

Joseph D. Zak, Ph.D.

Department of Molecular & Cellular Biology
Harvard University
Cambridge, MA 02138

jzak@fas.harvard.edu
josepdzak.com
(734) 476-6985

SCHOLARLY PROFILE

My research has two objectives: first, to reveal the neural mechanisms through which the brain extracts salient information about physical objects in the environment; and second, to uncover the role of learning in the development of sensory circuits. My research uses electrophysiological, pharmacological, imaging, and computational approaches to meet these objectives.

EDUCATION

- 2015** **Ph.D. in Neuroscience**, Department of Physiology & Biophysics
University of Colorado Medical School, Aurora, CO
Thesis: Balancing excitation and inhibition in olfactory bulb glomeruli
Faculty Advisor: Nathan Schoppa, Professor of Physiology & Biophysics
NIH NRSA Pre-doctoral Fellowship, 2013-15
- 2008** **B.S. in Neuroscience**
University of Michigan, Ann Arbor, MI

RESEARCH EXPERIENCE

- 2015-** **Postdoctoral Fellow**, Department of Molecular & Cellular Biology
Harvard University, Cambridge, MA
Project: Information coding and normalization in olfactory sensory neurons
Faculty Advisor: Venkatesh Murthy, Professor of Molecular & Cellular Biology
NIH NRSA Postdoctoral Fellowship, 2017-20
NIH K99/R00 Pathway to Independence Award, 2020-24
- 2008-10** **Postbaccalaureate Research Assistant**
The Jackson Laboratory, Bar Harbor, ME
Project: Disruption of GABAergic circuits in a mouse model of Rett Syndrome
Faculty Supervisor: Zhong-wei Zhang, Professor of Research

PUBLICATIONS

Research Articles

1. **Zak JD**[†], Reddy G, Vergassola M, Murthy VN (2020) Antagonistic odor interactions in olfactory sensory neurons are widespread in freely breathing mice. *Nature Communications* 11:3350 † corresponding author
2. Gire DH**, **Zak JD****, Bourne JN, Goodson N, Schoppa NE (2019) Balancing extrasynaptic excitation and synaptic inhibition within olfactory bulb glomeruli. *eNeuro* 6(4)0247-19.2019 **equal contribution
3. Albeanu DF, Provost AC, Agarwal P, Soucy E, **Zak JD**, Murthy VN (2018) Olfactory marker protein (OMP) regulates formation and refinement of the olfactory glomerular map. *Nature Communications* 9:5073
4. **Zak JD**, Grimaud J, Li R-C, Lin C-C, Murthy VN (2018) Calcium-activated chloride channels clamp odor-evoked spike activity in olfactory receptor neurons. *Scientific Reports* 8:10600

5. Reddy G**, **Zak JD****, Vergassola M, Murthy VN (2018) Antagonism in olfactory receptor neurons and its implications for the perception of odor mixtures. *eLife* 7:e35958 **equal contribution
6. **Zak JD**, Whitesell JD, Schoppa NE (2015) Metabotropic glutamate receptors promote disinhibition of olfactory bulb glomeruli that scales with input strength. *Journal of Neurophysiology* 113(6):1907-20
7. Gire DH, Franks KM, **Zak JD**, Tanaka KF, Whitesell JD, Mulligan AA, Hen R, Schoppa NE (2012) Mitral cells of the olfactory bulb are mainly excited through a multi-step signaling path. *Journal of Neuroscience* 32:2964-75
8. Zhang Z-W, **Zak JD**, Liu H (2010) MeCP2 is required for normal development of GABAergic circuits in the thalamus. *Journal of Neurophysiology* 103(5):2470-81

Reviews & Commentary

1. **Zak JD****, Wallace J**, Murthy VN (2020) How neuroscience labs can limit their environmental impact. *Nature Reviews Neuroscience* 21:347-8 *Featured on Journal Cover.* **equal contribution
2. **Zak JD** (2016) A computational framework for temporal sharpening of stimulus input in the olfactory system. *Journal of Neurophysiology* 115(4):1749-51

PRESENTATIONS

Invited Presentations

Nonlinear stimulus encoding in the olfactory system

- Departmental Seminar Series, Molecular & Cellular Biology, Harvard University (2020)
- International Symposium on Olfaction and Taste (2020)

Odor mixture coding in mouse olfactory receptor neurons

Society for Neuroscience, Annual Meeting (2019)

In vivo odor tuning and antagonism in individual olfactory sensory neurons

Ludwig-Maximilians-Universität (2019)

Extrasynaptic glutamate promotes nonlinearities in the balance of neural excitation and inhibition

Department of Neuroscience, Amgen (2019)

Normalization of sensory inputs to the olfactory bulb

Department of Biology, Stonehill College (2019)

Disruption of sensory transduction and odor coding in olfactory receptor neurons

Genetics Interest Group, The Jackson Laboratory (2018)

Electrical and chemical signaling in olfactory networks

Department of Biomedical Sciences, Western Michigan University School of Medicine (2018)

Nonlinear interactions between excitation and inhibition gate olfactory bulb output

