

Emily Graczyk, PhD

emily.graczyk@case.edu

Education History

CASE WESTERN RESERVE UNIVERSITY – Cleveland, OH August 2013 – May 2018
 PhD in Biomedical Engineering GPA: 4.0/4.0
 Doctoral dissertation: Natural perceptual characteristics and psychosocial impacts of touch evoked by peripheral nerve stimulation

UNIVERSITY OF SOUTH CAROLINA – Columbia, SC August 2009 – May 2013
 Bachelors of Science in Biomedical Engineering GPA: 4.0/4.0
 Minor: Neuroscience
 Undergraduate honors thesis: Redesigning the conductive vinyl sticky pad

Professional Appointments

CASE WESTERN RESERVE UNIVERSITY – Cleveland, OH August 2018 - present
 Research Associate – Department of Biomedical Engineering
 WOC Employee – Louis Stokes Cleveland VA Medical Center, APT Center
 Affiliated Researcher - University Hospitals, Department of Neurological Surgery

Grants

DOD CDMRP OP180054 (PI: Graczyk) 9/30/19 – 9/29/21

Evaluating the impact of prosthetic device features on the experience of prosthesis use

Our goal is to understand the critical factors associated with outcome acceptance following limb loss. We aim to develop a unified theoretical model that describes the psychosocial experience of upper limb prosthesis use and predicts outcome acceptance.

Amount Funded: \$347,904

DARPA Intelligent Neural Interfaces HR00111990044 (PI: Graczyk) 5/1/19 – 10/31/20

Coupled learning of neural features and electrical stimulation controller for maximizing discriminable information content of the peripheral nerves

The goal of the project is to use artificial intelligence to define a set of controllable neural features that can be obtained via electrical stimulation of the nerves to provide a similar discriminable response as that obtained from typical mechanical touch stimuli.

Amount Funded: \$999,880

VA Merit Review I01 RX003355-01 (PI: Tyler) 4/1/20 – 3/31/25

Peripheral interfaces in amputees for sensorimotor integration

The goal of the project is to understand the functional, social, and usage outcomes of an advanced bidirectional hand prosthesis with implanted electrodes for sensory restoration and intuitive motor control. We will determine the effect of having both natural sensation and intuitive control compared to traditional prosthesis, as well as the relative impact of having natural sensation alone and having intuitive control alone.

Estimated Funding: \$1,197,284

Role: Co-investigator

Fellowships and Scholarships

- NATIONAL SCIENCE FOUNDATION GRADUATE RESEARCH FELLOWSHIP
 Three-year full tuition and stipend scholarship for PhD study in STEM fields, awarded based on the intellectual merit and broader impacts of the student's research proposal and graduate preparation

- MUSCULOSKELETAL TRAINING GRANT (T32) TRAINEESHIP
NIH-funded T32 training program in the University Hospitals Department of Orthopedics
- MAGELLAN SCHOLAR AWARD
Undergraduate funding for research project, awarded through proposal competition by USC Office of Undergraduate Research
Project title: Transcranial Direct Current Stimulation During ASL fMRI in Stroke Perilesional Areas
- MCNAIR SCHOLARS AWARD
Highest scholarship offered to out-of-state undergraduate students at the University of South Carolina
Highly competitive, four-year award based on academics, extracurricular activities, and an interview
- ROBERT C. BYRD HONORS SCHOLARSHIP
Federally funded, state-administered, four-year scholarship recognizing exceptional high school seniors
- PASSPORT TRAVEL GRANT
Financial award from the USC Study Abroad Office to help fund a summer study abroad experience

