

# Zhi-De Deng

✉ zzzdeng@alum.mit.edu

☎ +1 919 564 5282

🔗 [www.zzzdeng.net](http://www.zzzdeng.net)

---

## Research Specialties

- § Noninvasive brain stimulation: technology development, modeling, device safety, translational and clinical applications
- § Computational electromagnetics
- § Electrophysiological and neuroimaging biomarker development
- § Neural plasticity
- § Nonlinear dynamics of physiological systems
- § Translational neuromodeling

---

## Education

Expected 2024 **M.H.Sc., Clinical Research**, Duke University

2013 **Ph.D., Electrical Engineering**, Columbia University

- § Dissertation: *Electromagnetic Field Modeling of Transcranial Electric & Magnetic Stimulation: Targeting, Individualization, and Safety of Convulsive & Subconvulsive Applications*

2011 **M.Phil., Electrical Engineering**, Columbia University

- § Graduate minor in Neuroscience

2007 **M.Eng., Electrical Engineering and Computer Science**, MIT

- § Thesis: *Stochastic Chaos and Thermodynamic Phase Transitions: Theory and Bayesian Estimation Algorithms*

2007 **S.B., Electrical Science and Engineering**, MIT

2006 **S.B., Physics**, MIT

- § Minor in Economics

## Professional Appointments & Employment

### Academic

- 2019–present **Staff Scientist, Director of Computational Neurostimulation Research Program**, Noninvasive Neuromodulation Unit, Experimental Therapeutics & Pathophysiology Branch, Intramural Research Program, NIMH
- 2016–present **Adjunct Assistant Professor**, Department of Psychiatry & Behavioral Sciences, Duke University School of Medicine
- 2016–2019 **Research Fellow**, Noninvasive Neuromodulation Unit, Experimental Therapeutics & Pathophysiology Branch, Intramural Research Program, NIMH  
     § Richard J. Wyatt Memorial Fellowship for Translational Research
- 2015–present **Faculty**, Duke Institute for Brain Sciences, Duke University
- 2014–2016 **Medical Instructor**, Department of Psychiatry & Behavioral Sciences, Duke University School of Medicine  
     § Duke Translational Medicine Institute KL2 Fellow
- 2013–2014 **Postdoctoral Associate**, Department of Psychiatry & Behavioral Sciences, Duke University School of Medicine
- 2010–2013 **Visiting Graduate Research Assistant**, Department of Psychiatry & Behavioral Sciences, Duke University School of Medicine
- 2007–2010 **Graduate Research Assistant**, Department of Psychiatry, Columbia University College of Physicians and Surgeons/New York State Psychiatric Institute  
     § Columbia Irving Institute for Clinical and Translational Research T32 Fellow
- 2006–2007 **Graduate Research Assistant**, Harvard–MIT Division of Health Sciences and Technology, Massachusetts Institute of Technology
- 2005–2006 **Undergraduate Research Assistant**, Harvard–MIT Division of Health Sciences and Technology, Massachusetts Institute of Technology

### Nonprofit Organization

- 2017–present **Co-founder, Scientific Advisor**, Singula Institute

### Internships

- 2004 **Executive Intern**, Department of Anesthesiology, New York–Presbyterian Hospital/Weill Cornell Medical College
- 2003 **Internship Coordinator**, The New York Times Company Foundation
- 2002 **News Technology Intern**, The New York Times Company

## Publications (\*denotes first, joint first, or senior author)

### Refereed Journal Articles

- \*84 P.L. Robins, S.N. Makaroff, M. Dib, S.H. Lisanby, and **Z.-D. Deng**, “Electric field characteristics of transcranial rotating permanent magnetic stimulation,” *Bioengineering*, vol.11, no.3, 258, Mar. 2024.  
PMCID: PMC10871468 DOI: 10.3390/bioengineering11030258
- \*83 **Z.-D. Deng**, B. Luber, S.M. McClintock, R.D. Weiner, M.M. Husain, and S.H. Lisanby, “Clinical outcomes of magnetic seizure therapy vs electroconvulsive therapy for major depressive episode: A randomized clinical trial,” *JAMA Psychiatry*, vol.81, no.3, pp.240–249, Mar. 2024.  
PMCID: PMC10701670 DOI: 10.1001/jamapsychiatry.2023.4599
- \*82 C.C. Abbott, J. Miller, D. Farrar, M. Argyelan, M. Lloyd, T. Squillaci, B. Kimbrell, S. Ryman, T.R. Jones, J. Upston, D.K. Quinn, A.V. Peterchev, E. Erhardt, A. Datta, S.M. McClintock, and **Z.-D. Deng**, “Amplitude-determined seizure-threshold, electric field modeling, and electroconvulsive therapy antidepressant and cognitive outcomes,” *Neuropsychopharmacology*, vol.49, no.4, pp.640–648, Mar. 2024. Commentary in pp.635–636.  
PMCID: PMC10876627 DOI: 10.1038/s41386-023-01780-4
- 81 W.A. Wartman, K. Weise, M. Rachh, L. Morales, **Z.-D. Deng**, A.R. Nummenmaa, and S.N. Makaroff, “An adaptive h-refinement method for the boundary element fast multipole method for quasi-static electromagnetic modeling,” *Physics in Medicine and Biology*, vol.69, no.4, 055030, Feb. 2024.  
PMCID: PMC10902857 DOI: 10.1088/1361-6560/ad2638
- 80 S.K. Kar, A. Agrawal, A. Silva-dos-Santos, Y. Gupta, and **Z.-D. Deng**, “The efficacy of transcranial magnetic stimulation in the treatment of obsessive-compulsive disorder: An umbrella review of meta-analyses,” *CNS Spectrums*, online ahead of print, Dec. 2023.  
PMID: 38053347 DOI: 10.1017/S1092852923006387
- 79 M. Argyelan, **Z.-D. Deng**, O.T. Ousdal, L. Olteidal, B. Angulo, M. Baradits, A.J. Spitzberg, U. Kessler, A. Sartorius, A. Dols, K.L. Narr, R. Espinoza, J.A. van Waarde, I. Tondolkar, P. van Eijndhoven, G.A. van Wingen, A. Takamiya, T. Kishimoto, M.B. Jørgensen, A. Jørgensen, O.B. Paulson, A. Yrondi, P. Péran, C. Soriano-Mas, N. Cardoner, M. Cano, L. van Diermen, D. Schrijvers, J.-B. Belge, L. Emsell, F. Bouckaert, M. Vandenbulcke, M. Kiebs, R. Hurlmann, P.C.R. Mulders, R. Redlich, U. Dannlowski, E. Kavakbasi, M.D. Kritzer, K.K. Ellard, J.A. Camprodon, G. Petrides, A.K. Malhotra, and C.C. Abbott, “Electroconvulsive therapy-induced volumetric brain changes converge on a common causal circuit in depression,” *Molecular Psychiatry*, online ahead of print, Nov. 2023.  
PMID: 37985787 DOI: 10.1038/s41380-023-02318-2
- 78 S.N. Makaroff, Z. Qi, M. Rachh, W.A. Wartman, K. Weise, G.M. Noetscher, M. Danezhzand, **Z.-D. Deng**, L. Greengard, and A.R. Nummenmaa, “A fast direct solver for surface-based whole-head modeling of transcranial magnetic stimulation,” *Scientific Reports*, vol.13, no.8, 18657, Oct. 2023.  
PMCID: PMC10618282 DOI: 10.1038/s41598-023-45602-5

## Refereed Journal Articles (continue)

- \*77 B. Kadriu, **Z.-D. Deng**, C. Kraus, J.N. Johnston, A. Figtman, I.D. Henter, S. Kasper, and C.A. Zarate, Jr., "The impact of body mass index on clinical features of bipolar disorder: A STEP-BD study," *Bipolar Disorder*, online ahead of print, Aug. 2023.  
PMCID: PMC10839568 DOI: 10.1111/bdi.13370
- \*76 **Z.-D. Deng**, P.L. Robins, M. Dannhauer, L.M. Haugen, J.D. Port, and P.E. Croarkin, "Optimizing TMS coil placement approaches for targeting the dorsolateral prefrontal cortex in depressed adolescents: An electric field modeling study," *Biomedicines*, vol.11, no.8, 2320, Aug. 2023.  
PMCID: PMC10452519 DOI: 10.3390/biomedicines11082320
- 75 C. Kraus, A. Kautzky, V. Watzal, A. Gramser, B. Kadriu, **Z.-D. Deng**, L. Bartova, C.A. Zarate, Jr., R. Lanzenberger, D. Souery, S. Montgomery, J. Mendlewicz, J. Zohar, G. Fanelli, A. Serretti, and S. Kasper, "Body mass index and clinical outcomes in individuals with major depressive disorder: Finding from the GSRD European Multicenter Database," *Journal of Affective Disorder*, vol.335, pp.349–357, Aug. 2023.  
PMCID: PMC10502963 DOI: 10.1016/j.jad.2023.05.042
- 74 M. Teferi, W. Makhoul, **Z.-D. Deng**, D.J. Oathes, Y.I. Sheline, and N.L. Balderston, "Continuous theta burst stimulation to the right dorsolateral prefrontal cortex may increases potentiated startle in healthy individuals," *Biological Psychiatry: Global Open Science*, vol.3, no.3, pp.470–479, July 2023.  
PMCID: PMC10382694 DOI: 10.1016/j.bpsgos.2022.04.001
- 73 J. Miller, T.R. Jones, J. Upston, **Z.-D. Deng**, S.M. McClintock, E. Erhardt, D. Farrar, D.K. Quinn, and C.C. Abbott, "Electric field, ictal theta power, and clinical outcomes in electroconvulsive therapy," *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, vol.8, no.7, pp.760–767, July 2023.  
PMCID: PMC10329999 DOI: 10.1016/j.bpsc.2023.03.001
- 72 A. Guillen, C.C. Abbott, **Z.-D. Deng**, Y. Huang, P. Pascoal-Faria, D.Q. Truong, and A. Datta, "Impact of modeled field of view in electroconvulsive therapy current flow simulations," *Frontiers in Psychiatry*, vol.14, 1168672, May 2023.  
PMCID: PMC10232815 DOI: 10.3389/fpsy.2023.1168672
- 71 M. Alawi, P.F. Lee, **Z.-D. Deng**, Y.K. Goh, and P.E. Croarkin, "Modelling the differential effects of age on transcranial magnetic stimulation induced electric fields," *Journal of Neural Engineering*, vol.20, no.2, 026016, Mar. 2023.  
PMCID: PMC10278869 DOI: 10.1088/1741-2552/ac9a76
- 70 X. Chen, R. Ma, W. Zhang, G.Q. Zeng, Q. Wu, A. Yimiti, X. Xia, J. Cui, Q. Liu, X. Meng, J. Bu, Q. Chen, Y. Pan, N.X. Yu, S. Wang, **Z.-D. Deng**, A.T. Sack, M. Mc Laughlin, and X. Zhang, "Alpha oscillatory activity is causally linked to working memory retention," *PLOS Biology*, vol.21, no.2, e3001999, Feb. 2023.  
PMCID: PMC9983870 DOI: 10.1371/journal.pbio.3001999
- 69 Z. Fu, C.C. Abbott, J. Miller, **Z.-D. Deng**, S.M. McClintock, M.S.E. Sendi, J. Sui, and V.D. Calhoun, "Cerebro-cerebellar functional neuroplasticity mediates the effect of electric field on electroconvulsive therapy outcomes," *Translational Psychiatry*, vol.13, 43, Feb. 2023.  
PMCID: PMC9902462 DOI: 10.1038/s41398-023-02312-w

