

ALAA A. AHMED

Professor
Department of Mechanical Engineering
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EDUCATION

1999 – 2005 University of Michigan
PhD Biomedical Engineering, 2005
MSE Mechanical Engineering, 2001
MS Biomedical Engineering, 2000

1995 – 1999 American University in Cairo, Egypt
BS Mechanical Engineering, 1999

EMPLOYMENT

2022 – present Professor
Department of Mechanical Engineering
University of Colorado, Boulder, CO

2022 – 2023 Director for External Relations
Biomedical Engineering Program
University of Colorado, Boulder, CO

2021 – 2022 Graduate Chair
Biomedical Engineering Program
University of Colorado, Boulder, CO

2020 – 2022 Associate Professor
Department of Mechanical Engineering
University of Colorado, Boulder, CO

2017 – 2020 Associate Professor
Department of Integrative Physiology
Department of Mechanical Engineering
University of Colorado, Boulder, CO

2015 – 2017 Associate Professor
Department of Integrative Physiology
University of Colorado, Boulder, CO

2008 – 2015 Assistant Professor
Department of Integrative Physiology
University of Colorado, Boulder, CO

2007 – 2008 Research Associate
Department of Engineering
University of Cambridge, U.K.

2006 – 2007 Whitaker Foundation International Scholar
Department of Engineering
University of Cambridge, U.K.

2005 – 2006 NIH Postdoctoral Research Fellow
Medical School
University of Michigan

2001 – 2004 NIH Predoctoral Research Fellow
Institute of Gerontology
University of Michigan

AFFILIATIONS

2022 – Present Professor
Biomedical Engineering Program
University of Colorado, Boulder, CO

2019 – 2022 Associate Professor
Biomedical Engineering Program
University of Colorado, Boulder, CO

2017 – Present Fellow
ATLAS
University of Colorado, Boulder, CO

2014 – Present Fellow
Institute of Cognitive Science, Department of Psychology
University of Colorado, Boulder, CO

2008 – Present Member
Center for Neuroscience
University of Colorado, Boulder, CO

2008 – Present Member
Center for Research on Training
University of Colorado, Boulder, CO

2015 – 2017 Associate Professor (courtesy)
Department of Mechanical Engineering
University of Colorado, Boulder, CO

2011 – 2015 Assistant Professor (courtesy)
Department of Mechanical Engineering
University of Colorado, Boulder, CO

SCIENTIFIC APPOINTMENTS

1. Reviewing Editor, eLife, 2023-present.
2. Secretary/Treasurer, Society for the Neural Control of Movement (NCM), 2023-present.
3. Standing Member, NIH Motor Function Speech and Rehabilitation Study-Section, 2020-present.
4. Board Member, Society for the Neural Control of Movement (NCM), 2015-2021.
5. Executive Board Member, Institute of Cognitive Science, CU Boulder, 2016-2018.

HONORS & AWARDS

6. Best Poster Award, Society for Neuroeconomics, 2015.
7. National Science Foundation (NSF) CAREER Award, 2014.
8. DARPA Young Faculty Award, 2012.
9. Junior Faculty Development Award, CU Boulder, 2009.
10. Royal Society Conference Grant, University of Cambridge, 2008.
11. Whitaker Foundation International Scholar Grant, University of Cambridge, 2006-2007.
12. NIH Postdoctoral Fellowship, University of Michigan Medical School, 2005-2007.

13. Distinguished Dissertation Award Nominee¹, University of Michigan, 2005
14. Outstanding Mentor Award, University of Michigan College of Engineering, 2005.
15. NIH Predoctoral Fellowship, University of Michigan Institute of Gerontology, 2001-2004.
16. Clinical Biomechanics Award, Annual Meeting of the American Society of Biomechanics, 2003.
17. First Place, Best Presentation Award, 4th Annual Mechanical Engineering Graduate Student Symposium, University of Michigan, 2003.
18. Best Content Award, College of Engineering Graduate Student Poster Competition, University of Michigan, 2003.
19. Second Place, Best Presentation Award, 3rd Annual Mechanical Engineering Graduate Student Symposium, University of Michigan, 2002.
20. Dean's Honors List, The American University in Cairo, 1995-1999.
21. Academic Merit Scholarship (40% tuition waiver), The American University in Cairo, 1995-1999.