Ludwig-Maximilians-Universität München - Harvard University Young Scientist Forum (2016)

Intrinsic and pharmacologic mechanisms of signal filtering at olfactory bulb glomeruli

Novartis Institute for Biomedical Research (2015)

Neuroscience in the classroom

Denver Museum of Nature & Science Minds on Brains Workshop (2015)

Cellular and population analyses of signal filtering at olfactory bulb glomeruli

- Department of Molecular and Cellular Biology, Harvard University (2014)
- Department of Neurobiology, Duke University (2014).
- Department of Neurobiology & Anatomy, University of Utah (2014)
- Rocky Mountain Regional Neuroscience Group, SfN Chapter (2014)

Control of GABA release and glomerular output by metabotropic glutamate receptors in the olfactory bulb

Front Range Neuroscience Group, SfN Chapter (2013)

Differential modulation of mitral and tufted cells in the olfactory bulb

A.R. Martin Lectureship, University of Colorado Medical School (2013)

Conference Abstracts

- Zak JD**, Reddy G, Vergassola M, Murthy VN (2020) Antagonism normalizes input to the olfactory system in freely breathing animals. Computational and Systems Neuroscience Meeting (CoSyNe), Denver, CO
- Wallace J, **Zak JD**, Murthy VN (2019) Optophysiological mapping of inputs to adult-born granule cells. Society for Neuroscience, Annual Meeting, Chicago, IL
- Wu H, Jayakumar S, Grimaud J, **Zak JD**, Masset P, Kapoor V, Murthy VN (2019) Olfactory evidence accumulation in mice. Society for Neuroscience, Annual Meeting, Chicago, IL
- Zak JD**, Murthy VN (2019) Odor mixture representation in cortical projections to the olfactory bulb. Association for Chemoreception Sciences, Annual Meeting, Bonita Springs, FL
- Zak JD**, Murthy VN (2018) Coding of odor mixtures in cortical feedback projections to the olfactory bulb. Society for Neuroscience, Annual Meeting, San Diego, CA
- Reddy G, **Zak JD**, Vergassola M, Murthy VN (2018) Antagonism in olfactory receptor neurons and its implications for the perception of odor mixtures. Annual Meeting of the American Physical Society, Los Angeles, CA
- Zak JD**, Grimaud J, Li R-C, Lin C-C, Yau, K-W, Murthy VN (2017) Calcium-activated chloride channels suppress odor-evoked activity in olfactory receptor neurons in vivo. Society for Neuroscience, Annual Meeting, Washington D.C.
- Zak JD**, Grimaud J, Li R-C, Lin C-C, Yau, K-W, Murthy VN (2017) Olfactory receptor neuron tuning and excitability in the absence of calcium-activated chloride channels. Conference on Frontiers in Olfaction, International Center for Theoretical Physics, Trieste, Italy
- Zak JD**, Gire DH, Schoppa NE (2015) Non-linear interactions between GABAergic inhibition and extrasynaptic glutamate gate output of olfactory bulb glomeruli. Society for Neuroscience, Annual Meeting, Chicago, IL
- Zak JD**, Schoppa NE (2014) Cellular and population analyses of signal filtering at olfactory bulb glomeruli. Society for Neuroscience, Front Range Chapter Meeting, Fort Collins, CO
- Zak JD**, Schoppa NE (2014) Cellular and population analyses of signal filtering at olfactory bulb glomeruli. Society for Neuroscience, Annual Meeting, Washington D.C.
- Zak JD**, Schoppa NE (2014) Cellular Mechanisms Underlying Olfactory Signal-Filtering at Olfactory Bulb Glomeruli. Association for Chemoreception Sciences, Annual Meeting, Bonita Springs, FL
- Zak JD**, Schoppa NE (2013) Control of glomerular output by metabotropic glutamate receptors in the olfactory bulb. Society for Neuroscience, Front Range Chapter Meeting, Fort Collins, CO
- Bourne JN, **Zak JD**, Dulla CG, Schoppa NE (2013) Optical detection of glutamate transients within olfactory bulb glomeruli. Society for Neuroscience, Annual Meeting, San Diego, CA
- Zak JD**, Schoppa NE (2013) Control of glomerular output by metabotropic glutamate receptors in the olfactory bulb. Society for Neuroscience, Annual Meeting, San Diego, CA
- Zak JD**, Gire DH, Schoppa NE (2012) Balancing excitation and inhibition within olfactory bulb glomeruli. Society for Neuroscience, Front Range Chapter Meeting, Fort Collins, CO
- Zak JD**, Gire DH, Schoppa NE (2012) Balancing excitation and inhibition within olfactory bulb glomeruli. Society for Neuroscience, Annual Meeting 2012, New Orleans, LA

TEACHING & ADVISING

Teaching

Responsibilities included leading discussion, overseeing labs, grading all assignments, meeting with students during office hours, holding review sessions.