## Refereed Journal Articles (continue)

- \*68 S.N. Makaroff, H. Nguyen, Q. Meng, H. Lu, A. Nummenmaa, and **Z.-D. Deng**, “Modeling transcranial magnetic stimulation coils with magnetic cores,” *Journal of Neural Engineering*, vol.20, no.1, 016028, Jan. 2023.  
PMCID: PMC10481791 DOI: 10.1088/1741-2552/acae0d
- 67 S. Qi, V.D. Calhoun, D. Zhang, J. Miller, **Z.-D. Deng**, K.L. Narr, Y.I. Sheline, S.M. McClintock, R. Jiang, X. Yang, J. Upston, T.R. Jones, J. Sui, and C.C. Abbott, “Links between electroconvulsive therapy responsive and cognitive impairment multimodal brain networks in late-life major depressive disorder,” *BMC Medicine*, vol.22, 477, Dec. 2022. Correction: vol.21, 113, 2023.  
PMCID: PMC9733153 DOI: 10.1186/s12916-022-02678-6
- 66 H. Li, **Z.-D. Deng**, D. Oathes, and Y. Fan, “Computation of transcranial magnetic stimulation electric fields using self-supervised deep learning,” *NeuroImage*, vol.264, 119705, Dec. 2022.  
PMCID: PMC9854270 DOI: 10.1016/j.neuroimage.2022.119705
- 65 A. Richie-Halford, M. Cieslak, L. Ai, S. Caffarra, S. Covitz, A.R. Franco, I.I. Karipidis, J. Kruper, M. Milham, B. Avelar-Pereira, E. Roy, V.J. Sydnor, J. Yeatman, The Fibr Community Science Consortium [including **Z.-D. Deng**], T.D. Satterthwaite, and A. Rokem, “An analysis-ready and quality controlled resource for pediatric brain white-matter research,” *Scientific Data*, vol.9, 616, Oct. 2022. Correction: vol.10, 247, 2023.  
PMCID: PMC9556519 DOI: 10.1038/s41597-022-01695-7
- 64 J. Miller, T. Jones, J. Upston, **Z.-D. Deng**, S.M. McClintock, S. Ryman, D. Quinn, and C.C. Abbott, “Ictal theta power as an electroconvulsive therapy safety biomarker: A pilot study,” *The Journal of ECT*, vol.38, no.2, pp.88–94, June 2022.  
PMCID: PMC10680084 DOI: 10.1097/YCT.0000000000000812
- 63 H. Bagherzadeh, Q. Meng, **Z.-D. Deng**, H. Lu, E. Hong, Y. Yang, and F.-S. Choa, “Angle-tuned coils: Attractive building blocks for TMS with improved depth–spread performance,” *Journal of Neural Engineering*, vol.19, no.2, 026059, May 2022.  
PMCID: PMC10644970 DOI: 10.1088/1741-2552/ac697c
- 62 B. Luber, S.W. Davis, **Z.-D. Deng**, D. Murphy, A. Martella, A.V. Peterchev, and S.H. Lisanby, “Using diffusion tensor imaging to effectively target TMS to deep brain structures,” *NeuroImage*, vol.249, 118863, Apr. 2022.  
PMCID: PMC8851689 DOI: 10.1016/j.neuroimage.2021.118863
- \*61 **Z.-D. Deng**, M. Argyelan, J. Miller, D. Quinn, M. Lloyd, T.R. Jones, J. Upston, E. Erhardt, S.M. McClintock, and C.C. Abbott, “Electroconvulsive therapy, electric field, neuroplasticity, and clinical outcomes,” *Molecular Psychiatry*, vol.27, no.3, pp.1676–1682, Mar. 2022. Commentary in vol.27, no.9, pp.3571–3572.  
PMCID: PMC9095458 DOI: 10.1038/s41380-021-01380-y
- 60 N.L. Balderston, J.C. Beer, D. Seok, W. Makhoul, **Z.-D. Deng**, T. Girelli, M. Teferi, N. Smyk, M. Jaskir, D.J. Oathes, R.T. Shinohara, and Y.I. Sheline, “Proof of concept study to develop a novel connectivity-based electric-field modelling approach for individualized targeting of transcranial magnetic stimulation treatment,” *Neuropsychopharmacology*, vol.47, no.2, pp.588–598, Jan. 2022.  
PMCID: PMC8674270 DOI: 10.1038/s41386-021-01110-6

## Refereed Journal Articles (continue)

- 59 S.H. Lisanby, S.M. McClintock, W.V. McCall, R.G. Knapp, C.M. Cullum, M. Mueller, **Z.-D. Deng**, A.A. Teklehaimanot, M.V. Rudorfer, E. Bernhardt, G. Alexopoulos, S.H. Bailine, M.C. Briggs, E.T. Geduldig, R.M. Greenberg, M.M. Husain, S. Kaliora, V. Latousakis, L.S. Liebman, G. Petrides, J. Prudic, P.B. Rosenquist, S. Sampson, K.G. Tobias, R.D. Weiner, R.C. Young, C.H. Kellner, Prolonging Remission in Depressed Elderly (PRIDE) Work Group, "Longitudinal neurocognitive effects of combined electroconvulsive therapy (ECT) and pharmacotherapy in geriatric major depressive disorder: Phase 2 of the PRIDE study," *American Journal of Geriatric Psychiatry*, vol.30, no.1, pp.15–28, Jan. 2022.  
PMCID: PMC8595359 DOI: 10.1016/j.jagp.2021.04.006
- 58 B. Kadriu, C.A. Farmer, P. Yuan, L.T. Park, **Z.-D. Deng**, R. Moaddel, I.D. Henter, B. Shovestul, E.D. Ballard, C. Kraus, P.W. Gold, R. Machado-Vieira, and C.A. Zarate, Jr., "The kynurenine pathway and bipolar disorder: Intersection of the monoaminergic and glutamatergic systems and immune response," *Molecular Psychiatry*, vol.26, no.8, pp.4085–4095, Aug. 2021.  
PMCID: PMC7225078 DOI: 10.1038/s41380-019-0589-8
- 57 A. Takamiya, F. Bouckaert, M. Laroy, J. Blommaert, A. Radwan, A. Khatoun, **Z.-D. Deng**, M. Mc Laughlin, W. Van Paesschen, F.-L. De Winter, J. Van den Stock, S. Sunaert, P. Sienaert, M. Vandenbulcke, and L. Emsell, "Biophysical mechanisms of electroconvulsive therapy-induced volume expansion in the medial temporal lobe: A longitudinal *in vivo* human imaging study," *Brain Stimulation*, vol.14, no.4, pp.1038–1047, July–Aug. 2021.  
PMCID: PMC8474653 DOI: 10.1016/j.brs.2021.06.011
- 56 E.A. Friðgeirsson, **Z.-D. Deng**, D. Denys, J.A. van Waarde, and G.A. van Wingen, "Electric field strength induced by electroconvulsive therapy may be associated with clinical outcome: A pilot study," *NeuroImage: Clinical*, vol.30, 102581, Feb. 2021.  
PMCID: PMC7895836 DOI: 10.1016/j.nicl.2021.102581
- 55 P.J.C. Suen, S. Doll, M.C. Battistuzzo, G. Busatto, L.B. Razza, F. Padberg, E. Mezger, L. Bulubas, D. Keeser, **Z.-D. Deng**, and A.R. Brunoni, "Association between tDCS computational modeling and clinical outcomes in depression: Data from the ELECTDCS trial," *European Archives of Psychiatry and Clinical Neuroscience*, vol.271, no.1, pp.101–110, Feb. 2021.  
PMCID: PMC8100980 DOI: 10.1007/s00406-020-01127-w
- 54 C.C. Abbott, D. Quinn, J. Miller, E. Ye, S. Iqbal, M. Lloyd, T.R. Jones, J. Upston, **Z.-D. Deng**, E. Erhardt, and S.M. McClintock, "Electroconvulsive therapy pulse amplitude and clinical outcomes," *American Journal of Geriatric Psychiatry*, vol.29, no.2, pp.166–178, Jan. 2021.  
PMCID: PMC7744398 DOI: 10.1016/j.jagp.2020.06.008
- 53 M.L. Cox, **Z.-D. Deng**, H. Palmer, A. Watts, L. Beynel, J.R. Young, S.H. Lisanby, J. Migaly, and L.G. Appelbaum, "Utilizing transcranial direct current stimulation to enhance laparoscopic technical skills training: A randomized controlled trial," *Brain Stimulation*, vol.13, no.3, pp.863–872, May–June 2020.  
PMCID: PMC8474665 DOI: 10.1016/j.brs.2020.03.009

## Refereed Journal Articles (continue)

- 52 S. AronsonFischell, T. J. Ross, **Z.-D. Deng**, B. J. Salmeron, and E. A. Stein, "Transcranial direct current stimulation applied to the dorsolateral and ventromedial prefrontal cortices in smokers modifies cognitive circuits implicated in the nicotine withdrawal syndrome," *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, vol. 5, no. 4, pp. 448–460, Apr. 2020.  
PMCID: PMC7150637 DOI: 10.1016/j.bpsc.2019.12.020
- 51 S. H. Lisanby, S. M. McClintock, G. Alexopoulos, S. H. Bailine, E. Bernhardt, M. C. Briggs, C. M. Cullum, **Z.-D. Deng**, M. Dooley, E. T. Geduldig, R. M. Greenberg, M. M. Husain, S. Kaliora, R. G. Knapp, V. Latoussakis, L. S. Liebman, W. V. McCall, M. Mueller, G. Petrides, J. Prudic, P. B. Rosenquist, M. V. Rudorfer, S. Sampson, A. A. Teklehaimanot, K. G. Tobias, R. D. Weiner, R. C. Young, C. H. Kellner, on behalf of the CORE/PRIDE Work Group, "Neurocognitive effects of combined electroconvulsive therapy (ECT) and venlafaxine in geriatric depression: Phase 1 of the PRIDE study," *American Journal of Geriatric Psychiatry*, vol. 28, no. 3, pp. 304–316, Mar. 2020. Commentary in pp. 317–319.  
PMCID: PMC7050408 DOI: 10.1016/j.jagp.2019.10.003
- 50 N. L. Balderston, E. M. Beydler, C. Roberts, **Z.-D. Deng**, T. Radman, T. Lago, B. Luber, S. H. Lisanby, M. Ernst, and C. Grillon, "Mechanistic link between right prefrontal cortical activity and anxious arousal revealed using transcranial magnetic stimulation in healthy subjects," *Neuropsychopharmacology*, vol. 45, no. 4, pp. 694–702, Mar. 2020.  
PMCID: PMC7021903 DOI: 10.1038/s41386-019-0583-5
- 49 L.-Z. Yang, W. Zhang, W. Wang, Z. Yang, H. Wang, **Z.-D. Deng**, C. Li, B. Qiu, D.-R. Zhang, R. Cohen Kadosh, H. Li, and X. Zhang, "Neural and psychological predictors of cognitive enhancement and impairment due to neurostimulation," *Advanced Science*, vol. 7, no. 4, 1902863, Feb. 2020.  
PMCID: PMC7029648 DOI: 10.1002/advs.201902863
- 48 N. L. Balderston, E. M. Beydler, M. Goodwin, **Z.-D. Deng**, T. Radman, B. Luber, S. H. Lisanby, M. Ernst, and C. Grillon, "Low-frequency parietal repetitive transcranial magnetic stimulation reduces fear and anxiety," *Translational Psychiatry*, vol. 10, no. 1, 68, Feb. 2020.  
PMCID: PMC7026136 DOI: 10.1038/s41398-020-0751-8
- 47 T. Dufor, S. Grehl, A. D. Tang, M. Doulazmi, M. Traoré, N. Debray, C. Dubacq, **Z.-D. Deng**, J. Mariani, A. M. Lohof, and R. M. Sherrard, "Neural circuit repair by low-intensity magnetic stimulation requires cellular magnetoreceptors and specific stimulation patterns," *Science Advances*, vol. 5, no. 10, eaav9847, Oct. 2019.  
PMCID: PMC6821463 DOI: 10.1126/sciadv.aav9847
- 46 M. Argyelan, L. Oltegal, **Z.-D. Deng**, B. Wade, M. Bikson, A. Joanlanne, S. Sanghani, H. Bartsch, M. Cano, A. M. Dale, U. Dannlowski, A. Dols, V. Enneking, R. Espinoza, U. Kessler, K. L. Narr, K. J. Oedagaard, M. L. Oudega, R. Redlich, M. L. Stek, A. Takamiya, L. Emsell, F. Bouckaert, P. Sienaert, J. Pugol, I. Tendolkar, P. van Eijndhoven, G. Petrides, A. K. Malhotra, and C. Abbott, "Electric field causes volumetric changes in the human brain," *eLife*, vol. 8, e49115, Oct. 2019.  
PMCID: PMC6874416 DOI: 10.7554/eLife.49115