PUBLICATIONS

- * Indicates post-doctoral trainee under the supervision of Dr. Ahmed
- ** Indicates graduate student under the supervision of Dr. Ahmed
- *** Indicates undergraduate student under the supervision of Dr. Ahmed

Pre-prints:

1. **Healy, C. M., & **Ahmed, A. A.** Physical Effort Pre-Crastination Determines Preference in an Isometric Task. *bioRxiv* (2024).

Book:

1. Shadmehr, R. & **Ahmed, A. A.** *Vigor: neuroeconomics of movement control*. (MIT Press, 2020).

Reviews & Commentaries

2. Constantinidis, C., **Ahmed, A. A.**, Wallis, J. D. & Batista, A. P. Common mechanisms of learning in motor and cognitive systems. *Journal of Neuroscience* **43**, 7523-7529 (2023).
3. Shadmehr, R. & **Ahmed, A. A.** Movement control, decision-making, and the building of Roman roads to link them. *Behavioral and Brain Sciences* **44**, (2021).
4. Shadmehr, R. & **Ahmed, A. A.** Precis of Vigor: Neuroeconomics of movement control. *Behavioral and Brain Sciences* 1–10 (2020).
5. **Sukumar, S. & **Ahmed, A. A.** Walking: How visual exploration informs step choice. *Current Biology* **31**, R376–R378 (2021).
6. Shadmehr, R., Reppert, T. R., *Summerside, E. M., Yoon, T. & **Ahmed, A. A.** Movement vigor as a reflection of subjective economic utility. *Trends in neurosciences* **42**, 323–336 (2019).
7. **Courter, R. J. & **Ahmed, A. A.** To break a habit, timing's everything. *Nature human behaviour* **3**, 1244–1245 (2019).

Research Articles:

8. **Bruening, G., **Courter, R., **Sukumar, S., *O'Brien, M.K., & **Ahmed, A.A.** Disentangling the effects of metabolic cost and accuracy on movement vigor. *PLoS Computational Biology*. (in press)

¹ Thesis was nominated by the Department of Biomedical Engineering for the University of Michigan 2005 Distinguished Dissertation Award. Each department nominates one dissertation annually.

9. **Summerside, E., **Courter, R., Shadmehr, R. & **Ahmed, A. A.** Slowing of movements in healthy aging as a rational economic response to an elevated effort landscape. *Journal of Neuroscience* (in press).
10. **Sukumar, S., Shadmehr, R. & **Ahmed, A. A.** Effects of reward history on decision-making and movement vigor. *Journal of neurophysiology* (in press).
11. **Courter, R., Alvarez, E., Enoka, R.M. & **Ahmed, A.A.** Metabolic costs of walking and arm reaching in persons with mild multiple sclerosis. *Journal of neurophysiology* **129**, 819-832 (2023).
12. **Healy, C. M., Berniker, M. & **Ahmed, A. A.** Learning vs. minding: How subjective costs can mask motor learning. *PloS one* **18**, e0282693 (2023).
13. **Korbisch, C.C., **Apuan, D.R., Shadmehr, R. & **Ahmed. A.A.** Saccade vigor reflects the rise of decision variables during deliberation. *Current Biology* (2022).
14. **Pienciak-Siewert, A. & **Ahmed, A. A.** Whole body adaptation to novel dynamics does not transfer between effectors. *Journal of neurophysiology* **126**, 1345–1360 (2021)
15. **Summerside, E. M. & **Ahmed, A. A.** Using metabolic energy to quantify the subjective value of physical effort. *Journal of the Royal Society Interface* **18**, 20210387 (2021).
16. Yoon, T., Jaleel, A., **Ahmed, A. A.** & Shadmehr, R. Saccade vigor and the subjective economic value of visual stimuli. *Journal of neurophysiology* **123**, 2161–2172 (2020).
17. **Pienciak-Siewert, A., ***Horan, D. P. & **Ahmed, A. A.** Role of muscle coactivation in adaptation of standing posture during arm reaching. *Journal of neurophysiology* **123**, 529–547 (2020).
18. *O'Brien, M. K. & **Ahmed, A. A.** Asymmetric valuation of gains and losses in effort-based decision making. *PloS one* **14**, e0223268 (2019).
19. Hamilton, L. D., Mazzo, M. R., Petrigna, L., **Ahmed, A. A.** & Enoka, R. M. Poor estimates of motor variability are associated with longer grooved pegboard times for middle-aged and older adults. *Journal of neurophysiology* **121**, 588–601 (2019).
20. **Summerside, E. M., Shadmehr, R. & **Ahmed, A. A.** Vigor of reaching movements: reward discounts the cost of effort. *Journal of neurophysiology* **119**, 2347–2357 (2018).
21. Yoon, T., Geary, R. B., **Ahmed, A. A.** & Shadmehr, R. Control of movement vigor and decision making during foraging. *Proceedings of the National Academy of Sciences* **115**, E10476–E10485 (2018).
22. **Summerside, E. M., Kram, R. & **Ahmed, A. A.** Contributions of metabolic and temporal costs to human gait selection. *Journal of The Royal Society Interface* **15**, 20180197 (2018).
23. **Pienciak-Siewert, A., ***Horan, D. P. & **Ahmed, A. A.** Trial-to-trial adaptation in control of arm reaching and standing posture. *Journal of Neurophysiology* **116**, 2936–2949 (2016).
24. **O'Brien, M. K. & **Ahmed, A. A.** Rationality in human movement. *Exercise and sport sciences reviews* **44**, 20–28 (2016).
25. Shadmehr, R., *Huang, H. J. & **Ahmed, A. A.** A representation of effort in decision-making and motor control. *Current biology* **26**, 1929–1934 (2016).
26. **O'Brien, M. K. & **Ahmed, A. A.** Threat affects risk preferences in movement decision making. *Frontiers in behavioral neuroscience* **9**, 150 (2015).
27. *Nikooyan, A. A. & **Ahmed, A. A.** Reward feedback accelerates motor learning. *Journal of neurophysiology* **113**, 633–646 (2015).
28. **Pienciak-Siewert, A., Barletta, A. J. & **Ahmed, A. A.** Transfer of postural adaptation depends on context of prior exposure. *Journal of neurophysiology* **111**, 1466–1478 (2014).
29. *Huang, H. J. & **Ahmed, A. A.** Reductions in muscle coactivation and metabolic cost during visuomotor adaptation. *Journal of neurophysiology* **112**, 2264–2274 (2014).

