

Curriculum Vitae  
**Paul D. Marasco Ph.D.**

**Positions**

Associate Staff Scientist, Department of Biomedical Engineering, Lerner Research Institute, Cleveland Clinic  
Research Health Scientist/ Principal Investigator, Advanced Platform Technology (APT) Center of Excellence  
Louis Stokes Cleveland Department of Veterans Affairs Medical Center  
Director of Amputee Research, Department of Physical Medicine and Rehabilitation  
Louis Stokes Cleveland Department of Veterans Affairs Medical Center  
Adjunct Professor, Department of Cognitive Science, Case Western Reserve University

**Research Interests**

Sensory Integration with Prosthetic devices, Amputee Research, Cognitive Embodiment, Visual-Tactile Integration, Sensory Neurophysiology, Brain Organization, Neural Plasticity, Kinesthesia, Diabetic Sensory Neuropathy

**Education**

Post Doctoral Fellowship, Center for Bionic Medicine (CBM) *formerly: Neural Engineering Center for Artificial Limbs (NECAL)*, Rehabilitation Institute of Chicago, Chicago IL, 2006-2009  
Ph.D. Neuroscience, Vanderbilt Brain Institute, Vanderbilt University, Nashville TN, 2006  
B.A. Biology, University of Colorado, Colorado Springs CO, 1999

**Grants/Awards**

*Current Funding:*

National Institutes of Health (NIH) Director's Transformative R01 Research Award, 1R01NS081710 - 01,  
"Restoring upper limb movement sense to amputees; a move towards natural control of prosthetic limbs"  
Role: Principal Investigator (2013-2017)  
Defense Advanced Research Project Agency (DARPA), Department of Defense, 61732-LS-DRP, Under  
P-1108-114403/DARPA-BAA-11-08 Reliable Peripheral Interfaces (RPI), "A touch feedback tactor array  
system for long-term implementation of physiologically relevant cutaneous touch with prosthetic limbs."  
Role: Principal Investigator (2012-2015)  
VA RR&D Merit Review Award "Peripheral Interfaces in Amputees to Restore Sensation"  
Role: Co-Investigator (2014-2017)

*Previous Funding:*

Advanced Platform Technology Center of Excellence, Innovation Incentive II, "Advanced Materials for Water  
Managing Prosthetic Socket Liners"  
Role: Principal Investigator (2013-2014)  
VA RR&D Career Development Award, Level-2 No. A7253W. "Proprioception in Rat Cortex to Examine  
Sensory Feedback for Prosthetics."  
Role: Principal Investigator (2010-2013)  
VA RR&D Merit Review Award "Novel modalities for assessing the cortical tissue-electrode interface"  
Role: Co-Investigator (2010-2013)  
National Institute on Disability and Rehabilitation Research (NIDRR), Mary E. Switzer Merit Fellowship  
"An investigation of percepts to touch following integration of physiologically relevant sensory  
feedback with artificial limbs."  
Role: Principle Investigator (2010)  
Advanced Platform Technology Center research support award  
Role: Award Recipient (2009)  
NICHD NO1-HD-5-3402 HHSN27500503402C "Hyper-Reinnervation to Improve Myoelectric Prosthesis

Control in Shoulder Disarticulation".

Role: Co-Investigator (2006-2009)

*Awards:*

International Functional Stimulation Society Travel Award sponsored by: Project SMART (September 2012)

Globe Foundation Fellowship (September 2006-September 2007)

Fine Science Tools Travel Award (2004)

Fundamental Neuroscience Training Grant (2002-2004)

Zaebst Memorial Fellowship (1998-1999)

Colorado Scholars Award (1997-1998), (1998-1999)

Most Promising Biology Student (Spring 1994)

President's List (Spring 1997, Spring 1999)

Dean's List (Spring 1996, Fall 1998)

President, Tri Beta Biology Honor Society

**Publications**

Hebert JS, Olson JL, Morhart MJ, Dawson MR, Marasco PD, Kuiken TA, Chan KM. Novel targeted sensory reinnervation technique to restore functional hand sensation after transhumeral amputation. *IEEE TNRSSE* (in press).

