

Brian Harvey Smith

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Education

1978 Juniata College, BS Biology
1985 University of Kansas, PhD Entomology

Postdoctoral Training

1988-90 ARL Division of Neurobiology, University of Arizona, Tucson "Neuroethological Studies of Memory in a Model System" with Dr. John G. Hildebrand
1987 Department of Entomology, University of California at Berkeley, "Olfactory conditioning in Honey Bees" with Dr. Wayne M. Getz
1986 Institute for Neurobiology of the Free University of Berlin, West Germany, "Neurophysiological and behavioral analysis of olfactory learning in *Apis mellifera*." with Dr. Randolph Menzel
1985 Institute for Developmental Biology, Tübingen, West Germany, "Role of learning and pheromonal communication in primitively social bees." with Dr. Wolf Engels

Professional Appointments

2017/18 Associate Dean of Graduate Initiatives, ASU
2016 Trustees of ASU Professor, Arizona State University
2011/14 Director, School of Life Sciences, Arizona State University
2009/11 Faculty Leader, Organismal, Integrative and Systems Biology in the School of Life Sciences at Arizona State University
2008/11 Director, Interdisciplinary Graduate Program in Neuroscience, Arizona State University
2007 Research Professor, Barrow Neurological Institute, Phoenix, Arizona
2005 Professor, School of Life Sciences, Arizona State University
2002 Professor, Mathematical Biosciences Institute, Ohio State University
2001 Adjunct Professor, ARL Division of Neurobiology, University of Arizona
2001 Professor, Department of Entomology, Ohio State University
1998 Appointment to Department of Evolution, Ecology & Organismal Biology, Ohio State University
1998 Appointment to Department of Psychology, Ohio State University
1996 Associate Professor, Department of Entomology, Ohio State University
1993 Appointment to OSU Neurobiotechnology Center
1991 Appointment to Neuroscience Graduate Studies Program, Ohio State University
1990 Assistant Professor, Department of Entomology, Ohio State University

Language Ability

German - reading and speaking

International Visiting Researcher

2021 Bresslau Visiting Professor, Institute of Zoology, University of Cologne, Germany
2019 Visiting researcher, University of Magdeburg, Germany
2017/18 Presidential Fellowship Chinese Academy of Sciences, Beijing
2015 Senior Fellow, Zukunftskolleg, University of Konstanz, Germany

- 2012-2014 Department of Plant Protection, King Saud University, Riyadh, Saudi Arabia
- 1998/9 Visiting faculty California Institute of Technology
- 1993 Guest professor at the Free University of Berlin, Germany
- 1984 Department of Genetics, University of Sao Paulo, Riberão Preto, Brazil,
"Pheromonal communication in stingless bees."
- 1981 Uppsala University Ecological Station, Sweden, "Chemical analysis of volatile
compounds used in communication."
- 1980 Smithsonian Tropical Research Institute, Republic of Panama, "Interspecific
communication among the highly social stingless bees."

Honors

- 2015 Trustees of ASU Professor, Arizona State University
- 2003 Fellow, American Association for the Advancement of Science
- 2002 Fulker Award from the Behavior Genetics Association for the best paper published in the journal of
Behavior Genetics Vol. 31, 2001
- National Institute of Mental Health National Research Service Award
- NATO Fellowship in Science (for research in West Germany)
- Deutscher Akademischer Austauschdienst (German Academic Exchange Service)

Administration experience

Arizona State University

University

- Associate Director of Graduate Initiatives, Graduate College ASU
- Promotion & Tenure (2007 – 2010)
Chair of University P&T 2009 and 2010
- President's Faculty Advisory Committee (2009-present)
- Leadership Fellow in the Office of the Provost (2010)
Responsibilities include development of online programs and development of a promotion
& tenure conflict of interest statement for ASU
- Leader, Neuroscience Leadership Team for Office of Knowledge Enterprise Development
(2015/16)
- Chair, Committee to develop university-wide Neuroscience major that will be launched in Fall
2017.

School of Life Sciences

- Director, School of Life Sciences (July 1, 2011- June 30, 2014)
- Faculty Leader, Organismal, Integrative & Systems Biology (2009-2011)
21 faculty members (9 Professor, 8 Associate Professor, 4 Assistant Professors)

Graduate College

- Chair (interim), Interdisciplinary Graduate Program in Biological Design (2012 – 2013)
In charge of reorganization of the program
- Chair, Interdisciplinary Graduate Program in Neuroscience (2007 – 2011)
Proposal to establish the program; received Board of Regents approval Jan 2008
neuroscience.asu.edu

Ohio State University

Department

- Promotion & Tenure committee (1996-2005)
- Graduate Committee (1994-1998; Chair, 1997/98)
- Seminar Committee (Chair, several years)

College of Biological Sciences

- Promotion & Tenure committee (2001-2004)
- Dean's Advisory committee (2001-2003)
- Curriculum committee (1998)
- Chair, ad hoc committee for reorganization of organismal biology in the College of Biological Sciences (1996/97)

This committee concluded by merging and renaming the Department of Zoology and part of the Department of Plant Biology into the Department of Evolution, Ecology and Organismal Biology. Entomology elected to remain separate because of the agricultural mission and affiliations of many of the faculty.

University

- Graduate Committee of the Graduate School (1995-1997)
- Honors program advisory committee (1997-1998)

Teaching Experience

Team-based science

2018/18 Developed a year-long training workshop for PhD students in team-based research for the ASU PLS program (www.plusalliance.org). Included 30 students from ASU, Kings College London and the University of New South Wales. In-person and remote workshops were conducted in and with AU and the UK using training approaches from *knowinnovation.com*.

