



Investigator: Shalini Narayana, MBBS, PhD **Grant Award Year:** 2022

Amount of PERF[®] Grant: \$300,000

Investigator Institution: University of Tennessee. College of Medicine, Memphis

Project Title: A National Consortium of Pediatric TMS Centers: Creating Infrastructure to Improve Language Mapping and Support Neurosurgical Decision-Making

Project Description: Transcranial magnetic stimulation (TMS) is a safe, non-invasive technique that localizes critical language areas. TMS identifies more bilateral language regions than other non-invasive mapping modalities. The central hypothesis of this project is that TMS identifies true topographic language representation, often in both hemispheres, with more sensitivity than other non-invasive modalities.

Project Goals/Objectives: The goal of this project is to refine transcranial magnetic stimulation (TMS) language mapping so that it better informs surgical decision making and improves outcomes of children undergoing epilepsy surgery. Aims: 1) project infrastructure, 2) interrater reliability, 3) accuracy

Outcome of Research: Identifying crucial speech and language areas safely in the brain prior to epilepsy or brain tumor surgery continues to be a challenge in children. This study investigated the effectiveness of transcranial magnetic stimulation (TMS), a newer non-invasive language mapping procedure in children. TMS often identifies speech and language regions in left and right sides (hemispheres) of the brain. In this project, we examined whether the regions in left and right hemispheres identified by TMS are “true positive” language regions that should be avoided during epilepsy surgery vs. “false positive” and can be resected safely if necessary to stop seizures. In order to do this, we first build a TMS Language Mapping Consortium consisting of 8 busy pediatric epilepsy centers and evaluated whether a structured consensus meeting would improve the agreement between clinicians in identifying TMS-induced speech errors. Indeed, after consensus, overall interrater reliability metric improved from moderate to substantial agreement. *This has led to the development of standardized guidelines enabling reliable interpretation across centers, consistent clinical application, and multicenter research.* To confirm TMS findings against the gold standard methods,

in 15 individuals who underwent epilepsy surgery, we evaluated the performance of TMS in the left hemisphere against direct brain stimulation mapping. *The results of this study add to the prior evidence TMS may be most useful for predicting language-negative regions for surgery and that in children, TMS can still provide useful adjunctive information where other language mapping modalities are less effective.* Through series of other studies, we have found that children in whom TMS identified speech and language areas in the right hemisphere, were less like to suffer from post operative speech and language difficulties, *suggesting that TMS identifies functional compensation.* Finally, this study provided tailored training opportunities for junior investigators.

Additional funding based on this project's results:

1. AES Post doctoral research fellowship grant, 2026- PI: Radha Kodali, Ph.D. AI-Driven Recognition of Normal and Disrupted Speech in TMS Mapping. **Not funded.**
2. St. Baldricks's Foundation, Childhood cancer research grant 2026. PI: Narayana. Predicting language outcomes using multimodal plasticity markers in pediatric brain tumors – **Not funded.**
3. NIH R03 2026, PIs: Narayana and Kodali. AI Tool for Automated Recognition of Normal and Disrupted Speech to Improve TMS-Language Mapping and Clinical Review Accessibility, Impact score 34, 27th percentile. Resubmitted July 2026. **Pending review**
4. NIH R21 2026, PIs: Narayana and Kodali. Multimodal Predictive Modeling for Functional Outcomes in Pediatric Epilepsy and Brain Tumor Surgery. Not scored. **Resubmission – March 2027.**

Subsequent Publications

- Kodali R, **Narayana S** (2024). DirichNet Model for Detection of TMS-induced Speech Errors in Patients Undergoing Epilepsy Surgery. *ICASSP 2025 - 2025 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Hyderabad, India, 2025, pp. 1-5, doi: 10.1109/ICASSP49660.2025.10890566.
2. Kodali R, Qureshi H, Noorizadeh N, Holder CM, Mudigoudar B, Fulton S, Patterson A, Weatherspoon SE, Shimony N, Boop F, Wheless JW, **Narayana S** (2026). Validating language localization by transcranial magnetic stimulation: A comparative study of adults and children. *Epilepsy Research* (2026) 107870.
 3. Kodali R, Eakes J, Wheless JW, Noorizadeh N, **Narayana S** (2026). Automated Timing-Based Classification of Normal and Disrupted Pediatric Speech in TMS Language Mapping. In review *Speech Communications*.

4. Baumer F, Jones T, Calley C, Greiner H, Jayakar A, Kanaris M, Matthew M, Lundstrum B, Noorizadeh N, Kodali R, Varner JA, Rodriguez M, Rotenberg A, Starnes K, Tarapore PE, Tsuboyama M, Cannito M, Wheless JW, **Narayana S** (2026). Improving interrater reliability in pediatric TMS language mapping: A multi-center consortium study. In preparation.

5. **Narayana S**, Jones T, Calley C, Greiner H, Jayakar A, Lundstrum B, Noorizadeh N, Rotenberg A, Starnes K, Tarapore PE, Tsuboyama M, Wheless JW, Narayana S (2026). Consortium for Standardizing TMS Language Mapping Protocols and Establishing Best Practice Guidelines for Using TMS in Presurgical Evaluation of Language in Children: Consensus Paper. In preparation

Subsequent Presentations

Abstracts with Oral presentation

1. Jones T, Baumer F, Calley C, Greiner H, Noorizadeh N, Varner J, Kanaris M, Lundstrom B, Rodriguez M, Starnes DK, Rotenberg A, Tarapore PE, Jayakar A, Tsuboyama M, **Narayana S** (2024) Validity Of TMS-Induced Speech Error Classification: A Consortium Interrater Reliability Study. Annual Meeting of the American Epilepsy Society, December 2024, Los Angeles CA, USA.

2. Kodali R, Noorizadeh N, Chourasia N, McGregor A, Mudigoudar B, Patterson A, Weatherspoon S, Klimo P, Shimony N, Boop F, Wheless JW, **Narayana S**. Age- and lobe-dependent speech-language network plasticity in brain tumor patients identified by TMS to aid surgical planning. 51th Annual Meeting of the International Society for Pediatric Neurosurgery. October 2025. Lyon, France.

3. Noorizadeh N, Wheless JW, Weatherspoon S, Rivas Coppola M, Patterson A, Klimo P, Shimony N, **Narayana S**. Role of right hemisphere language cortex and tracts as functional compensation in left temporal tumors of childhood. 51th Annual Meeting of the International Society for Pediatric Neurosurgery. October 2025. Lyon, France.

4. Jones T, Baumer F, Calley C, Greiner H, Jayakar A, Kanaris M, Matthew M, Lundstrom B, Noorizadeh N, Varner J, Rodriguez M, Rotenberg A, Starnes DK, Tarapore PE, Tsuboyama M, Cannito M, **Narayana S** (2025) Guideline implementation for improving TMS language mapping inter-rater reliability: A consortium Study. Annual Meeting of the American Epilepsy Society, December 2025, Atlanta GA, USA.

5. Kodali R, Noorizadeh N, Wheless JW, **Narayana S** (2026). Automated Detection of Pediatric Voice Onset and Response Times in Speech during TMS Language Mapping. ACNS Annual Meeting, February 2026, New Orleans, LA, USA.