## Refereed Journal Articles (continue)

- \*45 L. Beynel, L.G. Appelbaum, B. Luber, C.A. Crowell, S.A. Hilbig, W. Lim, D. Nguyen, N.A. Chrapliwy, S.W. Davis, R. Cabeza, S.H. Lisanby, and **Z.-D. Deng**, "Effects of on-line repetitive transcranial magnetic stimulation (rTMS) on cognitive processing: a meta-analysis and recommendations for future studies," *Neuroscience and Biobehavioral Reviews*, vol.107, pp.47–58, Dec. 2019.  
PMCID: PMC7654714 DOI: 10.1016/j.neubiorev.2019.08.018
- 44 S.M. Goetz, S.M. Madhi Alavi, **Z.-D. Deng**, and A.V. Peterchev, "Statistical model of motor evoked potentials," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol.27, no.8, pp.1539–1545, Aug. 2019.  
PMCID: PMC6719775 DOI: 10.1109/TNSRE.2019.2926543
- 43 T. Popa, L.S. Morris, R. Hunt, **Z.-D. Deng**, S. Horovitz, K. Mente, H. Shitara, K. Baek, M. Hallett, and V. Voon, "Modulation of resting connectivity between the mesial frontal cortex and basal ganglia," *Frontiers in Neurology*, vol.10, 587, June 2019.  
PMCID: PMC6593304 DOI: 10.3389/fneur.2019.00587
- 42 M.J. Dubin, I.P. Ilieva, **Z.-D. Deng**, J. Thomas, A. Albright, K. Kravets, B.D. Brody, P.J. Christos, J.H. Kocsis, C. Liston, and F.M. Gunning, "A double-blind pilot dosing study of low field magnetic stimulation (LFMS) for treatment-resistant depression (TRD)," *Journal of Affective Disorders*, vol.249, pp.286–293, Apr. 2019.  
PMCID: PMC6486658 DOI: 10.1016/j.jad.2019.02.039
- 41 P.E. Croarkin, P.A. Nakonezny, **Z.-D. Deng**, M. Romanowicz, J.L. Vande Voort, D. Doruk Camsari, K.M. Schak, J.D. Port, and C.P. Lewis, "High frequency repetitive TMS for suicidal ideation in adolescents with depression," *Journal of Affective Disorders*, vol.239, pp.282–290, Oct. 2018.  
PMCID: PMC6431788 DOI: 10.1016/j.jad.2018.06.048
- 40 B. Wang, M.R. Shen, **Z.-D. Deng**, J.E. Smith, J.J. Tharayil, C.J. Gurrey, L.J. Gomez, and A.V. Peterchev, "Redesigning existing transcranial magnetic stimulation coils to reduce energy: Application to low field magnetic stimulation," *Journal of Neural Engineering*, vol.15, no.3, 036022, Apr. 2018.  
PMCID: PMC5929994 DOI: 10.1088/1741-2552/aaa505
- 39 S. Grehl, D. Martina, C. Goyenvalle, **Z.-D. Deng**, J. Rodger, and R.M. Sherrard, "In vitro magnetic stimulation: A simple stimulation device to deliver defined low intensity electromagnetic fields," *Frontiers in Neural Circuits*, vol.10, 85, Nov. 2016.  
PMCID: PMC5093126 DOI: 10.3389/fncir.2016.00085
- \*38 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, "Effects of anatomical variability on electric field characteristics of electroconvulsive therapy and magnetic seizure therapy: A parametric modeling study," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol.23, no.1, pp.22–31, Jan. 2015.  
PMCID: PMC4289667 DOI: 10.1109/TNSRE.2014.2339014
- 37 J.K. Mueller, E.M. Grigsby, V. Prevosto, F.W. Petraglia, III, H. Rao, **Z.-D. Deng**, A.V. Peterchev, M.A. Sommer, T. Egner, M.L. Platt, and W.M. Grill, "Simultaneous transcranial magnetic stimulation and single-neuron recording in alert non-human primates," *Nature Neuroscience*, vol.17, no.8, pp.1130–1136, Aug. 2014.  
PMCID: PMC4115015 DOI: 10.1038/nn.375



## Refereed Journal Articles (continue)

- \*36 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, "Coil design considerations for deep transcranial magnetic stimulation," *Clinical Neurophysiology*, vol.125, no.6, pp.1202–1212, June 2014. Commentary in pp.1077–1078.  
PMCID: PMC4020988 DOI: 10.1016/j.clinph.2013.11.038
- \*35 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, "Controlling stimulation strength and focality in electroconvulsive therapy via electrode size, spacing, and current amplitude," *The Journal of ECT*, vol.29, no.4, pp.325–335, Dec. 2013.  
PMCID: PMC3905244 DOI: 10.1097/YCT.0b013e3182a4b4a7
- 34 B. Luber, J. Stener, A. Tucker, C. Habeck, A.V. Peterchev, **Z.-D. Deng**, R. Basner, Y. Stern, and S.H. Lisanby, "Extended remediation of sleep deprived-induced working memory deficits using fMRI-guided transcranial magnetic stimulation," *Sleep*, vol.36, no.6, pp.857–871, June 2013.  
PMCID: PMC3649828 DOI: 10.5665/sleep.2712
- \*33 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, "Electric field depth–focality tradeoff in transcranial magnetic stimulation: Simulation comparison of 50 coil designs," *Brain Stimulation*, vol.6, no.1, pp.1–13, Jan. 2013. Commentary in pp.14–15.  
PMCID: PMC3568257 DOI: 10.1016/j.brs.2012.02.005
- 32 W.H. Lee, **Z.-D. Deng**, T.S. Kim, A.F. Laine, S.H. Lisanby, and A.V. Peterchev, "Regional electric field induced by electroconvulsive therapy in a realistic head model: Influence of white matter anisotropic conductivity," *NeuroImage*, vol.59, no.3, pp.2110–2123, Feb. 2012.  
PMCID: PMC3495594 DOI: 10.1016/j.neuroimage.2011.10.029
- \*31 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, "Electric field strength and focality of electroconvulsive therapy and magnetic seizure therapy: A finite element simulation study," *Journal of Neural Engineering*, vol.8, no.1, 016007, Jan. 2011.  
PMCID: PMC3903509 DOI: 10.1088/1741-2560/8/1/016007
- 30 N.M. Arzeno, **Z.-D. Deng**, and C.-S. Poon, "Analysis of first-derivative based QRS detection algorithms," *IEEE Transactions on Biomedical Engineering*, vol.55, no.2, pp.478–484, Feb. 2008.  
PMCID: PMC2532677 DOI: 10.1109/TBME.2007.912658

## Refereed Proceedings

- 29 M. Alawi, P.F. Lee, Y.K. Goh, **Z.-D. Deng**, and P.E. Croarkin, "Modelling of transcranial magnetic stimulation (TMS) induced fields in different age groups," *Proceedings of International Conference for Innovation in Biomedical Engineering and Life Sciences*, Jan. 2021, vol.81, pp.68–75.  
DOI: 10.1007/978-3-030-65092-6\_8
- \*28 **Z.-D. Deng** and S.H. Lisanby, "Electric field characteristics of low-field synchronized transcranial magnetic stimulation (sTMS)," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, July 2017, pp.1445–1448.  
PMID: 29060150 DOI: 10.1109/EMBC.2017.8037106
- \*27 **Z.-D. Deng**, S.M. McClintock, and S.H. Lisanby, "Brain network properties in depressed patients receiving seizure therapy: A graph theoretical analysis of peri-treatment resting EEG," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2015, pp.2203–2206.  
PMID: 26736728 DOI: 10.1109/EMBC.2015.7318828

## Refereed Proceedings (continue)

- \*26 **Z.-D. Deng**, A. V. Peterchev, A. D. Krystal, B. Lubner, S. M. McClintock, M. M. Husain, and S. H. Lisanby, "Topography of seizures induced by electroconvulsive therapy and magnetic seizure therapy," *Proceedings of the IEEE Engineering in Medicine and Biology Society Conference on Neural Engineering*, Nov. 2013, pp.577–580.  
DOI: 10.1109/NER.2013.6696000
- 25 W. H. Lee, **Z.-D. Deng**, A. F. Laine, S. H. Lisanby, and A. V. Peterchev, "Influence of white matter conductivity anisotropy on electric field strength induced by electroconvulsive therapy," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2011, pp.5473–5476.  
PMID: 22255576 DOI: 10.1109/IEMBS.2011.6091396
- \*24 **Z.-D. Deng** and A. V. Peterchev, "Transcranial magnetic stimulation coil with electronically switchable active and sham modes," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2011, pp.1993–1996.  
PMID: 22254725 DOI: 10.1109/IEMBS.2011.6090561
- \*23 **Z.-D. Deng**, S. H. Lisanby, and A. V. Peterchev, "Transcranial magnetic stimulation in the presence of deep brain stimulation implants: Induced electrode currents," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2010, pp.6812–6824.  
PMID: 21095849 DOI: 10.1109/IEMBS.2010.5625958
- \*22 **Z.-D. Deng**, D. E. Hardesty, S. H. Lisanby, and A. V. Peterchev, "Electroconvulsive therapy in the presence of deep brain stimulation implants: Electric field effects," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2010, pp.2049–2062.  
PMID: 21096149 DOI: 10.1109/IEMBS.2010.5626517
- \*21 W. H. Lee, **Z.-D. Deng**, T. S. Kim, A. F. Laine, S. H. Lisanby, and A. V. Peterchev, "Regional electric field induced by electroconvulsive therapy: A finite element simulation study," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2010, pp.2045–2048.  
PMID: 21096148 DOI: 10.1109/IEMBS.2010.5626553
- \*20 **Z.-D. Deng**, S. H. Lisanby, and A. V. Peterchev, "Effect of head anatomical variability on neural polarization strength and focality in electroconvulsive therapy and magnetic seizure therapy," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Sept. 2009, pp.682–688.  
PMID: 19964484 DOI: 10.1109/IEMBS.2009.5334091
- \*19 **Z.-D. Deng**, A. V. Peterchev, and S. H. Lisanby, "Coil design considerations for deep brain transcranial magnetic stimulation," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2008, pp.5675–5679.  
PMID: 19164005 DOI: 10.1109/IEMBS.2008.4650502
- \*18 **Z.-D. Deng**, C.-S. Poon, N. M. Arzeno, and E. S. Katz, "Heart rate variability in pediatric obstructive sleep apnea," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2006, pp.3565–3568.  
PMID: 17946187 DOI: 10.1109/IEMBS.2006.260139
- \*17 N. M. Arzeno, C.-S. Poon, and **Z.-D. Deng**, "Quantitative analysis of QRS detection algorithms based on the first derivative of the ECG," *Proceedings of the IEEE Engineering in Medicine and Biology Society*, Aug. 2006, pp.1788–1791.  
PMID: 17946480 DOI: 10.1109/IEMBS.2006.260051

