

# Zhi-De Deng

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## 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

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## Education

expected 2019 **M.H.Sc., Clinical Research**, Duke University

- § Thesis: *Kappa Opioid Receptor and the Neural Circuitry of Anhedonia*

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

- 2016–present **Research Fellow**, 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
- 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 CTSA KL2 Scholar
    - § Developed Individualized Neurotargeted Seizure Therapy
  - 2013–2014 **Postdoctoral Associate**, Department of Psychiatry & Behavioral Sciences, Duke University School of Medicine
    - § Analyzed resting-state brain connectivity before and after electroconvulsive therapy and magnetic seizure therapy using graph theoretical methods
    - § Developed EEG biomarkers of therapeutic/neurocognitive outcomes in seizure therapy
  - 2010–2013 **Visiting Graduate Research Assistant**, Department of Psychiatry & Behavioral Sciences, Duke University School of Medicine
    - § Identified the fundamental depth–focality tradeoff in transcranial magnetic stimulation
    - § Designed novel magnetic stimulation coil with electronically-switchable active and sham modes, and coil compatible with electrophysiological systems for simultaneously recording of neuronal activity in nonhuman primates during transcranial magnetic stimulation
  - 2007–2010 **Graduate Research Assistant**, Department of Psychiatry, Columbia University College of Physicians and Surgeons/New York State Psychiatric Institute
    - § Designed novel coils for deep-brain transcranial magnetic stimulation
    - § Developed finite-element models to quantitatively compare the electric field distribution produced by various forms of seizure therapy
  - 2006–2007 **Graduate Research Assistant**, Harvard–MIT Division of Health Sciences and Technology, Massachusetts Institute of Technology
    - § Developed extended-Kalman and particle filter algorithms using Volterra series models to quantify intrinsic deterministic dynamical properties of nonlinear systems
  - 2005–2006 **Undergraduate Research Assistant**, Harvard–MIT Division of Health Sciences and Technology, Massachusetts Institute of Technology
    - § Developed noninvasive clinical diagnostic tools for pediatric obstructive sleep apnea syndrome based on nonlinear analysis of heart rate variability

### 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

- 36 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, no. 3, pp. 282–290, 2018. PMID: 30031247. DOI: 10.1016/j.jad.2018.06.048
- 35 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, 2018. PMCID: PMC5929994. DOI: 10.1088/1741-2552/aaa505
- 34 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, 2016. PMCID: PMC5093126. DOI: 10.3389/fncir.2016.00085
- \*33 **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, 2015. PMCID: PMC4289667. DOI: 10.1109/TNSRE.2014.2339014
- 32 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, 2014. PMCID: PMC4115015. DOI: 10.1038/nn.375. Presented at the White House Conference on the BRAIN Initiative, 2014
- \*31 **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, 2014. PMCID: PMC4020988. DOI: 10.1016/j.clinph.2013.11.038. Commentary in pp. 1077–1078. Top 10 most cited *Clin Neurophysiol* paper since 2014
- \*30 **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, 2013. PMCID: PMC3905244. DOI: 10.1097/YCT.0b013e3182a4b4a7. Top 10 most viewed *J ECT* paper in 2014
- 29 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, 2013. PMCID: PMC3649828. DOI: 10.5665/sleep.2712
- \*28 **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, 2013. PMCID: PMC3568257. DOI: 10.1016/j.brs.2012.02.005. Commentary in pp. 14–15
  - s Top 3 most highly cited paper in *Brain Stimulation* since 2013
  - s Journal cover and in issue highlights
  - s Featured at the Institute of Medicine Workshop on Non-Invasive Neuromodulation of the Central Nervous System, 2015

## Refereed Journal Articles (continue)

- 27 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, 2012. PMCID:PMC3495594. DOI:10.1016/j.neuroimage.2011.10.029
- \*26 **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, 2011. PMCID: PMC3903509. DOI:10.1088/1741-2560/8/1/016007
- 25 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, 2008. PMCID:PMC2532677. DOI:10.1109/TBME.2007.912658. **Top 15 most cited IEEE Trans Biomed Eng paper since 2008**

