**BIOGRAPHICAL SKETCH**

| Robert L. Rennaker II | **POSITION TITLE**<br>Chair Bioengineering at UT Dallas<br>Director TxBDC<br>CEO Vulintus, Inc.<br>CEO Optokinetix, LLC |
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***EDUCATION/TRAINING***

| INSTITUTION AND LOCATION | DEGREE | MM/YY | FIELD OF STUDY |
|---|---|---|---|
| Arizona State University | B.S.E. | Fall 1997 | Biomedical Engineering |
| Arizona State University | M.S. | Sp 2001 | Biomedical Engineering |
| Arizona State University | Ph.D. | Su 2002 | Biomedical Engineering |

## A. Personal Statement

I have spent the past 20 years working on the development of biomedical devices to improve human health. As a US Marine I am committed to developing devices and treatments to help those who have given sacrificially in the defense of our country. I formed Vulintus in 2008 to develop technology to improve methods of biomedical research into neuropathologies that could ultimately benefit wounded veterans and the general public at large. Currently Vulintus has a modest catalogue of over a dozen and a half biomedical research products we sell, and most of our business is focused on technology development. Optokinetix was formed in 2014 to transition the NeuroTriage technology out of the university. The NeuroTriage technology is currently being commercialized with a partnership in Irvine California. Our model is to work with high level researchers to create transformative technology to help improve human health and then partner with UTD Spinoffs and other companies to commercialize these devices. At UT Dallas our programs are focused on creating engineers that can solve real world problems with engineering solutions. Our research is focused on derisking technologies at the university so they get to the patients that need them.

## B. Positions and Honors

### Positions and Employment

| | | |
|---|---|---|
| 06/1988-05/1993 | United States Marine | MCAS New River, Jacksonville, NC |
| 01/1998-06/2002 | Whitaker Ph.D. Fellow | Arizona State University, Tempe, AZ |
| 08/2002-05/2009 | Assistant Professor, Aerospace and Mechanical Engineering & Center for Biomedical Engineering | University of Oklahoma, Norman, OK |
| 06/2009-08/2009 | Associate Professor, Aerospace and Mechanical Engineering & Center for Biomedical Engineering | University of Oklahoma, Norman, OK |
| 08/2009-Present | Associate Professor, Brain and Behavioral Sciences & Erik Johnson School of Engineering | University of Texas at Dallas, Richardson, TX |
| 04/2008-Present | Owner/CEO | Vulintus, LLC |
| 05/2012-Present | Director of the Texas Biomedical Device Center | University of Texas at Dallas, Richardson, TX |
| 06/2013-Present | Department Head, Biomedical Engineering | University of Texas at Dallas, Richardson, TX |
| 09/2014-Present | Full Professor, Biomedical Engineering | University of Texas at Dallas, Richardson, TX |
| 09/2014-Present | Owner/CEO | Optokinetix LLC |
| 09/2015-Present | Consultant | Konan Medical USA |

### Honors

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|---|---|
| 1988-1993 | United States Marine Corps Awards: Letter of Recommendation, Letters of Appreciation (3), Meritorious Mast (3), Navy and Marine Corps Achievement Medal - Desert Storm, Marine Corps Good Conduct Medal, Expeditionary Marine Corps Medal, Navy Unit Commendation (2), National Defense Medal, Southwest Asia Service Medal, Humanitarian Service Medal, Naval Sea |

| | |
|---|---|
| | Service (2), Kuwait Liberation Medal |
| 1998 | Whitaker Foundation Ph.D. Fellowship |
| 2003 | The University of Oklahoma Tom J. Love Outstanding Professor |
| 2007 | The University of Oklahoma Alumni Teaching Award |
| 2009 | The University of Oklahoma Presidential Associates Presidential Professorship |
| 2013 | UT Dallas, Cecil H. and Ida Green Professor in Systems Biology |
| 2014 | UT Dallas Texas Instruments Distinguished Chair in Bioengineering |