## Reviews, Protocols, & Consensus Papers

- \*16 M. Dannhauer, L. J. Gomez, P. L. Robins, D. Wang, N. I. Hasan, A. Thielscher, H. R. Siebner, Y. Fan, and **Z.-D. Deng**, “Electric field modeling in personalizing transcranial magnetic stimulation interventions,” *Biological Psychiatry*, vol. 95, no. 6, pp. 494–501, Mar. 2024.  
PMCID: PMC10922371 DOI: 10.1016/j.biopsych.2023.11.022
- 15 L. M. Oberman, S. M. Francis, L. Beynel, M. Hynd, M. Jaime, P. L. Robins, **Z.-D. Deng**, J. Stout, J. W. van der Veen, and S. H. Lisanby, “Design and methodology for a proof of mechanism study of individualized neuronavigated continuous theta burst stimulation for auditory processing in adolescents with autism spectrum disorder,” *Frontiers in Psychiatry*, vol. 15, 1304528, Feb. 2024.  
PMCID: PMC10881663 DOI: 10.3389/fpsyt.2024.1304528
- \*14 **Z.-D. Deng**, P. L. Robins, W. Regenold, P. Rohde, M. Dannhauer, and S. H. Lisanby, “How electroconvulsive therapy works in the treatment of depression: Is it the seizure, the electricity, or both?” *Neuropsychopharmacology*, vol. 49, no. 1, pp. 150–162, Jan. 2024.  
PMCID: PMC10700353 DOI: 10.1038/s41386-023-01677-2
- 13 A. R. Brunoni, H. Ekhtiari, A. Antal, P. Auvichayapat, C. Baeken, I. M. Benseñor, M. Bikson, P. Boggio, B. Borroni, F. Brighina, J. Brunelin, S. Carvalho, W. Caumo, P. Ciechanowski, L. Charvet, V. P. Clark, R. Cohen Kadosh, M. Cotelli, A. Datta, **Z.-D. Deng**, R. De Raedt, D. De Ridder, P. B. Fitzgerald, A. Floel, F. Frohlich, M. S. George, P. Ghobadi-Azbari, S. Goerigk, R. H. Hamilton, S. J. Jaberzadeh, K. Hoy, D. J. Kidgell, A. Khojasteh Zonoozi, A. Kirton, S. Laureys, M. Lavidor, K. Lee, J. Leite, S. H. Lisanby, C. Loo, D. M. Martin, C. Miniussi, M. Mondino, K. Monte-Silva, L. Morales-Quezada, M. A. Nitsche, A. H. Okano, C. S. Oliveira, B. Onarheim, K. Pacheco-Barrios, F. Padberg, E. M. Nakamura-Palacios, U. Palm, W. Paulus, C. Plewnia, A. Priori, T. K. Rajji, L. B. Razza, E. M. Rehn, G. Ruffini, K. Schellhorn, M. Zare-Bidoky, M. Simis, P. Skorupinski, P. Suen, A. Thibaut, L. C. L. Valiengo, M.-A. Vanderhasselt, S. Vanneste, G. Venkatasubramanian, I. R. Violante, A. Wexler, A. J. Woods, and F. Fregni, “Digitalized transcranial electrical stimulation: A consensus statement,” *Clinical Neurophysiology*, vol. 143, pp. 154–165, Nov. 2022.  
PMCID: PMC10031774 DOI: 10.1016/j.clinph.2022.08.018
- 12 L. Borrione, P. C. Cirillo, L. V. M. Aparicio, B. A. Cavendish, D. O. Moura, J. P. de Souza, I. Klein, J. Gallucci-Neto, P. Suen, F. Padberg, S. Goerigk, M.-A. Vanderhasselt, **Z.-D. Deng**, J. O’Shea, P. A. Lotufo, I. M. Bensenor, and A. R. Brunoni, “A study protocol for an ongoing multi-arm, randomized, double-blind, sham-controlled clinical trial with digital features, using portable transcranial electrical stimulation and internet-based behavioral therapy for major depression disorders: The PSYLECT study,” *Expert Review of Neurotherapeutics*, vol. 22, no. 6, pp. 513–523, June 2022.  
PMCID: PMC10627342 DOI: 10.1080/14737175.2022.2083959
- 11 W. T. Regenold, **Z.-D. Deng**, and S. H. Lisanby, “Noninvasive neuromodulation of the prefrontal cortex in mental health disorders,” *Neuropsychopharmacology*, vol. 47, no. 1, pp. 361–372, Jan. 2022.  
PMCID: PMC8617166 DOI: 10.1038/s41386-021-01094-3
- 10 N. L. Balderston, C. Roberts, E. M. Beydler, **Z.-D. Deng**, T. Radman, B. Luber, S. H. Lisanby, M. Ernst, and C. Grillon, “A generalized method for conducting electric-field optimized, fMRI-guided, transcranial magnetic stimulation,” *Nature Protocols*, vol. 15, no. 11, pp. 3595–3614, Nov. 2020.  
PMCID: PMC8123368 DOI: 10.1038/s41596-020-0387-4

## Reviews, Protocols, & Consensus Papers (continue)

- 9 L. Borriane, H. Bellini, L. B. Razza, A. G. Avila, C. Baeken, A.-K. Brem, G. Busatto, A. F. Carvalho, A. Chekroud, Z. J. Daskalakis, **Z.-D. Deng**, J. Downar, W. Gattaz, C. Loo, P. A. Lotufo, M. D. G. M. Martin, S. M. McClintock, J. O'Shea, F. Padberg, I. C. Passos, G. A. Salum, M.-A. Vanderhasselt, R. Fraguas, I. Benseñor, L. Valiengo, and A. R. Brunoni, "Precision non-implantable neuromodulation therapies: A perspective for the depressed brain," *Brazilian Journal of Psychiatry*, vol. 42, no. 4, pp. 403–419, July–Aug. 2020.  
PMCID: PMC7430385 DOI: 10.1590/1516-4446-2019-0741
- 8 B. Kadriu, **Z.-D. Deng**, C. Kraus, I. D. Henter, S. H. Lisanby, and C. A. Zarate, Jr., "Not so fast: Recent successes and failures in treating depression," *Journal of Clinical Psychiatry*, vol. 81, no. 4, 19ac13138, May 2020.  
PMCID: PMC7681914 DOI: 10.4088/JCP.19ac13138
- \*7 **Z.-D. Deng**, B. Lubner, N. L. Balderston, M. Velez Afanador, M. M. Noh, J. Thomas, W. C. Altekruze, S. L. Exley, S. Awasthi, and S. H. Lisanby, "Device-based modulation of neurocircuits as a therapeutic for psychiatric disorders," *Annual Review of Pharmacology and Toxicology*, vol. 60, pp. 591–614, Jan. 2020.  
PMCID: PMC8100981 DOI: 10.1146/annurev-pharmtox-010919-023253
- 6 E. Kallioniemi, S. M. McClintock, **Z.-D. Deng**, M. M. Husain, and S. H. Lisanby, "Magnetic seizure therapy: Towards personalized seizure therapy for major depression," *Personalized Medicine in Psychiatry*, vol. 17–18, pp. 37–42, Nov.–Dec. 2019.  
PMCID: PMC7442165 DOI: 10.1016/j.pmip.2019.04.003
- \*5 M. Bikson, A. R. Brunoni, L. E. Charvet, V. P. Clark, L. G. Cohen, **Z.-D. Deng**, J. P. Dmochowski, D. J. Edwards, F. Fröhlich, E. S. Kappenman, K. O. Lim, C. Loo, A. Mantovani, D. P. McMullen, L. C. Parra, M. Pearson, J. D. Richardson, J. M. Rumsey, P. Sehatpour, D. I. Sommers, G. Unal, E. M. Wassermann, A. J. Woods, and S. H. Lisanby, "Rigor and reproducibility in research with transcranial electrical stimulation: An NIMH-sponsored workshop," *Brain Stimulation*, vol. 11, no. 3, pp. 465–480, May–June 2018.  
PMCID: PMC5997279 DOI: 10.1016/j.brs.2017.12.008
- 4 S. M. Goetz and **Z.-D. Deng**, "The development and modeling of devices and paradigms for transcranial magnetic stimulation," *International Review of Psychiatry*, vol. 29, no. 2, pp. 115–145, Apr. 2017.  
PMCID: PMC5484089 DOI: 10.1080/09540261.2017.1305949
- \*3 **Z.-D. Deng**, S. M. McClintock, N. E. Oey, B. Lubner, and S. H. Lisanby, "Neuromodulation for mood and memory: From the engineering bench to the patient bedside," *Current Opinion in Neurobiology*, vol. 30, pp. 38–43, Feb. 2015.  
PMCID: PMC4342851 DOI: 10.1016/j.conb.2014.08.015
- 2 S. M. McClintock, J. Choi, **Z.-D. Deng**, L. G. Appelbaum, A. D. Krystal, and S. H. Lisanby, "Multifactorial determinants of the neurocognitive effects of electroconvulsive therapy," *The Journal of ECT*, vol. 30, no. 2, pp. 165–176, June 2014.  
PMCID: PMC4143898 DOI: 10.1097/YCT.000000000000137
- 1 A. V. Peterchev, M. A. Rosa, **Z.-D. Deng**, J. Prudic, and S. H. Lisanby, "Electroconvulsive therapy stimulus parameters: Rethinking dosage," *The Journal of ECT*, vol. 26, no. 3, pp. 159–174, Sept. 2010.  
PMCID: PMC2933093 DOI: 10.1097/YCT.0b013e3181e48165

## Book Chapters

- \*9 **Z.-D. Deng** and S.H. Lisanby, "Next generation seizure therapy," *The Oxford Handbook of Transcranial Stimulation*, E.M. Wassermann, A.V. Peterchev, U. Ziemann, S.H. Lisanby, H.R. Siebner, and V. Walsh, Eds., 2<sup>nd</sup> ed. Oxford, UK: Oxford Academic. DOI: 10.1093/oxfordhb/9780198832256.013.41
- 8 R.J. Ilmoniemi, **Z.-D. Deng**, L.J. Gomez, L.M. Koponen, J.O. Nieminen, A.V. Peterchev, and C.M. Epstein, "Transcranial magnetic stimulation coils," *The Oxford Handbook of Transcranial Stimulation*, E.M. Wassermann, A.V. Peterchev, U. Ziemann, S.H. Lisanby, H.R. Siebner, and V. Walsh, Eds., 2<sup>nd</sup> ed. Oxford, UK: Oxford Academic. DOI: 10.1093/oxfordhb/9780198832256.013.4
- 7 J. Thomas, **Z.-D. Deng**, S. Awasthi, and S.H. Lisanby, "Magnetic seizure therapy," in *Neuropsychology of Depression*, S.M. McClintock and J. Choi, Eds. New York: Guilford Press, 2022, ch.21, pp.383–406.
- 6 B. Kadriu, S. Subramanian, **Z.-D. Deng**, I.D. Henter, L.T. Park, and C.A. Zarate, Jr., "Rapid-acting antidepressants," in *Primer on Depression*, M.H. Trivedi, Ed. Oxford, UK: Oxford University Press, 2019, ch.13, pp.218–240. DOI: 10.1093/med/9780190929565.003.0013
- \*5 **Z.-D. Deng**, C. Liston, F.M. Gunning, M.J. Dubin, E.A. Friðgeirsson, J. Lilien, G.A. van Wingen, and J.A. van Waarde, "Electric field modeling for transcranial magnetic stimulation and electroconvulsive therapy," in *Brain and Human Body Modeling: Computational Human Modeling at EMBC 2018*, S.N. Makarov, M. Horner, and G.M. Noetscher, Eds. Switzerland: Springer Nature, 2019, ch.4, pp.75–84. PMID: 31725245 DOI: 10.1007/978-3-030-21293-3\_4
- \*4 S.N. Makarov, G. Bogdanov, G.M. Noetscher, W. Appleyard, R. Ludwig, J.T. Joutsa, and **Z.-D. Deng**, "Design and analysis of a whole body non-contact electromagnetic subthreshold stimulation device with field modulation targeting nonspecific neuropathic pain," in *Brain and Human Body Modeling: Computational Human Modeling at EMBC 2018*, S.N. Makarov, M. Horner, and G.M. Noetscher, Eds. Switzerland: Springer Nature, 2019, ch.5, pp.85–123. PMID: 31725237 DOI: 10.1007/978-3-030-21293-3\_5
- 3 B. Luber and **Z.-D. Deng**, "Application of non-invasive brain stimulation in psychophysiology," in *Handbook of Psychophysiology*, J.T. Cacioppo, L.G. Tassinary, G. Berntson, Eds., 4<sup>th</sup> ed. Cambridge, UK: Cambridge University Press, 2016, ch.7, pp.116–150. DOI: 10.1017/9781107415782.007
- 2 S.H. Lisanby and **Z.-D. Deng**, "Magnetic seizure therapy for the treatment of depression," in *Brain Stimulation: Methodologies and Interventions*, I. Reti, Ed. Hoboken, NJ: Wiley-Blackwell, 2015, ch.8, pp.123–148. DOI: 10.1002/9781118568323.ch8
- 1 A.V. Peterchev, **Z.-D. Deng**, and S.M. Goetz, "Advances in transcranial magnetic stimulation technology," in *Brain Stimulation: Methodologies and Interventions*, I. Reti, Ed. Hoboken, NJ: Wiley-Blackwell, 2015, ch.10, pp.165–190. DOI: 10.1002/9781118568323.ch10

## Letters to the Editor, Commentaries, & Technical Reports

- \*5 **Z.-D. Deng**, R.D. Wiener, and S.H. Lisanby, “Concerns regarding clinical outcomes of magnetic seizure therapy vs electroconvulsive therapy for major depressive episode—Reply,” *JAMA Psychiatry*, accepted Feb. 2024.
- 4 A.R. Brunoni, **Z.-D. Deng**, and F. Padberg, “Enhancing repetitive transcranial magnetic stimulation effects for depression treatment: *Navigare necesse est*—and smart clinical trial designs,” *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, vol. 7, no. 6, pp. 527–529, June 2022.  
PMID: 35680342 DOI: 10.1016/j.bpsc.2022.03.006
- \*3 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, “On the characterization of coils for deep transcranial magnetic stimulation,” *Clinical Neurophysiology*, vol. 126, no. 7, pp. 1456–1457, July 2015.  
PMID: 25468237 DOI: 10.1016/j.clinph.2014.10.144
- \*2 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, “On the stimulation depth of transcranial magnetic stimulation coils,” *Clinical Neurophysiology*, vol. 126, no. 4, pp. 843–844, Apr. 2015.  
PMID: 25088734 DOI: 10.1016/j.clinph.2014.06.048
- \*1 **Z.-D. Deng** and A.V. Peterchev, “Safety of transcranial magnetic stimulation and electroconvulsive therapy in patients with a deep brain stimulation implant,” Technical report for St. Jude Medical/Advanced Neuromodulation System, Plano, TX, 2010.

