BIOGRAPHICAL SKETCH

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NAME: Andermann, Mark Lawrence David

eRA COMMONS USER NAME (credential, e.g., agency login): MAndermann

POSITION TITLE: Professor of Medicine

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Marianopolis College, Montreal, Canada	CEGEP	06/1996	Pure and Applied Science
McGill University, Montreal, Canada	B.Sc.	06/1999	Honors Math / Physics
Harvard University, Cambridge, MA	Ph.D.	12/2005	Biophysics (Neuroscience)
Helsinki University of Technology, Finland	Postdoc	04/2007	Neurobiology
Harvard Medical School, Boston, MA	Postdoc	06/2012	Neurobiology

A. Personal Statement

The goal of my lab is to understand the neural circuit mechanisms underlying attention to, and imagery, learning and memory of, motivationally salient sensory cues. To understand these neural phenomena at the level of local cortical microcircuitry, I previously developed a paradigm for chronic two-photon calcium imaging of visual responses in identified neurons and axonal boutons in primary visual cortex and higher visual cortical areas of mice performing visual discrimination tasks or running on a trackball. My lab has extended these methods to image neurons in mouse lateral cortical areas homologous to primate inferotemporal cortex, parahippocampal gyrus, and insular cortex, as well as deep brain imaging of earlier stages of the visual pathway. My lab is located in the Division of Endocrinology at the Beth Israel Deaconess Medical Center, BIDMC, in an environment with strengths in molecular biology, circuit mapping, subcortical circuitry and neuroendocrinology. Through collaborations with the lab of Dr. Brad Lowell, we have a unique ability to pursue studies of neural sensitivity to motivationally salient stimuli (e.g. learned food-predicting cues vs. water-predicting cues) using natural manipulations of motivational states (e.g. hunger and thirst), together with optetrode recordings and photostimulation and tracking of specific hypothalamic cell types that rapidly promote food- and water-seeking. Our investigation of circuit and neuromodulation in cortex, amygdala, thalamus, and ventral tegmental area builds on the technical and conceptual expertise described above. We also have active longstanding collaborations with Maria Lehtinen's lab at Boston Children's Hospital, which build on our complementary expertise in food intake and deep-brain two photon imaging (Andermann) and on the biology of the choroid plexus (Lehtinen) to investigate leptin transport across the blood-cerebrospinal fluid barrier.

I have demonstrated a strong ability to train and mentor students and postdocs. I have mentored over 37 full-time undergraduate co-op students (while a postdoctoral fellow and in my own lab), and I have focused intensively on training PhD students and postdocs in systems neuroscience since starting my lab (currently 5 postdoctoral fellows, 2 MD/PhD students, 4 PhD students, 3 undergraduate students, and 2 technicians).

Ongoing and recently completed projects that I would like to highlight include:

R01DK109930, NIH / NIDDK Andermann (PI) 7/1/2016-6/30/2021
"Neural pathway linking nutritional state to food-cue responses in insular cortex"
The major aims are to assess differences in neuronal responses in insular cortex of well-trained mice across states of satiety, natural hunger, and hunger induced by hypothalamic AgRP neuron stimulation.

NIH Director' Pioneer Award DP1OD027799-01, NIH / NCCIH Andermann (PI) 9/30/2019-7/31/2024
"Look inward: brainstem and cortical circuits for boosting interoceptive attention"
The major goal of this grant is to track and manipulate the activity of gut and lung afferents that innervate the nucleus of the solitary tract in awake mice, to image responses to afferent stimulation in insular cortex, and to assess whether behavior modulates neural responses vagal afferent stimulation.

Klarman Family Foundation Program in Eating Disorders Research Andermann (PI) 10/1/2017-9/30/2020
"*Focus on the positive: pathways for biasing responses to mixed-valence food cues."*
The major aim of this project was to test whether the pathway from paraventricular thalamus to basolateral amygdala is dysregulated in a mouse model of anorexia nervosa, resulting in biased responses towards aversive visual cues and away from appetitive visual cues in insular cortex.

