



Doctoral Dissertation Defense Announcement

“An Experiential Account of Semantic Category Organization in the Brain”



Stephen Mazurchuk

Candidate for Doctor of Philosophy in Biophysics
School of Graduate Studies
Medical College of Wisconsin

Committee in Charge:

Jeffrey R. Binder, MD (Advisor)
Leonardo Fernandino, PhD
William Gross, MD, PhD
Andrew Anderson, PhD
Sharon Thompson-Schill, PhD (UPenn)

Date: Friday, May 24th, 2024

Time: 10:00 AM (CST)

Defense Location: Bolger Auditorium (H1400)

Zoom: <https://mcw-edu.zoom.us/j/93970319709?pwd=M1h5SVQ4Y3BkeFR2UktuWVYrdlhoZz09>

Meeting ID: 939 7031 9709 Passcode: Semantic

Graduate Studies:

Cognitive Neuroscience

Medical Genetics: Undiagnosed and Rare Disease

Introduction to Precision Medicine

Foundations of Public Health

Artificial Intelligence (at UWM)

Functional MRI Contrast Mechanisms

Nuclear Magnetic Resonance

Ethics and Integrity in Science

Research Ethics Discussion Series

Biophysics Journal Club

Biophysics Seminar Course

Reading and Research

Doctoral Dissertation

Dissertation

“An Experiential Account of Semantic Category Organization in the Brain”

There have been extensive efforts to understand how concepts are represented in the brain. One phenomenon that has received much attention is the loss of knowledge seemingly restricted to a single category of items. This clinical observation, combined with many functional magnetic resonance imaging studies that find differential activation across the cortex depending on the category of the stimuli, has led to a general view of category related functional organization across the cortex. One class of models put forward to explain this phenomenon are experiential models of cognition. These models posit that those regions of the cortex involved in experiencing an object (e.g., perceiving an object) are also involved in representing semantic knowledge about the object. The idea that some perceptual, or *experiential*, information (e.g., color, sound, shape, touch, etc.) is differentially important across categories of concepts, combined with the well accepted view that some regions of the brain preferentially process a particular type of perceptual information, has long been held as a potential explanation for the category related organization of the cortex. However, while this hypothesis has motivated the development of several models of semantic cognition, the ability of a specific experiential model to explain category related organization of the cortex has hitherto not been explicitly examined. Experiential models, like the one examined in this dissertation, propose that, ultimately, all semantic knowledge is grounded in what is experienced.

This dissertation first describes and validates a dataset that is well suited for addressing some of the core predictions of experiential models of cognition. Following data validation, evidence for the categorical organization of the semantic system was found via both univariate and multivariate analysis. Then, encoding models constructed for each point on the cortical surface demonstrated that experiential features can be used to predict both activation category contrasts, as well as activation patterns for individual stimuli across categorical boundaries. It was further observed that the ability of a comparable non-experiential semantic model to generalize across categories is accomplished using the same information that is in the experiential model.

The subsequent chapter examines a relatively understudied yet distinctly represented category of concepts: body parts. We found that a robust network of regions was significantly more involved in the representation of body part concepts compared to concepts from other concrete object noun categories. The implicated set of areas was shown to be predicted by experiential features using several analysis techniques. The distribution of involved regions also provides possible insight as to why semantic representations of body part concepts are often spared relative to concepts from other categories.

Lastly, feature sensitivity maps across the cortex were generated for a set of 14 experiential features. These maps were observed to hierarchically converge as the distance from canonical primary sensory cortices increased. The maps are also individually discussed with reference to prior literature. Results were mixed with regard to how well individual feature maps matched expectations derived from prior literature, and possible reasons for this are discussed.

Taken together, the results of this dissertation offer strong support for many of the core predictions of an experiential account of concept representation.

Stephen Mazurchuk
Curriculum Vitae
smazurchuk@mcw.edu

Education

- 2019 – present Ph.D. Candidate
Medical College of Wisconsin, Department of Biophysics
Advisor: Jeffrey R. Binder, M.D.
- 2017 – 2019 Medical Student (M1-M2)
Medical College of Wisconsin, Medical Scientist Training
Program
- 2013 – 2017 B.S. in Biomedical Engineering
SUNY Buffalo

Research Experience

- 2019 - Present Doctoral Student
Medical College of Wisconsin, Department of Biophysics
Advisor: Jeffrey R. Binder
- 2015 – 2016 Funded Summer Researcher (2 years)
University of Wisconsin – Milwaukee, Department of Physics
Advisor: Peter Schwander, PhD
- 2014 Summer Research
University at Buffalo, Department of Biomedical Engineering
Advisor: Jonathan Lovell, PhD