## C. Peer-reviewed publications

1. Daniel R. Hulseya, Jonathan R. Rileya, Kristofer W. Loerwald, **Robert L. Rennaker II**, Michael P. Kilgard, Seth A. Hays; Parametric characterization of neural activity in the locus coeruleus in response to vagus nerve stimulation; Experimental Neurology Volume 289, March 2017, Pages 21–30; https://doi.org/10.1016/j.expneurol.2016.12.005
2. Eric C. Meyers MS, Rafael Granja MD, Bleyda R. Solorzano BS, Mario Romero-Ortega PhD, Michael P. Kilgard PhD, **Robert L. Rennaker II PhD**, Seth Hays PhD ; Median and ulnar nerve injuries reduce volitional forelimb strength in rats First published: 21 March 2017Full publication history, DOI: 10.1002/mus.25590
3. Ethan Meltzer, Peter V Sguigna, Adnan Subei, Shin Beh, Eric Kildebeck, Darrel Conger, Amy Conger, Marlen Lucero, Benjamin S Frohman, Ashley N Frohman, Shiv Saidha, Steven Galetta, Peter A Calabresi, **Robert Rennaker,** Teresa C Frohman, Randy H Kardon, Laura J Balcer, Elliot M Frohman; Retinal Architecture and Melanopsin-Mediated Pupillary Response Characteristics A Putative Pathophysiologic Signature for the Retino-Hypothalamic Tract in Multiple Sclerosis; January 30, 2017; doi:10.1001/jamaneurol.2016.5131
4. Simon DM, Charkhkar H, St John C, Rajendran S, Kang T, Reit R, Arreaga-Salas D, McHail DG, Knaack GL, Sloan A, Grasse D, Dumas TC, **Rennaker RL**, Pancrazio JJ, Voit WE. Design and Demonstration of an Intracortical Probe Technology with Tunable Modulus. J Biomed Mater Res A. V105, Issue 1 2016 Sep 12. **DOI:** 10.1002/jbm.a.35896 [Epub ahead of print] PubMed PMID: 27615364.
5. Sindhurakar A, Butensky SD, Meyers E, Santos J, Bethea T, Khalili A, Sloan AP, **Rennaker RL 2nd**, Carmel JB. An Automated Test of Rat Forelimb Supination Quantifies Motor Function Loss and Recovery After Corticospinal Injury. Neurorehabil Neural Repair. 2016 Aug 16. pii: 1545968316662528. [Epub ahead of print] PubMed PMID: 27530125.
6. Pruitt DT, Schmid AN, Danaphongse TT, Flanagan KE, Morrison RA, Kilgard MP, **Rennaker RL 2nd**, Hays A. Forelimb training drives transient map reorganization in ipsilateral motor cortex. Behav Brain Res. 2016 Oct 15;313:10-6. doi:10.1016/j.bbr.2016.07.005. Epub 2016 Jul 5. PubMed PMID: 27392641; PubMed Central PMCID: PMC4987250.
7. Hays SA, Ruiz A, Bethea T, Khodaparast N, Carmel JB, **Rennaker RL 2nd**, Kilgard MP. Vagus nerve stimulation during rehabilitative training enhances recovery of forelimb function after ischemic stroke in aged rats. Neurobiol Aging. 2016 Jul;43:111-8. doi: 10.1016/j.neurobiolaging.2016.03.030. Epub 2016 Apr 7. PubMed PMID: 27255820.
8. Centanni TM, Booker AB, Chen F, Sloan AM, Carraway RS, **Rennaker RL**, LoTurco JJ, Kilgard MP. Knockdown of Dyslexia-Gene Dcdc2 Interferes with Speech Sound Discrimination in Continuous Streams. J Neurosci. 2016 Apr 27;36(17):4895-906. doi: 10.1523/JNEUROSCI.4202-15.2016. PubMed PMID: 27122044; PubMed Central PMCID: PMC4846679.
9. Meyers E, Sindhurakar A, Choi R, Solorzano R, Martinez T, Sloan A, Carmel J, Kilgard MP, **Rennaker RL 2nd**, Hays S. The supination assessment task: An automated method for quantifying forelimb rotational function in rats. J Neurosci Methods. 2016 Jun 15;266:11-20. doi: 10.1016/j.jneumeth.2016.03.007. Epub 2016 Mar 11. PubMed PMID: 26976724.
10. Daniel R Hulsey, Seth A Hays, Navid Khodaparast, Andrea Ruiz, Priyanka Das, **Robert L Rennaker**, Michael P Kilgard; Reorganization of Motor Cortex by Vagus Nerve Stimulation Requires Cholinergic Innervation; Brain Stimulation 2016 doi:10.1016/j.brs.2015.12.007
11. Jesse Dawson, David Pierce, Anand Dixit, Teresa J Kimberley, Michele Robertson, Brent Tarver, Omar Hilmi, John McLean, Kirsten Forbes, Michael P Kilgard, **Robert L Rennaker**, Steven C Cramer, Matthew Walters,