30. *Huang, H. J. & **Ahmed, A. A.** Older adults learn less, but still reduce metabolic cost, during motor adaptation. *Journal of neurophysiology* **111**, 135–144 (2014).
31. **O'Brien, M. K. & **Ahmed, A. A.** Take a stand on your decisions, or take a sit: posture does not affect risk preferences in an economic task. *PeerJ* **2**, e475 (2014).
32. **O'Brien, M. K. & **Ahmed, A. A.** Does risk-sensitivity transfer across movements? *Journal of neurophysiology* **109**, 1866–1875 (2013).
33. **Trent III, M. C. & **Ahmed, A. A.** Learning from the value of your mistakes: evidence for a risk-sensitive process in movement adaptation. *Frontiers in computational neuroscience* **7**, 118 (2013).
34. Wilder, M. H., Jones, M., **Ahmed, A. A.**, Curran, T. & Mozer, M. C. The persistent impact of incidental experience. *Psychonomic bulletin & review* **20**, 1221–1231 (2013).
35. Berniker, M., **O'Brien, M. K., Kording, K. P. & **Ahmed, A. A.** An Examination of the Generalizability of Motor Costs. *PloS one* **8**, e53759 (2013).
36. *Huang, H. J., Kram, R. & **Ahmed, A. A.** Reduction of metabolic cost during motor learning of arm reaching dynamics. *Journal of Neuroscience* **32**, 2182–2190 (2012). ^ Featured in Time, PBS, Forbes^{1*}
37. ***Manista, G. C. & **Ahmed, A. A.** Stability limits modulate whole-body motor learning. *Journal of Neurophysiology* **107**, 1952–1961 (2012).
38. *Huang, H. J. & **Ahmed, A. A.** Tradeoff between stability and maneuverability during whole-body movements. *PloS one* **6**, e21815 (2011).
^ featured PLoS one image of the week (<http://blogs.plos.org/everyone/2011/07/18/worth-a-thousand-words-44/>)
39. **Ahmed, A. A.** & Wolpert, D. M. Transfer of dynamic learning across postures. *Journal of neurophysiology* **102**, 2816–2824 (2009).
40. **Ahmed, A. A.**, Wolpert, D. M. & Flanagan, J. R. Flexible representations of dynamics are used in object manipulation. *Current Biology* **18**, 763–768 (2008).
41. **Ahmed, A. A.** & Ashton-Miller, J. A. On use of a nominal internal model to detect a loss of balance in a maximal forward reach. *Journal of neurophysiology* **97**, 2439–2447 (2007).
42. **Ahmed, A. A.** & Ashton-Miller, J. A. Effect of age on detecting a loss of balance in a seated whole-body balancing task. *Clinical Biomechanics* **20**, 767–775 (2005).
43. **Ahmed, A. A.** & Ashton-Miller, J. A. Is a “loss of balance” a control error signal anomaly? Evidence for three-sigma failure detection in young adults. *Gait & posture* **19**, 252–262 (2004).