Publications

1. **Mazurchuk S**, Fernandino L, Tong J, Conant LL, Binder JR. The Neural Representation of Body Part Concepts. *Cereb Cortex*. Accepted
2. **Mazurchuk S**, Conant LL, Tong J, Binder JR, Fernandino L. Stimulus repetition and sample size considerations in item-level representational similarity analysis. *Language, Cognition and Neuroscience*, July 2023. DOI: 10.1080/23273798.2023.2232903
3. Tong J, Binder JR, Humphries C, **Mazurchuk S**, Conant LL, Fernandino L. A Distributed Network for Multimodal Experiential Representation of Concepts. *J Neurosci*. 2022 Sep 14;42(37):7121-7130. doi:

Abstracts

Mazurchuk S, Conant LL, Binder JR, Fernandino L. Artifact concepts are more reliably represented than animal concepts across the cortex. Poster at: Society for the Neurobiology of Language; 2023

Kim S, Binder JR, Tong J, **Mazurchuk S**, Heffernan J. Neural and Experiential Semantic Correlates of the Unergative-Unaccusative Verb Distinction. Poster at: Society for the Neurobiology of Language; 2023.

Tong J, Fernandino L, **Mazurchuk S**, Conant L, Binder J. Category-specific representation of animal, food, tool, and vehicle concepts in the brain. Poster at: Society for the Neurobiology of Language; 2022 Oct 8; Philadelphia, PA

Mazurchuk S, Fernandino L, Tong JQ, Conant L, Binder J. Activation of Speech, Taste, and Visual Scene Experiential Content During Concept Retrieval. Poster at: Society for the Neurobiology of Language; 2022 Oct 8; Philadelphia, PA

Tong J, Fernandino L, **Mazurchuk S**, Conant LL, Binder J. A Shared Representational Code for Object and Event Concepts. Poster at: Society for the Neurobiology of Language; 2022 Oct 8; Philadelphia, PA.

Mazurchuk S, Fernandino L, Tong JQ, Conant L, Binder J. Experiential and Taxonomic Semantic Representations in the Cerebellum. Poster at: MCW Graduate Student Symposium. 2022; Virtual

Fernandino L, Tong J, **Mazurchuk S**, Conant L, Binder J. A Set of Ten Experiential Features Outperforms Taxonomic and Distributional Models in Predicting Neuroimaging and Behavioral Data. Poster at: Cognitive Neuroscience Society; 2022 Jun 1; San Francisco, CA.

Tong J, Fernandino L, **Mazurchuk S**, Conant L, Binder J. A Common Neural Mechanism Underlying Object and Event Concept Representation. Poster at: Cognitive Neuroscience Society; 2022 Jun 1; San Francisco, CA.

Mazurchuk S, Fernandino L, Tong JQ, Conant L, Binder J. An Experiential Basis for Posterior Middle Temporal Gyrus Body Part Concept Representation. Poster at: Cognitive Neuroscience Society. 2022 Jun 1; San Francisco, CA

Tong J, Binder J, **Mazurchuk S**, Humphries C, Conant L, Fernandino L. Event associated experiential features are involved in event representation at brain

regions preferentially representing event concepts. Poster at: Society for the Neurobiology of Language; 2021 Oct 1; Virtual

Mazurchuk S, Fernandino L, Tong J, Humphries C, Conant L, Binder J. The Cortical Representation of Body Part Concepts. Poster at: Society for the Neurobiology of Language; 2021; Virtual

Tong J, **Mazurchuk S**, Fernandino L, Humphries C, Conant L, Binder J. Temporoparietal Specialization for Event Knowledge Demonstrated by Multivoxel Pattern Classification and Representational Similarity Analysis. Poster at: Society for the Neurobiology of Language; 2020 Oct 1; Virtual

Mazurchuk S, Jagtap J, Sharma G, Flister M, Joshi A. Classifying congenic rats from dynamic near infra-red time series images. Poster at: World Molecular Imaging Conference; 2018 Jun 29;

Leadership Development

2021 – 2023	Biophysics graduate student representative
2020 – present	MD-PhD Student Interviewer

Community Involvement

2018 – present	Volunteer – Kinship Community Food Center
2022 – present	Volunteer – UPLIFT Teens
2021 – present	Volunteer – MCW BrainExpo
2020	STEP-UP – MCAT Tutor
2017 – 2018	Volunteer – Saturday clinic for the uninsured
2017 – 2018	Volunteer – Greater Milwaukee Free Clinic