## Refereed IEEE Proceedings

- \*24 **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*, 2017, pp.1445–1448. PMID:29060150. DOI:10.1109/EMBC.2017.8037106
- \*23 **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*, 2015, pp.2203–2206. PMID:26736728. DOI:10.1109/EMBC.2015.7318828
- \*22 **Z.-D. Deng**, A.V. Peterchev, A.D. Krystal, B. Luber, 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*, 2013, pp.577–580. DOI:10.1109/NER.2013.6696000
- 21 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*, 2011, pp.5473–5476. PMID:22255576. DOI:10.1109/IEMBS.2011.6091396
- \*20 **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*, 2011, pp.1993–1996. PMID:22254725. DOI:10.1109/IEMBS.2011.6090561
- \*19 **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*, 2010, pp.6812–6824. PMID:21095849. DOI:10.1109/IEMBS.2010.5625958
- \*18 **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*, 2010, pp.2049–2062. PMID:21096149. DOI:10.1109/IEMBS.2010.5626517

## Refereed IEEE Proceedings (continue)

- \*17 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*, 2010, pp.2045–2048. PMID:21096148. DOI:10.1109/IEMBS.2010.5626553
- \*16 **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*, 2009, pp.682–688. PMID:19964484. DOI:10.1109/IEMBS.2009.5334091
- \*15 **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*, 2008, pp.5675–5679. PMID:19164005. DOI: 10.1109/IEMBS.2008.4650502
- \*14 **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*, 2006, pp.3565–3568. PMID:17946187. DOI:10.1109/IEMBS.2006.260139
- \*13 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*, 2006, pp.1788–1791. PMID:17946480. DOI:10.1109/IEMBS.2006.260051. **Student paper competition finalist**

## Review Articles & Consensus Papers

- \*12 M. Bikson, A.R. Brunoni, L.E. Charvet, V.P. Clark, L.G. Cohen, **Z.-D. Deng**, J.P. Dmochowski, D.J. Edwards, F. Frohlich, 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. PMCID:PMC5997279. DOI:10.1016/j.brs.2017.12.008
- 11 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, 2017. PMCID:PMC5484089. DOI:10.1080/09540261.2017.1305949
- \*10 **Z.-D. Deng**, S.M. McClintock, N.E. Oey, B. Luber, 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, 2015. PMCID:PMC4342851. DOI:10.1016/j.conb.2014.08.015
- 9 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, 2014. PMCID:PMC4143898. DOI:10.1097/YCT.0000000000000137. **Top 5 most cited J ECT paper since 2014**
- 8 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, 2010. PMCID:PMC2933093. DOI:10.1097/YCT.0b013e3181e48165. **Top 5 most cited J ECT paper since 2010**

## Book Chapters

- 7 B. Kadriu, S. Subramanian, **Z.-D. Deng**, I. Henter, L. Park, and C.A. Zarate, Jr., “Rapid-acting antidepressants,” in *Primer on Depression*, M. Trivedi, Ed. Oxford, UK: Oxford University Press.
- 6 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, pp.116–150. DOI: 10.1017/9781107415782.007
- 5 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, pp.123–148. DOI: 10.1002/9781118568323.ch8
- 4 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, pp.165–190. DOI: 10.1002/9781118568323.ch10

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

- \*3 **Z.-D. Deng**, S.H. Lisanby, and A.V. Peterchev, “On deep transcranial magnetic stimulation coil characterization,” *Clinical Neurophysiology*, vol.126, no.7, pp.1456–1457, 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, 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.