Journal-equivalent conference proceedings (acceptance rate < 30%):

44. **Sukumar, S., Shadmehr, R., **Ahmed, A. A.**, “Effort expenditure links control of vigor with decision-making” *Motor Learning and Motor Control (Satellite meeting of the Society for Neuroscience)*, online: <http://www.motor-conference.org/openconf.php>, November 2020.
45. **Korbisch, C. K., **Apuan, D. R., **Ahmed, A. A.**, “Saccade vigor reveals relative utility in effort-based choice,” *Motor Learning and Motor Control (Satellite meeting of the Society for Neuroscience)*, Chicago, IL, October 2019.
46. **Summerside, E. M., Shadmehr, R., **Ahmed, A. A.**, “Effort cost of reaching increases with aging,” *Motor Learning and Motor Control (Satellite meeting of the Society for Neuroscience)*, San Diego, CA, November 2018.

¹ TIME: <http://ideas.time.com/2013/08/20/dont-just-practice-over-practice/>

PBS: <http://www.pbs.org/wgbh/nova/blogs/secretlife/blogposts/the-science-of-smart-dont-just-learn-overlearn/>

Forbes: <http://www.forbes.com/sites/daviddisalvo/2012/02/13/of-mind-and-muscle-how-top-performers-become-more-efficient-with-practice/>

47. Shadmehr R., *Huang H. J., **Ahmed A. A.**, “Effort, reward and vigor in decision making and movement control”, *Translational and Computational Motor Control*, Chicago, IL, October 2015.
48. **O’Brien, M. K., **Ahmed A. A.**, “The influence of threat on movement and economic decision making under risk”, *Translational and Computational Motor Control Meeting*, San Diego, CA, November 2013.
49. *Huang, H. J., **Ahmed, A. A.**, “Is there a reaching speed that minimizes metabolic cost?”, *Advances in Computational Motor Control Meeting*, New Orleans, LA, November 2012.
50. *Huang, H. J., Kram, R., **Ahmed, A. A.**, “Reduction of metabolic cost when learning novel arm reaching dynamics”, *Advances in Computational Motor Control Meeting*, Washington D.C., November 2011.
51. **Trent, M. C., **Ahmed A. A.**, “Movement adaptation under risk and instability”, *Advances in Computational Motor Control Meeting*, Washington D.C., November 2011.

CONFERENCE PRESENTATIONS (selected)