Introductory Biology

Freshman seminar (BIO 189) 'The Neuroscience of Magic' (19 students) at Arizona State University

Introductory Biology (Biol 101) for non-majors (ca. 500 students) at Ohio State University

Introductory Honors Biology (Biol 116) for majors at Ohio State University

Introductory Biology (Biol 188) at Arizona State University

Advanced Biology

Arizona State University

Science Writing seminar (BIO 590) at Arizona State University

- Seminar offered every year to help graduate students learn writing skills, particularly for grant proposals

Neuroscience Journal Club (BIO/NEU 590)

Animal Physiology lecture and laboratory (BIO 360/361)

Neurobiology (BIO 467)

Animal Behavior Research Techniques (BIO 494/595)

Workshop "Small Brains, Big Ideas" – Developed a laboratory exercise to train South and Central American graduate students in us of the honey bee as a model for Neuroscience research

Sensory Ecology ANB/NEU 598

Systems & Behavioral Neuroscience (BIO 477) course for majors

Ohio State University

Neuroethology (Zoology 632)

Behavioral Neuroscience (Neuroscience 726)*

Molecular Neuroscience (Neuroscience 800)*

* Lectures on behavioral and cellular mechanisms of learning in both courses

Seminar on Learning Mechanisms (Neuroscience 797)

Developmental Neuroscience (Neuroscience 790)

* Lectures on cell-cell interactions, neurotrophins and cell death

Honors seminar – The Honey Bee Dance Language Controversy (Honors 597)

Honey Bee Biology (Entomology 360)

Research Supervision

Undergraduate thesis students

*Many former and current undergraduate students were/are supervised by senior graduate students and postdoctoral researchers and are not listed here

Cornelia Weller - Zusammenhaenge zwischen Pheromoneabgabe, Groesse und Verhalten bei *Lasioglossum malachurum* - Koeniginnen und Arbeiterinnen (Hymenoptera: Halictidae). University of Tübingen, 1986.

Manfred Ayasse - Wie Beeinflussen Weibchen-Pheromone die Partnerwahl bei Maennlichen Furchenbienen? Paarungs-strategien bei *Lasioglossum malachurum* (Hymenoptera; Halictidae). University of Tuebingen, 1987.

Karin Bohrer - Larvenernaehrung und Kastendifferenzierung bei *Lasioglossum malachurum* (Hymenoptera; Halictidae). University of Tuebingen, 1987.

Ward Hamlet - Behavioral and biochemical analysis of the effects of protein synthesis inhibition on long-term recall in the honey bee. University of Arizona, 1989.

Arthur McNair - Effect of caffeine and forskolin on recall in the honey bee and light-odor interaction during learning in the honey bee. University of Arizona, 1989.

Francine Ganje - Second-order olfactory conditioning in the honey bee: Extinction induced frustration effects. University of Arizona, 1989.

Robert Barlow - The development of GABAergic modulation in the ventral nerve cord of the honey bee. The Ohio State University, 1991.

Gabrielle Lamm - Motoneurons that innervate muscles of the honey bee sting. The Ohio State University, 1992.

Kristi Buxton - The effect of nitric oxide synthase inhibitors on olfactory learning and generalization in the honey bee. Ohio State University, 1997.

Sandeep Singh – Odor discrimination in the fruit fly, *Drosophila melanogaster*. Ohio State University, 2000
*Denman award for undergraduate research

Melissa Cousins – The effect of nitric oxide synthase inhibitors on olfactory discrimination in the moth *Manduca sexta*. Ohio state University, 2001 *Denman award for undergraduate research

Amy Lutmerding – Discrimination of complex floral odors by the honey bee *Apis mellifera*.

ASU

Gregory Deleo (2008) “Peak shift in perception of odor mixtures”

Nicole Rennell (2008) “Peak shift in perception of odor mixtures”

Francis Villarreal (2009) “Experience-related changes in the salience of conditioning stimuli in honey bees”

Note: personnel in my lab each mentor undergraduates students (ca 30/year)

Honors thesis main advisor

Parisa Allveri (2009) “Competition Between Components of Odor Mixtures: Blocking”

Kimberly Dickens (2009) “Prevalence of EEG Abnormalities in Female Anorexia and Bulimia Nervosa Patients”

Rebecca Bramble (2009) “Experience-based changes in the salience of conditioning cues”

Mary Petersen (2014/5) “Mechanisms of latent inhibition in honey bees”

Graduate students

Ohio State University

Brian Burrell — The modulation of stinging behavior by biogenic amines in the honey bee. Ph.D. (1996) main advisor, The Ohio State University. Present position: Associate Professor, University of South Dakota..

Seetha Bhagavan — An ethological and biochemical analysis of individual differences in learning performance in honey bee workers. Ph.D. (1996) main advisor, The Ohio State University. Present position; Scientific Review Administrator, NIH. .

Shirly Benatar — A genetic analysis of discrimination conditioning in the honey bee. M.S. (1993), The Ohio State University.

Diana Sammataro — Behavioral studies of tracheal mites on honey bees. Ph.D. (1996) co-advisor, The Ohio State University. Present position: USDA Honeybee Research Laboratory, Tucson, AZ.

Kellie Robinson — Toward a molecular analysis of associative learning in the honey bee, *Apis mellifera*, via massed conditioning and genetic transformation. Ph.D. (December 1999) main advisor, The Ohio State University. Present position; Postdoctoral researcher, Lawrence Livermore Laboratories.

Young soo Kim — Taste processing of mixtures of sugars and amino acids in the honey bee. Ph.D. (March 2000) main advisor.

Sathees Chandra — Mapping quantitative trait loci involved in honey bee reversal learning. Ph.D. (June 2000) main advisor. Associate Professor Roosevelt University, Chicago IL

Abdulaziz Alqarni – Comparison of naturally mated and instrumentally inseminated honey bee queens. PhD (Dec 2001) main advisor. Professor, King Saud University, Riyadh, Saudi Arabia.

Heather Dean – Non-associative and associative mechanisms of olfactory learning in the locust, *Schistocerca americana*. M.S. (June 2000 - California Institute of Technology). Present position: Ph.D. program Duke University.

Stephanie Christine – Dopaminergic regulation of motor control in the honeybee. M.S. (2003) main advisor.

Cynthia Ford – Odor discrimination in fruit flies. M.S. (2006) main advisor.

Laurie Vroman – Role of salience in attention to odors. M.S. (2006) main advisor.