NIH Director's New Innovator Award: DP2DK105570-01 Andermann (PI) 09/30/14-06/30/19
"Multiphoton imaging of thoughts of food during natural and induced hunger states."
The aims were to determine the neural mechanisms by which natural and artificial states of hunger drive non-cue-evoked, spontaneous reactivation of visual representations associated with food imagery in postrhinal cortex, and how cortical spontaneous activity relates to hippocampal ripple activity during quiet waking.

Citations:

1. Burgess, C, Ramesh, R, Livneh, Y, and Andermann, ML. Gating of visual processing by physiological need. Review in ***Current Opinion in Neurobiology*****,** Nov 8;49:16-23. PMCID: PMC5889964.
2. Andermann, ML**,** and Lowell, BB**. Towards a wiring-diagram understanding of appetite control. Review in ***Neuron****,* 2017. *95*: 757:778*.* ** co-corresponding author. PMCID: PMC5657399.

B. Positions, Scientific Appointments, and Honors

Positions and Scientific Appointments

2006-2007	Postdoctoral fellow: Laboratories of Riitta Hari, Mikko Sams and Iiro Jääskeläinen, Helsinki University of Technology, Helsinki, Finland.
2007-2012	Postdoctoral Fellow: Laboratory of R. Clay Reid, Harvard Medical School, Boston, MA
July-Dec, 2012-	Instructor, Harvard Medical School (HMS) and Division of Endocrinology, Metabolism and Diabetes, Dept. of Medicine, Beth Israel Deaconess Medical Center (BIDMC), Boston, MA
Dec, 2012-	Assistant Professor, HMS and Div. of Endocrinology, Dept. of Medicine, BIDMC, Boston, MA
2012-	Faculty, admissions committee member, and thesis committee member (13 current students; 8 past students), PhD Program in Neuroscience, Harvard Medical School
2012-	Faculty member, PhD Program in Biophysics, Harvard Medical School
2012-	Editorial reviewer, Science, Nature, Nature Methods, Nature Neuroscience, Nature Comm., Cell, Neuron, eLife, PNAS, J. Neurosci., Cerebral Cortex, Current Biology, J. Neurophys.
2013	Reviewer, Harvard Catalyst Pilot grant program
2014	Faculty search committee member, Kirby Neurobiology Center, Boston Children's Hospital
2014, 2018	Ad hoc reviewer, National Science Foundation Peer Review Committee
Sept, 2017-	Associate Professor, HMS and Div. of Endocrinology, Dept. of Medicine, BIDMC, Boston, MA
April 2021-	Professor, HMS and Div. of Endocrinology, Dept. of Medicine, BIDMC, Boston, MA
2018	Ad hoc reviewer, NIDDK Peer Review Committee, NIH
2018	Reviewer, Bertarelli Collaborative Awards for Sensory Disorders, Harvard Medical School
2018-	Ad hoc reviewer, Boston Nutrition and Obesity Research Center Pilot & Feasibility Program
2019	Faculty search committee member, Helsinki Institute of Life Sciences
2019	Reviewer, Mind, Brain and Behavior Inter-faculty Initiative Seed Grants
2019-	Editorial Board Member, Annual Reviews of Neuroscience
2019	Advisor, Allen Institute for Brain Research

2019 Faculty search committee member, Division of Endocrinology, Boston Children's Hospital
2020 Reviewer, Neurobiology of Motivated Behavior Study Section, NIH
2020 Reviewer, Director's New Innovator Award Study Section, NIH
2021 Reviewer, Bioengineering of Neuroscience and Vision Technologies (BNVT) Study Section, NIH

