Advancing neuroscience research and education in Northwest Arkansas

Neuroimaging methods allow researchers to see and measure the living human brain. Researchers from diverse backgrounds are flocking to neuroscience to study the roots of human feelings, thoughts, and behaviors. The complexity of the problems in neuroscience inspires researchers to band together across universities to share skills and data. This enthusiasm is bolstered by federal funding initiatives such as the BRAIN Initiative, as well as significant philanthropy across the globe. The University of Arkansas (UA) can join the endeavor by building a neuroimaging center that houses a magnetic resonance imaging (MRI) scanner. The resource would position UA as a scientific and geographic hub between researchers in midwestern and southern states.

Neuroscience integrates researchers across disciplines to address profound questions. The questions in neuroscience are conceptually deep: how can science and technology promote human flourishing and combat disease? The questions are also technical, such as developing novel measurements of the brain, curating and computing large datasets, and disseminating resources and knowledge. Solutions to these problems require collaboration between faculty spanning the liberal arts and physical sciences. A neuroimaging center at UA would cultivate the integrative neuroscience efforts on campus and unify researchers to pursue innovative research.

Innovative research enhances the university's competitiveness for extramural funding. UA is investing heavily in neuroscience research. In the past 8 years, the university hired 10 faculty in the biological, physical, and psychological sciences who study the brain. Together, the faculty formed an Integrative Systems Neuroscience group (https://brainresearch.uark.edu). Their laboratories study human addiction, aging, choice, creativity, development, evolution, learning, memory, motion, and perception; and integrate across animal models. This expertise transforms ethological descriptions of human nature to explanation, prediction, and control. Whereas the faculty are already competitive for extramural grants with the current instrumentation on campus, the addition of an MRI scanner enables laboratories to execute larger and longer grants (e.g., from the NSF Cognitive Neuroscience and Collaborative Research in Computational Neuroscience divisions, and the National Institutes of Health [NIH]).

Successful grant applications to federal institutes combine multiple methodologies, for example, linking measurements of brain structure and function, converging evidence between imaging modalities and across animal species, and testing stimulation techniques on brain and behavior. An exciting example of a recent grant at UA grew from collaboration between Connie Lamm (Co-PI; psychological science), Lindsay Ham (psychological science), Erica Westerman (biological sciences), and Justin Zhan (computer science and data science). They received an R21 from the NIH to study how stress can bias learning processes in ways that lead to substance use disorders.

Neuroscience research extends beyond the academy. An MRI scanner enhances clinical research on neuropsychiatric maladies and disorders marked by addiction. Basic scientists can partner with clinicians at the University of Arkansas Medical Sciences to develop new biomarkers and therapies. Neuroscience also attracts partners with commercial interests. Human neuroimaging produces data previously inaccessible to consumer and pharmaceutical industries. Inventions stimulate economic growth by improving the efficacy and availability of products. Critically, clinical and commercial applications generate grants and revenue which cycle to support basic research.

A neuroimaging center will also enhance undergraduate, graduate, and postdoctoral education at UA. The acquisition and analysis of MRI data requires a unique synthesis of skills. For example, detailed consideration of space and time in experimental design, computer programming, statistical analysis, and clear communication. These skills poise students to flexibly compete in job markets that emerging technologies will change in unpredictable ways. The center will offer training in MRI safety and data analysis, and host activities such as seminar series, journal clubs, and graduate teaching assistantships (see **Management and Operation**).

The MRI scanner will additionally complement the courses offered by several departments at UA. For example, psychology courses can study links between the brain and the constructs previously accessible only by self report and peripheral physiology. Biology courses can examine homologies between human and animal brains. Physics students will see real-world applications of spectroscopy and magnetic resonance. Computer scientists and statisticians can apply their techniques on data about brain structure and function. Students pursuing business and entrepreneurship can explore commercial applications. Artists can design immersive virtual realities for experiments and work creatively with brain visualizations.

A neuroimaging center benefits not only UA, but also its neighboring institutions. External researchers will rely on the MRI scanner to expand their research programs (e.g., laboratories at Arkansas Tech University, Missouri State University, University of Arkansas at Fort Smith, and John Brown University). Their usage of the MRI scanner will support its ongoing maintenance (see **Management and Operations**). The neuroimaging center will also help UA researchers to foster collaborations with neuroscientists in neighboring states (e.g., Laureate Institute for Brain Research, Washington University in St Louis, and The University of Texas at Dallas; see **Co-PIs**). The partnerships will establish UA as a hub for research and innovation in the region.

Thus the University of Arkansas can lead in a moment full of problems and possibilities. Neuroscience is growing in size and complexity. International consortia are collecting large neuroimaging datasets and researchers are designing sophisticated methods to analyze the data. These advances pose new technological and logistical challenges. Barriers to the endeavor range from the acquisition of insightful brain data to the faithful dissemination of data, methods, and results. Neuroscience researchers at UA can help overcome these barriers. The establishment of a modern neuroimaging facility with an MRI scanner will position the university to lead in this moment. Laboratories across the university will benefit from an MRI scanner, and the faculty will govern the resource with wisdom from the past and foresight for the future.