Arizona State University

Joseph Latshaw — Colony-level effects on differences in learning performance. M.S. (OSU 2003) and Ph.D. (ASU 2008) program main advisor. Private honey bee breeding business

Danielle Protas – Mechanisms of calcium-mediated excitation and plasticity in primary olfactory pathways of the honey bee (Ph.D. August 2014). Lecturer Utah Community College System.

Ryan Brackney – The Temporal Organization of Operant Behavior: A Response Bout Analysis (Ph.D. August 2015) co-Chair. Position in technology industry.

Christina Burden - Sublethal Effects of Heavy Metal and Metalloid Exposure on Honey Bees: Behavioral Modifications and Potential Mechanisms (Ph.D. Dec 2016). Assistant Professor, Union College, Lincoln, NB.

Hussain Ali - Behavioral and physiological responses of honey bees toward environmental stresses (Ph.D. December 2016, King Saud University, Riyadh, Saudi Arabia). co-Advisor. Research Officer, Agricultural research institute Tarnab, Pakistan.

Mary Petersen – Disruption of tyramine receptor increases behavioral expression of Latent Inhibition (M.S. May 2017). Officer, US Air Force

Christopher Jernigan - Effects of odorant-environment complexity on behavioral, neural, and neuroanatomical plasticity at different time scales (Ph.D. August 2018) Postdoctoral researcher Cornell University.

Meghan Duell – Matter of Size: Behavioral, Morphological and Physiological performance scaling among stingless bees. (Ph.D. December 2018) Postdoctoral researcher Western University, Canada.

Nicole Desjardins – Sublethal effects of environmental contaminants on honey bees. Current PhD program Chair

Maria Gabriela Navas Zuloaga – Modeling the exploitation/exploration tradeoff in social insects. Current Applied Math PhD program.

Shawn Mahoney – Active sensing of odors in honey bees and fruit flies. Current Ph.D. Animal Behavior. Chair

Alvin Hozan – How antennal movement affects odor detection and discrimination in honey bees. Current MS Biology.

Post Doctoral

- George Yocum (Ph.D., Ohio State University, 1993)— Developmental expression of protein biosynthesis in ventral nerve cords of queen and worker honey bees. Present position: Research Scientist with the USDA.
- Holly Ferguson — Genetic transformation of honey bees. Present position: Researcher with the USDA
- Robert S. Thorn (Ph.D. University of Washington, 1994) —Patterns of neuroblast division in developing antennal lobes of worker honey bees. Present position since 1997: Unknown.
- Sharoni Shafir (Ph.D. Stanford University, 1995) — Cognitive mechanisms involved in honey bee-plant relationships. Present position since 1998: Professor, Hebrew University, Israel.
- Jay Hosler (Ph.D. Notre Dame University, 1995) — Synaptic plasticity in the honey bee olfactory system. Present position since 2000: Associate Professor, Juniata College, Huntingdon, PA.
- Sathees Chandra (Ph.D. Ohio State University, 2000) Mapping quantitative trait loci involved in honey bee reversal learning. Present position: Associate Professor, Department of Biology, Roosevelt University, Chicago
- Bradley Worden (Ph.D., Ohio State University, 1999) Quantitative trait loci for learning traits in honey bees. Present position: Postdoctoral Researcher, University of Arizona.
- Kevin Daly (Ph.D. University of Arizona, 1998) — Synaptic plasticity in the olfactory system of the moth *Manduca sexta*. Present position: Associate Professor, West Virginia University.
- Dhruba Naug (Ph.D., Indian Institute of Science, Bangalore, India, 1998) Socially mediated patterns of nutrient flow in honey bee colonies. Present position: Associate Professor, Colorado State University.
- Geraldine Wright (Ph.D. Oxford University, 1998) — The relationship between floral odors and the nutritional ecology of pollinators. Present position: Lecturer, University of Newcastle, UK.
- Tahira Farooqui (Ph.D., Ohio State University, 1994) Biogenic amines as neuromodulators of behavioral plasticity in the honey bee.
- Matthieu Dacher (Ph.D., University of Toulouse, 2005) Inhibitory transmission in the insect antennal lobes. Present position: Tenure-track faculty University of Caen, France
- Fernando Locatelli (Ph.D., University of Buenos Aires, Argentina) Neural plasticity in the antennal lobes of the honey bee. Present position: Tenure-track faculty University of Buenos Aires, Argentina.
- Patricia Fernandez (Ph.D., University of Buenos Aires, Argentina) The role of temporal information in odor discrimination in the honey bee. Present position: Tenure-track faculty University of Buenos Aires, Argentina.
- Martin Strube-Bloss (Ph.D. Free University of Berlin, Germany, 2008) Transformation of the read-out of olfactory processing in higher-order processing in the honey bee brain. Present position: Researcher Max Planck
- Julie Mustard (Ph.D. University of Arizona, 1999) Dopaminergic modulation in the honey bee brain. Present position: Assistant Professor University of Texas Brownsville.
- Richard Gerkin (Ph.D. Stanford University) Olfactory coding and plasticity in the mouse olfactory bulb.
- Xiaojiao Guo (PhD Beijing 2016). Biogenic amine receptors in the honey bee. Present position: Assistant Professor Chinese Academy of Sciences, Beijing.
- Meghan Bennett (PhD Dec 2017 North Dakota State University) Multimodal processing in the honey bee brain. Present position: Researcher USDA Honey Bee Laboratory, Tucson AZ
- Chelsea Cook (PhD. Dec 2015 University of Colorado) Social networks in honey bee foraging. Present position: Assistant Professor Marquette University

Research Assistant Professor

Irina Sinakevitch (Ph.D. Univ of Paris, France) Octopamine receptor distribution in the honey bee brain.

Current

Majid Ghaninia Tabarestani (PhD 2009 Max Planck Institute for Chemical Ecology, Jena Germany) Natural floral odor chemistry

Research Associate Professor

Current

Hong Le (Ph.D. Beijing Normal University) Calcium imaging of local interneurons in the honey bee antennal lobes. Currently Research Associate Professor Arizona State University.