## Articles in Review, Preprints, Contracted Chapters

- 0 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."
- \*0 **Z.-D. Deng** *et al.*, "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.
- \*0 **Z.-D. Deng** and S.H. Lisanby, "Next generation seizure therapy," in *The Oxford Handbook of Transcranial Stimulation*, A.V. Peterchev, E.M. Wassermann, U. Ziemann, V. Walsh, H.R. Siebner, and S.H. Lisanby, Eds., 2<sup>nd</sup> ed. Oxford, UK: Oxford University Press.
- 0 M.J. Dubin, I. Ilieva, **Z.-D. Deng**, J. Thomas, A. Cochran, B.D. Brody, P.J. Christos, J.H. Kocsis, C. Liston, and F.M. Gunning, "Mood-enhancing effects of low field magnetic stimulation in treatment-resistant depression: the relationship to dosing."
- 0 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 cryptochrome."
- 0 S.M. Goetz, S.M. Madhi Alavi, **Z.-D. Deng**, and A.V. Peterchev, "Statistical model of motor evoked potentials for simulation of transcranial magnetic and electric stimulation." *bioRxiv* DOI:10.1101/406777
- 0 R.J. Ilmoniemi, **Z.-D. Deng**, L.J. Gomez, L.M. Koponen, J.O. Nieminen, and C.M. Epstein, "Coil design for transcranial magnetic stimulation," in *The Oxford Handbook of Transcranial Stimulation*, A.V. Peterchev, E.M. Wassermann, U. Ziemann, V. Walsh, H.R. Siebner, and S.H. Lisanby, Eds., 2<sup>nd</sup> ed. Oxford, UK: Oxford University Press.
- 0 B. Kadriu, C.A. Farmer, B. Shovestul, R. Moaddel, P. Yuan, E.D. Ballard, **Z.-D. Deng**, I. Henter, R.T. de Sousa, R. Machado-Vieira, L.T. Park, P.W. Gold, and C.A. Zarate, Jr., "The Kynurenine pathway and bipolar disorder: the intersection of monoaminergic, glutamatergic, and immune response."
- 0 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. Teklehaimanot, K.G. Tobias, R.D. Weiner, R.C. Young, and C.H. Kellner, "Neurocognitive effects of combined electroconvulsive therapy (ECT) and venlafaxine in geriatric depression: phase 1 of the PRIDE study."
- \*0 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 stimulation device with field modulation." *bioRxiv* DOI:10.1101/416065
- 0 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."
- 0 T. Radman, **Z.-D. Deng**, A.C. Nugent, E.M. Lo, M.J. Koval, B. Luber, A.D. Krystal, and S.H. Lisanby, "Peri-stimulus EEG power and coherence during paired associative stimulation predicts subsequent potentiation."



## 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, <http://hdl.handle.net/10022/AC:P:20557>
- \*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, <http://hdl.handle.net/1721.1/41649>

## Selected Abstracts (10/70)

- \*10 **Z.-D. Deng**, C. Liston, F.M. Gunning-Dixon, and M.J. Dubin, “Electric field induced by repetitive transcranial magnetic stimulation in patients depression,” *Proceedings of the IEEE Engineering in Medicine and Biology Society*, 2018.
- \*9 **Z.-D. Deng**, E. Axfjörð Fridgeirsson, J. Lilien, G. van Wingen, and J. van Waarde, “Electric field induced by electroconvulsive therapy in patients with depression,” *Proceedings of the IEEE Engineering in Medicine and Biology Society*, 2018.
- \*8 **Z.-D. Deng**, E.M. Lo, L. Beynel, E. Fang, B. Lubner, and A.D. Krystal, “Cortical excitability in patients with treatment resistant depression,” *Biological Psychiatry*, vol. 81, no. 10, p. S242, 2017.
- \*7 **Z.-D. Deng**, S.W. Davis, G. Asturias, M. Glidewell, C. Liston, and M.J. Dubin, “Effect of repetitive transcranial magnetic stimulation on the structural connectome in patients with major depression,” *Clinical Neurophysiology*, vol. 128, no. 3, p. e144–e145, 2017.
- \*6 **Z.-D. Deng**, W. Lim, L.M. Haugen, J.D. Port, and P.E. Croarkin, “Electric field induced by repetitive transcranial magnetic stimulation in adolescents with major depressive disorder: comparison of coil localization approaches,” *Neuropsychopharmacology*, vol. 41, no. S1, p. S478, 2016.
- \*5 **Z.-D. Deng**, S.M. McClintock, T. Jones, and C.C. Abbott, “Engaging medial temporal lobes with ECT pulse amplitude to improve clinical outcomes,” *Neuropsychopharmacology*, vol. 41, no. S1, p. S173–S174, 2016.
- \*4 **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.
- \*3 **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**
- \*2 **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**
- \*1 **Z.-D. Deng**, A.V. Peterchev, and S.H. Lisanby, “Focality of neural stimulation with magnetic seizure therapy and electroconvulsive therapy in humans and non-human primates,” *Biological Psychiatry*, vol. 65, no. 8, pp. 219S–220S, 2009.