NSF BIOGRAPHICAL SKETCH

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POSITION TITLE & INSTITUTION: Assistant Professor, University of Arkansas

(a) PROFESSIONAL PREPARATION

INSTITUTION	LOCATION	MAJOR / AREA OF STUDY	DEGREE (if applicable)	YEAR YYYY
University of California	Berkeley, CA	Psychology	BA	2010
Stanford University	Stanford, CA	Psychology	PHD	2019
Indiana University	Bloomington, IN	Neuroscience	Postdoctoral Fellow	2019 - 2020

(b) APPOINTMENTS

2020 - present Assistant Professor, University of Arkansas, Fayetteville, AR
2019 - 2020 Postdoctoral Researcher, Indiana University, Bloomington, IN
2013 - 2019 Graduate Student Researcher, Stanford University, Stanford, CA
2010 - 2013 Research Associate, University of California, San Francisco, CA

(c) PRODUCTS

Products Most Closely Related to the Proposed Project

1. MacNiven K, Leong J, Knutson B. Medial forebrain bundle structure is linked to human impulsivity. Science Advances. 2020 September 16; 6(38):eaba4788-. Available from: https://advances.sciencemag.org/lookup/doi/10.1126/sciadv.aba4788 DOI: 10.1126/sciadv.aba4788
2. Leong J, MacNiven K, Samanez-Larkin G, Knutson B. Distinct neural circuits support incentivized inhibition. NeuroImage. 2018 September; 178:435-444. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1053811918304725 DOI: 10.1016/j.neuroimage.2018.05.055
3. Seaman K, Leong J, Wu C, Knutson B, Samanez-Larkin G. Individual differences in skewed financial risk-taking across the adult life span. Cognitive, Affective, & Behavioral Neuroscience. 2017 October 23; 17(6):1232-1241. Available from: http://link.springer.com/10.3758/s13415-017-0545-5 DOI: 10.3758/s13415-017-0545-5
4. Ho T, King L, Leong J, Colich N, Humphreys K, Ordaz S, Gotlib I. Effects of sensitivity to life stress on uncinate fasciculus segments in early adolescence. Social Cognitive and Affective Neuroscience. 2017 September; 12(9):1460-1469. Available from: https://academic.oup.com/scan/article/12/9/1460/3778352 DOI: 10.1093/scan/nsx065
5. Leong J, Pestilli F, Wu C, Samanez-Larkin G, Knutson B. White-Matter Tract Connecting Anterior Insula to Nucleus Accumbens Correlates with Reduced Preference for Positively Skewed Gambles. Neuron. 2016 January; 89(1):63-69. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0896627315010880 DOI: 10.1016/j.neuron.2015.12.015

Other Significant Products, Whether or Not Related to the Proposed Project

(d) SYNERGISTIC ACTIVITIES

1. Emotions sway what people see and do. One framework that can link human emotions to perception and behavior is along the axes of affective valence and arousal. Positive and negative arousal are generated in the brain by neuromodulatory systems that innervate not only the cortical circuits that process visual stimuli, but also the subcortical circuits that drive behavioral choices. My laboratory at the University of Arkansas builds tools to measure the structure and function of these circuits, and our current scientific aim is to understand the influence of emotions on perception and choice. I have additional expertise with cloud-computing resources, which helps me to train my research team to conduct innovative and reproducible analyses.

2. Teaching: I taught introductory neuroscience at Stanford University for 4 years. My course included undergraduate, graduate, high school, and international students. Teaching the course was challenging because my students came from different backgrounds, but the experience was useful. I discovered new ways to convey the complex questions that neuroscience can address. As an Assistant Professor at the University of Arkansas, I adapted my introductory neuroscience course for undergraduate students who may have diverse backgrounds and interests. I also teach a graduate course on neuroimaging analysis, which includes a lab component that works with real MRI datasets; and an upper-division undergraduate course on affective science, which introduces students to the empirical study of emotions by tracing linguistic theories to physiological research to emerging synergies between human and animal neuroscience.

3. Postdoctoral Research: I developed a novel research program to study how rewards can enhance visual appearance. The research adapts an established paradigm where covert attention can increase the subjective contrast of stimuli. My experiments will test whether rewards increase the effect of attention on visual appearance, and then attempt to reduce the effect in populations struggling with drug addiction and problematic gambling. I additionally contributed to the Brainlife platform, which hosts neuroimaging analyses in an internet web browser. I analyzed a large diffusion MRI dataset (~2,000 subjects) with whole-brain and targeted tractography analyses. I also built an application on Brainlife for task-FMRI analyses, which allows researchers to reproducibly analyze large datasets.

4. Graduate Research: I discovered a novel white-matter tract connecting the anterior insula to the nucleus accumbens (NAcc) in humans. I found that the tract's structural coherence was associated with reduced NAcc functional responses to risky gambles and decreased gambling behavior. Anatomy can guide psychological models of motivated behaviors. The models should link brain structure to function to behavior, and span levels from physiological measures in animals to neuroimaging measures in humans to computational theories. The full stack can reciprocally provide targets to control motivated behaviors, such as risk taking and addiction.

5. Post-baccalaureate Research: I was a research associate at the University of California, San Francisco Memory and Aging Center for 3 years prior to my doctoral program. I coordinated the Alzheimer's Disease Neuroimaging Initiative (ADNI), an international effort to characterize biomarkers for Alzheimer's disease. I also helped build a database for longitudinal data from 17,000 participants, and I developed tools for biomedical researchers to perform analyses that combined multi-modal neuroimaging data with clinical outcomes, genetics, and peripheral physiology.