‡ Indicates journal-equivalent conference proceeding

1. ‡**Korbisch, C. K., **Apuan, D. R, **Ahmed, A. A.**, “Saccade vigor reveals relative utility in effort-based choice,” *Motor Learning and Motor Control (Satellite meeting of the Society for Neuroscience)*, Chicago, IL, October 2019, *podium presentation*.
2. **Bruening, G., **Ahmed, A. A.**, “How well do computational effort proxies represent metabolic cost of reaching?,” *XXVII Congress of the International Society of Biomechanics*, Calgary, C.A., July 2019, *poster presentation*.
3. **Sukumar, S., Shadmehr, R., **Ahmed, A. A.**, “Effect of travel effort on movement vigor during foraging,” *Multidisciplinary Conference on Reinforcement Learning and Decision Making*, Montreal, C.A., July 2019, *poster presentation*.
4. **Korbisch, C. K., **Apuan, D. R, **Ahmed, A. A.**, “Saccade vigor reveals relative utility in effort-based choice,” *Annual Meeting of the Society for the Neural Control of Movement*, Toyama, Japan, May 2019, *poster presentation*.
5. ‡**Summerside, E. M., Shadmehr, R., **Ahmed, A. A.**, “Effort cost of reaching increases with aging,” *Motor Learning and Motor Control (Satellite meeting of the Society for Neuroscience)*, San Diego, CA, November 2018, *podium presentation*.
6. **Ahmed A. A.** “Coming to terms with Effort”, *Annual Meeting of the Society for the Neural Control of Movement*, Santa Fe, NM, May 2018, *podium presentation*.
7. **Summerside, E. M., Shadmehr, R., **Ahmed, A. A.**, “Aging reduces reward sensitivity,” *Annual Meeting of the Society for the Neural Control of Movement*, Santa Fe, NM, May 2018, *podium presentation*.
8. **Ahmed A. A.** “The role of reward and effort in movement decisions and learning”, *Annual Meeting of the Society for the Neural Control of Movement*, Dublin, Ireland, April 2017, *podium presentation*.
9. **Bruening G., *O’Brien M. K., Shadmehr R., **Ahmed A. A.**, “Effect of mass on the cost of effort in movement control”, *Annual Meeting of the Society for the Neural Control of Movement*, Dublin, Ireland, April 2017, *poster presentation*.
10. **Healy C. M., **Ahmed A. A.**, “Sprint to the finish: How effort and time interact in movement decisions”, *46th Annual Meeting of the Society for Neuroscience*, San Diego, CA, November 2016, *poster presentation*.

11. **Summerside, E. M., **Ahmed A. A.**, “Subjective value of effort explains movement vigor”, *Annual Meeting of the Society for the Neural Control of Movement*, Montego Bay, Jamaica, April 2016, *podium presentation*.
12. ‡Shadmehr R., *Huang H. J., **Ahmed A. A.**, “Effort, reward and vigor in decision making and movement control”, *Translational and Computational Motor Control*, Chicago, IL, October 2015, *podium presentation*.
13. Shadmehr R., Huang H. J., **Ahmed A. A.**, “Effort, reward and vigor in decision making and movement control”, *Annual Meeting of the Society for Neuroeconomics*, Miami, FL, September 2015, *poster spotlight: poster/podium presentation*.
14. *O’Brien M. K., **Ahmed A. A.**, “Loss aversion in effort-based decisions”, *Annual Meeting of the Society for Neuroeconomics*, Miami, FL, September 2015, *poster presentation*.
15. Shadmehr, R., **Ahmed A. A.**, “Effort, reward and vigor in decision making and movement control”, *Annual Meeting of the Society for the Neural Control of Movement*, Charleston, South Carolina, U.S.A., April 2015, *podium presentation*.
16. **Summerside, E. M., **Ahmed A. A.**, “Using metabolic cost to determine the subjective value of effort in movement decisions”, *44th Annual Meeting of the Society for Neuroscience*, Washington D.C., November 2014, *podium presentation*.
17. **Pienciak-Siewert, A., *Huang, H. J., **Ahmed A. A.**, “Optimal stability-maneuverability trade-off in postural control”, *36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Chicago, IL, August 2014, *poster presentation*.
18. **Summerside, E. M., **Ahmed, A. A.**, “Quantifying the subjective value of effort in movement decision making”, *Dynamic Walking*, Zurich, Switzerland, June 2014, *podium presentation*.
19. *Nikooyan.A. A, **Ahmed A. A.**, “Reward accelerates motor adaptation”, *Annual Meeting of the Society for the Neural Control of Movement*, Amsterdam, Netherlands, April 2014, *podium presentation*.
20. *Nikooyan.A. A, **Ahmed A. A.**, “Reward feedback accelerates motor adaptation”, *4th Annual Meeting of the Regional Rocky Mountain American Society of Biomechanics*, Estes Park, CO, April 2014, *podium presentation*.
21. **O’Brien, M. K., **Ahmed A. A.**, “Postural threat affects movement decisions under risk”, *4th Annual Meeting of the Regional Rocky Mountain American Society of Biomechanics*, Estes Park, CO, April 2014, *podium presentation*.
22. ‡**O’Brien, M. K., **Ahmed A. A.**, “The influence of threat on movement and economic decision making under risk”, *Translational and Computational Motor Control Meeting*, San Diego, CA, November 2013, *poster presentation*.
23. **Trent, M. C., **Ahmed A. A.**, “Learning from the value of your mistakes: evidence for a risk-sensitive process in movement adaptation”, *1st Multidisciplinary Conference on Reinforcement Learning and Decision Making*, Princeton, NJ, October 2013, *poster presentation*.
24. **O’Brien, M. K., **Ahmed A. A.**, “The influence of threat on movement and economic decision making under risk”, *Stress and Social Economic Decision Making, a preconference at the Annual Meeting of the Society for Neuroeconomics*, Lausanne, Switzerland, September 2013, *poster presentation*.
25. **Trent, M. C., **Ahmed A. A.**, “Learning from the value of your mistakes: evidence for a risk-sensitive process in movement adaptation”, *Annual Meeting of the Society for Neuroeconomics*, Lausanne, Switzerland, September 2013, *poster presentation*.
26. *Huang, H. J., **Ahmed, A. A.**, “Is there a reaching speed that minimizes metabolic cost?”, *Dynamic Walking*, Pittsburgh, PA, June 2013, *podium presentation*.