Publications

- Cuberovic, I., Resnik, L., Gill, A., Tyler, D.J., **Graczyk, E.L.** Learning of artificial sensation through long-term home use of a sensory-enabled prosthesis. *Frontiers in Neuroscience*. 13, 853 (2019).
- Joyner, J.S., Benz, H.L., Kluger, D.T., Page, D.M., Wendelken, S.M., Davis, T.S. George, J.A., Clark, G.A., **Graczyk, E.L.**, Cuberovic, I., Lukyanenko, P., Tyler, D.J., Manzo, J., Civilico, E. A quantitative virtual reality assessment of sensate prosthetic hands. *J. Neurosci. Methods*. *In review*.
- Ereifej, E.S., Shell, C.E., Schofield, J.S., Charkhkar, H., Cuberovic, I., Dorval, A.D., **Graczyk, E.L.**, Kozai, T.D.Y., Otto, K.J., Tyler, D.J., Welle, C.G., Widge, A.S., Zariffa, J., Moritz, C.T., Bourbeau, J., Marasco, P.D. Neural engineering: the process, applications, and its role in the future of medicine. *J. Neural Eng.* (2019).
- Cuberovic, I., Schiefer, M., **Graczyk, E.**, Roy S., Anderson, J.R., Tyler, D. Peripheral neural correlates of perception of artificial sensory location. *In review*.
- Segil, J.L., Cuberovic, I., **Graczyk, E.L.**, Weir, R.F., Tyler, D. Integration of simultaneous artificial sensory percepts to identify prosthetic hand postures. *In review*.
- Christie, B., **Graczyk, E.**, Charkhkar, H., Tyler, D., Triolo, R. Visuotactile synchrony of stimulation-induced sensation and natural somatosensation. *J. Neural Eng.* 16, 4 (2019).
- **Graczyk, E.L.**, Gill, A., Tyler, D., Resnik, L. The benefits of sensation on the experience of a hand: a qualitative case series. *PLoS ONE*. 14, 1:e0211469 (2019).
- Schiefer, M.A., **Graczyk, E.L.**, Sidik, S., Tan, D.W., Tyler, D.J. Artificial tactile and proprioceptive feedback improves performance and confidence on object identification tasks. *PLoS ONE*. 13, 12:e0207659 (2018). Cited 7 times.
- **Graczyk, E. L.**, Resnik, L., Schiefer, M. A., Schmitt, M. Tyler, D. J. Home use of a neural-connected sensory prosthesis provides the functional and psychosocial experience of having a hand again. *Scientific Reports*. 8, 1: 9866 (2018). Cited 25 times.
- **Graczyk, E.L.**, Delhay, B.P., Schiefer, M.A., Bensmaia, S.J., Tyler, D.J. Sensory adaptation to electrical stimulation of the somatosensory nerves. *J. Neural Eng.* 15, 4: 046002 (2018). Cited 18 times.
- French, J., Bardot, D., **Graczyk, E.**, Hess-Dunning, A., Lujan, J.L., Moynahan, M., Tan, W., Triolo, R., Zbrzeski, A. The need for understanding and engaging the patient as consumer of products developed by neural engineering. *J. Neural Eng.* 15, 4: 040201 (2018).
- **Graczyk, E.L.**, Schiefer, M.A., Saal, H.P., Delhay, B.P., Bensmaia, S.J., Tyler, D.J. The neural basis of perceived intensity in natural and artificial touch. *Sci. Transl. Med.* 8, 362ra142 (2016). Cited 78 times.

In preparation:

- Cuberovic, I., **Graczyk, E.**, Schiefer, M., Tyler, D. Perception of artificial tactile sensation through the functional workspace. *In preparation.*

Patents

- PCT/US2017/056070 – Systems and methods for controlling levels of perceived intensity of a sensory stimulus

Honors and Awards

- DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA) RISER REPRESENTATIVE
One of three DARPA Risers selected to represent the 2018 Riser class and present their research and ideas to the DARPA 60th Anniversary Symposium general assembly as a plenary session
- DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA) RISER 2018 – Sept 2018
One of 50 early career investigators selected to present at D60, the Agency's 60th Anniversary Symposium. Risers are nominated by DARPA program managers and selected to identify future superstars and showcase new ideas
- GRADUATE EXCELLENCE AWARD – Case Western Reserve University – May 2018
Awarded by the Department of Biomedical Engineering and Case School of Medicine
- THE WHOLE SCIENTIST – The Jackson Laboratory – Bar Harbor, Maine – May 2018
Received a scholarship from the NIH to attend this professional development workshop, which aims to expand professional skills and prepare young scientists for successful science careers
- STUDENT PODIUM PRESENTATION AWARD – 3rd place – Myoelectric Controls Symposium 2017
- OUTSTANDING PUBLICATION AWARD 2017 – Biomedical Engineering Department - Case Western Reserve University
- UNIVERSITY OF SOUTH CAROLINA OUTSTANDING SENIOR AWARD
Awarded to nominated students who have demonstrated significant achievements in service, leadership, and academics
- TAU BETA PI
Engineering Honor Society, selection based on academic achievement and quality of character
- PHI BETA KAPPA
Academic Honor Society
- RALPH H. JOHNSON VA MEDICAL CENTER HONORABLE MENTION
Runner up for award for oral presentation at MUSC Student Research Day 2010
- SOUTH CAROLINA HONORS COLLEGE
Individualized educational experience for academically gifted students
Students must fulfill additional curriculum requirements, maintain a 3.3 GPA, and culminate their studies with an Honors Thesis