Visiting Researchers

Paul Szyszka (Ph.D. Free University of Berlin, Germany) Fast odor processing in the honey bee peripheral and central nervous system. Currently Assistant Professor University of Konstanz, Germany.

Research Techniques and Courses

“The Cell and Molecular Biology of Learning and Memory” (1991), Cold Spring Harbor Laboratory
“Methods In Computational Neuroscience” (1988), Woods Hole Marine Biological Laboratories
“Neural Systems and Behavior”, course participant (1987), Woods Hole Marine Biological Laboratory

Organizational Memberships

American Association for the Advancement of Science
Society for Neuroscience
Animal Behavior Society
Association for Chemoreception Sciences

Research Support

Current

National Science Foundation/Department of Energy

“Collaborative Research: Encoding reward expectation in *Drosophila*”

Smith (ASU-PI) October 1, 2021-September 30, 2024 \$451,338

With B Gerber (U Magdeburg Germany), M Nawrot (U Cologne Germany), T Jovanic (Paris-Saclay Institute of Neuroscience France)

This application proposes to develop new behavioral conditioning protocols for investigating reward expectation and link them to the fruit fly brain connectome and computational modeling efforts.

National Science Foundation

“NeuroNex: From Odor to Action: Discovering Principles of Olfactory-Guided Natural Behavior”

Smith (ASU-PI and PI on one of the three main components) September 1, 2020-August 30, 2025

Total award across 16 investigators, 16 institutions, 4 countries \$20 million ASU - \$1,727,596

This application brings together three teams from the original NSF Ideas Lab “Cracking the Olfactory Code” program in 2015. This award now includes new investigators, esp international investigators from Canada, the UK and Germany. We propose a ‘team-of-teams’ approach to bring together and further develop insights from the original program.

Previous

ASU/Mayo Clinic collaborative seed grant program

“VR SCENT: VR Smell Composition Engine to assess Neurological Trauma”

Smith (ASU-PI): Stepanek (Mayo PI) January 1, 2020-December 31, 2020 Total: \$50,000

With C Spackman (ASU/SFIS), R Likamwa (Fulton Schools of Engineering), R Gerkin SOLS

This research proposes to develop a smell composition engine linked to Virtual Reality environments.

The work applies directly to assessing neurological trauma, but it can be used in other applications, such as simulating remote environments (ASU Interplanetary program).

DARPA

“Energy-efficient neuromorphic computing in light of the structural and functional evolution of multi-scale insect brains”

Smith (PI) April 3, 2019-March 31, 2021 Total: \$1,000,000

With Y. Cao (co-PI, ASU Fulton Schools Of Engineering), J. Harrison (co-PI, ASU SOLS) and M. Bazhenov (co-PI, UC San Diego School of Medicine)

This research proposes to use several species of highly social bees, combined with computational modeling and neuromorphic models based on machine learning, to study energy use and modifications of brain anatomy as brains become miniaturized through evolution.

National Institutes of Health (NIGMS) R01 GM113967

“Multiscale model of exploration-exploitation tradeoff: from genes to collectives”

Smith (PI) September 1, 2015-May 31, 2020 Total: \$1,923,000

With co-PI J. Gadau (ASU), and with co-PIs on subcontracts: R Huerta (UCSD); N Pinter-Wollman (UCLA). Gadau and Pinter are co-mentors on the F32 award to CN Cook and linked to this application.

The goal of this research is to integrate a new model animal, the honey bee, with a new modeling approach, multiscale modeling, to understand the proximate and ultimate causes of how complex, adaptive collective behaviors emerge from a collection of individuals who vary in their behavioral rules.

USDA National Inst Food & Agriculture Proposal Number: 2016-07929

“AFRI Food Security Challenge Area: Evaluation of the dose-response of honey bees to carboximide and strobilurin fungicides: from cellular mechanism to integrated management”

Smith (co-PI) June 1, 2017-May 31, 2021 Total: \$652,600

With J. Harrison (PI, ASU), J Fewell (co-PI, ASU) and G.DeGrandi-Hoffman (co-PI, USDA)

The goal of this research is to investigate the toxicity to honey bees of common fungicides used in agriculture, with the aim of increasing the health of pollinators of important food and feed crops.

Human Frontiers Science Program No specific ID number

“Odor-background segregation and source localization using fast olfactory processing”

Smith (PI) July 1, 2015-June 30, 2019 Total (incl 10%F&A): \$300,000

This was a collaborative award linked to three other awards to: R. Kanzaki (Univ of Tokyo, Japan); T. Nowotny (Univ Sussex, UK); P Szyzka (Univ Konstanz, Germany)

National Science Foundation 1556337

“Collaborative Research NSF Ideas Lab: Using natural odor stimuli to crack the olfactory code” Smith (PI) November 1, 2015-October 31, 2019 Total: \$750,000

This was a collaborative award linked to three other awards to: T. Sharpee (Salk Institute, San Diego CA); E. Hong (Calif Institute of Technology); A. Samuel (Harvard University)

Arizona Alzheimer’s Consortium (Smith PI) “Plasticity of odor coding in mouse olfactory bulb” (7/1/2016-6/30/2018)

NSF-CISE-IIS – (PI: BH Smith; co-PI: S Crook) “2014 CRCNS PI Conference” \$29,813.00 (9/1/2014-8/31/2015)

National Institutes of Health/NIDCD (PI: R Huerta co-PIs BH Smith and M Bazhenov) – “Collaborative Research: Dynamic and Distributed Memory in Olfaction” \$663,111 (ASU) \$1,737,481 total 7/1/2010-6/30/2015)

Office of Naval Research – “Chemical Discrimination and Localization using Biologically Based Olfactory Processing” \$80,000 (subcontract through UC San Diego, \$2.1 million total award) (May 1, 2010 – April 30, 2012 no cost extension through April 2013).

National Institutes of Health/NCRR (PI: Duch co-PI: BHS) 5/1/2011-4/30/2012 “Acquisition of a Leica TCS SP5 laser scanning confocal microscope” \$470,658 (October 1, 2011 - September 30, 2012).