Honors

1999-2001 National Science and Engineering Research Council of Canada (NSERC), Harvard.
2000-2001 Fonds pour la Formation de Chercheurs et l'Aide à la Recherche (Quebec), Harvard.
2000-2005 Howard Hughes Medical Institute Predoctoral Fellowship (field: Neuroscience), Harvard.
2006-2007 Marie Curie Incoming International Fellowship (EU), Helsinki University of Technology.
2007-2010 Helen Hay Whitney Postdoctoral Fellowship, Harvard Medical School.
2010-2012 Pierce Charitable Trust and Ludcke Foundation King Trust Postdoctoral Fellowship, Harvard.
2011 AFAR/GE Junior Investigator Award for Excellence in Imaging and Aging Research, Harvard.
2012-2015 Smith Family Foundation Award for Excellence in Biomedical Research, BIDMC, Harvard.
2013-2017 Pew Scholar Award in the Biomedical Sciences, BIDMC, Harvard Medical School.
2013-2014 AFAR New Investigator Award in Alzheimer's Disease, BIDMC, Harvard Medical School.
2013-2014 Dvorak Young Investigator Award in Basic Science, BIDMC, Harvard Medical School.
2014-2020 NIH Director's New Innovator Award (DP2).
2014 Krieg Cortical Explorer Award, Cajal Club.
2016 McKnight Scholar Award
2018 Armen H. Tashjian, Jr. Award for Excellence in Endocrine Research, Harvard Medical School
2019 Larry Katz Prize for Innovative Research in Neuroscience, Duke University
2019 NIH Director's Pioneer Award (DP1)

C. Contributions to Science

1. *Electrophysiological mapping of novel tactile feature representations in rat barrel cortex:* During my graduate work in Dr. Christopher Moore's lab at MIT, I became interested in how cortical neurons can selectively process task-relevant stimulus features from among a multitude of sensory inputs. While the rat barrel cortex was in heavy use due to the one-to-one projection between individual whiskers on the face and associated barrel columns in somatosensory cortex, the spatial representation of other sensory features in barrel cortex was not known. I developed novel tactile stimulation devices and found a systematic map of frequency preference across arcs of barrel columns in rat SI, similar to tonotopic maps in auditory cortex. I also discovered an emergent cortical direction map within a barrel column, which was systematically linked to somatotopy. The alignment between these novel sensory feature maps and the underlying cortical structure (identified barrel columns) has lead to new hypotheses for how task-relevant directional and frequency cues may be 'read out' in barrel cortex during behaviors involving active sensing.

    a. Neimark, MA*, Andermann, ML*, Hopfield, JJ, Moore, CI. Vibrissa resonance as a transduction mechanism for tactile encoding. ***J Neurosci***. 2003 Jul 23;23(16):6499-509. Erratum in: *J Neurosci*. 2003 Sep 17;23(24):0. (* co-first author).
    b. Andermann, ML, Ritt J, Neimark, MA, Moore, CI. (2004) Neural correlates of vibrissa resonance; band-pass and somatotopic representation of high-frequency stimuli. ***Neuron***. 42(3):451-63.
    c. Andermann, ML, and Moore, CI. (2006). A somatotopic map of vibrissa motion direction within a barrel column. ***Nature Neuroscience***. 9(4):543-51.
    d. Ritt, JT, Andermann, ML and Moore, CI. (2008). Embodied information processing: vibrissa mechanics and texture features shape micro-motions in actively sensing rats. ***Neuron***. 57(4):599-613. PMCID: PMC4391974.

2. *Two-photon calcium imaging of visual responses in behaving mice:* To understand the link between behavior and circuits at a cellular and subcellular level, I then began postdoctoral work with Dr. Clay Reid at Harvard Medical School. We developed a paradigm for robust, chronic two-photon imaging of entire volumes of neurons in visual cortex of anesthetized mice and awake mice performing visual discrimination tasks or across arousal states while running on a trackball. Neurons could be classified genetically, anatomically, and via post-hoc immunohistological staining. I then established methods for combining awake imaging with optogenetics and pharmacology, to examine neuromodulation of cell types during behavior. In efforts completed in my own lab, we extended the reach of cellular and subcellular imaging to

simultaneous recordings across entire cortical columns, by developing a method for chronic two-photon imaging via a periscope-like microprism. My lab then facilitated the dissemination of techniques required for chronic two-photon imaging in awake mice with repeated removal of the cranial window.