## Other Publications & Artworks

- \*2 **Z.-D. Deng**, “Brain: An intricate web,” *NIMH Scientific Training Day*, Sept. 2022. Voted first place in Science as Art Competition
- \*1 **Z.-D. Deng**, “Blind researchers and the pathologic brain,” *National Academy of Neuropsychology Bulletin*, vol. 33, no. 1, cover artwork, 2020.  
URL: <https://www.e-digital-editions.com/i/1241418-spring-issue>



## Articles in Review, Preprints, & Contracted Chapters

- \*0 **Z.-D. Deng**, N.M. Arzeno, E.S. Katz, H. Chang, C.L. Marcus, and C.-S. Poon, “Non-high frequency heart rate chaos: A noninvasive marker of REM sleep and obstructive sleep apnea syndrome in children,” *bioRxiv*, Oct. 2018.  
DOI: 10.1101/457630
- 0 L. Claudino, C. Gaillard, A. Gorka, E. Weiss, **Z.-D. Deng**, and M. Ernst, “Self-reported experience of anxiety arousal can modulate loss aversion in pathological anxiety.”
- 0 C. Lu, **Z.-D. Deng**, and F.-S. Choa, “Augmenting transcranial magnetic stimulation coil with magnetic material: An optimization approach,” *bioRxiv*, Jan. 2022.  
DOI: 10.1101/2022.01.21.477303
- 0 C. Thomas, **Z.-D. Deng**, Y. Huang, C.C. Abbott, G. Venkatasubramanian, and A. Datta, “Exploring the potential impact of race on cortical current flow due to ECT: A computational analysis.”
- \*0 **Z.-D. Deng**, M. Argyelan, J. Miller, D.K. Quinn, M. Lloyd, T.R. Jones, J. Upston, E. Erhardt, S.M. McClintock, A. Datta, and C.C. Abbott, “On assumptions and key issues in electric field modeling of ECT,” *engRxiv*, Aug. 2023.  
DOI: 10.31224/3190
- 0 L. Morales, W.A. Wartman, J. Ferreira, A. Miles, M. Daneshzand, H. Lu, A.R. Nummenmaa, **Z.-D. Deng**, and S.N. Makaroff, “Software package for transcranial magnetic stimulation coil and coil array analysis and design,” *bioRxiv*, Aug. 2023.  
PMCID: PMC10473578 DOI: 10.1101/2023.08.20.554037
- 0 J.R. Young, J. T. Galla, C.S. Polick, **Z.-D. Deng**, M. Dannhauer, A. Kirby, M. Dennis, C.W. Papanikolas, M.K. Evans, S.D. Moore, E.A. Dedert, M.A. Addicott, L.G. Appelbaum, and J.C. Beckham, “Multimodal smoking cessation treatment combining transcranial magnetic stimulation, cognitive behavioral therapy, and nicotine replacement therapy in veterans with posttraumatic stress disorder: A feasibility randomized controlled trial protocol,” *medRxiv*, Sept. 2023.  
PMCID: PMC10602046 DOI: 10.1101/2023.09.06.23294958
- 0 L. Beynel, H. Gura, Z. Rezaee, E. Ekpo, **Z.-D. Deng**, O. Joseph, P. Taylor, B. Luber, and S.H. Lisanby, “Lessons learned from an fMRI-guided rTMS study on performance in a numerical Stroop task.”
- 0 H. Nguyen, C.Q. Li, S. Hoffman, **Z.-D. Deng**, Y. Yang, and H. Lu, “Ultra-high frequency repetitive TMS at subthreshold intensity induces suprathreshold motor response via temporal summation.”
- 0 N.I. Hasan, M. Dannhauer, D. Wang, **Z.-D. Deng**, and L.J. Gomez, “Real-time computation of brain E-field for enhanced transcranial magnetic stimulation neuronavigation and optimization,” *bioRxiv*, Oct. 2023.  
PMCID: PMC10635016 DOI: 10.1101/2023.10.25.564044
- 0 M. Teferi, M. Patel, A. Casalvera, K.G. Lynch, W. Makhoul, **Z.-D. Deng**, D.J. Oathes, Y.I. Sheline, and N.L. Balderston, “Intermittent theta-burst stimulation to the right dorsolateral prefrontal cortex may increase potentiated startle in healthy individuals.”



## Articles in Review, Preprints, & Contracted Chapters

- 0 B. Luber, L. Beynel, **Z.-D. Deng**, L. G. Appelbaum, T. Jones, A. Harrison, D.L.K. Murphy, E. Lo, R.A. McKinley, and S.H. Lisanby, "Site- and frequency-specific enhancement of visual search performance with online individual alpha frequency (IAF) repetitive transcranial magnetic stimulation (rTMS) to the inferior frontal junction."
- 0 S.M. McClintock, **Z.-D. Deng**, M.M. Husain, V. Thakkar, E. Bernhardt, R.D. Weiner, B. Luber, and S.H. Lisanby, "Comparing the neurocognitive effects of electroconvulsive therapy and magnetic seizure therapy for the treatment of major depressive episode: A randomized clinical trial."

## Dissertation & Thesis

- \*2 **Z.-D. Deng**, “Electromagnetic Field Modeling of Transcranial Electric and Magnetic Stimulation: Targeting, Individualization, and Safety of Convulsive and Subconvulsive Applications,” Ph.D. dissertation, Columbia University, Department of Electrical Engineering, New York, NY, 2013. Sponsor: K.L. Shepard. Available: Columbia University Academic Commons, DOI: 10.7916/D8F47WCS
- \*1 **Z.-D. Deng**, “Stochastic Chaos and Thermodynamic Phase Transitions: Theory and Bayesian Estimation Algorithms,” M.Eng. thesis, Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science, Cambridge, MA, 2007. Sponsor: C.-S. Poon. Available: DSpace@MIT, HDL: 1721.1/41649

## Selected Abstracts (10/150)

- \*10 P.L. Robins, S.N. Makaroff, and **Z.-D. Deng**, “Electric field characteristics of rotating permanent magnet stimulation,” *Biomedical Engineering Society Annual Meeting*, 2023; also presented at *NIMH IRP Fellows’ Scientific Training Day*, 2023. **NIMH IRP Trainee Travel Award**
- \*9 J. Kim, B.A. Pritchard, G.R. Dold, R.H. Schor, S.H. Lisanby, and **Z.-D. Deng**, “Multi-channel Individualized Stimulation Therapy (MIST) system for treatment of depression,” *Proceedings of the IEEE Engineering in Medicine and Biology Society*, 2023.
- \*8 M. Dannhauer and **Z.-D. Deng**, “Optimizing the placements of multielectrode tES montages from EEG dipole modeling,” *Brain Stimulation*, vol.16, no.1, pp.136–137, 2023.
- \*7 P.L. Robins, M. Dannhauer, L.M. Haugen, J.D. Port, P.E. Croarkin, and **Z.-D. Deng**, “Comparison of coil localization approaches and induced electric fields in depressed adolescents receiving repetitive transcranial magnetic stimulation,” *Brain & Human Body Modeling Conference*, 2022. **First Place in International Student Competition**
- \*6 **Z.-D. Deng**, “Introduction to computational psychiatry,” *Journal of the American Academy of Child and Adolescent Psychiatry*, vol.60, no.10, pp.S308–S309, 2021.
- \*5 **Z.-D. Deng**, “Toward individualized seizure therapy,” *Neuropsychopharmacology*, vol.44, p.S75, 2019.
- \*4 **Z.-D. Deng**, E.M. Lo, L. Beynel, E. Fang, B. Luber, and A.D. Krystal, “Cortical excitability in patients with treatment resistant depression,” *Biological Psychiatry*, vol.81, no.10, p.S242, 2017.
- \*3 **Z.-D. Deng**, S.M. McClintock, and S.H. Lisanby, “Connectivity analysis of resting EEG in depressed patients receiving electroconvulsive therapy and magnetic seizure therapy,” *Neuropsychopharmacology*, vol.40, no.S1, p.S486, 2015.
- \*2 **Z.-D. Deng**, S.M. McClintock, and S.H. Lisanby, “EEG-based graph theoretical measures as biomarkers of clinical outcome in electroconvulsive and magnetic seizure therapy,” *The National Network of Depression Centers Annual Conference*, 2014. **Innovative Poster Award**
- \*1 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, “Improving the focality of electroconvulsive therapy: The roles of current amplitude, and electrode size and spacing,” *The Journal of ECT*, vol.26, no.2, p.151, 2010. **Best Abstract Award**

## Intellectual Property

- 8 PReCISION, Optimally Targeted, Electroconvulsive Therapy (PROTECT)  
 Inventors: **Z.-D. Deng**, J. Kim, G. R. Dold, B. A. Pritchard, R. H. Schor, S. H. Lisanby  
 § Invention disclosure submitted to NIH; Aug. 2023
- 7 Systems and methods for amplitude-determined seizure titrations and electric field modeling in electroconvulsive therapy  
 Inventors: C. C. Abbott, A. Datta, J. Upston, T. Jones, **Z.-D. Deng**  
 Assignee: University of New Mexico  
 § US Provisional Patent application No. 63/516,371; July 28, 2023
- 6 Systems and methods for multichannel individualized stimulation therapy  
 Inventors: **Z.-D. Deng**, B. A. Pritchard, J. Kim, G. R. Dold, R. H. Schor, S. H. Lisanby  
 Assignee: NIH  
 § US Provisional Patent application No. 63/495,244; Apr. 10, 2023
- 5 Systems and methods for E-field informed electroconvulsive therapy  
 Inventors: C. C. Abbott, **Z.-D. Deng**, J. Upston, T. Jones, A. Datta  
 Assignee: University of New Mexico  
 § PCT/US24/10363; Jan. 4, 2024  
 § US Provisional Patent application No. 63/437,017; Jan. 4, 2023
- 4 Whole body non-contact electrical stimulation device with variable parameters  
 Inventors: S. N. Makarov, G. M. Noetscher, V. S. Makarov, **Z.-D. Deng**  
 Assignee: NEVA Electromagnetics, LLC  
 § US No. 10,551,449; Feb. 4, 2020
- 3 Systems and methods for detecting a physiological abnormality in a patient by using cardiac or other chaos in combination with a non-increasing parasympathetic modulation  
 Inventors: C.-S. Poon, **Z.-D. Deng**  
 Assignee: MIT  
 § US No. 9,737,258; Aug. 22, 2017  
 § PCT WO/2014/120353; July 8, 2014
- 2 Transcranial magnetic stimulation coil with electronically switchable active and sham modes  
 Inventors: A. V. Peterchev, **Z.-D. Deng**  
 Assignee: Columbia University  
 § US Provisional Patent application No. 61/525,922; Aug. 22, 2011
- 1 Methods, apparatus, and systems for magnetic stimulation  
 Inventors: A. V. Peterchev, S. H. Lisanby, **Z.-D. Deng**  
 Assignee: Columbia University  
 § US No. 9,295,853; Mar. 29, 2016  
 § US No. 8,801,589; Aug. 12, 2014  
 § PCT WO/2010/017249, US 2011/0184223 A1, US 2009/052768; Aug. 4, 2009

