. **Innovation[X] 2021-2022 Proposal Application**
The School of Innovation and Innovation Partners are calling for proposals for the next round of our Innovation[X] Program, which provides grants that allow multidisciplinary teams of faculty, undergraduates, graduate students, and postdocs to work together to address complex real-world challenges.

Faculty may apply for grants of up to **$20,000** to facilitate year-long projects. The number of grants to be awarded will depend on funding and application levels. Funding begins September 1, 2021.

Additionally, we have partnered with the Mays Innovation Research Center to fund a set of proposals to study the process of innovation itself. Successful proposals for this subset will pursue topics such as, barriers to or preconditions for innovation, the effects of law and policy on innovation, the behavior or psychological requirements for innovation, innovation and health, the social impacts of innovation, international comparisons of innovation, or novel measurements of innovation.

Proposals are due by 11:59 PM on our **newly extended** deadline of **February 22, 2021** and must be submitted using this online form.

NOTE - Only one team leader/faculty member needs to submit a proposal for a given project.

Reminder of Requirements:

- Teams must consist of an interdisciplinary set of faculty members, and must include two (2) faculty members from different colleges/schools.
- Teams must include a multidisciplinary team of 10-20 students, both undergraduate and graduate, from across the university.
- At least 8-10 of these students must be undergraduates.
- The team must include students from at least two (2) different colleges/schools.
- Students must participate in the project for both Fall 2021 and Spring 2022 semesters, with limited exceptions.
- Proposals should demonstrate a team-based approach to a complex problem and include meaningful deliverables.

Please contact Assistant Director Emily Finbow at innovationx@tamu.edu or 979-862-6071 with questions.

. For which tracks would you like your proposal to be considered?

- ○ Track A - Traditional Innovation[X] Project
- ○ Track B - Special Track - "Process of Innovation" Innovation[X] Project
- ◉ Both Track A and Track B

. Project Title

Human brain processes during complex locomotor navigation

. *Please provide the following information for the Primary Point of Contact for the Project (Project Leader)*

. Prefix

Dr.

. First Name

Andrew

. Last Name

Nordin

. Email Address

nordina@tamu.edu

. Phone Number

702-201-7764

. Gender Identity

- (selected) Man
- Woman
- Trans Man
- Trans Woman
- Genderqueer
- Non-Binary/Gender non-conforming
- Not listed above, please specify
- Prefer not to respond

.
Ethnic and Racial Identity

- Hispanic/Latino/a/x
- American Indian or Alaska Native
- Asian/Pacific Islander/Desi-American
- Black/African American

- (selected) White
- Bi-racial / Multi-Racial (please specify): [ ]
- Not listed (please specify): [ ]
- Prefer not to respond

. Project Information

. Please provide brief background/context for the issue this project seeks to address. (2,000 character maximum)

This project leverages innovative methods for imaging the human brain during walking to better understand how multisensory processing occurs during real-world locomotor behaviors. Next-generation mobile brain imaging technologies will be developed and integrated with methods to track eye gaze behavior and human movement dynamics while exploring complex, realistic environments in immersive virtual reality. Navigating complex environments is part of daily human life, yet we understand surprisingly little about how the brain is able to maintain dynamic balance during gait while multitasking and managing sensory feedback from sight, scent, and sounds in the environment. Distributed parallel brain processes are therefore necessary for basic locomotor control, spatial navigation, and cognition, which emphasize a need to study whole brain processes in complex real-world environments. Despite the rich body of scientific literature examining neural control of locomotion, studying brain processes during freely moving behaviors has remained largely prohibited due to technical limitations. The limited availability of neuroimaging methods suitable for measuring neural dynamics during whole body movement highlights a need to devise innovative solutions for non-invasively measuring brain activity. Many complementary neuroimaging methods exist, but the portability, millisecond precision, and relatively low cost of electroencephalography (EEG) make it well-suited for studying mobile human brain dynamics. Because ambulatory abilities have substantial influence on quality of life, imaging the brain during gait can help to identify causes of, and possible interventions for, gait deficits due to aging, traumatic injury, stroke, or neurodegenerative diseases. Assistive devices that incorporate brain-computer interfaces are also dependent on the applied knowledge gained from cortical locomotor control studies.