Presentations

- Cuberovic, I., Resnik, L., Gill, A., Tyler, D.J., **Graczyk, E.L.** Learning artificial sensation through long-term home use of a sensory-enabled prosthesis. Poster presentation at: 49th annual Society for Neuroscience (SfN) Conference. Oct 19-23, 2019. Chicago, IL.
- **Graczyk E.** Prostheses that feel: Clinical and technical considerations for restoring sensation to upper and lower limb amputees. Symposium presentation at: American Orthotic and Prosthetic Association National Assembly. Sept 25-28th, 2019; San Diego, CA.
- **Graczyk E.** Electrical activation of the nervous system to investigate and augment sensory perception. Plenary presentation at: Defense Advanced Research Projects Agency (DARPA) 60th Anniversary Symposium (D60). Sept 7th, 2018. Fort Washington, MD.

- **Graczyk E**, Cuberovic I, Tyler D. Sensory percepts evoked by biomimetic electrical stimulation for artificial touch. Poster presentation at: 43rd annual Neural Interfaces Conference. June 25-27th, 2018. Minneapolis, MN.
- **Graczyk E**, Michaels R, Tyler D. Symbiotic human-machine interfaces for enhancing human performance and capability. Podium presentation at: U.S. Air Force Research Laboratory (AFRL) Air Force 2030 Initiative Conference; 2018 May 10-11; Bloomington, IN.
- **Graczyk E**, Tyler D. Preparing technology for safe, robust, and reliable take home trials. Podium presentation at: annual PI meeting of the Defense Advanced Research Projects Agency (DARPA) Hand Proprioception and Touch Interfaces (HAPTIX) program; 2018 Feb 21-22; Charleston, SC.
- **Graczyk E**, Delhaye B, Schiefer M, Cuberovic I, Bensmaia S, Tyler D. Biomimetic stimulation patterns elicit more natural tactile sensations. Podium presentation at: 21st annual meeting of the North American Neuromodulation Society (NANS); 2018 Jan 11-14; Las Vegas, NV.
- **Graczyk E**, Resnik L, Schmitt M, Tyler D. Home use of a sensory restoration system: Sensation stability and impact on usage. Podium presentation at: 2017 Myoelectric Controls Symposium; 2017 Aug 15-18; Fredericton, New Brunswick, Canada.
- Resnik L, **Graczyk E**, Tyler D. Measuring user experience of a sensory enabled upper limb prosthesis. Poster presentation at: 2017 Myoelectric Controls Symposium; 2017 Aug 15-18; Fredericton, New Brunswick, Canada.
- Cuberovic I, **Graczyk E**, Schiefer M, Anderson R, Tyler D. Patient-specific considerations in implementing artificial sensory locations. Podium presentation at: 2017 Myoelectric Controls Symposium; 2017 Aug 15-18; Fredericton, New Brunswick, Canada.
- **Graczyk E**, Schiefer M, Delhaye B, Saal H, Bensmaia S, Tyler D. Fascicular organization affects tactile sensation evoked from peripheral nerve stimulation. Poster presentation at the 46th annual Society for Neuroscience (SfN) Conference. Nov 12-16, 2016. San Diego, CA.
- Schiefer M, Cuberovic I, **Graczyk E**, Tyler D. Muscle contraction is significantly associated with proprioception restored with electrical nerve stimulation with a Flat Interface Nerve Electrode (FINE). Poster presentation at the 46th annual Society for Neuroscience (SfN) Conference. Nov 12-16, 2016. San Diego, CA.
- Tyler D, **Graczyk E**, Schiefer M, Cuberovic I, Malone K, Keith M, Anderson J. Evolution of human-in-the-loop neuroprosthesis – toward an artificial hand. Podium presentation at the 46th annual Society for Neuroscience (SfN) Conference. Nov 12-16, 2016. San Diego, CA.
- **Graczyk E**, Schiefer M, Schmitt M, Resnik L, Tyler D. Five-week case study on home use of a sensory restoration system for upper limb amputees. Poster presentation at the 42nd Neural Interfaces Conference (NIC) in collaboration with the North American Neuromodulation Society. June 25-29, 2016. Baltimore, MD.
- **Graczyk E**, Schiefer M, Delhaye B, Saal H, Bensmaia S, Tyler D. The role of sensory adaptation in artificial tactile intensity. Poster presentation at the 42nd Neural Interfaces Conference (NIC) in collaboration with the North American Neuromodulation Society. June 25-29, 2016. Baltimore, MD.
- Cuberovic, I., **Graczyk, E. L.** Schiefer, M. A., Tyler, D. J., “Peripheral Nerve Stimulation Restores Proprioceptive Sensation,” NIC-NANS Meeting, Baltimore, MD, June 27, 2016.
- **Graczyk, E.**, Schiefer, M. A., Tan, D., Keith, M., Anderson, J. R., Tyler, J., & Tyler, D. J. Restoring Sensation in Amputees: Clinical Considerations. Podium presentation at: 2014 Myoelectric Controls Symposium; 2014 Aug 18-22; Fredericton, New Brunswick, Canada.
- **Graczyk, E.**, Tan, D., Schiefer, M. A., & Tyler, D. J. Perception of Visual-Tactile Synchrony with Sensations Evoked by Peripheral Nerve Stimulation. Poster presentation at: 41st Annual Neural Interfaces Conference; 2014 Jun 22-25; Dallas, TX.
- **Graczyk E**, Fridriksson J. Effect of articulatory complexity on respiratory planning. Poster session presented at: 13th Annual Discovery Day at the University of South Carolina; 2013 April 26; Columbia, SC.