National Institutes of Health – “SUPPLEMENT: Behavioral and Physiological Mechanisms of Olfaction” \$352,640 (October 1, 2009 – September 30, 2011).

National Institutes of Health – “Behavioral and Physiological Mechanisms of Olfaction” \$1,794,000 (competitive renewal; August 1, 2004 – July 31, 2010).

National Institutes of Health – “Prairie Technologies 2-Photon Microscope” \$450,000 (July 1, 2009- June 30, 2010).

National Institutes of Health/National Science Foundation – “The Importance of Temporal Information for Olfactory Coding” \$999,709 (July 1, 2005 – June 30, 2009)

National Institutes of Health – “D1-like dopamine receptors in learning and behavior” \$147,500 (co-PI with Dr. Julie Mustard; April 1, 2004 – March 31 2007).

National Science Foundation – “How Social Organization Influences an Infectious Process: The Honey Bee Colony As a Model” \$272,000 (co-PI with Dr. Dhruva Naug; September 1, 2003 – August 31, 2006).

National Institutes of Health – “Plasticity of Odor Coding in a Model System” \$150,000 (co-PI with K.S. Daly; April 1, 2002 –March 31, 2005).

United States-Israel Binational Science Foundation – Mechanisms Underlying Choice behavior in Response to Resource Variability Co-PI with Dr. Sharoni Shafir, \$114,000 (September 1, 1999 - March 31, 2004).

National Institutes of Health – “Behavioral and Physiological Mechanisms of Olfaction” \$1,019,573 (competitive renewal; September 30, 1998 –September 29, 2004).

Defense Advance Research Projects Agency (DARPA) “Plasticity of odor-guided behavior in moths” \$398,029

National Institutes of Health – NIDCD: “Cyclic nucleotides and memory in olfactory glomeruli”. Co-PI with Dr. Robert S. Thorn. \$52,500 (1.Sept.1997-31.August.2000)

National Institutes of Health – NIDCD: “An Analysis of Blocking in Odor Mixtures” Sponsor for NRSA to Dr. Jay Hosler.

National Institutes of Health – General Medicine: "A Behavior Genetic Analysis of Learning Performance" \$279,470 (1.May.95 – 30.April.99)

National Institute of Mental Health – Behavioral Physiology: “Behavioral and Physiological Mechanisms of Olfaction” \$502,812 (1.Apr.1993 – 31.Mar.1999)

California Apiary Board and California Almond Board: “Breeding Honey Bees for Resistance to Mite Infestations” \$25,000 (1.August.1995 – 31.July.1996). In collaboration with Dr. Marla Spivak, University of Minnesota.

The Ohio State University Seed Grant Program “Genetic Transformation of Honey Bees” \$54,000 (1.Apr.1993 – 30.Sept.1994)

California Department of Food and Agriculture “An Integrated Pest Management Approach to the Control of Honey Bee Tracheal Mites ” \$29, 660 (1.Apr.1993 – 31.Mar.1995)

California Department of Food and Agriculture “Control of Honey Bee Tracheal Mites With Natural Products: Testing of Vegetable Oil Formulations” \$6,000 (1.Feb.1992 – 31.Jan.1993)

Whitehall Foundation and The Ohio State University Seed Grant Program “Environmentally Induced Differences In the Central Nervous System: The Terminal Ganglion In Different Castes of Honey Bees” \$15,000 and \$17,000

National Science Foundation and the Hasselblad Foundation "Computational Models of Olfactory and Spatial Cognition" \$60,000 (with Drs. JG Hildebrand and L Nadel) University of Arizona Small Grants Program

National Institute of Mental Health National Research Service Award \$95,000 to study olfactory learning in honey bees

Invited presentations on Original Research and Organization of Symposia (2000 - present)

2021 ISCE

2019 University of Cologne, October 2019

Organization for Computational Neuroscience, Barcelona Spain July 2019

Workshops for PhD student training in team science for ASU/King’s College/Univ of New South

- Wales PLuS program; January (London) and February (Sydney)
Information Theory and Applications Workshop, San Diego CA February
Pacific Branch of the Entomological Society of America, April
- 2018 World Life Sciences Congress, Beijing China October
International Society of Chemical Ecology, Budapest, Hungary August
Symposium on use of PER to assay honey bee health Ordu, Turkey May
Southern Chinese Agricultural University, Guangzhou China March
Chinese Academy of Sciences, Beijing China March
Gordon Research Conference on Floral Volatiles Italy February; organized section on perception of floral volatiles February
- 2017 APIMONDIA Istanbul, Turkey
Queen Mary University of London, UK
University of Sussex, UK
University of Zürich, Switzerland
Chinese Academy of Sciences, Beijing, China
South China Agricultural University, Guangzhou, China
- 2016 Center for Evolutionary Medicine & Public Health Arizona State University
Society for Neuroethology International meeting Montevideo, Uruguay
International Symposium on Olfaction & Taste, Tokyo Japan
Japanese Association for the Study of Taste and Smell Tokyo, Japan
Neural Coding 2016 University of Cologne, Germany
International Entomological Society Orlando, Florida
Small Brains, Big Ideas Workshop Valparaiso, Chile
- 2015 National Institute for Mathematical and Biological Synthesis, Univ Tennessee, co-organizer for workshop on olfaction
Free University Berlin, meeting on honey bee brain atlas
Zukunftscolleg Jour Fixe, University of Konstanz public lecture about brain evolution and function
Kavli Institute for Theoretical Physics, UC Santa Barbara, workshop on olfaction
European Society for Evolutionary Biology, Lausanne Switzerland
International Congress of Comparative Physiology and Biochemistry, Krakow Poland
- 2014 Second Annual Winter q-bio [Quantitative Biology] Meeting, Kona Hawaii
12th Asian Apicultural Association Conference in Antalya, Turkey
Janelia Farm symposium on Structure and Function of the Insect Mushroom Body
Janelia Farm symposium on Learning and Memory – Comparing Fruit Flies and Honey Bees
Workshop “Small Brains, Big Ideas” Santiago and Valparaiso Chile
- 2013 Workshop on honey bee behavior at King Saud University, Riyadh Saudi Arabia
Bernstein program in Computational Neuroscience, Berlin Germany
Odor Spaces workshop Hannover, Germany (Sept)
Neuroethology congress Argentina (Oct)
Workshop on Olfactory Coding Valparaiso, Chile (Oct)
- 2012 King Saud University, Riyadh Saudi Arabia; 3 lectures
Workshop on Biogenic Amines in the Insect Brain, Free University of Berlin, Germany
Invited lecture Max Planck Institute München
Special symposium on Insect Olfaction. University of Würzburg, Germany.
International Congress of Entomology, Daegu South Korea
Workshop “Small Brains, Big Ideas” Santiago and Valparaiso Chile (included outreach talk to 200+ 7th through 12th graders in Valparaiso Chile).
- 2011 Chemical Ecology workshop, Beijing China
European Symposium on Insect Taste and Olfaction, St Petersburg, Russia
Janelia Farm symposium on Learning and Memory – Comparing Fruit Flies and Honey Bees
- 2010 University of California Riverside, Neuroscience Program