Navzer Engineer; Safety, Feasibility, and Efficacy of Vagus Nerve Stimulation Paired With Upper-Limb Rehabilitation After Ischemic Stroke, Stroke 47(1) Pages 143-150

12. Arreaga-Salas DE, Avendaño-Bolívar A, Simon D, Reit R, Garcia-Sandoval A, **Rennaker RL**, Voit W.; Integration of High-Charge-Injection-Capacity Electrodes onto Polymer Softening Neural Interfaces. ACS Appl Mater Interfaces. 2015 Dec 9;7(48):26614-23.
13. Khodaparast N, Kilgard MP, Casavant R, Ruiz A, Qureshi I, Ganzer PD, **Rennaker RL 2nd**, Hays SA. Vagus Nerve Stimulation During Rehabilitative Training Improves Forelimb Recovery After Chronic Ischemic Stroke in Rats. Neurorehabil Neural Repair. 2015 Nov 4. pii: 1545968315616494
14. Sloan AM, Fink MK, Rodriguez AJ, Lovitz AM, Khodaparast N, **Rennaker RL**, Hays SA. A Within-Animal Comparison of Skilled Forelimb Assessments in Rats. PLoS One. 2015 Oct 27;10(10):e014125
15. Becker AM, Meyers E, Sloan A, **Rennaker R**, Kilgard M, Goldberg An Automated Task for the Training and Assessment of Distal Forelimb Function in a Mouse Model of Ischemic Stroke. J Neurosci Methods. 2015 Oct 17. pii: S0165-0270(15)00376-3.
16. Fielding J, Clough M, Beh S, Millist L, Sears D, Frohman AN, Lizak N, Lim J, Kolbe S, **Rennaker RL 2nd**, Frohman TC, White OB, Frohman EM; Ocular motor signatures of cognitive dysfunction in multiple sclerosis. Nat Rev Neurol. 2015 Sep 15. doi: 10.1038/nrneurol.2015.174.
17. David Pruitt, Ariel Schmid, Lily Kim, Caroline Abe, Jenny Trieu, Conne Choua, Seth Hays, Michael Kilgard, **Robert L Rennaker II**; Vagus nerve stimulation delivered with motor training enhances recovery of function after traumatic brain injury J. Neurotrauma; doi:10.1089/neu.2015.3972
18. Hays SA, Khodaparast N, Hulsey DR, Ruiz A, Sloan Am, **Rennaker RL**, Kilgard MP. Vagus nerve stimulation during rehabilitative training improves functional recovery after intracerebral hemorrhage. *Stroke* 45:3097-3100, 2014.
19. Pruitt D, Hays S, Schmid A, Choua C, Kim L, Trieu J, Kilgard MP, **Rennaker RL**. Controlled-cortical impact reduces volitional forelimb strength in rats. *Brain Research* 25:1582-1591, 2014.
