in the important problem of understanding human mobility and its connection to the perceptual system. A person's ability to independently move through their environments is vital to their quality of life, and there is incredibly little known about the connection between visual and motor neuroscience during locomotion to support an understanding of how visuo-locomotor behavior might be affected by retinal (or motor) diseases. There is a desperate need for scientists with interdisciplinary training to tackle the study of perception and action problems which are of great interest to public health and wellbeing. Trenton is uniquely positioned both with his training in perception and action from Brown and the proper resources and environment at Northeastern to become this scientist that is so vital to progress in visual and motor neuroscience.