## Intellectual Property

- 4 Whole body non-contact electrical stimulation device with variable parameters. Co-inventors: S.N. Makarov, G.M. Noetscher, V.S. Makarov; Assignee: NEVA Electromagnetics, LLC  
§ U.S. Provisional Patent application No. 15/868,038, Jan. 11, 2018
- 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. Co-inventor: C.-S. Poon; Assignee: MIT  
§ US No. 9,737,258, Aug. 22, 2017, also published as WO 2014120353 A1
- 2 Transcranial magnetic stimulation coil with electronically switchable active and sham modes. Co-inventor: A. V. Peterchev; Assignee: Columbia University  
§ U.S. Provisional Patent application No. 61/525,922, Aug. 22, 2011
- 1 Methods, apparatus, and systems for magnetic stimulation. Co-inventors: A. V. Peterchev, S.H. Lisanby; 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

### Ongoing Research Support

- June 2018– **Individualized Low Amplitude Seizure Therapy (iLAST)**  
June 2020 NARSAD/Brain & Behavior Research Foundation  
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.
- Sept. 2016– **ECT Pulse Amplitude and Medial Temporal Lobe Engagement**  
July 2020 NIH/NINDS U01 MH111826 (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.
- June 2016– **Fast-Fail Trials: Mood and Anxiety Spectrum Disorders (FAST-MAS)**  
present 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 JNJ-67953964, which has been demonstrated to be a selective kappa opiate receptor antagonist.

### Pending Research Support

- Efficacy of Biomarker-Guided rTMS for Treatment Resistant Depression**  
NIH/NIMH R01 MH118388 (PI: J. Downar, F.M. Gunning, C.M. Liston)  
Role: Consultant

## NIH Protocols

### **Safety and Feasibility of Individualized Low Amplitude Seizure Therapy**

NIMH Protocol T-M-2191 (PI: S. H. Lisanby)

Role: Lead Associate Investigator

### **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

### **Non-Invasive Brain Stimulation Technique Development**

NIMH Protocol 18-M-0015 (PI: S. H. Lisanby)

Role: Associate Investigator

### **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

### **Evaluation of Patients with Mood and Anxiety Disorders and Healthy Volunteers**

NIMH Protocol 01-M-0254 (PI: C. A. Zarate, Jr.)

Role: Associate Investigator

### **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

### **fMRI-Guided Repetitive TMS in a Model of Anxiety with Healthy Individuals**

NIMH Protocol 17-M-0042 (PI: C. Grillon)

Role: Associate Investigator

### **Modulation of the Parieto-Frontal Communication**

NINDS Protocol T-N-3895 (PI: M. Hallett)

Role: Associate Investigator

### **Influence on Plasticity of Brain Temperature**

NINDS Protocol 15-N-0066 (PI: M. Hallett)

Role: Associate Investigator

### **Identifying Neurobiological Mechanisms that Underlie Acute Nicotine Withdrawal and Drive Early Relapse in Smokers**

NIDA Protocol 12-DA-N474 (PI: E. A. Stein)

Role: Associate Investigator

## Completed Research Support

### **Apr. 2015– Transcranial Direct Current Stimulation as a Treatment for Acute Fear**

Jan. 2017 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.