Fox JD, Capadona JR, Marasco PD, Rowan SJ. (2013) Bioinspired Water-Enhanced Mechanical Gradient Nanocomposite Films That Mimic the Architecture and Properties of the Squid Beak. *J Am Chem Soc.*

Marasco PD, Kim K, Colgate JE, Peshkin MA, Kuiken TA. (2011) Robotic touch shifts perception of embodiment to a prosthesis in Targeted Reinnervation amputees. *Brain.* 134: 747-58

Marasco PD, and Kuiken TA. (2010) Amputation with median nerve redirection (Targeted Reinnervation) reactivates forepaw barrel subfield in rats. *Journal of Neuroscience* 30:16008-16014.

Marasco PD, Schultz AE, Kuiken TA. (2009) Sensory capacity of reinnervated skin after redirection of amputated upper limb nerves to the chest. *Brain.* 132(pt 6): 1441-8.

Schultz AE, Marasco PD, Kuiken TA. (2009) Vibrotactile detection thresholds for chest skin of amputees following targeted reinnervation surgery. *Brain Research.* 1251:121-9.

Kuiken TA\*, Marasco PD\*, Lock BA, Harden RN, Dewald JP. (2007) Redirection of cutaneous sensation from the hand to the chest skin of human amputees with targeted reinnervation. *Proceedings of the National Academy of Sciences U S A.* 104: 20061-6. (\*these authors contributed equally to this work)

Marasco PD, Tsuruda PR, Bautista DM, Catania KC. (2007) The fine structure of Eimer's organ in the coast mole (*Scapanus orarius*). *Anatomical Record.* 290: 437-448.

Marasco PD, and Catania KC. (2007) Response properties of primary afferents supplying Eimer's organ. *Journal of Experimental Biology.* 210: 765-780

Kuiken TA, Miller LA, Lipschutz RD, Lock BA, Stubblefield K, Marasco PD, Zhou P, Dumanian GA. (2007) Targeted reinnervation for enhanced prosthetic arm function in a woman with proximal amputation. *The Lancet* 369: 371-380

Marasco PD, Tsuruda PR, Bautista DM, Julius D, Catania KC. (2006) Neuroanatomical evidence for segregation of nerve fibers conveying light touch and pain sensation in Eimer's organ of the mole. *Proceedings of the National Academy of Sciences U S A.* 103: 9339-9344

Henry EC, Marasco PD, Catania KC. (2005) Plasticity of the cortical dentition representation after tooth extraction in naked mole-rats. *Journal of Comparative Neurology* 485: 64-74

Appel, B., P. Marasco, L. McClung and A.J. Latimer (2003) lunatic fringe Regulates delta-notch induction of hypochord in zebrafish. *Developmental Dynamics* 228: 281-286

Crish, S.D., C. Comer, P. D. Marasco and K.C. Catania (2003) Somatosensation in the superior colliculus of the star-nosed mole. *Journal of Comparative Neurology* 464: 415-425

**Book Chapters**

Marasco PD., "Targeted Sensory Reinnervation", chapter 8, in: *Targeted Muscle Reinnervation*, Kuiken and

Schultz, Eds. CRC Press Taylor & Francis Group, Boca Raton, 2014 ISBN 978-1-4398-6080-9  
Capadona, JR and PD Marasco “Brain Response to Neural Prostheses”, chapter 6, in: *The Textbook of Neural Repair*, Seltzer et al. Eds, 2<sup>nd</sup> Edition. (*in-press*)

