

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

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

- 2016–2019 **Research Fellow**, Noninvasive Neuromodulation Unit, Experimental Therapeutics & Pathophysiology Branch, Intramural Research Program, NIMH
 § Richard J. Wyatt Memorial Fellowship for Translational Research
- 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 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**, 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

- *40 **Z.-D. Deng**, N.L. Balderston, M. Velez Afanador, M.M. Noh, J. Thomas, W.C. Altekruze, S.L. Exley, S. Awasthi, B. Lubner, and S.H. Lisanby, "Device-based modulation of neurocircuits as a therapeutic for psychiatric disorders," to appear in *Annual Review of Pharmacology and Toxicology*, vol. 60, 2020.
- 39 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, 2019. PMID: 30784726. DOI: 10.1016/j.jad.2019.02.039
- 38 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, 2018. PMID: 30031247. DOI: 10.1016/j.jad.2018.06.048
- *37 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, 2018. PMCID: PMC5997279. DOI: 10.1016/j.brs.2017.12.008
- 36 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
- 35 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
- 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.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, 2015. PMCID: PMC4342851. DOI: 10.1016/j.conb.2014.08.015
- *32 **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

Refereed Journal Articles (continue)

- 31 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](#)
- *30 **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](#)
- 29 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](#)
- *28 **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](#)
- 27 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
- *26 **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](#)
- 25 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
- *24 **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
- 23 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](#)
- 22 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 20 most cited IEEE Trans Biomed Eng paper since 2008](#)

Refereed IEEE Proceedings

- *21 **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
- *20 **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
- *19 **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
- 18 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
- *17 **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
- *16 **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
- *15 **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
- *14 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
- *13 **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
- *12 **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

Refereed IEEE Proceedings (continue)

- *11 **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
- *10 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**

Book Chapters

- 9 J. Thomas, **Z.-D. Deng**, and S.H. Lisanby, "Magnetic seizure therapy," to appear in *Handbook of Neurocognitive Function in Depression: Scientific Foundations and Clinical Practice*, S.M. McClintock and J. Choi, Eds. New York: Guilford Press.
- 8 B. Kadriu, S. Subramanian, **Z.-D. Deng**, I.D. Henter, L.T. Park, and C.A. Zarate, Jr., "Rapid-acting antidepressants," to appear in *Primer on Depression*, M. Trivedi, Ed. Oxford, UK: Oxford University Press. *PsyArXiv* DOI:10.31234/osf.io/xwk57
- *7 **Z.-D. Deng**, C. Liston, F.M. Gunning, M.J. Dubin, E. Axfjörð Fridgeirsson, J. Lilien, G. 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.
- 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., 4th 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 **Z.-D. Deng**, A.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* DOI:10.1101/457630
- *0 **Z.-D. Deng**, M.M. Noh, and S.H. Lisanby, “Next generation seizure therapy,” in *The Oxford Handbook of Transcranial Stimulation*, E.M. Wassermann, V. Walsh, A.V. Peterchev, U. Ziemann, S.H. Lisanby, and H.R. Siebner, Eds., 2nd ed. Oxford, UK: Oxford University Press.
- 0 N.L. Balderston, C. Roberts, E. Masi, **Z.-D. Deng**, T. Radman, B. Luber, S.H. Lisanby, M. Ernst, and C. Grillon, “Causal link between right dlPFC activity and anxiety revealed using rTMS.”
- 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,” *bioRxiv* DOI:10.1101/455329
- 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,” *bioRxiv* DOI:10.1101/424317
- 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:10.1101/406777v3
- 0 R.J. Ilmoniemi, **Z.-D. Deng**, L.J. Gomez, L.M. Koponen, J.O. Nieminen, and C.M. Epstein, “Transcranial magnetic stimulation devices: coils,” in *The Oxford Handbook of Transcranial Stimulation*, E.M. Wassermann, V. Walsh, A.V. Peterchev, U. Ziemann, S.H. Lisanby, and H.R. Siebner, Eds., 2nd ed. Oxford, UK: Oxford University Press.
- 0 E. Kallioniemi, S.M. McClintock, M.M. Husain, **Z.-D. Deng**, and S.H. Lisanby, “Magnetic seizure therapy: towards personalized seizure therapy for major depression.”
- 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,” *bioRxiv* DOI:10.1101/432609
- 0 L.-Z. Yang, W. Zhang, W. Wang, Z. Yang, H. Wang, **Z.-D. Deng**, C. Li, B. Qiu, R. Cohen Kadosh, H. Li, and X. Zhang, “Cross-hemispheric communication predicts neuromodulation responsiveness.”

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 (10/84)

- 10 S. N. Makarov, D. N. Pham, G. M. Noetscher, A. Nummenmaa, and **Z.-D. Deng**, “Boundary element fast multipole method for TES modeling” *Proceedings of the IEEE Engineering in Medicine and Biology Society*, 2019.
- *9 **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.
- *8 **Z.-D. Deng**, E. Axfjörð Fridgeirsson, J. Lilien, G. van Wingen, and J.A. van Waarde, “Electric field induced by electroconvulsive therapy in patients with depression,” *Proceedings of the IEEE Engineering in Medicine and Biology Society*, 2018.
- *7 **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.
- *6 **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.
- *5 **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.
- *4 **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.
- *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

- 4 Electromagnetic apparatus for creating strong low-frequency circularly-polarized magnetic fields in a large volume. Co-inventors: S.N. Makarov, G.M. Noetscher, V.S. Makarov, G. Bogdanov, W.L. Appleyard; 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 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.
- 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.