a. Kerlin, AM*, Andermann, ML*, and Reid, RC. (2010). Broadly tuned response properties of diverse inhibitory neuron subtypes in mouse visual cortex. ***Neuron***. 67(5): 858-871. (* co-first author). PMCID: PMC3327881.
b. Andermann, ML, Kerlin, AM, Roumis, DK, Glickfeld, LL, and Reid, RC. (2011) Functional specialization of mouse higher visual cortical areas. ***Neuron***, 72(6): 1025-39. PMCID: PMC3876958.
c. Andermann, ML*,**, Gilfoy, N*, Goldey, G*, Sachdev, R*, Wolfel, M, McCormick, DA, Reid, RC, and Levene, MJ**. (2013). Chronic multiphoton microscopy of entire visual cortical columns in awake mice using microprisms. ***Neuron***. 80(4):900-13. (* co-first, ** co-corr). PMCID: PMC3840091.
d. Glickfeld, LL, Andermann, ML, Bonin, V, and Reid, RC. (2013). Cortico-cortical projections in mouse visual cortex are functionally target specific. ***Nature Neuroscience***, 16(2):219-26. PMC3808876.

3. *Deep-brain Two-photon calcium imaging of retinal ganglion cell axons and choroid plexus in behaving mice:* We recently extended these methods to chronic imaging of visual responses in individual retinal ganglion cell axonal boutons. We combined this work with analysis of 3D EM datasets, and discovered new rules governing convergence of retinal axons onto dLGN neurons depending on their functional properties (Liang et al., *Cell* 2018). We then found that some retinal axons but not other were suppressed by arousal, resulting in selective gating of visual information to the thalamus (Liang, Fratzl, Reggiani et al., *Current Biology, 2020*). Using a similar imaging approach, we visualized the choroid plexus epithelium in awake mice. We observed subcellular calcium activity in epithelial cells and diverse surveillance and defense behaviors in choroid plexus immune cell processes (Shipley, Dani et al., *Neuron* 2020).

a. Liang, L, Fratzl, A, Goldey, G, Ramesh, RN, Sugden, A, Morgan, J, Chen, C**, and Andermann, ML**. (2018) A fine-scale functional logic to convergence from retina to thalamus. ***Cell,*** 173(6):1343-1355.e24. (* co-corresponding author). PMCID: PMC6003778.
b. Liang, L*,**, Fratzl, A*, Reggiani, J*, El Mansour, O, Chen, C**, and Andermann, ML**. (2020) Retinal inputs to the thalamus are selectively gated by arousal. ***Current Biology,*** advanced online, Aug 13, 2020. (* co-first author; ** co-corresponding author). PMCID: PMC7665906.
c. Shipley, FB*, Neil Dani, N* Xu H, Deister C, Cui J, Head JP, Klein EM, Marsh S, Sadegh C, Fame RM, Shannon ML, Flores VI, Kishkovich T, Jang E, He K, Zhang Y, Kirchhausen T, Holtzman MJ, Wyart C, Moore CI, Andermann ML**, Lehtinen MK**. Tracking calcium dynamics and immune surveillance at the choroid plexus blood-cerebrospinal fluid interface. **Co-corresponding author. ***Neuron,*** 108(4):623-639.e10. PMCID: PMC7847245.
d. Cui, J, Shipley, FB, Shannon, ML, Alturkistani, O, Dani, N, Webb, MD, Sugden, AU, Andermann, ML, Lehtinen, MK. Inflammation of the embryonic blood-cerebrospinal fluid barrier following maternal immune activation. ***Developmental Cell,*** 2020 Oct 5; 55(5):617-628.e6. PMCID: PMC7725967.