## **Abstracts**

- Marasco, P.D., J.S. Hebert (2013) Vibration of reinnervated muscle induces perceptual illusion of joint movement in an upper limb amputee with targeted sensory reinnervation. 2013 NIH Common Fund High Risk-High Reward Research Program Symposium
- Marasco, P.D., (2012) An electrophysiological investigation of the neural substrates of limb movement feedback. International Functional Electrical Stimulation Society 2012; “Smart Machines-Neural Evolution”
- Marasco, P.D., A.S. Ianni (2011) Electrophysiological examination of peripheral response properties and cortical organizational characteristics of kinesthesia in a rat model: Steps towards providing limb position feedback for prosthetic limbs. Society for Neuroscience 39<sup>th</sup> annual meeting
- Harris, J.P., P.D. Marasco, D.J. Tyler (2011) Lipopolysaccharide-induced response degrades intracortical Recordings. Society for Neuroscience 39<sup>th</sup> annual meeting
- Koppaka, S.S., A.E. Hess, P.D. Marasco, D.J. Tyler (2011) Insertion mechanics of the perineurium and epineurium. Biomedical Engineering Society annual meeting
- Marasco, P.D., A.E. Schultz, K. Kim, J.E. Colgate, M.A. Peshkin, T.A. Kuiken. (2010) Direct sensory feedback for prosthetics: neural mechanisms of function, plasticity, and ownership. Biomedical Engineering Society annual meeting October 2010 (platform presentation)
- Ko, J.H., M. de la Garza, P.D. Marasco, G.A. Dumanian, T.A. Kuiken (2010) The effects of targeted reinnervation on neuroma formation in a novel rat hindlimb model. Plastic Surgery Research Council 55<sup>th</sup> annual meeting (platform presentation)
- Marasco, P.D., K. Kim, J.E. Colgate, M.A. Peshkin, and T.A. Kuiken (2009) Mechanical touch interface applied to redirected sensory nerves drives perceptual shift towards embodiment of a prosthetic arm in a Targeted Reinnervation amputee. Society for Neuroscience 38<sup>th</sup> annual meeting (platform presentation)
- Marasco, P.D and T.A. Kuiken (2008) Median nerve redirection (Targeted Reinnervation) following forelimb amputation reactivates the forepaw barrel subfield in the somatosensory cortex of adult rats; with correlations to Targeted Reinnervation in human amputees to provide physiologically relevant sensory feedback for prosthetic limbs. Society for Neuroscience 38<sup>th</sup> annual meeting (platform presentation)
- Marasco, P.D., A.E. Schultz, J.S. Sensinger, and T.A. Kuiken (2008) Investigation of sensation in amputees who have undergone Targeted Reinnervation. 38<sup>th</sup> Neural Interfaces Conference (platform presentation)
- Marasco, P.D., A.E. Schultz and T.A. Kuiken (2008) Tactile and spatial acuity in amputees with Targeted Reinnervation. Society for Neuroscience, Chicago chapter annual meeting
- Marasco, P.D., B.A. Lock and T.A. Kuiken (2007) Restoring somatic sensation of the hand in human amputees Society for Neuroscience 37<sup>th</sup> annual meeting
- Marasco, P.D., and K.C. Catania (2005) An investigation of the mechanosensory Eimer’s organ in the Coast Mole using the fluorescent cationic styryl dye AM1-43. Society for Neuroscience 35<sup>th</sup> annual meeting
- Marasco, P.D., and K.C. Catania (2004) The response properties of primary afferents innervating mechanosensory Eimer’s organs; clues to the functional organization of a putative texture detecting array. Society for Neuroscience 34<sup>th</sup> annual meeting
- Marasco, P.D., and K.C. Catania (2003) The anatomical organization of the brainstem trigeminal complex in the star-nosed mole. Society for Neuroscience 33<sup>rd</sup> annual meeting
- Henry, E.C., P.D. Marasco and K.C. Catania (2003) Plasticity of the oral-facial cortical representation after tooth extraction in the naked mole-rat: a possible mechanism for phantom tooth pain? Society for Neuroscience 33<sup>rd</sup> annual meeting

## **Other Publications**

Marasco, P.D. (2012) The Turn (haiku poetry and photo project). The Great Lakes Courier, Volume 1 Issues 1 (March, 2012), 4 (August 2012), Volume 2 Issue 1 (May 2013), Volume 2 Issue 1 (May 2013), Volume 2 Issue 5 (September 2013)

<http://greatlakescourier.com/read/2012/03/13/the-turn>  
<http://www.greatlakescourier.com/read/2012/08/17/the-turn>  
<http://www.greatlakescourier.com/read/2013/05/03/the-turn>  
<http://greatlakescourier.com/read/2013/07/30/the-turn>  
<http://greatlakescourier.com/read/2013/09/04/the-turn>

## **Invited Lectures**

Invited Speaker: Defense Advanced Research Projects Agency (DARPA) Sensorimotor Prosthetics Workshop, Doug Weber Ph.D., Program Officer. “Sensory Neurophysiology, Embodiment and Prosthetics”, February 2014.