- University of Sussex, UK, Department of Biology
 Association for Chemoreception Sciences, organized symposium “Transient Dynamics, Metastable States and the Importance of Temporal Codes for Chemosensory Processing”, Tampa FL
 Free University of Berlin, Germany, International Symposium on Neurobiology “Honeybee Neuroscience – a New, Old Model System, Bridging Genomics, Physiology and Behavior. Where To in The Next 50 Years?”
 Zukunftskolleg Annual meeting, University of Konstanz, Germany
 University of Sussex, UK, “International Workshop on Dynamical Olfaction”
 Symposium “Genetics and Evolutionary Biology of Bees”, Riberao Preto, Brazil
 Plenary lecture “Honey Bee Learning and Memory” symposium EurBee 2010, Ankara, Turkey
- 2009 COSYNE conference, Snow Bird, UT
 Workshop on Neuromorphic Engineering, Telluride CO
 Insect Learning & Memory, France (declined)
 Olfactory Coding in Insects, Free University of Berlin Germany
 Behavioral Physiology & Sociobiology, University of Wuerzburg, Germany
 Pavlovian Society, Burlington VT
- 2008 Janelia Farm (HHMI) conference on “Learning and Memory: A Synthesis of Flies and Honey Bees”, Session Chair, Washington, DC
 University of Virginia Neuroscience Graduate Program, Charlottesville, VA
 College of Medicine ASU/University of Arizona, Phoenix, AZ
 International Congress of Entomology, session organizer, Durban, South Africa
 Workshop on Neuromorphic Engineering, Telluride CO
 University of Illinois, Department of Entomology, Urbana-Champaign, IL
 2nd Annual ASU-BNI Neuroscience Symposium, Phoenix, AZ
- 2007 Cold Spring Harbor Laboratory conference on the Honey Bee Genome
 PI meeting Collaborative Research Computational Neuroscience, Washington, DC
 Workshop on Neuromorphic Engineering, Telluride CO
 Animal Behavior Society, Burlington VT
 Institute for Nonlinear Science, San Diego CA
 Annual Meeting of the Entomological Society of Canada, Saskatoon Saskatchewan, CA
- 2006 Session organizer and keynote speaker Gordon Research Conference on ‘Genes & Behavior’, Ventura, CA
 1st Annual ASU-BNI Neuroscience Symposium, Phoenix, AZ
 Poster Association for Chemoreception Sciences meeting, Sarasopta, FL
 Invited seminar ‘Insect CNS-MMX’ meeting, Bäckaskog Castle, Sweden
 Presentation on sponsored research at NSF Collaborative Research on Computational Neuroscience meeting, Washington, DC
 Symposium speaker Society for Mathematical Biology, Raleigh-Durham, NC
 Symposium speaker Conference on Mathematical Neuroscience, Andorra
 Symposium speaker International Entomology Congress, Izmir, Turkey
- 2005 Invited seminar, Conference on Chemosensory Modulation, Jackson, WY
 Invited seminar, Joint Mathematics Meetings, Atlanta, GA
- 2004 Invited seminar, Hebrew University, Israel
 Workshop on “Coherence and Coordination in the Brain: Perspectives From Olfaction And Birdsong” at the Aspen Center for Physics, Colorado.
 Invited seminar International Congress of Entomology, Brisbane, Australia.
 Invited seminar, “Insect Sensors and Robotics” meeting, Brisbane, Australia.
- 2003 Invited seminar, University of Florida Center for Smell and Taste, Gainesville, FL
 Invited seminar, Winter Conference on Learning & Memory, Park City, UT.
 Invited seminar Washington State University, Pullman, WA.
 Invited seminar symposium Entomological Society of America

- Invited seminar Case Western Reserve IGERT program
- 2002 Purdue University, Department of Horticulture and Crop Science, Lafayette, IN
Virginia Commonwealth University, Department of Biology, Richmond, VA
Chair, symposium on Neuroscience, Gordon Conference on Floral Chemistry, Ventura, CA
Invited symposium presentation, Association for Chemical Senses, Sarasota, FL
Invited symposium presentation, IUSSI meetings, Japan
Invited symposium presentation, Gordon Conference on Neuroethology, Oxford, UK
Department of Biology, Vanderbilt University, Nashville, TN
Department of Biology, Indiana University, Bloomington, IN
Symposium presentation, Association for the Study of Animal Behaviour, London, UK
Seminar Rothamsted Agricultural Research Station, UK.
- 2001 Invited symposium presentations Entomological Society of America, San Diego, CA
Invited symposium presentation “Minibrain Symposium”, Tsukuba, Japan October
Invited symposium presentation, European IUSSI meetings, Berlin, Germany
Invited symposium presentation 7th European Symposium for Insect Taste and Olfaction Grass
Foundation lecture Eastern Nerve Net meetings, Woods Hole MA
Invited seminars Department of Neurobiology & Behavior, Cornell University
Invited seminars The Hebrew University of Jerusalem, Rehovot, Israel
- 2000 Invited seminar North Carolina State University
XXI International Congress of Entomology, Iguassu Falls, Brasil
Building a Community to Foster New approaches to Study Genes Brain and Behavior with the
Honey Bee, Bellagio, Italy
Progress In Invertebrate Neurobiology, Berlin, Germany
NASA Center for Advanced Studies in the Space Life Sciences symposium on Invertebrate Sensory
Information Processing