27. ‡*Huang, H. J., **Ahmed, A. A.**, “Is there a reaching speed that minimizes metabolic cost?”, *Advances in Computational Motor Control Meeting*, New Orleans, LA, November 2012, *podium presentation*.
28. **Pienciak, A., **Barletta, A. J., **Ahmed A. A.**, “Stance width affects learning and transfer of postural control in novel dynamic environments”, *42nd Annual Meeting of the Society for Neuroscience*, New Orleans, LA, November 2012, *podium presentation*.
29. ‡*Huang, H. J., Kram, R., **Ahmed, A. A.**, “Reduction of metabolic cost when learning novel arm reaching dynamics”, *Advances in Computational Motor Control Meeting*, Washington D.C., November 2011, *podium presentation*.
30. ‡**Trent, M. C., **Ahmed A. A.**, “Movement adaptation under risk and instability”, *Advances in Computational Motor Control Meeting*, Washington D.C., November 2011, *poster presentation*.

INVITED TALKS (selected)

Conferences, Keynotes:

1. “Vigor as a reflection of decision variables during deliberation and learning”, CMU NSF Workshop: The Neural Basis of Internal States, Invited Speaker, Pittsburgh, PA, USA, May 2023.
2. “Movement as a window to the mind”, Annual meeting of the North American Society for the Psychology of Sport and Physical Activity (NASPSA), Keynote Speaker, Kona, HI, USA May 2022.
3. “What do our movements reveal about preference?”, CEREBBRAL Symposium (Purdue University Center for Research on Brain, Behavior, and NeuroRehabilitation), Keynote Speaker, Purdue University, West Lafayette, IN, U.S.A., April 2021.
4. “Movement, probability and the brain,” Whitaker Alumni Technical and Career Summit, Invited Speaker, University of Wisconsin-Madison, Madison, WI, U.S.A., June 2020 (postponed due to Covid-19).
5. “Should I stay or should I go: what do our movements reveal about preference?”, Speech Motor Control Conference, Keynote Speaker, Santa Barbara, CA, U.S.A., February 2020.
6. “Movement vigor as a reflection of subjective economic utility”, XXVII Congress of the International Society of Biomechanics, Keynote speaker, Calgary, C.A., July 2019.

Departments:

7. “A unifying framework for movement control and decision making”, World-Wide Seminar Series in Theoretical Neuroscience, Invited Speaker, Virtual, October 2023.
8. “Movement vigor as a window to the mind” *Department of Bioengineering*, University of Colorado School of Medicine, Denver, CO, U.S.A., March 2023.
9. “Saccade vigor reflects rise of decision variables during deliberation” *Department of Neuroscience*, Regis University, Denver, CO, U.S.A., February 2023.
10. “Saccade vigor reflects the rise of decision variables during deliberation.” *Princeton University Psychology Seminars*, Princeton University, Princeton, NJ, U.S.A., October 2022.
11. “Movement as a window to the mind” *University of Utah Cognitive and Motor Neuroscience Seminar*, University of Utah, Salt Lake City, UT, U.S.A., April 2022. [forthcoming]
12. “Movement control reveals the subjective economic value of past experience and future expectations” *Colorado School of Mines Quantitative Biosciences and Engineering Program Seminar*, Colorado School of Mines, Golden, CO, U.S.A., February 2022.
13. “A unifying framework for decision making and movement control” *Canadian-German International Research Training Group (IRTG) Brain in Action seminar series*. [virtual] January 2022