4. *Tracking neural correlates of cue-outcome learning in association cortex and amygdala:* My lab has developed strategies for mapping visual responses, behavioral modulation, and cross-day changes in visual responses across learning, in lateral association cortex, in mouse basal amygdala and in dopaminergic axons in amygdala – uncharted territory for cellular-level imaging studies in awake animals. We then established chronic imaging of offline reactivation of patterns of cue-response cortical neurons.

a. Burgess, CR*, Ramesh, RN*, Sugden, AU, Levandowski, KM, Minnig, MA, Fenselau, HF, Lowell, BB, and Andermann, ML. (2016) Hunger-dependent enhancement of food cue responses in mouse postrhinal cortex and lateral amygdala. ***Neuron*****,** 91(5):1154-69. (* co-first author). PMCID: PMC5017916.
b. Ramesh, RN*, Burgess, CR*, Sugden, AU, Gyetvan, M, and Andermann, ML. (2018) Intermingled ensembles in visual association cortex encode stimulus identity or expected value. ***Neuron***, 100(4):900-915. (* co-first author). PMCID: PMC6250571.
c. Lutas, A., Kucukdereli, H., Alturkistani, O., Carty, C., Sugden, A.U., Fernando, K., Diaz, V., Flores Maldonado, V., and Andermann, ML. (2019) State-specific gating of salient cues by midbrain dopaminergic input to basal amygdala. ***Nat. Neurosci***. 22(11):1820-1833. PMCID: PMC6858554.

d. Sugden AU, Sugden LA, Zaremba JD, McGuire KL, Ramesh RN, Alturkistani O, Lutas A, Burgess CR, and Andermann ML. (2020) Cortical reactivations of recent sensory experiences predict bidirectional network changes during learning. ***Nat. Neurosci.*** June 8. PMCID: PMC7392804.

5. *In vivo recordings and stimulation in defined populations of hypothalamic neurons:* One goal of our lab is to connect the activity of neurons driving various basic motivational drives with activity of cortical neurons that may encode motivation-specific percepts, memories, and imagery. We have recently employed a combination of optogenetics and tetrode electrophysiology to directly record, for the first time, spiking activity of agouti-related peptide (AgRP) neurons and putative pro-opiomelanocortin (POMC) neurons in the arcuate nucleus of the hypothalamus in behaving mice. We found that, consistent with recent studies using calcium indicators, firing of these populations of neurons tracked negative energy balance at a timescale of hours, but also changed their firing on the timescale of seconds as new sources of food became available. We have used GCaMP6 fiber photometry to monitor the activity of inputs to these AgRP neurons. We have also linked activity in AgRP neurons with visual behavior and insular cortex activity (Livneh et al., *Nature* 2017). These studies illustrate our expertise in stimulating and recording from specific neurons in deep brain areas using calcium recordings and extracellular electrophysiology. More recently, we have expanded this work to examine hypothalamic neurons responsible for mating drive, and the interaction between mating and hunger drives (Zhang et al., *Nature, in press*).

   a. Mandelblat-Cerf, Y*, Ramesh, RN*, Burgess, CR*, Patella, P, Yang, Z, Lowell, BB, and Andermann, ML. (2015). Arcuate hypothalamic AgRP and putative POMC neurons show opposite changes in spiking across multiple timescales. (* co-first author). ***eLife****.* Jul 10; 4. doi: 10.7554/eLife.07122. PMCID: PMC4498165.
   b. Mandelblat-Cerf, Y, Kim, A, Burgess, CR, Subramanian, S, Tannous, B, Lowell, BB**, and Andermann, ML**. (2017). Bidirectional anticipation of future osmotic challenges by vasopressin neurons. ***Neuron,*** Jan 4; 93(1):57-65. PMCID: PMC5215952.
   c. Livneh, Y, Ramesh, RN, Burgess, CR, Levandowski, K, Madara, J, Fenselau, H, Goldey, G, Diaz, VE, Jikomes, N, Resch, J, Lowell, BB**, and Andermann, ML** (2017). Homeostatic circuits selectively gate food cue responses in insular cortex. ***Nature****,* 546(7660):611-616. PMCID: PMC5577930.
   d. Livneh, Y, Sugden, A, Madara, JC, Essner, RA, Flores, VI, Sugden, LA, Resch, JM, Lowell, BB*, and Andermann, ML* (2020). Insular cortex estimates current and future physiological states. ***Neuron****,* 105(6):1094-1111.e10. *Co-corresponding author. PMCID: PMC7083695.

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