## Completed Research Support (continue)

- July 2014– **Individualized Optimally-Targeted Seizure Therapy**  
 June 2016 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.
- Mar. 2015– **Safety and Feasibility of Low Amplitude Electroconvulsive Therapy**  
 June 2016 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.
- Apr. 2009– **Prolonging Remission In Depressed Elderly (PRIDE)**  
 Mar. 2016 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.
- Apr. 2015– **Low Field Magnetic Stimulation Coil Design**  
 June 2016 Tal Medical (PI: A.V. Peterchev)  
 Role: Co-I  
 This project develops a novel coil system for low field magnetic stimulation.
- Nov. 2015– **Concurrent Cognitive Behavioral Therapy and Transcranial Magnetic Stimulation in Obsessive-Compulsive Disorder**  
 June 2016 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.
- Jan. 2014– **Evoked Potentials as Markers of Ketamine-Induced Cortical Plasticity in Patients with Major Depressive Disorder**  
 Dec. 2015 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.
- July 2005– **Magnetic Seizure Therapy for the Treatment of Depression**  
 July 2011 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.
- July 2010– **Translational Research Evaluating Neurocognitive Memory Processes**  
 Jan. 2015 NIH/NIMH K23 MH087739 (PI: S.M. McClintock)  
 Role: Postdoctoral Fellow  
 This study informs the cognitive component processes underlying memory impairment after electroconvulsive therapy.

## Completed Research Support (continue)

- July 2010– **Rational Dosing for Electric and Magnetic Seizure Therapy**  
 Dec. 2015 NIH/NIMH R01 MH091083 (PI: S. H. Lisanby)  
 Role: Graduate Research Associate, 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.
- Sept. 2010– **Field Shaping and Coil Design for Transcranial Magnetic Stimulation**  
 June 2011 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.
- Aug. 2007– **Development of a Novel TMS Device with Controllable Pulse Shape**  
 July 2009 NIH/NIBIB R21 EB006855 (PI: A. V. Peterchev)  
 Role: Graduate Research Associate  
 This project develops an efficient transcranial magnetic stimulation device that produces nearly rectangular pulses with adjustable amplitude, width, and directionality.
- Sept. 2005– **Nonlinear Analysis of Heart Rate Variability**  
 June 2009 NIH/NHLBI R01 HL079503 (PI: C.-S. Poon)  
 Role: Graduate Research Associate  
 This project develops advanced nonlinear estimation and adaptive control algorithms for the modeling and analysis of the cardiovascular system.

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## Scholarships, Fellowships, & Honors

- 2018 **Richard J. Wyatt Memorial Fellowship Award for Translational Research**, NIMH
- 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 **Summer Research Institute in Geriatric Mental Health**, Weill Cornell Medical College
- 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

- 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

- 2018 UCLA Brain Mapping Seminar  
*Computational neurostimulation: engineering better brain stimulation therapies*
- 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*
- 2018 APA Annual Conference Presidential Symposium  
*ECT in the era of new brain stimulation treatments: road map of future enhancements*
- 2018 ADAA Anxiety and Depression Conference  
*Individualized electroconvulsive therapy for treatment of depression*
- 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*

- 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

- 2017 **Lecturer**, National Institute of Neurological Disorders and Stroke  
*Clinical Neuroscience Program Lecture Series*  
§ Lectured on transcranial magnetic stimulation basic principles, devices, and dosing
- 2017 **Lecturer**, National Institutes of Health  
*fMRI Course*  
§ Lectured on physics of neuromodulation
- 2016 **Instructor**, Department of Neuroscience, Duke University  
*Research Independent Study*  
§ Supervised senior honors thesis
- 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)  
§ Lectured on brain stimulation physics, technology, dosing, and clinical applications
- 2015–2016 **Research Mentor**, Matching Undergraduates to Science and Engineering Research Program, Duke University
- 2015–2016 **Faculty**, Biosciences Collaborative for Research Engagement, Duke University
- Spring 2010 **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)  
§ Guided students on design projects of simulated continuous-time filters and data converters using the Cadence design environment
- Fall 2009 **Teaching Assistant**, Department of Electrical Engineering, Columbia University Fu Foundation School of Engineering and Applied Science  
*The Digital Information Age*  
§ Exposed non-engineering students to modern electrical engineering and technology. Supervised projects on design and implementation of digital circuits and microprocessor