. What are the goals for this project? (5,000 character maximum)

There are three main goals for the project: (1) To develop next-generation wireless technologies for recording high-fidelity electrical brain activity during locomotion, (2) To measure human brain and body dynamics during gait in immersive virtual reality environments, (3) To identify brain structures and electrocortical dynamics during complex, realistic locomotor behaviors. This project introduces hardware and signal processing advancements for capturing high-fidelity electrical brain dynamics during locomotion in real-world settings and will establish best practices for recording and analyzing mobile EEG data during complex locomotor navigation. Mobile EEG innovations have shown it is possible to study human brain processes during gait when appropriately eliminating signal contaminants due to electrode and cable motions. Advancing mobile EEG data collection and signal cleaning methods using next-generation sensor configurations and wireless recording technologies provides a unique opportunity to enhance real world neuroimaging capabilities. By establishing new state of the art methods, the project provides a platform to transform the capabilities of cognitive and motor neuroscience studies. Because naturalistic behaviors frequently require object avoidance and interception during locomotion, our aim is to measure human brain and body dynamics during these tasks. Encountering objects to circumvent or step over and targets to reach or intercept occurs during daily activities that span grocery shopping to competitive sports. Multisensory processing is required to maintain awareness of external goals and dynamic objects in the environment. By studying human electrocortical activity while subjects walk within immersive virtual reality, it is possible to better understand sensorimotor and cognitive processes that dynamically interact during daily life. Immersive virtual reality has become increasingly common in gaming, training simulations, and rehabilitation settings because of the nearly unlimited possibilities for generating customized environments and scenarios. Combing treadmill-based immersive virtual reality with mobile high-density EEG recordings allows us to study human brain processes in settings ranging from simple to complex. By creating virtual environments that can be explored through self-paced treadmill locomotion, we are able to investigate human brain dynamics during spatial navigation while systematically introducing visual and auditory stimuli, and mechanical perturbations through continuously adjusted terrain via the treadmill. We will use novel mobile EEG recording and data processing methods to study independent and interactive brain processes during locomotion, object avoidance, interception, and spatial navigation while introducing competing sensory stimuli in complex virtual environments. We will track eye movements and gaze behavior to precisely pinpoint visual target identification using portable wireless eye tracking equipment worn as conventional eyeglasses with four onboard cameras. We will also record full body biomechanics using motion capture and ground reaction forces from a dual belt force measuring treadmill. Deciphering basic locomotor control from multisensory processing and multitasking can help to uncover the neural underpinnings of complex, real-world navigation. We will identify the cortical structures and electrocortical dynamics involved in basic human locomotion, including visual target identification, motion tracking, step sequencing, and foot placement, in addition to auditory, somatosensory, and vestibular processing during gait. Outcomes from the project will include groundbreaking data recording and analysis methods that will provide unprecedented insight into human brain and body dynamics during complex locomotor behavior. Knowledge gained from these unprecedented experiments will also help to generate next-generation neurotechnologies.

. What are anticipated outcomes from this project? (e.g., publications, website, app, data collection for further research/grant) (2,000 characters maximum)

During the project, we will develop methods for recording high-density mobile EEG together with eye gaze behavior and human movement biomechanics. We will also create immersive virtual reality environments integrated into a treadmill-based setup that is installed in many gait labs around the world. This technical work will lead to papers published for the purpose of sharing equipment configurations and data processing steps. Students will produce instructional videos that will be shared via our laboratory websites. These methods will provide the foundation for conducting human subject testing outside the lab using completely wireless and portable recording equipment. The long-term goal of the proposed 4-year project, currently under review with the National Science Foundation, is to measure human brain and body dynamics during a real-world soccer game. Here, we provide the technical capabilities to make this possible. If our NSF proposal is funded, this Innovation-X proposal will fund 9 undergraduate students to work alongside three NSF-supported graduate students. If unfunded by NSF, these data will be incorporated into a future proposal. Students working on the project will submit abstracts for presentation at the Texas A&M Institute for Neuroscience Annual Symposium. Our research findings will lead to several impactful publications aimed at identifying human electrocortical dynamics during locomotor navigation in immersive virtual reality environments. Following manuscript acceptance for publication, raw EEG, eye-tracking, and biomechanical subject data will be uploaded to PhysioBank, an archive for physiological recordings. With access to these data, the research community will be able to test additional hypotheses about locomotor navigation that will enhance the value of the dataset outside of the proposed project. PhysioNet is supported by the National Institute of General Medical Sciences and the National Institute of Biomedical Imaging and Bioengineering.