Instructor of Record, Harvard University, Cambridge, MA

- “Neurobiology of Learning and Memory” Neuro 101F (fall/spring 2016-21)

Teaching Assistant, Harvard University, Cambridge, MA

- “Foundations of Neuroscience” BIOS S-50 (summer 2020)
- “Becoming a Brain Scientist: Neuroscience and Psychology Research” MBB 102 (summer 2018)

Guest Lecturer, Harvard University, Cambridge, MA

- “Artificial and Natural Intelligence” FRSEMR 50F (spring 2019)

Graduate Student Teaching Assistant, University of Colorado Medical School, Aurora CO

- “Systems Neuroscience” NRSC 7610 (spring 2015)

Undergraduate Teaching Assistant, University of Michigan, Ann Arbor, MI

- “Neurobiology Laboratory” MCDB 423 (spring 2008)

Pedagogical Training

College Teaching Practices Certificate Program, Harvard University (2017)

Advising

Thesis advisor - Harvard College senior (2017-18)

Thesis Title: “Neural and behavioral effects of olfactory masking agents”

Harvard College junior (2016-17)

Visiting Scholar, Harvard University (2015-16)

Graduate Student, Neuroscience Program, University of Colorado (2014-15)

Tutoring

Neuroscience Program Tutor, Molecular and Cellular Neuroscience, University of Colorado Medical School (2011-12)

HONORS & AWARDS

Fellowships & Funding

NIH NIDCD Pathway to Independence Award (K99/R00 DC017754), 2020-24

Title: Learning-mediated plasticity in cortical feedback projections to the olfactory bulb

Sponsor: Venkatesh Murthy, Professor of Molecular and Cellular Biology, Harvard University

Co-sponsor: Naoshige Uchida, Professor of Molecular and Cellular Biology, Harvard University

NIH NIDCD Alzheimer’s Disease Administrative Supplement (related to R01 DC011291 to V. Murthy), 2021

Title: Alzheimer’s disease-related pathology in corticobulbar circuits

Sponsor: Venkatesh Murthy, Professor of Molecular and Cellular Biology, Harvard University

NIH NIDCD NRSA (F32 DC015938) Individual Postdoctoral Fellowship, 2017-20

Title: Information coding in individual olfactory sensory axons

Sponsor: Venkatesh Murthy, Professor of Molecular and Cellular Biology, Harvard University

NIH NIDCD NRSA (F31 DC013480) Individual Predoctoral Fellowship, 2013-16

Title: Balancing excitation and inhibition in olfactory bulb glomeruli

Sponsor: Nathan Schoppa, Professor of Physiology & Biophysics, University of Colorado

Co-sponsor: Diego Restrepo, Professor of Cell & Developmental Biology, University of Colorado

Teaching Awards

Harvard University Certificate of Distinction in Teaching (fall/spring 2017, spring, 2018, fall 2019)

Academic Recognition

Sponsored Membership, AAAS/Science Program for Excellence in Science (2012-16)

A.R. Martin Award for 1st Year Graduate Scholarship, University of Colorado Medical School (2011)

Presentation Awards

Beauty of the Brain Image Award, Harvard Brain Initiative (2019)

Outstanding Graduate Student Presentation, 29th Annual University of Colorado Research Forum (2013)

Top Student Poster Presentation, Front Range Neuroscience Group, SfN Chapter (2014)

Outstanding Graduate Student Presentation, 28th Annual University of Colorado Research Forum (2013)

Invited Student Presentation, Front Range Neuroscience Group, SfN Chapter (2013)
A.R. Martin Lectureship Invited Student Presentation, University of Colorado Medical School (2013)
Top Student Poster Presentation, Front Range Neuroscience Group, SfN Chapter (2012)

Travel Awards

Young Scientist Travel Award, Harvard Brain Science Initiative (2019)
Postdoctoral Award for Professional Development, Harvard University (2017)
Association for Chemoreception Sciences Annual Meeting, Travel Award (2014)

PROFESSIONAL SERVICE & ADDITIONAL PROFESSIONAL EXPERIENCE

Peer Review Service

Section Editor - *Data in Brief*
Ad Hoc Reviewer – *PLoS Computational Biology*, *PLoS One*, *Journal of Neurophysiology*
With supervision - *Journal of Neuroscience*, *Nature Communications*, *Nature Neuroscience*, *eLife*, *Journal of Physiology*, *eNeuro*

Professional Development

2020 Undergraduate Mentoring Workshop Series, Harvard University
2020 Laboratory Management Workshop, Harvard University
2016-17 **IMPACT Fellow**, Massachusetts Institute of Technology

Technical Training

2019 Imaging Workshop, Howard Hughes Medical Institute, Ashburn, VA

Committee Service

2020 Career Development Panel, Harvard University
2014-15 Neuroscience Program Executive Committee, University of Colorado Medical School
2011-15 Neuroscience Program Retreat Committee, University of Colorado Medical School
2011-15 Neuroscience Program Student Recruitment, University of Colorado Medical School

Outreach

2011-15 Denver Regional Science Fair Outreach
2011-15 Rocky Mountain Smell and Taste Center, Neuroscience Outreach

Professional Membership

Association for Chemoreception Sciences, 2013 –
American Association for the Advancement of Science, 2012-16
Society for Neuroscience, 2011 –

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