- Fall 2009 **Recitation Instructor**, Department of Biostatistics, Columbia University Mailman School of Public Health  
*Biostatistics* (graduate level)  
 s Taught public health graduate students statistical methods and analysis software. Composed supplementary course material
- 2003–2007 **Teaching Assistant**, Department of Mathematics, MIT  
*Multivariable Calculus* (Fall '03–'06), *Differential Equations* (Spring '04–'07)
- Fall 2004 **Grader**, Department of Electrical Engineering and Computer Science, MIT  
*Signals and Systems*

## Thesis Committee

- 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, <http://hdl.handle.net/10161/14299>

## Mentees

### Graduate Students

- 2012 M. Kshirsagar, Biomedical Engineering, Duke University

### Postbaccalaureate IRTAs (NIH)

- 2018–present M. Noh, Bioengineering, MIT  
 2016–present M. Velez Afanador, Microbiology, University of Puerto Rico

### Undergraduate Students

- 2014–2017 G. Asturias, Neuroscience & Psychology, Duke University (Distinction)  
 M. Glidewell, Biomedical Engineering, Duke University  
 Z. Feng, Biomedical Engineering and Biology, 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, Biology, Duke University  
 E. Shinder, Biology, Duke University  
 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  
 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

- 2017–present **Anxiety and Depression Association of America**, member
- 2014–present **Organization for Human Brain Mapping**, member
- 2004–present **Institute of Electrical and Electronics Engineers**, Engineering in Medicine and Biology Society, member
- 2017–2018 **International Society for CNS Clinical Trials and Methodology**, 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

- review editor Frontiers in Psychiatry: Neuroimaging and Stimulation
- ad hoc* reviewer AIP Advances
- American Journal of Psychiatry
- Australasian Physical and Engineering Sciences in Medicine
- BioMedical Engineering OnLine
- Brain Stimulation
- Cerebral Cortex
- Clinical EEG and Neuroscience
- Computational and Mathematical Methods in Medicine
- Computer Methods and Programs in Biomedicine
- IEEE Transactions on Biomedical Engineering
- IEEE Transactions on Neural Systems and Rehabilitation Engineering
- IEEE Transactions on Magnetics
- Journal of ECT
- Journal of Neural Engineering
- JoVE
- Medical & Biological Engineering & Computing
- Medical Hypotheses
- NeuroImage Clinical
- Neuromodulation: Technology at the Neural Interface
- Neuroscience Letters
- PLoS One
- Translational Psychiatry

#### Grant Review Panels

- Duke Institute for Brain Sciences, Research Incubator Awards

#### Conference Proceedings Review

- 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

## Public Education & Outreach

- 2018 University of Pennsylvania, Wharton Undergraduate Health Care Club  
Public seminar: *Technology and the future of mental health treatment*
- 2017–2018 Judge, Postbac Poster Day, NIH
- 2016 Innovation Leader, Psychiatry Innovation Lab, American Psychiatric Association
- 2016 Duke Psychiatry, Mood Disorders Support and Education Group  
Public lecture: *Brain stimulation treatments for severe mood disorders*
- 2016 Duke Translational Medicine Institute, Undergraduate Research Society  
Public seminar: *Engineering meets psychiatry*
- 2015 Duke Psychiatry, Mood Disorders Support and Education Group  
Public lecture: *New frontiers in treatments for mood disorders*

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## Certifications

- 2015–2016 Health Disparities Research Curriculum, Duke Translational Medicine Institute CTSA
- 2015 Tackling the Challenges of Big Data, MIT Professional Education Program
- renewed 2016 Collaborative Institutional Training Initiative certified
- 2013 IRB/IACUC/HIPAA trained for clinical and preclinical research, Duke Medicine
- 2009 Transcranial magnetic stimulation administration certified, Columbia University  
Medical Center/New York State Psychiatric Institute
- renewed 2016 Basic Life Support, American Heart Association