. Is this proposed project an extension of existing work or a new endeavor? (1,200 character maximum)

This research builds upon mobile EEG hardware and signal processing innovations developed by Dr. Nordin to study human brain and body dynamics, but the project is a new endeavor that utilizes recently acquired equipment to study human biomechanics and motor neuroscience. The project is part of larger 4-year proposed study under consider by the National Science Foundation's Integrative Strategies for Understanding Neural and Cognitive Systems initiative. High-density mobile EEG, eye-tracking, three-dimensional motion capture, force measurements, and projected virtual reality will be integrated to study how the human brain processes multisensory information while navigating complex, realistic environments with obstacles to avoid, objects to intercept, and external landmarks to reach. The project will provide insight into dynamic brain processes in freely moving humans that have never been measured before. Using state of the art high-density mobile EEG methods for recording high-fidelity electrical brain activity during movement, we will conduct groundbreaking research that provides training opportunities for three doctoral students and nine undergraduate research assistants.

. Is Institutional Review Board (IRB) approval required for this project?

Yes

. *Team Participants*

. Please list all Team Leaders below (including yourself), including Prefix, Name, Title, and Department/School.

Dr. Andrew Nordin, Assistant Professor, Healthy & Kinesiology Dr. Heather Burte, Research Assistant Professor, Psychology & Brain Sciences

. Do any of the team leaders listed above have plans for a sabbatical or other extended leave away from campus during the 2021-22 academic year? Note: Selecting "yes" will not automatically disqualify a team, but rather will indicate that we need to have a discussion with your team about the nature of the planned leave in relation to the project.

No

. Please list all Team Contributors below, including Name, Title, and Department/School. *Please exclude anyone you already listed as a Team Leader.*

Dr. Ann McNamara, Assistant Professor, Visualization

. Do you plan to assign someone other than a faculty leader as a “project manager” for your team (i.e., a graduate student, postdoc, staff person)?

- (•) Yes
- ( ) No
- ( ) Not sure yet

. What would be the ideal composition of team members for this project? What majors, disciplines, skills, backgrounds, or perspectives would you like to have on the team? (2,000 characters maximum)

In alignment with the multidisciplinary nature of the project and the affiliations of the faculty team leaders and contributor, Drs. Nordin, Burte, and McNamara, our ideal research team will span disciplines including neuroscience, kinesiology, psychology, biomedical engineering, computer science, and visualization. Based on the structure of the project, with three technical challenges and three main goals, we will aim to match the background and skillset of each undergraduate research assistant with a project component focused on (1) mobile EEG and biomechanics, (2) eye-tracking, or (3) immersive virtual reality. Doctoral student, Seongmi Song has experience analyzing mobile EEG and biomechanics data and has created data processing pipelines in MATLAB. Undergraduate students working closely with Dr. Nordin and Song will ideally have backgrounds in biomedical engineering, neuroscience, biology, kinesiology, electrical engineering, or computer science, with familiarity in human physiology, anatomy, biomechanics, neuroscience, and/or MATLAB coding. Doctoral student Sungjoon Park has experience collecting and processing eye-tracking data and is currently conducting research in Dr. Burte’s lab. Undergraduate students working closely with Dr. Burte and Sungjoon will ideally have backgrounds in psychology, neuroscience, biomedical engineering, or computer science, with familiarity creating data analysis scripts in MATLAB, eye-tracking, spatial navigation, neuroscience, and/or human vision. Doctoral student, Scott Phillips has data analysis experiences in biomedical engineering and is currently finalizing work with a research team at University of California, San Diego. Undergraduate students working closely with Drs. Nordin and McNamara, and Scott will ideally have backgrounds in biomedical, electrical or mechanical engineering, computer science, or visualization, with familiarity creating 3D renderings, coding, biomechanics, and/or virtual reality.

. Will your team also include any external organizations or individuals as either partners, clients, study subjects, beneficiaries of the work, etc.?

No

. *Travel*

. Does your proposal include travel for students beyond Bryan/College Station?

- ( ) Yes
- (•) No
- ( ) Not sure yet

. Where would the team travel?

N/A

. When do you anticipate that this travel would take place? (e.g., Fall 2021, Spring 2022, some other academic break, TBD)

N/A

. Do you expect that all students selected for the team would be able to travel, or just a select number?

N/A

. *Collaboration with Students*

. Ideally, how many undergraduate students would you select to participate on this team? (Numeric responses only, please)

9

. Ideally, how many graduate students would you select to participate on this team?