Guest Lecturer: Basic Cellular and Molecular Neuroscience, MMED 415, Dawn Taylor Ph.D. Dept. of Neuroscience, Lerner Research Institute, Cleveland Clinic, October 2013

Invited Speaker: Case Western Reserve University Biology Department Seminar, “An electrophysiological investigation of the neural substrates of limb movement feedback”, March 2013

Invited Speaker: Case Western Reserve University Department of Biomedical Engineering Seminar Series “An Electrophysiological investigation of the neural substrates of limb movement feedback”, February 2013

Invited Speaker: International Functional Electrical Stimulation Society (IFESS) Somatosensory Prostheses, September 2012

Invited Speaker: International Functional Electrical Stimulation Society (IFESS) Using a Novel Targeted Sensory Reinnervation Technique and Machine Learning Algorithms to Enhance Control and Improve Function of Myoelectric Prostheses after Upper Limb Amputation, September 2012

Invited Speaker/Contributor: TATRC LEGS Integrated Research Team Summit, August 2012

Invited Speaker: Dept of Cognitive Science Colloquium Series, Case Western Reserve University, April 2012

Invited Speaker: Targeted Muscle Reinnervation – Current Approaches and Future Directions, October 2011

Guest Lecturer: Performance and the Embodied Mind, Cogs 329, Yanna Popova D.Phil. Dept of Cognitive Science Case Western Reserve University, September 2011

Invited Speaker: Biomedical Engineering Society annual meeting, October 2010

Featured Speaker: American Orthotic and Prosthetic Association National Assembly, September 2008

Invited Speaker: Dupage Area Engineer’s Week public outreach event, February 2007

## *Scheduled Speakerships:*

Keynote Speaker: MEC Symposium, Institute of Biomedical Engineering, University of New Brunswick, August 2014

## **Service**

Member: Advanced Platform Technology Center of Excellence Leadership Committee. Ongoing

Scientific Review Group: VA Rehabilitation Research and Development (RR&D) SPiRE.

Scientific Review Group: US Army Medical Research and Materiel Command (USAMRMC), American Institute of Biological Sciences (AIBS).

Scientific Member: Louis Stokes Cleveland Department of Veterans Affairs Medical Center Institutional Animal Care and Use Committee. Ongoing

IACUC Representative: Subcommittee on Research Safety (SRS), Louis Stokes Cleveland Department of Veterans Affairs Medical Center. Ongoing

Editorial Board Member for: Journal of Rehabilitation Robotics, January 2013-Ongoing

Scientific Reviewer for: Science Translational Medicine, Ongoing

Scientific Reviewer for: Neurorehabilitation and Neural Repair, Ongoing

Scientific Reviewer for: IEEE Transactions on Neural Systems & Rehabilitation Engineering, Ongoing

Scientific Reviewer for: Biomedical Signal Processing and Control, Ongoing

Scientific Reviewer for: Disability and Rehabilitation: Assistive Technology, Ongoing

Scientific Reviewer for: Transactions on Biomedical Engineering, Ongoing

Scientific Reviewer for: Expert Reviews of Medical Devices, Ongoing

Scientific Reviewer for: Restorative Neurology and Neuroscience

Community Outreach: "From the Earliest Human Technology to the Latest" Demonstration of flintknapping and advanced prosthetic limbs to the 3<sup>rd</sup> grade Discovery Classroom, Emerson Elementary, Lakewood Ohio, January 2013

Invited as the host editor for a *Frontiers in Neuroscience* Research Topic: The current state of embodied prosthetic limbs

## **Popular Press**

Interview, description of current work: Josh Fischman, "Revolution in Artificial Limbs Brings Feeling Back to Amputees" **National Geographic, Daily News**, February 24, 2014

<http://news.nationalgeographic.com/news/2014/02/140222-artificial-limbs-feeling-prosthetics-medicine-science>

Perspective: Casey Murphy, Motor remapping after targeted reinnervation. **O&P Business News**, January 2014. <http://www.healio.com/orthotics-prosthetics/prosthetics/news/print/o-and-p-business-news/%7B19709dc8-741f-47ff-a635-abdd3ac59d8b%7D/targeted-reinnervation-helps-remap-motor-representations-after-amputation>

Perspective: Laura Sanders, "Electrodes dupe brain into feeling touch" **Science News**, November 16, 2013

