

# David A. Tovar

✉ david.tovar@vanderbilt.edu    ☎ 443-939-9580    📄 3000 Vanderbilt Pl., Nashville, TN, 37212  
🆔 0000-0002-5449-6289

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*Researcher specializing in computational neuroscience with a focus on human-inspired AI and interpretable models of human behavior and physiology.*

## Education

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Jul 2013 – May 2022 | **Vanderbilt School of Medicine**  
*MD*

Aug 2016 – Sep 2021 | **Vanderbilt University**  
*PhD in Neuroscience*  
*Dissertation - Of Machines and Men: Searching for the What, When, and Where of Perception*

Aug 2007 – Aug 2011 | **University of Maryland, College Park**  
*BS in Neurobiology & Physiology*  
*BS in Psychology*

## Work Experience

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May 2022 – May 2024 | **Meta**  
*Research Scientist in Applied Perception Science - Contractor*

July 2022 – Present | **Vanderbilt University**  
*Assistant Research Professor in Psychology and Data Science*  
*Group Leader in Brain Inspired Artificial Intelligence*

January 2025 – Present | **Mind Matrix Analytics LLC**  
*Founder & CEO*  
*Advanced analyses and model building for behavior, physiology, and neural signals*

## Skills

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<u>Data Acquisition</u>	<u>Data Analysis</u>	<u>Programming Languages</u>	<u>Toolboxes/Packages</u>
Psychophysics	Behavioral Models	Python	PyTorch
EEG	EEG	MATLAB	CoSMoMVPA
MEG	fMRI	Bash	Psychtoolbox
fMRI	Monkey Electrophysiology	R	AFNI
AR and VR User Studies	Artificial Neural Networks	CODE V	Fieldtrip
Motion Tracking	MALDI		
	Graphic User Interfaces		

## Research Experience

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July 2022 - Present | **Brain-Inspired Multimodal AI Research**  
*Vanderbilt University - Principal Investigator*

- Develop AI models to understand cognitive processes in artificial and natural intelligence.
- Study multimodal integration across neural, behavioral, and physiological signals.
- Investigate parallels between multisensory integration in models and biological systems, refining models via cross-modal fine-tuning.
- Examine how training on one modality enhances human alignment and brain plasticity.
- Build scalable, generalizable models to advance neuroscience and clinical applications.
- Assess how training data diversity impacts model performance and human alignment.

## Research Experience

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June 2022 - May 2024	<b>Predictive Optical Models of Visual Experience in AR Glasses</b> <i>Meta Contract- Research Scientist</i> <ul style="list-style-type: none"><li>• Developed optical simulations with ray tracing to simulate typical use cases across optics</li><li>• Used Bayesian Optimizations to find lens components most relevant to user experience</li><li>• Created physiological (HRV, EDR, Pupillometry) models of user experiences</li></ul>
Sep 2018 - May 2022	<b>Assessing correspondence between artificial neural networks and dynamic brain activity</b> <i>Vanderbilt University &amp; University of Sydney - Graduate Student</i> <ul style="list-style-type: none"><li>• Explored how neural network architecture differences affect brain correspondence</li><li>• Manipulated training set to study performance and brain correspondence</li></ul>
Sep 2017 - May 2022	<b>Decoding stimulus specific information from neural activity in localized brain circuits using machine learning techniques</b> <i>Vanderbilt University - Graduate Student</i> <ul style="list-style-type: none"><li>• Analyzed linear multielectrode array recordings in monkeys to decode visual processes in the brain</li><li>• Investigated the type of visual information captured across brain signals by analyzing action potentials, local field potentials, and current source density</li></ul>
Sep 2016 - June 2020	<b>Decoding object information from audio and visual presentations and how they integrate in the brain</b> <i>Vanderbilt University &amp; University of Lausanne - Graduate Student</i> <ul style="list-style-type: none"><li>• Revealed how visual and auditory objects are processed across space and time in the brain</li><li>• Linked neural classification results directly to behavior</li><li>• Provided insights into how the brain maximizes visual and auditory information</li></ul>
Sep 2011 - Jun 2013	<b>Developing quality control measures for fMRI scans</b> <i>FDA Center of Devices and Radiological Health - ORISE Fellow</i> <ul style="list-style-type: none"><li>• Engineered a quality assurance fMRI phantom and developed protocols to test fMRI scan reliability and accuracy</li></ul>
Jun 2011 - Jun 2013	<b>Uncovering the dynamics of how the brain processes visual objects and their relation to behavior</b> <i>University of Maryland - Research Assistant</i> <ul style="list-style-type: none"><li>• Designed experiments to investigate how task requirements affect visual object processing in the brain</li><li>• Collected and synthesized MEG and fMRI data, colocalizing scans</li></ul>