20. Centanni TM, Chen F, Booker AM, Engineer CT, Sloan AM, **Rennaker RL**, LoTurco JJ, Kilgard MP. Sound processing deficits and training-induced neuroplasticity in rats with Dyslexia gene knockdown. *PLoS One* 9(5):E98439, 2014.
21. Zhao Y, **Rennaker RL**, Hutchens C, Ibrahim TS. Implanted miniaturized antenna for brain computer interface applications: analysis and design. *PLoS One* 9(7):e103945, 2014.
22. Hays SA, Khodaparast N, Ruiz A, Sloan AM, Hulsey DR, **Rennaker RL**, Kilgard MP. The timing and amount of vagus nerve stimulation during rehabilitative training affects post-stroke recovery of forelimb strength. *Neuroreport*, 2014 (in press).
23. Khodaparast N, Hays SA, Sloan AM, Fayyaz T, Hulsey DR, **Rennaker RL**, Kilgard MP. Vagus Nerve Stimulation Delivered During Motor Rehabilitation Improves Recovery in a Rat Model of Stroke. *Neurorehabilitation and Neural Repair* 28(7):698-706, 2014.
24. Centanni TM, Sloan AM, Reed AC, Engineer CT, **Rennaker RL**, Kilgard MP. Detection and identification of speech sounds using cortical activity patterns. *Neuroscience* 258:292-306, 2014.
25. Ware T, Simon D, Liu C, Musa T, Vasudevan S, Sloan AM, Keefer EW, **Rennaker RL**, Voit W. Thiol-ene/acrylate substrates for softening intracortical electrodes. *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, Vol 102 (1); pp 1-11 2014.
26. Hays SA, **Rennaker RL**, Kilgard MP. Targeting Plasticity with Vagus Nerve Stimulation to Treat Neurological Disease. *Progress in Brain Research*, 207:275-299 2013.
27. Simon D, Ware T, Marcotte R, Lund BR, Smith DW DiPrima M, **Rennaker RL**, Voit W. A comparison of polymer substrates for photolithographic processing of flexible bioelectronics. *Biomedical Microdevices*, Vol 15 (6) 925-939 2013.
28. Centanni TM, Booker AB, Sloan AM, Majer BJ, Carraway RS, Khodaparast N, **Rennaker RL**, LoTurco JJ, Kilgard MP. Knockdown of the dyslexia-associated gene Kiaa0319 impairs temporal responses to speech stimuli in rat primary auditory cortex. *Cerebral Cortex*, Feb 8, 2013.
29. Zhao Y, Tang L, **Rennaker RL**, Hutchens C, Ibrahim TS. Studies in RF Power Communication, SAR, and Temperature Elevation in Wireless Implantable Neural Interfaces. *PLoS ONE* 8(11): 1-11, 2013;