## Research Support

### Pending Research Support

- 2024.02 **Targeting the causal depression network with electroconvulsive therapy**  
NIH/NIMH R33/R61 (PI: M. Argyelan)  
Role: Intramural NIH collaborator
- resub  
2022.10 **Charge-based brain modeling engine with boundary element fast multipole method**  
NIH/NIBIB R01 MH130490 (PI: S.N. Makarov)  
Role: Intramural NIH collaborator
- 2023.11 **Optimizing accelerated iTBS intersession interval to target Connectivity in Depression (CONNECT-D)**  
NIH/NIMH U01 (PIs: Y.I. Sheline, Z.J. Daskalakis, P.B. Fitzgerald)  
Role: Intramural NIH collaborator
- 2023.06 **Improving the optimization of TMS coil placement with precise calculation of electric fields and robust computation of personalized functional networks**  
NIH/NIMH R01 (PI: Y. Fan)  
Role: Intramural NIH collaborator

### Ongoing Research Support

- 2024–  
2027 **ADEPT: Adaptive trial for the treatment of depression associated with concussion using repetitive transcranial magnetic stimulation protocols**  
Congressionally Directed Medical Research Programs (PI: D.L. Brody)  
Role: Intramural NIH collaborator  
This study aims to compare different types of TMS that may alleviate depressive symptoms in US military service members with a history of concussion.
- 2023.03 **Cognitive and neural correlates of TMS motor intracortical inhibition in schizophrenia**  
NIH/NIMH K01 (PI: S.H. Hare)  
Role: Intramural NIH collaborator/advisor  
This study investigates the clinical significance of a paired-pulse TMS marker of cortical excitability, the short-interval intracortical inhibition, which is consistently reduced in individuals with schizophrenia.
- 2022.09–  
2027.06 **Novel electric-field modeling approach to quantify changes in resting state functional connectivity following theta burst stimulation**  
NIH/NIMH U01 MH130447 (PI: N.L. Balderston)  
Role: Intramural NIH collaborator  
This study aims to develop a model using whole-brain estimates of the TMS-induced electric field to predict changes in resting state functional connectivity following neuromodulatory TMS, and validate this model in a large cohort of healthy volunteers receiving multiple doses of either intermittent or continuous theta burst stimulation.
- 2023.02–  
present **Development of a novel, scalable, neurobiologically-guided transcranial magnetic stimulation protocol for the treatment of cannabis use disorder**  
Centre for Addiction and Mental Health, Toronto, ON, Canada (PI: V.M. Tang)  
Role: Consultant  
This proof-of-concept clinical trial will evaluate the feasibility and tolerability of a 4-week course of rTMS to the prefrontal cortex and insula as a treatment for cannabis use disorder.

## Ongoing Research Support (continue)

- 2022.08–  
2027.05 **Deciphering mechanisms of ECT outcomes and adverse effects (DECODE)**  
NIH/NIMH R01 (MH128686 PI: Y.I. Sheline; MH128690 PIs: K.L. Narr, R. Espinoza; MH128691 PI: S.M. McClintock; MH128692 PI: C.C. Abbott)  
Role: Intramural NIH collaborator  
This multi-site prospective study aims to study the mechanism of ECT-induced antidepressant benefits and cognitive adverse effects to determine optimal ECT dose.
- 2021.02–  
2023.01 **Electroconvulsive therapy amplitude titration for improved clinical outcomes in late-life depression**  
NIH/NIMH R61/R33 MH125126 (PI: C.C. Abbott)  
Role: Intramural NIH collaborator  
This study uses titrated amplitude ECT, individualized based on seizure threshold, to improve clinical response while minimizing cognitive impairment in geriatric depression.
- 2020.05–  
2023.04 **Neuromodulation of social cognitive circuitry in people with schizophrenia spectrum disorders**  
NIH/NIMH R61/R33 MH120188 (PIs: A.N. Voineskos, D.M. Blumberger)  
Role: Intramural NIH collaborator  
This study uses advanced brain imaging, and compare different brain stimulation techniques, to determine whether targeting the dorsomedial prefrontal cortex can engage social cognitive brain circuitry in people with schizophrenia spectrum disorders.
- 2019.04–  
2026.02 **Efficacy of biomarker-guided rTMS for treatment resistant depression**  
NIH/NIMH R01 MH118388 (PIs: C.M. Liston, F.M. Gunning, N.R. Williams)  
Role: Intramural NIH collaborator  
This confirmatory efficacy trial tests a novel, biotype-guided treatment selection strategy for rTMS in treatment-resistant depression.
- 2019.09–  
2023.07 **Examining the mechanisms of anxiety regulation using a novel, sham-controlled, fMRI-guided rTMS protocol and a translational laboratory model of anxiety**  
NIH/NIMH K01 MH121777 (PI: N.L. Balderston)  
Role: Intramural NIH collaborator/advisor  
This study uses rTMS to study the effect of right dlPFC activity on objective and subjective measures of induced anxiety, anxiety-related working memory deficits, and TMS-evoked BOLD responses during simultaneous TMS–fMRI.
- 2020.09–  
2025.08 **Personalized circuit-based neuromodulation targets for depression**  
NIH/NIMH K23 MH121657 (PI: S.H. Siddiqi)  
Role: Intramural NIH collaborator/advisor  
This study aims to better understand how distinct brain circuits can be mapped and selectively stimulated with TMS to treat different symptoms of major depression.

## NIH Protocols

- 2021–present **A feasibility study of Transcranial Electric Stimulation Therapy (TEST) for treatment resistant depression (TRD)**  
NIMH Protocol 21-M-0031 (PI: S. H. Lisanby)  
Role: Associate investigator
- 2020–present **Role of GABAergic transmission in auditory processing in Autism Spectrum Disorder**  
NIMH Protocol 20-M-0159 (PI: S. H. Lisanby)  
Role: Associate investigator
- 2019–present **Safety and feasibility of individualized low amplitude seizure therapy**  
NIMH Protocol 19-M-0073 (PI: S. H. Lisanby)  
Role: Associate investigator
- 2019–present **Mechanism of action underlying ketamine's antidepressant effects: an investigation of the AMPA throughput theory in patients with treatment-resistant major depression**  
NIMH Protocol 19-M-0107 (PI: C. A. Zarate, Jr.)  
Role: Associate investigator
- 2017–present **Concurrent fMRI-guided rTMS and cognitive therapy for the treatment of major depressive episodes**  
NIMH Protocol 17-M-0147 (PI: S. H. Lisanby)  
Role: Associate investigator
- 2017–present **Development of non-invasive brain stimulation techniques**  
NIMH Protocol 18-M-0015 (PI: S. H. Lisanby)  
Role: Associate investigator
- 2017–present **Development of functional and structural magnetic resonance imaging techniques for the study of mood and anxiety disorders**  
NIMH Protocol 07-M-0021 (PI: A. C. Nugent)  
Role: Associate investigator
- 2017–present **Identifying neurobiological mechanisms that underlie acute nicotine withdrawal and drive early relapse in smokers**  
NIDA Protocol 12-DA-N474 (PI: A. Janes)  
Role: Associate investigator
- 2016–present **Neuropharmacologic imaging and biomarker assessments of response to acute and repeated-dosed ketamine infusions in major depressive disorder**  
NIMH Protocol 17-M-0060 (PI: C. A. Zarate, Jr.)  
Role: Associate investigator
- 2016–present **Evaluation of patients with mood and anxiety disorders and healthy volunteers**  
NIMH Protocol 01-M-0254 (PI: C. A. Zarate, Jr.)  
Role: Associate investigator
- 2018–2019 **Modulation of the parieto-frontal communication**  
NINDS Protocol 18-N-0054 (PI: M. Hallett)  
Role: Associate investigator
- 2017–2019 **Effect of TMS to frontoparietal attention network on anxiety potentiated startle**  
NIMH Protocol 17-M-0042 (PI: C. Grillon)  
Role: Associate investigator

## Completed Research Support

### 2016.09– **ECT pulse amplitude and medial temporal lobe engagement**

2020.07 NIH/NINDS U01 MH11826 (PI: C. C. Abbott)

Role: Co-I

This study explores the impact of targeted hippocampal engagement with varying levels of electroconvulsive therapy current amplitude in elderly patients with clinical, neuropsychological and neuroimaging assessments.

### 2018.06– **Individualized low amplitude seizure therapy (iLAST)**

2020.06 Brain & Behavior Research Foundation Young Investigator Award 26161

Role: PI

This study aims to develop a novel form of seizure therapy for depression that avoids the neurocognitive side effects of electroconvulsive therapy by using computational modeling to direct multi-electrode configurations that provide targeted and individualized dosing.

### 2016.06– **Fast-Fail Trials: Mood and Anxiety Spectrum Disorders (FAST-MAS)**

2017.12 NIMH 271201200006I-3-27100003-1 (PI: A. D. Krystal)

Role: Data analyst

The goal of this project is to establish the kappa opiate receptor occupancy and mu opiate receptor effects after two weeks of daily dosing with the investigational agent LY2456302, which has been demonstrated to be a selective kappa opiate receptor antagonist.

### 2015.04– **Transcranial direct current stimulation as a treatment for acute fear**

2017.01 NIH/NIMH R21 MH106772 (PI: A. D. Krystal)

Role: Co-I

This study investigates the utility of transcranial direct current stimulation to engage a target neural circuit, which could serve as the basis for developing better therapies for those suffering from acute fear related difficulties.

### 2014.07– **Individualized optimally-targeted seizure therapy**

2016.06 NIH/NCATS KL2 TR001115 (Training Grant PI: R. M. Califf)

Role: PI

This award from the Duke Translational Medicine Institute prepares the fellow for a successful career as a multidisciplinary independent investigator in the field of brain stimulation. The goal of the project is to develop a novel individualized neurotargeted seizure therapy.

### 2015.03– **Safety and feasibility of low amplitude electroconvulsive therapy**

2016.06 Duke University School of Medicine, Pilot fund

Role: PI

This study evaluates whether neurocognitive side effects of electroconvulsive therapy can be improved by reducing the current pulse amplitude.

### 2009.04– **Prolonging Remission In Depressed Elderly (PRIDE)**

2016.03 NIH/NIMH U01 MH084241 (PI: S. H. Lisanby)

Role: Data analyst

This study evaluates the efficacy and neurocognitive effects of combined electroconvulsive and pharmaco-therapy in prolonging remission in elderly patients with major depression.

### 2015.04– **Low field magnetic stimulation coil design**

2016.06 Tal Medical (PI: A. V. Peterchev)

Role: Co-I

This project develops a novel coil system for low field magnetic stimulation.



## Completed Research Support (continue)

- 2015.11–2016.06 **Concurrent cognitive behavioral therapy and transcranial magnetic stimulation in obsessive-compulsive disorder**  
 American Psychiatric Association Research Scholarship (Grantee: Y. Hu)  
 Role: Acting PI  
 The purpose of this pilot study is to evaluate the feasibility of repetitive transcranial magnetic stimulation of the supplementary motor area concurrently with elements of exposure and response prevention in patients with obsessive-compulsive disorder.
- 2014.01–2015.12 **Evoked potentials as markers of ketamine-induced cortical plasticity in patients with major depressive disorder**  
 Janssen Research & Development, LLC (PI: A.D. Krystal)  
 Role: Co-I  
 This open-label trial evaluates the utility of somatosensory, motor, and transcranial magnetic stimulation-based evoked potentials as markers of cortical plasticity in response to a single intravenous infusion of ketamine in patients with depression.
- 2005.07–2011.07 **Magnetic seizure therapy for the treatment of depression**  
 Stanley Medical Research Institute (PI: S.H. Lisanby)  
 Role: Postdoctoral fellow  
 This two-center, randomized, double-blind controlled trial compares the antidepressant efficacy and side effects of magnetic seizure therapy and electroconvulsive therapy.
- 2010.07–2015.01 **Translational research evaluating neurocognitive memory processes**  
 NIH/NIMH K23 MH087739 (PI: S.M. McClintock)  
 Role: Postdoctoral fellow  
 This study informs the cognitive component processes underlying memory impairment after electroconvulsive therapy.
- 2010.07–2015.12 **Rational dosing for electric and magnetic seizure therapy**  
 NIH/NIMH R01 MH091083 (PI: S.H. Lisanby)  
 Role: Graduate research assistant, contributed to grant writing  
 This study lays a foundation for optimizing stimulus parameters of electric and magnetic seizure therapy through computational modeling and preclinical studies of seizure induction.
- 2010.09–2011.06 **Field shaping and coil design for transcranial magnetic stimulation**  
 NIH/NCRR TL1 RR024158 (Training Grant PI: H.N. Ginsberg)  
 Role: Predoctoral fellow  
 This award from the Columbia University Irving Institute for Clinical and Translational Research supports clinical research training for predoctoral students in the basic sciences. The goal of the project is to develop novel coil design for deep transcranial magnetic stimulation.
- 2007.08–2009.07 **Development of a novel TMS device with controllable pulse shape**  
 NIH/NIBIB R21 EB006855 (PI: A.V. Peterchev)  
 Role: Graduate research assistant  
 This project develops an efficient transcranial magnetic stimulation device that produces nearly rectangular pulses with adjustable amplitude, width, and directionality.
- 2005.11–2009.06 **Nonlinear analysis of heart rate variability**  
 NIH/NHLBI R01 HL079503 (PI: C.-S. Poon)  
 Role: Graduate research assistant  
 This project develops advanced nonlinear estimation and adaptive control algorithms for the modeling and analysis of the cardiovascular system.