Pending Research Support

- Feb. 2019 **How does brain stimulation induce plasticity in the cerebellum?**
 Australian Research Council DP200101531 (PI: J. Rodger, A. Tang, H. Fujiyama)
 Role: Partner investigator
- Feb. 2019 **Precision non-implantable neuromodulation**
 São Paulo Research Foundation (PIs: A. R. Brunoni, L. Valiengo, R. Fraguas)
 Role: Advisory committee
- Oct. 2018 **Neuromodulation of social cognitive circuitry in people with schizophrenia spectrum disorders**
 NIH/NIMH R61 MH120188 (PIs: A. N. Voineskos, Z. J. Daskalakis)
 Role: Intramural NIH collaborator

Pending Research Support (continue)

- Feb. 2018 **Efficacy of biomarker-guided rTMS for treatment resistant depression**
 NIH/NIMH R01 MH118388 (PIs: J. Downar, F.M. Gunning, C.M. Liston)
 Role: Intramural NIH collaborator

NIH Protocols

- 2019– **Safety and feasibility of individualized low amplitude seizure therapy**
 NIMH Protocol 19-M-0073 (PI: S. H. Lisanby)
 Role: Lead associate investigator
- 2019– **Mechanism of action underlying ketamine's antidepressant effects: an investigation of the AMPA throughput theory in patients with treatment-resistant major depression**
 NIMH Protocol T-M-2310 (PI: C. A. Zarate, Jr.)
 Role: Associate investigator
- 2017– **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– **Development of non-invasive brain stimulation techniques**
 NIMH Protocol 18-M-0015 (PI: S. H. Lisanby)
 Role: Associate investigator
- 2017– **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– **fMRI-guided repetitive TMS in a model of anxiety with healthy individuals**
 NIMH Protocol 17-M-0042 (PI: C. Grillon)
 Role: Associate investigator
- 2016– **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– **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– **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

Uniform Services University–NIH Protocol

- 2019– **ADEPT: Adaptive trial for the treatment of depression associated with concussion using repetitive transcranial magnetic stimulation protocols**
 Center for Neuroscience and Regenerative Medicine protocol (PI: L. M. Oberman)
 Role: Associate investigator

Completed Research Support

- June 2016– **Fast-Fail Trials: Mood and Anxiety Spectrum Disorders (FAST-MAS)**
 Dec. 2017 NIMH 2712012000061-3-27100003-1 (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.
- 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.
- 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.

Completed Research Support (continue)

- Jan. 2014–
Dec. 2015 **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.
- July 2005–
July 2011 **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.
- July 2010–
Jan. 2015 **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.
- July 2010–
Dec. 2015 **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.
- Sept. 2010–
June 2011 **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.
- Aug. 2007–
July 2009 **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.
- Sept. 2005–
June 2009 **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

- 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

- Approved 2019 NIMH TMS-EEG Workshop
Chair
- Accepted 2019 International College of Neuropsychopharmacology
Workshop: *Neurobiological and clinical characterization, and treatment development for treatment resistant depression*
- Accepted 2019 American Society of Clinical Psychopharmacology Annual Meeting
Co-chair: *Treatment-resistant mood disorders across the lifespan: novel therapeutics*

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

- 2019 Mount Sinai Icahn School of Medicine, Depression and Anxiety Center Seminar
Rational design of individualized noninvasive brain stimulation
- 2019 International Brain Stimulation Conference
Panel: *Individualized brain stimulation: addressing heterogeneity across modalities*
- 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 2nd 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
Panel: *ECT in the era of new brain stimulation treatments: road map of future enhancements*
- 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*
- 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 Addition 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

- 2018–2019 **Research Mentor**, Fischell Department of Bioengineering, University of Maryland, College Park, A. James Clark School of Engineering
Capstone Design Competition
- 2017 **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
- 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)
- Fall 2009 **Teaching Assistant**, Department of Electrical Engineering, Columbia University Fu Foundation School of Engineering and Applied Science
The Digital Information Age
- Fall 2009 **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)

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

Medical Student

2018 A. V. Sathappan, UCSD

Graduate Student

2012 M. Kshirsagar, Biomedical Engineering, Duke University

NIH Postbaccalaureate IRTAs

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

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, 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
 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**, Engineering in Medicine and Biology Society, member
- 2014–present **Organization for Human Brain Mapping**, member
- 2017–2018 **Anxiety and Depression Association of America**, 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
- 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
- Journal of ECT
- Journal of Neural Engineering
- Journal of Neuroscience Methods
- JoVE
- Medical & Biological Engineering & Computing
- Medical Hypotheses
- NeuroImage Clinical
- Neuromodulation: Technology at the Neural Interface
- Neuroscience Letters
- PLoS One
- Translational Psychiatry

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

Grant Review Panels

Duke Institute for Brain Sciences, Research Incubator Awards

Community Involvement & Outreach

- 2019 UCLA, CruX Neurotech Organization
Student group seminar: *Neuromodulation in psychiatry*
- 2018 University of Pennsylvania, Wharton Undergraduate Health Care Club
Student group seminar: *Technology and the future of mental health treatment*
- 2017–2019 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*

Certifications & Continuing Education

- 2018 AFNI Training Bootcamp, NIH
- 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