30. Khodaparast N, Hays SA, Sloan AM, Hulsey DR, Ruiz AD, Pantoja M, **Rennaker RL**, Kilgard MP. Vagus Nerve Stimulation During Rehabilitative Training Improves Forelimb Strength Following Ischemic Stroke. *Neurobiology of Disease* 60:80-88, 2013.
31. Donzis EJ, **Rennaker RL**, Thompson LT. Fear conditioning alters neuron-specific hippocampal place field stability via the basolateral amygdala. *Brain Research* 1525:16-25, 2013.
32. Marwardt NT, Stokol J, **Rennaker RL**. Sub-meninges implantation reduces immune response to neural implants. *Journal of Neuroscience Methods* 214(2):119-125, 2013.
33. Hays SA, Khodaparast N, Sloan AM, Fayyaz T, Hulsey DR, Ruiz AD, Pantoja M, Kilgard MP, **Rennaker RL**. The bradykinesia assessment task: an automated method to measure forelimb speed in rodents. *Journal of Neuroscience Methods* 214(1):52-61 2013.
34. Ware T, Simon D, **Rennaker RL**, Voit WE. Smart polymers for neural interfaces. *Polymer Reviews* 53(1):108-129, 2013.
35. Hays SA, Khodaparast N, Sloan AM, Hulsey DR, Pantoja M, Ruiz AD, Kilgard MP, **Rennaker RL**. The isometric pull task: a novel automated method for quantifying forelimb force generation in rats. *Journal of Neuroscience Methods* 212(2):329-337, 2012.
36. Ware T, Simon D, Hearon K, Liu C, Sagar Shah, Reeder J, Khodaparast N, Kilgard MP, Maitland DJ, **Rennaker RL**, Voit WE. Three-dimensional flexible electronics enabled by shape memory polymer substrates for responsive neural interfaces. *Macromolecular Materials and Engineering* 297(12):1192-1202, 2012.
37. Lovitz AM, Sloan AM, **Rennaker RL**, Wilson DA. Complex mixture discrimination and the role of contaminants. *Chemical Senses* 37(6):533-540, 2012.
38. Porter BA, Khodaparast N, Fayyaz T, Cheung RJ, Ahmed SS, Vrana WA, **Rennaker RL**, Kilgard MP. Repeatedly pairing vagus nerve stimulation with a movement reorganizes primary motor cortex. *Cerebral Cortex* 22(10):2365-2374, 2012.
39. Sloan AM, Dodd OT, **Rennaker RL**. Frequency discrimination in rats measured by tone-step detection and frequency change detection. *Hearing Research* 251(1-2):60-69, 2009.
40. Barnes DC, Hofacer RD, Zaman AR, **Rennaker RL**, Wilson DA. Olfactory perceptual stability and discrimination. *Nature Neuroscience* 11(12):1378-80, 2008.
41. Ibrahim TS, Abraham D, **Rennaker RL.** Electromagnetic power absorption and temperature changes due to brain machine interface operation. *Annals of Biomedical Engineering*, 35(5):825-834, 2007.
42. **Rennaker RL**, Miller J, Tang H, Wilson DA. Minocycline increases quality and longevity of chronic neural recordings. *Journal of Neural Engineering* 4(2):L1-L5, 2007.
43. **Rennaker RL**, Carey HL, Anderson SE, Sloan AM, Kilgard MP. Anesthesia suppresses nonsynchronous responses to repetitive broadband stimuli. *Neuroscience* 145(1):357-369, 2007.
44. **Rennaker RL**, Chen F, Ruyle AM, Sloan AM, Wilson DA. Spatial and temporal distribution of odorant-evoked activity in the piriform cortex. *Journal of Neuroscience*, 27(7):1534-1542, 2007.
45. Anderson S, Kilgard MP, Sloan AM, **Rennaker RL**. Response to broadband repetitive stimuli in auditory cortex of the unanesthetized rat. *Hearing Research* 213(1-2):107-117, 2006.
46. **Rennaker RL**, Ruyle AM, S. Street, A. Sloan: An economical multi-channel cortical electrode array for extended periods of recording during behavior. J Neuroscience Methods. 2005 Mar 15; 142(1):97-105.
47. **R.L. Rennaker**, A.M. Ruyle, Street SE, Sloan AM. A comparison of chronic multi-channel cortical implantation techniques: manual versus mechanical insertion. *Journal of Neuroscience Methods* 142(2):169-76, 2005.
48. Williams JC, **Rennaker RL**, Kipke DR. Long-term neural recording characteristics of wire microelectrode arrays implanted in cerebral cortex. *Brain Research Protocols* 4(3):303-313, 1999
49. Williams JC, **Rennaker RL**, Kipke DR. Stability of chronic multichannel neural recordings: Implications for a long-term neural interface. Neurocomputing 26-27:1069-1076, 1999.