## Leadership and Teaching Experience

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Sep 2016-May 2022	<b>Vanderbilt Medical Innovation Lab (VMIL)</b> <i>President (2016-2019), Vice President (2019-2022)</i> <ul style="list-style-type: none"><li>• Led VMIL, a student organization that brought together students from across Vanderbilt's professional schools to collaborate with faculty and staff at the medical center to identify clinical problems, prototype and test solutions</li></ul>
Jan 2021-May 2021	<b>Vanderbilt Data Science Institute</b> <i>Capstone Research Mentor</i> <ul style="list-style-type: none"><li>• Mentored a master's student on organizing and processing large structural and functional MRI data sets to classify patients with autism spectrum disorder (ASD) and age-matched controls</li></ul>

## Publications

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- 2025 | 1. Zhao, S. C., Hu, Y., Lee, J., Bender, A., Mazumdar, T., Wallace, M. & **Tovar, D. A.** Shifting Attention to You: Personalized Brain-Inspired AI Models. *arXiv* (2025).
- 2024 | 2. Hendrickson, A. S., Francis, K. L., Kumar, A., Le, J. P., Scarlett, J. M., Keene, C. D., **Tovar, D. A.** & Alonge, K. M. Assessing Translational Applicability of Perineuronal Net Dysfunction in Alzheimer's Disease Across Species. *Frontiers in Neuroscience* (2024).
3. Lee, J., Nkrumah, P. O., Zhao, S. C., Quackenbush, W. J., Leong, A., Mazumdar, T., Wallace, M. & **Tovar, D. A.** The Role of Image Quality in Shaping Neural Network Representations and Performance. *Cognitive Computational Neuroscience* (2024).
4. Mazumdar, T., Cai, V., ... & **Tovar, D. A.** Investigating the Emergence of Complexity from the Dimensional Structure of Mental Representations. *Cognitive Computational Neuroscience* (2024).
5. Rasdall, M. A., Cho, C., Stahl, A. N., **Tovar, D. A.**, ... & Rex, T. S. Primary Visual Pathway Changes in Chronic Mild Traumatic Brain Injury Participants: A Case-Control Study. *JAMA Ophthalmology* (2024).
6. **Tovar, D. A.**, Wilmott, J., ... & Guan, P. Identifying Behavioral Correlates to Visual Comfort. *SIGGRAPH Asia* (2024).
7. Yu, G., Harake, J. E., Zhao, S. C., Bender, A., ... & **Tovar, D. A.** Language Evolution in Large Language Models and Humans: A Comparative Analysis of Developmental Linguistics Across Ages and Sensory Modalities. *Cognitive Computational Neuroscience* (2024).
8. Zhao, S. C., Lee, J., Bender, A., Mazumdar, T., Leong, A., Nkrumah, P. O., Wallace, M. & **Tovar, D. A.** Brain-Inspired Embedding Model: Scaling and Perceptual Fine-tuning. *Cognitive Computational Neuroscience* (2024).
- 2023 | 9. Denervaud, S., **Tovar, D. A.**, Knebel, J.-F., Mullier, E., Alemán-Gómez, Y., Hagmann, P. & Murray, M. Exploring the interplay of age and pedagogy in the maturation of error-monitoring. *Mind, Brain and Education* (2023).
10. **Tovar, D. A.** AI Literature Review Suite. *arXiv* (2023).
11. **Tovar, D. A.**, Westerberg, J. A., Cox, M. A., Dougherty, K., Wallace, M. T., Bastos, A. M. & Maier, A. Near-field potentials index local neural computations more accurately than population spiking. *bioRxiv* (2023).
- 2021 | 12. Opoku-Baah, C., Schoenhaut, A. M., Vassall, S. G., **Tovar, D. A.**, Ramachandran, R. & Wallace, M. T. Visual Influences on Auditory Behavioral, Neural, and Perceptual Processes: A Review. *JARO - Journal of the Association for Research in Otolaryngology* **22**, 365–386 (2021).
13. **Tovar, D. A.**, Grootswagers, T., Jun, J., Cha, O., Blake, R. & Wallace, M. T. Getting the gist faster : Blurry images enhance the early temporal similarity between neural signals and convolutional neural networks. *bioRxiv*, 1–32 (2021).
- 2020 | 14. **Tovar, D. A.**, Murray, M. & Wallace, M. Selective enhancement of object representations through multisensory integration. *Journal of Neuroscience* **40**, 5604–5615 (2020).
15. **Tovar, D. A.**, Noel, J.-P., Ishizawa, Y., Patel, S. R., Eskandar, E. N. & Wallace, M. T. The neural computations for stimulus presence and modal identity diverge along a shared circuit. *bioRxiv*, 2020.01.09.900563 (2020).
16. **Tovar, D. A.**, Westerberg, J. A., Cox, M. A., Dougherty, K., Carlson, T. A., Wallace, M. T. & Maier, A. Stimulus Feature-Specific Information Flow Along the Columnar Cortical Microcircuit Revealed by Multivariate Laminar Spiking Analysis. *Frontiers in Systems Neuroscience* **14**, 1–14 (2020).
- 2019 | 17. Cha, O., Son, G., Chong, S. C., **Tovar, D. A.** & Blake, R. Novel procedure for generating continuous flash suppression: Seurat meets Mondrian. *Journal of Vision* **19**, 1–22 (2019).