## Scholarships, Fellowships, & Honors

- 2023–2024 **Scholar, Advanced Research Institute in Geriatric Mental Health**, Dartmouth College, supported by grant from NIH (R25MH068502)
- 2019 **NIMH Director's Award**, for scientific innovation at the interface of computation and psychiatry, NIMH Intramural Research Program
- 2018 **Richard J. Wyatt Memorial Fellowship Award for Translational Research**, NIMH Intramural Research Program
- 2018 **New Investigator Award**, American Society of Clinical Psychopharmacology
- 2018 **Travel Fellowship Award**, Society of Biological Psychiatry
- 2018 **Research Colloquium for Junior Investigators**, American Psychiatric Association
- 2018 **Alies Muskin Career Development Leadership Program**, Anxiety & Depression Association of America
- 2017 **NARSAD Young Investigator Award**, Brain & Behavior Research Foundation
- 2017 **Career Development Institute for Psychiatry**, Stanford University
- 2017 **New Investigator Award**, International Society for CNS Clinical Trials and Methodology
- 2016 **Certificate for Highly Cited Research**, Brain Stimulation, Elsevier
- 2015 **Young Investigator Memorial Travel Award**, American College of Neuropsychopharmacology
- 2015 **Scholar, Summer Research Institute in Geriatric Mental Health**, Weill Cornell Medical College, supported by grant from NIH (R25MH019946)
- 2015 **Chair's Choice Award**, Society of Biological Psychiatry
- 2014 **Innovative Poster Award, Young Investigator Award Finalist**, National Network of Depression Centers
- 2010 **Best Abstract Award**, International Society for Neurostimulation
- 2010 **Presidential Teaching Award Finalist**, Columbia University
- 2006 **Student Paper Competition Finalist**, IEEE Engineering in Medicine and Biology Society
- 2002 **New York Times College Scholarship**, New York Times Company Foundation

## Talks & Colloquia

### Grand Rounds

- 2023 Advanced Research Institute Grand Rounds in Mental Health and Aging Research  
*Neurostimulation revolution: Advancing treatment optimization and technology innovation*
- 2020 Westmead Hospital, Sydney, Australia  
*Advances in neuromodulation: Electroconvulsive therapy*
- 2018 Clinical TMS Society Grand Rounds Webinar  
*Transcranial magnetic stimulation: Physics, devices, and modeling*
- 2017 University of New Mexico School of Medicine, Psychiatry & Behavioral Sciences  
*Toward individualized electroconvulsive therapy for treatment of depression*
- 2015 Duke University School of Medicine, Department of Psychiatry & Behavioral Sciences  
*Toward next generation seizure therapy*
- 2015 Central Regional Hospital, Butner, NC  
*Individualized seizure therapy*

### Invited Talks, Seminars, Worskops, & Panels

- 2024 International Society for Magnetic Resonance in Medicine Annual Meeting  
*Tutorial: From basics to applications: MRI of neuromodulation using TMS and FUS*
- 2023 University of Texas Southwestern, Center for Depression Research and Clinical Care  
*Advancements in computational neurostimulation for depression treatment optimization and technology development*
- 2023 Brain and Human Body Modeling Conference, The Martinos Center for Biomedical Imaging, Massachusetts General Hospital  
Chair: *New modeling methods and targets: Spinal cord stimulation and novel stimulation*  
Chair: *Development and assessment of modeling methods*  
Contributed talk: *Effects of low intensity magnetic stimulation*  
Judge: Student competition
- 2023 International Conference of the IEEE Engineering in Medicine and Biology Society  
Panel: *Computational analysis of non-invasive neuromodulation constructs: Brain and spine*  
Contributed talk: *Modeling of transcranial magnetic stimulation and electroconvulsive therapy in the treatment of depression*
- 2023 University of Pittsburgh, Department of Psychiatry  
*Computational neurostimulation: Approach to treatment optimization and technology development*
- 2023 ADAA Anxiety and Depression Conference  
Panel: *Parsing through syndromic heterogeneity in youths with mental illness to identify neurocircuit mechanisms and develop novel treatments*  
Contributed talk: *Modeling and dose optimization for transcranial magnetic stimulation and electroconvulsive therapy for treatment of depression*
- 2023 International Brain Stimulation Conference  
Symposium chair: *Insights and challenges in preclinical models of TMS: Multimodal investigations across animal species*  
Fast-track oral symposium chair: *Advanced computational modeling and optimization methods for noninvasive brain stimulation*

## Invited Talks, Seminars, Worskops, & Panels (continue)

- 2022 International Network of tES-fMRI (INTF) Webinar Series  
*Electric field modeling and optimization approaches for individualized targeting*
- 2022 International Society for Magnetic Resonance in Medicine, workshop on MRI of Neuromodulation: Target Engagement, Neural Mechanism & Biomarker Development  
*Modeling of TMS* 📺
- 2022 Bergen Workshop of the Global ECT-MRI Collaboration  
*ECT device development* 📺
- 2022 International Congress of Clinical Neurophysiology  
Chair: *Towards optimized TMS targeting approaches*
- 2022 Brain and Human Body Modeling Conference, The Martinos Center for Biomedical Imaging, Massachusetts General Hospital  
Chair: *Modeling of transcranial electrical stimulation and deep brain stimulation*  
Contributed talk: *ECT, electric field, neuroplasticity, and clinical outcomes*
- 2022 European Conference of Brain Stimulation in Psychiatry  
Panel: *Beyond clinical syndromes: Understanding mechanisms of neuromodulation from a dimensional perspective*  
Contributed talk: *Depressive symptom dimensions and response trajectories in ECT and MST*
- 2022 Medical University of South Carolina, National Center of Neuromodulation for Rehabilitation  
*Model-driven design for brain stimulation therapies* 📺
- 2022 Society of Biological Psychiatry Annual Meeting  
Panel: *Dimensional approaches to device neuromodulation*  
Contributed talk: *Depressive symptom dimensions and response trajectories in ECT and MST*
- 2022 NIMH Intramural Research Program Investigators' Seminar Series  
*Seizure therapies: The next generation*
- 2022 Global ECT-MRI Collaboration (GEMRIC) Young Researchers Collective  
*ECT, electric field, neuroplasticity, and clinical outcomes*
- 2021 Butler Hospital, Brown University  
*Computational model driven design for brain stimulation*
- 2021 American Academy of Child and Adolescent Psychiatry Annual Meeting  
Panel: *Recent work with contemporary computational methods and artificial intelligence to advance the practice of child and adolescent psychiatry*  
Contributed talk: *Introduction to computational psychiatry*
- 2021 European College of Neuropsychopharmacology Congress  
Panel: *Neurobiology of rapid mood changes*  
Contributed talk: *Precision neurostimulation: Electroconvulsive therapy*
- 2021 University of Pennsylvania, Center for Neuromodulation in Depression and Stress  
*Electromagnetic brain stimulation from low to high intensity*
- 2021 Society for Brain Mapping & Therapeutics Annual Congress  
*Advances in electroconvulsive therapy for treatment of depression*

## Invited Talks, Seminars, Worskops, & Panels (continue)

- 2021 American Society of Clinical Psychopharmacology Annual Meeting  
Early Career Workshop: *How to give a virtual talk*
- 2021 International College of Neuropsychopharmacology Virtual World Congress  
Panel: *Next generation seizure therapy and neuromodulation*
- 2020 European Conference of Brain Stimulation in Psychiatry  
Panel: *What can we learn from ECT: Insights from the GEMRIC consortium*  
Contributed talk: *Using electric field modeling to inform ECT dosing and device development*
- 2020 NIH Basic Training Course on Transcranial Magnetic Stimulation  
*TMS physics, devices, modeling* 
- 2020 University of Minnesota Non-Invasive Brain Stimulation Workshop  
*Use of individual electric field models in clinical research* 
- 2020 American Society of Clinical Psychopharmacology Annual Meeting  
Panel: *New developments in neurostimulation* #coronacancelled
- 2020 VA Boston Healthcare System, Boston University School of Medicine, Harvard Medical School Neuropsychiatry Translational Research Fellowship Seminar  
*Precision neurostimulation: History, physics, computational modeling, engineering, and more*
- 2020 NYC Neuromodulation Online  
Discussant: *Noninvasive vagus nerve stimulation applied to stress management, opioid withdrawal, and neurocognitive disorders*
- 2020 Medical University of Vienna, Neuroimaging Lab  
*Precision seizure therapy*
- 2019 American College of Neuropsychopharmacology  
Panel: *Precision neurostimulation for treatment of psychiatric disorders*  
Contributed talk: *Rational design of precision seizure therapy*
- 2019 International Symposium on Advancing Stimulation Precision Medicine of Brain Disorders, Copenhagen University Hospital Hvidovre, Danish Research Centre for Magnetic Resonance  
*Rational design of precision seizure therapy*
- 2019 International College of Neuropsychopharmacology Meeting  
Workshop: *Neurobiological and clinical characterization, and treatment development for treatment resistant depression*  
Contributed talk: *Individualized electroconvulsive therapy: Reinventing ECT*
- 2019 American Society of Clinical Psychopharmacology Annual Meeting  
Co-chair: *Treatment-resistant mood disorders across the lifespan: Novel therapeutics*
- 2019 Mount Sinai Icahn School of Medicine, Depression and Anxiety Center  
*Rational design of individualized noninvasive brain stimulation*
- 2019 International Brain Stimulation Conference  
Panel: *Individualized brain stimulation: Addressing heterogeneity across modalities*  
Contributed talk: *Individualized electroconvulsive therapy for treatment of depression*

## Invited Talks, Seminars, Worskops, & Panels (continue)

- 2018 NIMH Intramural Research Program Investigators' Seminar Series  
*Computational neurostimulation: Engineering better noninvasive brain stimulation therapies*
- 2018 UCLA Brain Mapping Center  
*Computational neurostimulation: Engineering better brain stimulation therapies*  
  
Semel Institute for Neuroscience and Human Behavior, Neuromodulation Division  
*Modeling and design for magnetic stimulation*
- 2018 USC Mark and Mary Stevens Neuroimaging and Informatics Institute  
*Computational neurostimulation*
- 2018 2<sup>nd</sup> Bergen Workshop of the Global ECT-MRI Collaboration  
*Electric field modeling for electroconvulsive therapy*
- 2018 Joint NYC Neuromodulation Conference & NANS Summer Series  
Preconference workshop director: *Computational modeling in neuromodulation: Tools for engineers, clinicians, and researchers*  
Contributed talk: *Optimizing stimulation arrays and high-density EEG for brain targeting*
- 2018 Neuropsychiatric Drug Development Summit  
*Targeted intermittent device delivered interventions will ultimately prove superior to maintenance treatment with drugs for brain disorders*
- 2018 International Conference of the IEEE Engineering in Medicine and Biology Society  
Chair: *Computational human models for brain stimulation*  
Contributed talk: *Electric field induced by transcranial magnetic stimulation: Applications in depression and anxiety disorder*
- 2018 APA Annual Conference Presidential Symposium  
Presidential symposium: *ECT in the era of new brain stimulation treatments: Road map of future enhancements*  
Contributed talk: *Individualized neurotargeted seizure therapy: Reinventing ECT*
- 2018 ADAA Anxiety and Depression Conference  
Panel: *Personalized medicine for treatment resistant depressed patients: Novel strategies to optimize treatment with antidepressant medications, ketamine, and ECT*  
Contributed talk: *Individualized neurotargeted seizure therapy: Reinventing ECT*
- 2017 NIMH Non-Invasive Brain Stimulation Electric Field Modeling Workshop  
*Use of individual electric field models in clinical research* 
- 2017 NYC Neuromodulation Conference  
*Low field magnetic stimulation*
- 2016 NIDA, Neuroimaging Research Branch  
*Advances in transcranial magnetic stimulation technology*
- 2016 NIMH Workshop on Transcranial Electrical Stimulation: Mechanisms, Technology, and Therapeutic Applications  
*Effect of anatomical variability on electric field characteristics of tES*
- 2016 Mayo Clinic College of Medicine, Department of Molecular Pharmacology, Neurobiology of Alcoholism and Drug Addiction Lab  
*Transcranial magnetic stimulation technology development*  
  