**D. Research Support**

**Current Research Support**

DARPA BAA-16-24 05/2017-04/2019
Targeted Neuroplasticity Training (TNT) to Accelerate Complex Skill Learning ($5,800,000.00)

W.W. Caruth Jr. Foundation 09/2016-08/2017
Development of Targeted Plasticity System for Spinal Cord Injury Rehabiliation ($2,000,000.00)
Role: PI

DARPA-15-06-Office-Wide-BAA-FP-014; 09/2015-08/2017
Closed-loop Neuromodulation to Treat PTSD ($3,498,933.00)
The goal of this study is to evaluate the efficacy of Closed-loop Neuromodulation to treat PTSD
Role: Co-PI

DARPA-14-38-Office-Wide-BAA-FP-014; 04/2015-03/2016
Platform technology for Sensory, Motor and Affective Disorders ($636,785.00)
The goal of this study is to evaluate the efficacy of Targeted Plasticity to Enhance Fear Extinction in an animal model of PTSD
Role: PI

NINDS-R01 1R01NS085167-01A1 08/2014-07/2019
Vagus Nerve Stimulation Paired with Rehabilitative Training to Enhance Plasticity ($2,361,325.00)
The goal of this study is to demonstrate efficacy of Targeted Plasticity Therapy to treat stroke in aged animals and identify neural pathways that are modified.
Role: Co-PI

Fast-Track SBIR (NIH/ NINDS) 1R44NS086344-01A1 04/2014-09/2016
*Development of a turnkey system for assessing forelimb function in rats.* ($1,233,800.00)
Vulintus, Inc. proposes to develop “MotoTrak”, the first high-throughput, automated rat operant conditioning system capable of quantifying and tracking skilled forelimb performance in trained rats.
Role: Project Manager

**Completed Research Support**

Phase I SBIR (NIH/ NIDCD) 1R43DC013467-01A1 03/2013-02/2015
*Development of a software package for speech therapy.* ($209,650.00)
The goal of this project is to use a 3D EMA system to monitor tongue position and shape during speech to provide an interactive virtual environment to assist with speech therapy.
Role: Project Manager

Phase I SBIR (NIH/NINDS ) 1R43NS084598-01 09/2013-09/2014
*Development of shape memory polymer-based implantable electrode systems.* ($332,278.00)
The goal of this project is to develop a novel “soft” electrode technology that could extend the lifetime and increase the performance of implanted biomedical devices for the brain.
Role: Project Manager

NINDS-R01 5R01NS062065-04 05/2009-04/2013
*A Distributed Wireless Neural Interface System* ($1,265,000)
The goal of this study is to develop and test a highly advanced neural interface system that incorporates the best features of modern neural interfaces into a single system.
Role: Co-PI

NIDCD-R01 5R01DC008982-06 06/2008-05/2013
*Ensemble Coding in Olfactory Cortex* ($1,827,924)
The goal of this study is to explore how groups of neurons work together as an ensemble to interpret sensory input during olfactory behavior tasks.
Role: Co-PI

NSF-PFI 1114211 07/2011-06/2014
*Multifunctional Microelectrode Arrays for Neuroscience Research and Technology Development* ($599,783)
The goal of this study is to develop a multifunctional microelectrode array platform technology that has the potential to revolutionize how neuroscience research is conducted.
Role: Co-PI

SBIR-R43 1R43NS084598 09/2013-09/2014
*Development of Shape Memory Polymer-Based Implantable Electrode Systems.* ($332,278)
Small Business Innovation Research: Vulintus, LLC is developing a new “soft” electrode technology that could extend the lifetime and increase the performance of implanted biomedical devices in the brain.
Role: Co-I

U.S.ED-GAANN ($506,688) 08/2007-08/2011
*Graduate Assistance in Areas of National Need: Promoting Versatility in Doctoral Bioengineering Education.*
This program offers comprehensive educational experience that provides a background suitable for an academic or industrial career in bioengineering.
Role: Advisor to (2) Fellows

NIDCD-R21 1R21DC007112-01A1 ($407,000) 06/2005-05/2007
*Ensemble Coding in Olfactory Cortex*
The goal of this study was to develop and apply micro-electrode array technology and novel analytical tools to examine odor information processing in the olfactory and piriform cortex of rats.
Role: Co-PI

OCAST ($135,000) 06/2005-05/2008
*Distributed Neural Interface*
The goal of this study was to develop and apply micro-electrode array technology and novel analytical tools to examine odor information processing in the olfactory and piriform cortex of rats.
Role: PI

DOE-SC-23.2 DE-FG02-06ER64245 ($960,000) 06/2006-05/2010
Carbon Nanotube Technology Center
This grant supported the creation of a carbon nanotube research center at the University of Oklahoma and supported associated research into novel uses of carbon nanotubes.
Role: Co-I