- 2015 | 18. Ritchie, J. B., **Tovar, D. A.** & Carlson, T. A. Emerging Object Representations in the Visual System Predict Reaction Times for Categorization. *PLoS Computational Biology* **11** (2015).
19. **Tovar, D. A.**, Zhan, W. & Rajan, S. S. A rotational cylindrical fMRI phantom for image quality control. *PLoS ONE* **10** (2015).
- 2013 | 20. Carlson, T., **Tovar, D. A.**, Alink, A. & Kriegeskorte, N. Representational dynamics of object vision: The first 1000 ms. *Journal of Vision* **13**, 1–19 (2013).

## Conference Presentations

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- 2023 | 1. Quackenbush, W.J., Wallace, M. T., **Tovar, D.A.** Evaluating image quality and category representatitiveness in popular imagesets: A path towards computer vision, cognitive models, and multimodal datasets. Poster presented at Society for Neuroscience (SFN), Washington DC, United States.
- 2018 | 2. **Tovar, D.A.**, Westerberg, J.A., Cox, M.A., Dougherty, K., Carlson, T.A., Wallace, M.T., Maier, A. Multivariate analysis of V1 spiking dynamics for ocularity, orientation, and repetition. Poster presented at the Society for Neuroscience (SFN), San Diego, United States.
3. **Tovar, D.A.**, Grootswagers, T., Robinson, A.K., Wallace, M.T., Carlson, T.. Optimizing the number of visual presentations for time-resolved decoding studies. Poster presented at the European Conference on Visual Perception (ECP), Trieste, Italy.
4. Cotter, G., **Tovar, D.A.**, Wallace, M.T. Effects of self-referential processing and visual similarity on categorization of morphed faces. Poster presented at the European Conference on Visual Perception (ECP), Trieste, Italy.
5. **Tovar, D.A.**, Noel, J.P., Ishizawa, Y., Patel, S.R., Brown, E.N., Eskander, E.N. Dynamic decoding of unisensory and multisensory stimulus processing in conscious and unconscious primate neocortex. Poster presented at the International Multisensory Research Forum (IMRF)., Toronto, Canada.
- 2017 | 6. Venkat, N., **Tovar, D.A.**, Cascio, C., Wallace, M.T. Effects of stimulus strength and timing synchrony on the salience of the rubber hand illusion. Poster presented at the Science of Self., Sydney, Australia.
- 2014 | 7. Ritchie, J.B., **Tovar, D.A.**, Carlson, T. Emerging representational geometry for objects predicts reaction time for categorization. Paper presented at the 14th Annual Meeting of the Vision Sciences Society (VSS), St. Pete Beach, United States
- 2013 | 8. **Tovar, D.A.**, Carlson, T. The Temporal Dynamics of Top-Down Knowledge on Object Category Representations. Paper presented at the 13th Annual Meeting of the Vision Science Society (VSS), Naples, United States.
- 2013 | 9. Ritchie, J.B., Durvasula, S., Ma, J., **Tovar, D.A.**, Kriegeskorte, N., Carlson, T. Reaction time is predicted by representational distance. Paper presented at the 13th Annual Meeting of the Vision Science Society, Naples, United States.
- 2012 | 10. **Tovar, D.A.**, Zhan, W., Soltysik, D., Rajan, S.S. A Description of a Novel Phantom for fMRI Quality Control. Poster presented at the Radiological Society of North America 2012 Scientific Assembly and Annual Meeting, Chicago, United States.
11. Carlson, T.A., **Tovar, D.A.**, Alink, A., Kriegeskorte, N. Decoding the evolving structure of object representations. Poster presented at the McGovern 2012 MEG Symposium: Applications to Cognitive Neuroscience, Boston, United States.