<https://www.sciencenews.org/article/electrodes-dupe-brain-feeling-touch>

Interview, description of current work: John Mangels, "Cleveland research team's creation of squid-like material could lead to better prosthetics and implants" (Front Page Article) **The Plain Dealer** (Cleveland), June 2013

[http://www.cleveland.com/science/index.ssf/2013/06/cleveland\\_teams\\_creation\\_of\\_sq.html](http://www.cleveland.com/science/index.ssf/2013/06/cleveland_teams_creation_of_sq.html)

Interview, description of earlier work: Kurt de Swaaf, "When man and machine merge" (Article) **Der Standard** (Austria), October 2012.

<http://derstandard.at/1350259863837/Wenn-Mensch-und-Maschine-verschmelzen>

Interview, comments and description of current and past work: Megan Scudellari, "Missing Touch" (feature article); Kenneth Catania, "A Nose for Touch" (cover story), **The Scientist**, (Making Sense of Touch) September 2012.

<http://the-scientist.com/2012/09/01/missing-touch/>

<http://the-scientist.com/2012/09/01/a-nose-for-touch/>

Science news of the year: Body and Brain. Editors and writers survey of the top news from the world of science in 2011. "Rerouted for feeling" **Science News**, December 31, 2011; Vol. 180 #14 (p. 29)

[http://www.sciencenews.org/view/feature/id/337014/title/2011\\_Science\\_News\\_of\\_the\\_Year\\_Body\\_%2B\\_Brain](http://www.sciencenews.org/view/feature/id/337014/title/2011_Science_News_of_the_Year_Body_%2B_Brain)

Comment in: Ferris Jabr, "Monkeys 'feel' texture of virtual objects" **New Scientist** (online), October 5, 2011

<http://www.newscientist.com/article/dn21008-monkeys-feel-texture-of-virtual-objects.html>

News Highlight: "Study: Amputees Who Undergo TMR Perceive Limb as Part of Their Body" **O&P Edge**, February 9, 2011 [http://www.oandp.com/articles/NEWS\\_2011-02-09\\_02.asp](http://www.oandp.com/articles/NEWS_2011-02-09_02.asp)

Article on recent work; Interview: Laura Sanders, "Prosthetics that feel: Amputees with rerouted 'sense of touch' view limbs as part of body." **Science News**, February 26, 2011; Vol. 179 #5 (p. 10)

[http://www.sciencenews.org/view/generic/id/69296/title/Prosthetics\\_that\\_feel](http://www.sciencenews.org/view/generic/id/69296/title/Prosthetics_that_feel)

Perspective: Anthony Calabro, "DARPA Project Will Develop a System that Naturally Controls Prostheses", **O&P Business News**, February 1, 2011

<http://www.oandpbusinessnews.com/view.aspx?rid=79641#perspective>

Interview: Duncan Graham-Rowe "How to rewire the nervous system" **The Economist** (Technology Quarterly), September 2, 2010 <http://www.economist.com/node/16909945>

Interview: **ABC Primetime "Medical Mysteries"**, September 9, 2008

<http://abcnews.go.com/Health/MedicalMysteries/story?id=5715902&page=1>

Interview: **ABC News, Good Morning America**, September 9, 2008

Interview: Stephanie Lecci, Our World with Art Chimes, **NPR, Voice of America Radio**, December 2007

<http://voanews.com/english/science/ourworld.cfm>

Interview: Tom Randall, **Bloomberg News**, December 2007

Interview: Jim Ritter, "Artificial arm might feel like real thing," **Chicago Sun-Times**, November 29, 2007

Interview: Ben McGrath, A Reporter at Large, "Muscle Memory," **The New Yorker**, July 30, 2007, p. 40

[http://www.newyorker.com/reporting/2007/07/30/070730fa\\_fact\\_mcgrath](http://www.newyorker.com/reporting/2007/07/30/070730fa_fact_mcgrath)

Appearance in: The Beauty of Ugly, **Nature PBS**, November 2007

<http://www.pbs.org/wnet/nature/beautyofugly/>

### **Memberships**

Society for Neuroscience, Member

International Functional Electrical Stimulation Society, Member

Biomedical Engineering Society, Member (2010)