- Richardson JD, Fridriksson A, Franklin D, **Graczyk E**, Fridriksson J. Measuring structural connectivity to predict language impairment in aphasia. Poster session presented at: NLC 2012. Proceedings of the 4th Annual Society for the Neurobiology of Language Conference; 2012 Oct 25-27; San Sebastian, Spain.
- **Graczyk E**, Schnall B, Wolf E. Analyzing atypical ankle power generation in unilateral transtibial amputees. Poster session presented at: Annual National Institutes of Health Summer Poster Day; 2012 Aug 9; Bethesda, MD.
- **Graczyk E**, Hanayik T, Fridriksson J. Sensation ratings during high-definition transcranial direct current stimulation (HD-tDCS). Poster session presented at: 12th Annual Discovery Day at the University of South Carolina; 2012 April 20; Columbia, SC.
- **Graczyk E**, George MS. The effects of prolonged use on magnetic resonance scanner stability. Oral presentation at: Perry V. Halushka Research Day, Medical University of South Carolina; 2010 Nov 5; Charleston, SC.

Research Experience

DEPARTMENT OF NEUROLOGICAL SURGERY – University Hospitals – Cleveland, OH – 2018-2019
 Research Associate - PI: Dr. Jennifer Sweet

- Conducted a clinical trial of advanced stimulation patterning for spinal cord stimulation to reduce chronic pain and minimize side effects
 - Assessed the sensory percepts evoked by spinal cord stimulation with advanced stimulation patterns
 - Measured the degree of pain reduction enabled by spinal cord stimulation with advanced stimulation patterns
 - Worked alongside a multidisciplinary clinical team in Neurological Surgery

FUNCTIONAL NEURAL INTERFACES LAB – Case Western – Cleveland, OH – Aug 2013 – May 2018
 Graduate Student Fellow – PI: Dr. Dustin Tyler

WOC Employee – Louis Stokes Cleveland VA Medical Center, APT Center

Dissertation title: Natural perceptual characteristics and psychosocial impacts of touch evoked by peripheral nerve stimulation