14. "Movement vigor as a reflection of subjective economic value" *Department of Physiology and Biophysics*, University of Colorado School of Medicine, Denver, CO, U.S.A., October 2019.
15. "Movement vigor as a reflection of subjective economic utility" Seminar Series, *ATLAS*, University of Colorado Boulder, Boulder, CO, U.S.A., April 2019.
16. "Coming to terms with effort in decision making and movement control" *Department of Biomedical Engineering*, UNC Chapel Hill, Chapel Hill, NC, U.S.A., October 2018.
17. "Towards a unifying framework for decision making and motor control" *Topics in Cognitive Science Invited Course Lecture*, Institute of Cognitive Science, University of Colorado Boulder, Boulder, CO, U.S.A., April 2018.
18. "Effect of age on subjective movement costs in motor learning" *Department of Biomedical Engineering*, Georgia Tech/Emory, Atlanta, GA, U.S.A., September 2017.
19. "Towards a unifying framework for decision making and motor control" *Department of Mechanical Engineering*, University of Colorado Boulder, Boulder, CO, U.S.A., April 2017.
20. "Effect of age on subjective movement costs in motor learning" *Department of Biomedical Engineering*, Johns Hopkins University, Baltimore, MD, U.S.A., March 2017.
21. "Towards a unifying framework for decision making and motor control" *Topics in Cognitive Science Invited Course Lecture*, Institute of Cognitive Science, University of Colorado Boulder, Boulder, CO, U.S.A., April 2017.
22. "Towards a unified framework for decision making and motor control" *School of Kinesiology*, University of Michigan, Ann Arbor, MI, U.S.A., December 2016.
23. "A unifying framework for decision making and motor control" *Department of Integrative Physiology Colloquium*, University of Colorado Boulder, Boulder, CO, U.S.A., October 2016.
24. "A unifying framework for decision making and motor control" *CINC Tea*, University of Colorado Boulder, Boulder, CO, U.S.A., September 2016.
25. "A representation of effort in decision making and motor control" *Department of Psychology Seminar*, University of Oxford, Oxford, U.K., July 2016.
26. "Effort, reward, and vigor in decision making and motor control" *Department of Kinesiology Colloquium*, Penn State University, State College, PA, U.S.A., April 2016.
27. "Effort, reward, and vigor in decision making and motor control" *Department of Mechanical Engineering Colloquium*, University of Illinois at Chicago, Chicago, IL, U.S.A., February 2016.
28. "Effort, reward, and vigor in decision making and motor control" *Department of Kinesiology Colloquium*, University of Illinois at Urbana-Champaign, Urbana, IL, U.S.A., September 2015.
29. "Metabolic Cost in Movement Decision Making: A Neuroeconomic Framework" *Department of Mechanical Engineering Colloquium*, Colorado School of Mines, Golden, CO, U.S.A., January 2015.

TEACHING CONTRIBUTIONS**University Courses:**University of Colorado, Boulder, CO

Fall 2022	<u>Course Instructor</u> , Dynamics (MCEN 2043, 58 students)
Fall 2022	<u>Course Instructor</u> , Modeling of Human Movement (MCEN 4228/5228, 25 students)
Fall 2022	<u>Course Instructor</u> , Graduate Seminar in Biomedical Engineering (BMEN 6519, 8 students)
Fall 2021	<u>Invited Lecture</u> , Intro to Neuroscience (NRSC 5100) Topic: <i>The Motor System: Cerebellum & Basal Ganglia (one 3 hour lecture)</i>
Fall 2021	<u>Course Instructor</u> , Dynamics (MCEN 2043, 60 students)
Fall 2021	<u>Course Instructor</u> , Modeling of Human Movement (MCEN 4228/5228, 30 students)
Fall 2020	<u>Invited Lecture</u> , Intro to Neuroscience (NRSC 5100) Topic: <i>The Motor System: Cerebellum & Basal Ganglia (one 3 hour lecture)</i>
Fall 2020	<u>Course Instructor</u> , Dynamics (MCEN 2043, 18 students)
Fall 2020	<u>Course Instructor</u> , Modeling of Human Movement (MCEN 4228/5228, 30 students)
Fall 2019	<u>Invited Lecture</u> , Intro to Neuroscience (NRSC 5100) Topic: <i>The Motor System: Cerebellum & Basal Ganglia (one 3 hour lecture)</i>
Fall 2019	<u>Course Instructor</u> , Dynamics (MCEN 2043, 52 students)
Fall 2019	<u>Course Instructor</u> , MATLAB for Physiologists (IPHY 6680, 18 students)
Spring 2019	<u>Course Instructor</u> , Modeling of Human Movement (MCEN 4228/5228, 32 students)
Spring 2019	<u>Invited Lecture</u> , Neuromechanics of Human Movement (BMEN 2000)
Fall 2018	<u>Course Instructor</u> , Freshman Engineering Projects (GEEN 1400, 30 students)
Fall 2018	<u>Invited Lecture</u> , Intro to Neuroscience (NRSC 5100) Topic: <i>The Motor System: Cerebellum & Basal Ganglia (one 3 hour lecture)</i>