0

. Ideally, how many professional or doctoral students would you select to participate on this team?

3

. How will you facilitate collaborative inquiry on the team? How often and in what format will the team meet? How will you divide tasks? How you will ensure effective management of the project (e.g., appoint a student as a project manager, assign that role to a faculty leader, etc.)? (2,500 character maximum)

Because the project has three primary technical components that will be integrated to study human brain processes during complex locomotor navigation, we will rely on the expertise of each faculty member and their graduate students to complete the collaborative project. We will develop and use novel sensor and signal processing methods developed in Dr. Nordin's lab and managed by doctoral student Seongmi Song. By recruiting undergraduate students from Kinesiology, Neuroscience, and Biomedical Engineering, we will assemble a team of 3 undergraduate research assistants to fabricate high-density electrode arrays that will be used during human mobile EEG data collections. Using this setup, we will study electrical brain activity and monitor eye gaze behavior from eye-tracking equipment worn as glasses by the human subjects. Supervised by Dr. Burte, doctoral student Sungjoon Park will test the eye-tracking equipment during seated computer-based spatial exploration together with his team of 3 undergraduate research assistants recruited from psychology, biomedical engineering, and neuroscience. This team will calibrate the eye-tracking equipment and carry out preliminary testing by synchronizing the mobile eye gaze recording hardware with the mobile EEG equipment. Treadmill-based three-dimensional spatial navigation will take place in an immersive virtual reality environment created by an interdisciplinary team managed by Dr. Nordin's doctoral student Scott Philips and 3 undergraduate students from biomedical engineering, visualization, and computer science. Working together with Drs Nordin and McNamara, Scott, and his team of undergraduate assistants will develop the three-dimensional environments that will be integrated into the projected virtual reality system in Dr. Nordin's lab. Doctoral student project managers will meet with the undergraduate research assistants weekly, if not daily, while completing the project. Doctoral and undergraduate students from each project component will meet with their respective faculty advisors on a weekly basis in person or virtually via Zoom. On a biweekly basis, the three groups will meet together in person or through Zoom to discuss project progress, including technical challenges on each project component and collaborative efforts while preparing to conduct human data collections, data processing, analysis, and manuscript submission.

. What might students gain from their participation (e.g., conducting research directly with subjects, contributing to publications, using language skills)? What unique and differentiated learning opportunities would be available for graduate students? (2,500 character maximum)

Students will gain hands on experiences configuring, calibrating, testing, and obtaining written informed consent prior to collecting human subject testing using research equipment in a traditional biomechanics gait lab. Specific projects components will also require hardware and software testing, data stream synchronization, coding, and troubleshooting of mobile EEG, eye-tracking, and virtual reality equipment. Because we will form three collaborative groups tasked with completing specific project components, each doctoral student will gain valuable experience mentoring and managing a team of undergraduate research assistants. Each student will have opportunities to share progress and technical knowledge gained during the experimental setup and preliminary findings from human data collections that include mobile EEG, movement biomechanics, and eye gaze recordings during locomotor navigation in virtual reality. Support from the award will provide crucial opportunities for three academic trainees pursuing PhD degrees and nine undergraduate research assistants in disciplines that span motor neuroscience, psychology, kinesiology, computer science, visualization, and biomedical engineering. The project will deepen each student's studies on human locomotion, multisensory processing, spatial navigation, virtual reality, and biomedical sensor development. The knowledge gained from these experiences will be a critical step in their academic growth. As a group, we will circulate weekly literature updates via email to foster discussion and to encourage students to critically assess scientific papers on the topics of biomechanics, neural engineering, and motor neuroscience. Group meetings will be valuable opportunities to present scientific findings to a broad audience based on the academic diversity represented within the research team. Students will work together to prepare results for presentations and publications, with a short-term goal of the students submitting abstracts for presentation at the Texas A&M Institute for Neuroscience 13th Annual Symposium, typically held in April. Students will also gain experiences with the peer review process when preparing written documents and figures for scientific publications.

. *Timeline and Budget*

. Identify the timeline for the project, including start, completion and major project milestones.

NOTE - You may use the text box or upload a table or file in the next question.

. Timeline Upload (if needed)

Project_Timeline.png
98KB
image/png

. Total Budget Request (numeric response only, please). As a reminder, the maximum amount that can be requested is **$20,000.**

19900

. You may upload a budget table here encompassing the categories below, or you may complete the fields below through this form as applicable.