- Investigated tactile and proprioceptive sensation elicited by peripheral nerve stimulation in human amputees chronically implanted with peripheral nerve electrodes
 - Studied the influence of stimulation parameters on the perceived magnitude of sensation
 - Determined the neural basis of tactile intensity using experimental and modeling results
 - Assessed the influence of stimulation parameters on the perceived motion of the missing hand and the mechanism behind the perception of proprioception due to stimulation
- Studied the influence of stimulation patterns on sensation quality
 - Used computational modeling to predict the recruitment of populations of neurons due to stimulation
 - Developed stimulation patterns to mimic natural neural firing patterns
 - Assessed the impact of biomimetic stimulation patterns on sensation quality
- Developed a take-home sensory stimulation system for every-day, out-of-lab use by amputees
 - Created novel surveys and functional metrics to assess the impact of home use of sensory stimulation
 - Implemented the system: modified an existing nerve stimulator for this application, designed software to run the sensory stimulation program, built a user interface, instrumented a prosthetic hand with pressure and aperture sensors, designed and built a cabling system to connect the hand sensors and the nerve electrodes to the stimulator
 - Designed the study and administered testing sessions with clinical subjects
- Assessed functional outcomes of restored sensation in hand prostheses after limb loss

APHASIA LABORATORY – University of South Carolina – Columbia, SC – May 2011 – July 2013

Student Research Assistant – PI: Dr. Julius Fridriksson

- Investigated the effects of brain damage from stroke on language production and comprehension using brain imaging and stimulation techniques
- Helped collect and analyze MRI and fMRI data of participants with chronic aphasia
- Administered HD-tDCS on human participants and studied alternative placebo methods
- Developed experiments in E-prime and Matlab Psychtoolbox for aphasia treatment studies and clinical testing
- Utilized eye tracking to measure auditory comprehension
- Designed study to assess the role of respiration planning in speech motor planning

BME SUMMER INTERNSHIP (BESIP) – National Institutes of Health - Bethesda, MD – June-Aug 2012

Intern, Biomechanics Lab at Walter Reed National Military Medical Center – PI: Dr. Erik Wolf

- Collected and analyzed kinetic and kinematic gait data on military amputees
- Investigated ankle power generation of unilateral transtibial amputees
- Explored the definition of typical ankle power generation in transtibial amputees and potential causes of atypical cases

PALMETTO ACADEMY – Medical University of South Carolina - Charleston, SC– June-Aug 2010

Summer Intern, Brain Stimulation Lab – PI: Dr. Mark George

- Gained experience with transcranial magnetic stimulation and vagus nerve stimulation
- Installed sequences on MRI scanner, administered scans on phantoms and human volunteers
- Developed quality assurance protocol for monitoring MRI scanner
- Conducted preliminary study on effects of prolonged scanner use on MRI scanner stability

Industry Experience _____

MEDTRONIC – Minneapolis, MN

July-Sept 2017

Intern, Neuromodulation group

- Learned about business processes, policies, and regulations in medical device industry
- Assisted with animal experiments related to spinal cord stimulation for pain mitigation
- Gained experience with design and manufacture of medical device hardware and software

Teaching Experience _____

Graduate Teaching Assistant, Case Western Reserve University

Graduate-level BME Circuits and Instrumentation (EBME 401)

Spring 2015

Biomedical Engineering Design Experience (EBME 380)

Spring 2016, Fall 2016

Mentorship Experience _____

- Tanya Tebcherani – Masters student in Electrical Engineering 2019
 - Building a stimulation controller for the intelligent neural interfaces project
- Abigail Waltz – Undergraduate researcher – 1 year 2019
 - Constructing touch data sets from a biophysical model for the intelligent neural interfaces project
- Vanderbilt BME Senior Design Team 2018
 - Mentored a team of 5 undergraduate students from Vanderbilt University in completing their BME senior design project, provided guidance and advice on project completion
- Linda Yu – High school student from Hathaway Brown – 3 years 2016-2019
 - Inputted and analyzed data from sensory restoration studies; learned MATLAB coding and experimental design