## Students Mentored

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### Current Students

2024 – Present	<b>Anna Machado</b> <i>PhD Student in Biomedical Engineering</i>
2024 – Present	<b>Stephen Chong Zhao</b> <i>Master's Student in Data Science</i>
2024 – Present	<b>Yang Hu</b> <i>Master's Student in Data Science</i>
2024 – Present	<b>Jason Lee</b> <i>Undergraduate Student in Computer Science</i>
2024 – Present	<b>Trisha Mazumdar</b> <i>Undergraduate Student in Computer Science</i>
2024 – Present	<b>Justin Kong</b> <i>Undergraduate Student in Computer Science</i>
2024 – Present	<b>Tevin Park</b> <i>Undergraduate Student in Computer Science</i>
2024 – Present	<b>Grace Ko</b> <i>Undergraduate Student in Mathematics &amp; Computer Science</i>
2024 – Present	<b>Becky Nam</b> <i>Undergraduate Premed Student</i>

### Past Students and Current Positions

2016 – 2019	<b>Andrew Bender</b> <i>PhD Graduate Student at UCSD</i>
2016 – 2017	<b>Courtney Owens (Squires)</b> <i>Speech-Language Pathologist</i>
2016 – 2018	<b>Jonathan Amaro-Barron</b> <i>Adult Neurologist at Michigan</i>
2016 – 2018	<b>Nitya Venkat</b> <i>Orthopedic Surgeon at Columbia</i>
2017 – 2019	<b>Garret Cotter</b> <i>Gastroenterologist at Cleveland Clinic</i>
2017 – 2018	<b>Chidinma Ukadike</b> <i>Medicine-Pediatrics at University of Tennessee</i>
2017 – 2019	<b>Emma Sterling</b> <i>Obstetrics Gynecologist at University of Colorado</i>

### Funding - Awarded and Pending

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2023 – 2028	<b>Meta Reality Labs Research Unrestricted Gift (Awarded)</b> <i>Role: Co-PI - \$10,000,000 (DC)</i> <i>Title: Longitudinal Studies of Multisensory Development</i>
2023 – 2028	<b>NIH DP2 (DP2 AI171150-01) (Awarded)</b> <i>Role: Co-PI - \$2,332,500 (DC+IDC); subaward \$60,000</i> <i>Title: Maternal immune activation remodeling of offspring glycosaminoglycan sulfation patterns during neurodevelopment</i>
2025 – 2030	<b>NIH Ro1 (Ro1 OD039183-01) (Pending)</b> <i>Role: MPI - \$6,530,700</i> <i>Title: Translational Multimodal Spatial Modeling of Movement Disorders</i>
2025-2028	<b>Glenn Foundation Discovery Award (Pending)</b> <i>Role: Co-PI - \$525,000</i> <i>Title: Glycan Recoding in Human Brain Aging</i>
2025-2026	<b>Vanderbilt Seeding Success Grant (Pending)</b> <i>Role: PI - \$120,000</i> <i>Title: Brain Inspired AI Across Levels of Neural Processing</i>
2025	<b>Google Research Scholar Program (Pending)</b> <i>Role: PI - \$60,000</i> <i>Title: Learning Interpretable Physiological Embeddings for Cognition</i>