Department of Neurosurgery Research, Neural Engineering Lab  
*Optimizing transcranial magnetic stimulation*

## Invited Talks, Seminars, Worskops, & Panels (continue)

- 2016 NIMH, Experimental Therapeutics & Pathophysiology Branch  
*Engineering better electromagnetic brain stimulation therapies*
- 2015 International Society for ECT and Neurostimulation Annual Meeting  
Workshop: *Spatial targeting with transcranial magnetic stimulation*
- 2015 Duke University School of Medicine, Department of Psychiatry & Behavioral Sciences  
Chair's round: *Fundamentals of transcranial electric and magnetic stimulation dosing*
- 2015 Weill Cornell Medical College, Department of Biomedical Engineering  
*Transcranial magnetic stimulation: Pulse source, coil design, & concurrent neuroimaging*
- 2014 Duke University, Department of Biomedical Engineering  
*Modeling and coil design considerations for transcranial magnetic stimulation*

## Teaching & Mentoring

### Appointments

- 2022–present **Educational Counselor**, MIT
- 2018–2019 **Research Mentor**, Fischell Department of Bioengineering, University of Maryland, College Park, A. James Clark School of Engineering  
*Capstone Design Project: Detection of brain-to-brain synchrony for improved psychotherapy*
- 2017, 2019 **Lecturer**, NINDS  
*Clinical Neuroscience Program Lecture Series*
- 2017 **Lecturer**, NIMH  
*fMRI Course*
- 2016 **Instructor**, Department of Neuroscience, Duke University  
*Research Independent Study*
- 2014–2016 **Faculty**, Department of Psychiatry and Behavioral Sciences, Duke University School of Medicine  
*Visiting Fellowship in Transcranial Magnetic Stimulation & Electroconvulsive Therapy Fellowship* (Continuing Medical Education)
- 2015–2016 **Research Mentor**, Matching Undergraduates to Science and Engineering Research Program, Duke University
- 2015–2016 **Faculty**, Biosciences Collaborative for Research Engagement, Duke University
- 2010 Spring **Teaching Assistant, Columbia Video Network Course Assistant**, Department of Electrical Engineering, Columbia University Fu Foundation School of Engineering and Applied Science  
*Analog Systems in VLSI* (graduate level)
- 2009 Fall **Teaching Assistant**, Department of Electrical Engineering, Columbia University Fu Foundation School of Engineering and Applied Science  
*The Digital Information Age*
- 2009 Fall **Recitation Instructor**, Department of Biostatistics, Columbia University Mailman School of Public Health  
*Biostatistics* (graduate level)



2003–2007 **Teaching Assistant**, Department of Mathematics, MIT  
*Multivariable Calculus* (Fall '03–'06), *Differential Equations* (Spring '04–'07)

2004 Fall **Grader**, Department of Electrical Engineering and Computer Science, MIT  
*Signals and Systems*

## Thesis Committee

2019 D.Q. Truong, “Translational Modeling of Non-Invasive Electrical Stimulation,” Ph.D. dissertation, City College of the City University of New York, Department of Biomedical Engineering, New York, NY, 2019. Sponsor: M. Bikson. Available: CUNY Academic Works, [https://academicworks.cuny.edu/cc\\_etds\\_theses/774](https://academicworks.cuny.edu/cc_etds_theses/774)

2017 G. Asturias, “Effect of Repetitive Transcranial Magnetic Stimulation on the Structural and Functional Connectome in Patients with Major Depressive Disorder,” Undergraduate Honors Thesis, Duke University, Department of Psychology and Neuroscience, Durham, NC, 2017. Sponsor: Z.-D. Deng. Available: DukeSpace, HDL: 10161/14299

## Mentees

### Research Fellow/Postdoc

2022–2024 M. Dannhauer, Max Planck Institute for Human Cognitive and Brain Sciences

### Graduate Student

2012 M. Kshirsagar, Biomedical Engineering, Duke University

### NIH Postbaccalaureate IRTAs

2021–2024 P.L. Robins, Physics, Lawrence University

2018–2020 S.M. Awasthi, Biomedical Engineering, Johns Hopkins University

2018–2019 M.M. Noh, Bioengineering, MIT

2017–2019 J. Thomas, Physiology and Biophysics, University of Virginia

2016–2019 M. Velez Afanador, Microbiology, University of Puerto Rico

### Undergraduate Students

2014–2017 G. Asturias, Neuroscience & Psychology, Duke University (Distinction)

Z. Feng, Biomedical Engineering and Biology, Duke University

M. Glidewell, Biomedical Engineering, Duke University

S. Lee, Biomedical Engineering, Duke University

J.R. Lilien, Electrical & Computer Engineering, Duke University (Walter J. Seeley Award)

W. Lim, Biomedical Engineering, Duke University

F.M. Mercer, Women's Studies, Duke University

E. Salgado, Neuroscience & Psychology, Duke University (Distinction)

R. Shah, Neuroscience & Psychology, Duke University

E. Shinder, Biology, Duke University (Distinction)

E.P. Vienneau, Biomedical Engineering, Duke University (Howard G. Clark Award)

D.T. Weaver, Biology, Duke University

### Summer Interns

2018 M. Dib, Biomedical Engineering, University of Maryland, College Park

2017 E. Chung, Psychology, University of Maryland, College Park

2017 A.L. Halberstadt, Biology and Psychology, Carnegie Mellon University

2015 C.M. Prevost, Biomedical Engineering, Clemson University

2013 J.V. McCall, Biomedical Engineering, North Carolina State University

## Professional Affiliations & Services

### Professional Society Membership

- 2004–present **Institute of Electrical and Electronics Engineers**, Senior Member  
Engineering in Medicine and Biology Society
- 2019–present **American Society of Clinical Psychopharmacology**, Member
  - 2023–2027 Early Career Committee
  - 2023–2025 Technology Committee
  - 2023 Program Review Sub-Committee
  - 2020–2023 Technology Task Force
- 2021–present **Biomedical Engineering Society**, Member
- 2023–present **American College of Neuropsychopharmacology**, Associate Member
  - 2017–2018 **Anxiety and Depression Association of America**, Member
  - 2017–2019 **International Society for CNS Clinical Trials and Methodology**, Member
  - 2014–2018 **Organization for Human Brain Mapping**, Member
  - 2008–2012 **Society for Industrial and Applied Mathematics**, Student Member
  - 2005–2012 **Society for Neuroscience**, Student Member
  - 2004–2009 **American Physical Society**, Student Member

### Editorial & Grant Review Services

#### Peer Review Journals

- 2022–present Frontiers in Psychiatry
  - Associate Editor: Neuroimaging
  - Co-Editor on Research Topic: How Does Brain Stimulation Work? Neuroversion and Other Putative Mechanisms of Action
  - Associate Editor: Neurostimulation
  - Frontiers in Pharmacology
  - Guest Associate Editor: Neuropharmacology
  - Research Topic: Neurobiology of Rapid Mood Changes
- 2022–present Frontiers in Psychology
  - Review Editor: Addictive Behaviors
  - Review Editor: Consciousness Research
- 2024 Physics in Medicine and Biology
  - Guest Editor on Special Issue: Electromagnetic Modeling for Brain Stimulation

#### Conference Organizing Committee

- 2022–2023 Brain and Human Body Modeling Conference, The Martinos Center for Biomedical Imaging, Massachusetts General Hospital

#### Grant Review Panels

- 2022–2023 NIH BluePrint MedTech Program, reviewer
  - 2021 NIH Early Career Reviewer Program
  - Biophysics of Neural Systems Study Section, *ad hoc* reviewer
- 2018, 2021 Duke Institute for Brain Sciences, Research Incubator Awards

## Conference Proceedings/Abstract Review

- 2008-present International Conference of the IEEE Engineering in Medicine and Biology Society  
 IEEE/EMBS International Conference on Neural Engineering  
 IEEE/EMBS International Conference on Biomedical and Health Informatics  
 Biomedical Engineering Society Annual Meeting  
 American Society of Clinical Psychopharmacology Annual Meeting
- ad hoc reviewer* AIP Advances  
 American Journal of Psychiatry  
 Asian Journal of Psychiatry  
 Australasian Physical and Engineering Sciences in Medicine  
 Biological Psychiatry  
 BioMedical Engineering OnLine  
 Brain Sciences  
 Brain Stimulation  
 Cerebral Cortex  
 Clinical EEG and Neuroscience  
 Clinical Neurophysiology  
 CNS Spectrums  
 Computational and Mathematical Methods in Medicine  
 Computer Methods and Programs in Biomedicine  
 Cortex  
 European Psychiatry  
 Frontiers in Cell and Developmental Biology  
 Frontiers in Medicine: Intensive Care Medicine and Anesthesiology  
 Frontiers in Neurology: Applied Neuroimaging  
 Frontiers in Neuroscience: Brain Imaging Methods  
 IEEE Transactions on Biomedical Engineering  
 IEEE Transactions on Neural Systems & Rehabilitation Engineering  
 IEEE Transactions on Magnetics  
 Imaging Neuroscience  
 Journal of ECT  
 Journal of Neural Engineering  
 Journal of Neuroscience Methods  
 JoVE  
 Medical & Biological Engineering & Computing  
 Medical Hypotheses  
 Nature Mental Health  
 Neurolmage; Neurolmage Clinical  
 Neuromodulation: Technology at the Neural Interface  
 Neuroscience Letters  
 PLoS One  
 Scientific Reports  
 Translational Psychiatry

## Community Involvement & Outreach

- 2023-present NIH Research Workforce Diversity and Equity Outreach Special Interest Group
- 2022 Judge, NIMH Training Day Three-Minute Talks competition
- 2020 Mental Health Association of Maryland  
Presentation: *Fundamentals of transcranial brain stimulation*
- 2020 Jewish Social Service Agency  
Presentation: *Basics of brain stimulation devices: What are they and how do they work*
- 2020 Exhibitor, USA Science & Engineering Festival #coronacancelled
- 2019 University of Pennsylvania, Wharton Undergraduate Health Care Club  
Presentation: *Research in mental health treatment*
- 2019 Judge, MIT Hacking Medicine: DC Grand Hack
- 2019 NIH High School Scientific Training and Enrichment Program  
Presentation: *Bioelectricity and brain stimulation*
- 2019 NIH Take Your Child to Work Day  
Presentation: *How to fool your brain*
- 2019 UCLA, CruX Neurotech Organization  
Presentation: *Neuromodulation in psychiatry*
- 2018 University of Pennsylvania, Wharton Undergraduate Health Care Club  
Presentation: *Technology and the future of mental health treatment*
- 2017-present NIH Noninvasive Brain Stimulation Special Interest Group
- 2017-2019 Judge/Lead Judge, NIH Postbac Poster Day
- 2016 Innovation Leader, Psychiatry Innovation Lab, American Psychiatric Association
- 2016 Duke Psychiatry, Mood Disorders Support and Education Group  
Presentation: *Brain stimulation treatments for severe mood disorders*
- 2016 Duke Translational Medicine Institute, Undergraduate Research Society  
Presentation: *Engineering meets psychiatry*
- 2015 Duke Psychiatry, Mood Disorders Support and Education Group  
Presentation: *New frontiers in treatments for mood disorders*

---

## Continuing Education & Professional Development

- 2023 Mid-Level Leadership Program, NIH
- 2021-2022 Diversity and Inclusion Certificate Program, NIH
- 2019 Non-invasive Transcranial Brain Stimulation Course, Danish Research Centre for Magnetic Resonance, Copenhagen University Hospital Hvidovre
- 2015-2016 Health Disparities Research Curriculum, Duke Translational Medicine Institute CTSA
- 2015 Tackling the Challenges of Big Data, MIT Professional Education Program
- 2009 Transcranial magnetic stimulation administration certified, Columbia University Medical Center/New York State Psychiatric Institute
- renewed 2023 Basic Life Support, American Heart Association