For each item listed below or on your budget table upload, please enter both dollar amount and any relevant notes/justification.

Budget.png
33.8KB
image/png

. GRADUATE OR RESEARCH ASSISTANTSHIP (PHD) *(Suggested range: $15-18/hour; note: RAships for students in graduate school should include costs for tuition remission and fees)*

. RESEARCH ASSISTANTSHIP *(Suggested range: $12-15/hour)*

. INSTRUCTION (Teaching) - PHD STUDENT

. POST-DOCTORAL OR STAFF EFFORT

. UNDERGRADUATE STUDENT STIPEND OR WORK STUDY *(Suggested range: $11-14/hour)*

9 undergraduate students, $14/hour, 5hours/week, 30 weeks total

. INSTRUCTIONAL, RESEARCH OR OFFICE SUPPLIES

. COMPUTERS AND MINOR EQUIPMENT

. TRAVEL - DOMESTIC

. TRAVEL - INTERNATIONAL

. CONTRACT WORK

. MEETINGS - BUSINESS

. OTHER - MISC.

$1000 consumable supplies (conductive gel, elastic wrap, plastic tip syringes)

. Please briefly note below any other sources of project funds. *(Projects that match or leverage additional funds are strongly encouraged. Please note any such funds, awarded or proposed, here so that we understand the comprehensive outlay for the project.)*

The project provides hands on experiences for undergraduate student research assistants participating in a proposed 4-year study currently under review with the National Science Foundation through the Integrative Strategies for Understanding Neural and Cognitive Systems initiative. Drs. Nordin (PI) & Burte (Co-PI) submitted the research proposal to fund three doctoral students throughout the project that is aimed at better understanding human brain processes during complex locomotor navigation in virtual and real-world environments. Total costs for the project total $995,847 to cover graduate student and faculty salaries, human subject payments, conference attendance and travel, and to purchase new eye-tracking equipment for measuring eye gaze behavior during human spatial navigation. This Innovation X proposal, if funded, will provide financial support to pay undergraduate student research assistants who will work closely with the faculty mentors and doctoral students to conduct groundbreaking multidisciplinary human neuroscience research.

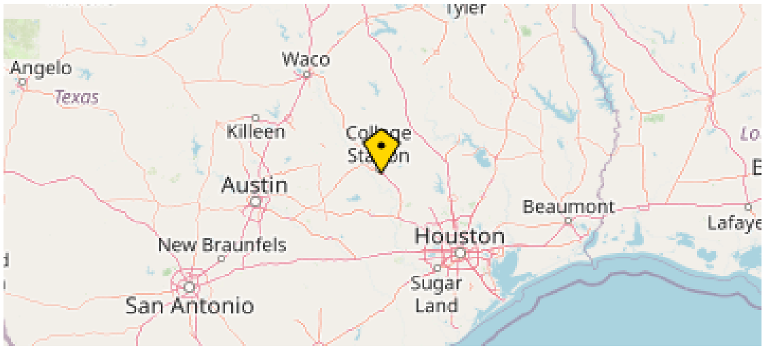
. Please name a Unit/Business Manager who could administer funds for project, if requested. Include their name, email address, and phone number:

Kelly Freeman, kelly-freeman@tamu.edu, 979-845-3456

Location Data

Location: (30.547805786133, -96.271499633789)

Source: GeoIP Estimation



Fall 2021

Weeks 1-5 (Aug. 30 - Oct. 1)

Group introductions, project description, graduate/undergraduate team assignment, literature review, hardware and software introductions and tutorials

Weeks 6-10 (Oct. 4 – Nov. 5)

Hardware and software configuration and synchronization, script development, benchtop testing

Weeks 11-15 (Nov. 8 - Dec. 10)

Hardware and software troubleshooting, review IRB documents to understand informed consent process, human subject pilot testing and recruitment

Spring 2022

Weeks 1-5 (Jan. 18 – Feb. 18)

Human subject data collections, data processing pipeline scripting

Weeks 6-10 (Feb. 21 – Mar. 25)

Human subject data collections, data processing and analysis

Weeks 11-15 (Mar. 28 – Apr. 29)

Human subject data collections, data processing, analysis, results preparation, and presentation

9 undergraduate student researchers working 5 hours per week at $14/hour
15 weeks in Fall 2021 and Spring 2022 (30 weeks total).

$18,900 personnel

$1000 consumable supplies (conductive gel, elastic wrap, plastic tip syringes)

Total requested: $19,900