Ad hoc reviews

Journal of Chemical Ecology	Behavioral Ecology and Sociobiology
Animal Behaviour	Journal of Insect Behavior
Behavioral Genetics	Quarterly Review of Biology
Behavioral and Brain Sciences	Journal of Neuroscience
Behavioral Research Methods, Instrumentation, and Computers	Nature Neuroscience
American Midland Naturalist	Journal of Insect Physiology
Current Genetics	Journal of the Kansas Entomological Society
Journal of Comparative Physiology	Journal of Comparative Neurology
Journal of Experimental Psychology: Animal Behavior Processes	Journal of Experimental Biology
Current Biology	Journal of Comparative Psychology
	Proceedings National Academy of Sciences
	Frontiers in Neuroscience

Reviewer for granting agencies

Zukunftskolleg, University of Konstanz Germany
Several panels at NSF
National Environment Research Council (UK)
Molecular, Cellular, & Developmental Neurobiology study section at NIH (ad hoc reviews)
Biobehavioral Regulation, Learning and Ethology study section at NIH (reviewer 1999-2005)
Ad hoc reviewer for several other NIH study sections
Site visits for evaluation of intramural NIH-NICHD research program (2006 and 2008)

Review Articles

- 1) Michener CD, Smith BH. (1987) Kin recognition in social wasps and bees. In *Kin Recognition in Animals* (D. Fletcher & C.D. Michener, eds.), pp. 209–242. John Wiley and Sons..

- 2) Smith BH (1988) Ethological aspects of olfactory learning and memory in the honey bee, pp. 97-104. In *10th Biosciences Colloquium On Africanized Honey Bees and Mites* (M. Delfino-Baker, et. al. eds.), pp. 97–104. Ellis Horwood Ltd., Chichester, England.
- 3) Smith BH, Abramson CI (1992) Insect learning: Case studies in comparative psychology. In *Encyclopedia of Learning and Memory* (L.I. Nadel & J. Byrne, eds.), pp. 276–283. Macmillan.
- 4) Smith BH (1993) Merging mechanism and adaptation: Learning, generalization, and the control of behavior. In *Insect Learning: Ecological and Evolutionary Perspectives* (A.C. Lewis & D.R. Papaj, eds.), pp. 126-157. Chapman and Hall, NY.
- 5) Smith BH, Getz WM (1994) Non-pheromonal olfactory processing in insects. *Annual Review Entomology*. 39: 351–375.
- 6) Smith, B.H. (1994) How flexible and how constrained is the concept of voluntary behavior? In *Flexibility and Constraint In Behavior* (R. Greenspan, B. Kyriacou, eds), pp. 195-208. Springer Verlag.
- 7) Smith BH, Breed MD (1995) The chemical basis for nestmate recognition and mate discrimination in social insects. In *Chemical Ecology of Insects 2* (RT Cardé, WJ Bell, eds), pp. 287-317. Chapman and Hall.
- 8) Smith, BH, Wright GA, Daly KS (2006) Learning-based recognition and discrimination of floral odors. In *The Biology of Floral Scents* (N Dudareva, E Pichersky, eds), pp. 263-295. CRC Press.
- 9) Smith BH, Huerta R, Bazhenov M (2011) Distributed plasticity for olfactory learning and memory in the honey bee brain. In *Honeybee Neurobiology and Behavior - a Tribute for Randolf Menzel* (D Eisenhardt, CG Galizia, M Giurfa, eds). Springer.

Refereed Publications

- 10) Roubik DW, Ackerman JD, Copenhagen C, Smith BH (1982) Pollination ecology of *Cochlospermum vitifolium*: Pollinator behavior and the reproductive success of a tropical tree. *Ecology* 63: 712-720.
- 11) Smith BH, (1983) Recognition of female kin by male bees through olfactory signals. *Proc Nat Acad Sci (USA)* 80: 4551-4553.
- 12) Smith BH, Roubik, DW (1983) Mandibular glands of stingless bees (Hymenoptera: Apidae): Chemical analysis of the contents and the biological function in two species of *Melipona*. *J Chemical Ecology* 9: 1465-1472.
- 13) Smith BH, Carlson RG, Frazier J (1985) Identification and bioassay of the macrocyclic lactone sex pheromones of the halictine bee *Lasioglossum zephyrum* (Hymenoptera: Halictidae). *J Chemical Ecology* 11: 1447-1456.
- 14) Smith BH (1987) Effects of genealogical relationship and colony age on the dominance hierarchy of the primitively eusocial bee *Lasioglossum zephyrum* (Hymenoptera: Halictidae). *Animal Behaviour* 35: 211–217.
- 15) Roubik DW, Smith BH, Carlson, RG (1987) Formic acid in caustic cephalic gland secretions of the stingless bee, *Oxytrigona* (Hymenoptera: Apidae). *J Chemical Ecology* 13: 1079-1086.
- 16) Crozier RH, Smith BH, Crozier YC (1987) Relatedness and population structure of the primitively eusocial bee *Lasioglossum zephyrum* in Kansas. *Evolution* 41: 902-910.
- 17) Smith BH, Ayasse M (1987) Kin-based male mating preferences in two species of halictine bees (Hymenoptera: Halictidae). *Behavioral Ecology and Sociobiology* 20: 313-318.
- 18) Smith BH, Wenzel JW (1988) Pheromonal correlation and kinship in the social bee *Lasioglossum zephyrum* (Hymenoptera: Halictidae). *J Chemical Ecology* 14: 87-94.
- 19) Tengö J, Eriksson J, Borg-Karlson AK, Smith BH (1988) Visual and chemical cues in the mating behavior of *Panurgus banksianus* and *P. calcaratus* (Hymenoptera: Andrenidae) *J Kansas Entomological Soc.* 61: 388-395.
- 20) Smith BH, Weller C (1989) Competitive signalling among gynes in a social halictine bee: The influence of bee size and pheromones on behavioral strategy. *J Insect Behav.* 2: 397-411.