- Samuel Morrison – Undergraduate researcher – 1 year 2018
 - Developed computational models for studying neural activation in response to electrical stimulation
- Miranda Anderson-Kenney – Undergraduate student from Rose Holman – Summer internship 2017
 - Designed a magnetic connector for quick and safe disconnect of cabling for the take home system
- Emily Szabo – Undergraduate researcher – 1 year 2017
 - Implemented sensors into a prosthetic hand
- Christian Stano – Undergraduate REU student from Vanderbilt – Summer internship 2016
 - Designed motion capture system for small-volume, high-accuracy assessment of hand posture
- Victoria Volk – Undergraduate REU student from St. Ambrose Univ – Summer internship 2016
 - Implemented sensors into prosthetic hands; analyzed data from the take home study
- Karly Franz – Undergraduate researcher – 1 year 2016
 - Designed and built an aperture sensor for a prosthetic hand with a 3D printed housing; wrote documentation for the take home system hardware
- Julia Johnson – Undergraduate researcher – 1 year 2015
 - Designed an aperture sensor for a prosthetic hand; designed circuits for data I/O to prosthetic hand sensors
- Adam Boe – Undergraduate researcher – 2 years 2014-2015
 - Developed custom database software to store sensory stimulation data and associated experimental data files

Leadership Experience

- DARPA HAND PROPRIOCEPTION AND TOUCH INTERFACES (HAPTIX) PROGRAM – Case Western Reserve University – Mar 2015 - present
 Science Team Leader – led team meetings of collaborating researchers and CWRU investigators working with the CWRU HAPTIX project, organized scientific goals and assigned responsibilities to team members, planned schedule of clinical subject experiments, developed experimental protocols, facilitated communication between the CWRU investigators and collaborating researchers, facilitated communication between the Science Team and the collaborating companies and engineers working on technical and hardware development for the project, presented scientific results to the larger CWRU team and DARPA HAPTIX leadership at quarterly meetings
- BME GRADUATE STUDENT ASSOCIATION – Case Western Reserve University - Aug2014-Jul2015
 Faculty Representative – facilitated communication between the graduate students and the BME department faculty, attended faculty meetings, organized student-faculty lunches
- CAROLINA BALLROOM DANCE CLUB – University of South Carolina - Aug 2009-May 2013
 President - organized annual collegiate ballroom competition and social dances, taught dance lessons to club members, created and managed club website
- TAU BETA PI ENGINEERING HONOR SOCIETY – SC Beta Chapter - Nov 2011-May 2013
 Treasurer - managed finances of organization, organized meetings and initiation ceremony
- THETA TAU ENGINEERING FRATERNITY– Zeta Delta Chapter - Jan 2010-May 2013
 Alumni Committee Chair - published a quarterly newsletter, procured donations from alumni
- STUDENT GOVERNMENT SENATE – University of South Carolina - March 2010-May 2011
 Environmental Affairs Chair - represented the interests of the College of Engineering to School Administration, proposed and passed legislation, oversaw committee’s activities

Reviewer Experience

- Biological Cybernetics - 2019
- PLoS Biology - 2019 - present
- Science Translational Medicine – 2019 - present
- PLoS One – 2018 - present
- Scientific Reports – 2018 - present

Professional Associations

- Society for Neuroscience

Volunteer Experience

- CLEVELAND GLOBAL SHAPERS
An offshoot of the World Economic Forum, the global shapers seek to promote the economic and social health of their city. We hosted or assisted with various community programs and events in order to bring about positive social change in Cleveland.
- GELFAND SCIENCE AND ENGINEERING FAIR FELLOWS PROGRAM
Worked with students at Cuyahoga County elementary and middle schools to develop and/or improve their science and engineering fair projects
- DAY OF SERVICE SITE LEADER
Led fellow University of South Carolina students in a day of volunteer work in the Columbia community once a semester
Cleaned up litter, packaged food for those in need, worked community events at children's museum
- AMIGOS DEL BUEN SAMARITANO
Volunteer at a free medical clinic for the Hispanic community in Columbia, SC

Skills

- Clinical research: psychophysics, data collection with human subjects, IRB and FDA IDE amendments, surgical planning for implanted devices
- Computational modeling of peripheral nerve stimulation
- Matlab programming, specifically Simulink, GUI development, Psychtoolbox, and SPM toolbox
- Experience with ANSYS/Maxwell 3D, NEURON, XPP, SPSS, Rstudio, Minitab, FSL, MRICron, LabView, Experiment Builder, the E prime Software Suite, Vicon Nexus and C-motion Visual 3D
- Arduino and C++ programming