Spring 2018 Course Instructor, Biomechanics (IPHY 4540, 56 students)

Fall 2017 Course Instructor, MATLAB for Physiology (IPHY 6680, 15 students)

Spring 2017 Course Instructor, Biomechanics (IPHY 4540, 34 students)

Fall 2016 Invited Lecture, Physiology of Aging (IPHY 6010)
Topic: *The Aging Motor System*

Fall 2015 Course Instructor, MATLAB for Physiology (IPHY 6680, 14 students)

Fall 2015 Invited Lecture, Intro to STEM Research Methods (ARSC 1450, 11 students)
Topic: *The Motor System*

Spring 2015 Invited Lecture, Intro to STEM Research Methods (ARSC 1450, 11 students)
Topic: *The Motor System*

Spring 2015 Course Instructor, Biomechanics (IPHY 4540, 73 students)

Fall 2014 Invited Lecture, Physiology of Aging (IPHY 6010)
Topic: *The Aging Motor System (one 3 hour lecture)*

Spring 2014 Course Instructor, Biomechanics (IPHY 4540, 75 students)

Fall 2013 Course Instructor, MATLAB for Physiology (IPHY 6680, 12 students)
Invited Lecture, Professional Skills (IPHY 4540)
Topic: *Work-Life Balance*

Spring 2013 Course Instructor, Biomechanics (IPHY 4540, 59 students)

Spring 2012 Course Instructor, Biomechanics (IPHY 4540, 62 students)
Course Instructor, MATLAB for Physiology (IPHY 6680, 20 students)

Fall 2011 Invited Lectures (2), Professional Skills (IPHY 4540)
Topics: *Setting up a research lab, Women in science*

Spring 2011 Course Instructor, Biomechanics (IPHY 4540, 42 students)

Fall 2010 Invited Lecture, Physiology of Aging (IPHY 6010)
Topic: *The Aging Motor System (one 3 hour lecture)*

Spring 2010 Course Instructor, Biomechanics (IPHY 4540, 58 students)

Fall 2009 Course Instructor, MATLAB for Physiology (IPHY 6680, 9 students)

Spring 2009 Course Instructor, Biomechanics (IPHY 4540, 36 students)

University of Cambridge, Cambridge, U.K.

Fall 2006 Supervisor, Engineering Structures, Michaelmas Term
Robinson College, University of Cambridge, Cambridge, U.K.

Summer School Courses:

September 2023 Lecturer, Computational movement control and decision making
Neurobridges 2023
Cluny, France

August 2022 Lecturer, Computational movement control and decision making
CNeuro
Basel, Switzerland

August 2018 Lecturer, Motor Control & Learning
8th Summer School Computational Sensory-Motor Neuroscience (CoSMo 2018)
University of Minnesota, Minneapolis, MN, U.S.A.

August 2017 Lecturer, Motor Control & Learning
7th Summer School Computational Sensory-Motor Neuroscience (CoSMo 2017)
University of Minnesota, Minneapolis, MN, U.S.A.

August 2016 Lecturer, Motor Control & Learning
6th Summer School Computational Sensory-Motor Neuroscience (CoSMo 2016)
University of Minnesota, Minneapolis, MN, U.S.A.

August 2014 Lecturer, Motor Control & Learning
4th Summer School Computational Sensory-Motor Neuroscience (CoSMo 2014)
University of Minnesota, Minneapolis, MN, U.S.A.

MEMBERSHIPS IN PROFESSIONAL SOCIETIES

American Association for the Advancement of Science
American Physiological Society
American Society of Biomechanics
Society for the Neural Control of Movement
Society for Neuroeconomics
Society for Neuroscience