- 21) Smith BH, Menzel R (1989) The use of electromyogram recordings to quantify odorant discrimination in the honey bee, *Apis mellifera*. *J Insect Physiol.* 35: 369-375.
- 22) Smith BH, Menzel R (1989) An analysis of variability in the feeding motor program of the honey bee: The role of learning in releasing a modal action pattern. *Ethology* 82: 68-81.
- 23) Kaitala V, Smith BH, Getz WM (1990) Nesting strategies of primitively eusocial bees: A model of nest usurpation during the solitary state of the nesting cycle. *J. Theor. Biol.* 144: 445-471.
- 24) Smith BH (1991) The olfactory memory of honey bee, *Apis mellifera*: I. Odorant modulation of short- and intermediate-term memory after single trial conditioning. *J Exp Biol.* 161: 367-382.
- 25) Smith BH, Abramson CI, Tobin TR (1992) Conditional withholding of proboscis extension in honey bees (*Apis mellifera*) during discriminative punishment. *J. Comp. Psych.* 105: 345-356.
- 26) Burrell B, Smith BH (1994) Age- but not caste-related regulation of abdominal mechanisms underlying the sting reflex of the honey bee, *Apis mellifera*. *J. Comp. Physiol.* 174: 581-597.
- 27) Sammataro D, Cobey S, Smith BH, Needham G (1994) Controlling tracheal mites (Acari: Tarsonemidae) in honey bees (Hymenoptera: Apidae) with vegetable oil. *Economic Entomol.* 87: 910-916.
- 28) Smith BH, Cobey S (1994) The olfactory memory of honey bee, *Apis mellifera*: II. Blocking between odorants in binary mixtures. *J. Experimental Biology* 195: 91-108.
- 29) Bhagavan S, Benatar S, Cobey S, Smith BH (1994) Effect of genotype but not of age or caste on olfactory learning performance in the honey bee, *Apis mellifera*. *Animal Behaviour.* 48: 1357-1369.
- 30) Burrell B, Smith BH (1995) Modulation of the honey bee sting response by octopamine. *J. Insect Physiology* 41: 671-680.
- 31) Benatar ST, Cobey S, Smith BH (1995) Selection on a haploid genotype for discrimination learning performance: Correlation between drone honey bees (*Apis mellifera*) and their worker progeny. *J. Insect Behavior* 8: 637-652.
- 32) Smith BH. (1996) The role of attention in learning about odorants. *Biological Bulletin. MBL.* 191: 76-83.
- 33) Smith, BH. (1997) An analysis of blocking in binary odorant mixtures: An increase but not a decrease in intensity of reinforcement produces unblocking. *Behavioral Neuroscience.* 111: 57-69.
- 34) Bhagavan S, Smith BH. (1997) Olfactory conditioning in the honey bee (*Apis mellifera*): Effects of CS intensity. *Physiology & Behavior* 61: 107-117.
- 35) Linster C, Smith BH. (1997) A computational model of the response of honey bee antennal lobe circuitry to odor blends: Overshadowing, blocking and unblocking can arise from lateral inhibition. *Behavioral Brain Research* 87: 1-14.
- 36) Thorn, RS, Smith BH. (1997) The olfactory memory of the honeybee, *Apis mellifera* III. Bilateral sensory input is necessary for induction and expression of olfactory blocking. *J. Experimental Biology* 200: 2045-2055.
- 37) Stopfer M, Bhagavan S, Smith BH, Laurent G. (1997) Impaired odour discrimination by desynchronization of odor-encoding neural assemblies. *Nature.*390: 70-74.
- 38) Gerber, B, Smith BH. (1998) Visual modulation of olfactory learning in honeybees. *J. Experimental Biology* 201: 2213-2217.
- 39) Chandra SBC, Smith BH. (1998) An analysis of synthetic processing of odor mixtures in the honey bee (*Apis mellifera*). *J. Experimental Biology* 201: 3113-3121.
- 40) Smith BH. (1998) An analysis interaction in binary odorant mixtures. *Physiology & Behavior.*, 65: 397-407.
- 41) Shafir S, Wiegman DD, Smith BH, Real LA. (1999) Risk-sensitivity of harnessed honey bees to variability in volume of reward. *Animal Behaviour*, 57: 1055-1061.
- 42) Linster C, Smith BH (1999) Generalization between binary odor mixtures and their components in the rat. *Physiology & Behavior* 66: 701-707. PMID:10386917

- 43) Chandra SBC, Hosler JS, Smith BH (2000) Heritable variation for latent inhibition and its correlation to reversal learning in the honey bee, *Apis mellifera*. *J. Comparative Psychology* 114: 86-97. PMID: 10739314
- 44) Kim Y-S, Smith BH (2000) Effect of an amino acid on feeding preferences and learning behavior in the honey Bee, *Apis mellifera*. *J. Insect Physiology* 46: 793-801. PMID: 10742528
- 45) Daly K, Smith BH (2000) Associative olfactory conditioning of the moth, *Manduca sexta*. *J. Experimental Biology* 203: 2025-2038 PMID: 10851119
- 46) Hosler JS, Buxton KL, Smith BH (2000) Impairment of olfactory discrimination by blockade of GABA and nitric oxide activity in the honey bee antennal lobes. *Behavioral Neuroscience*. 114: 514–525. PMID: 10883802
- 47) Masterman R, Smith BH Spivak M, (2000) Brood odor discrimination abilities in hygienic honey bees (*Apis mellifera* L.) using proboscis extension reflex conditioning. *J Insect Behavior* 13: 87-101
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- 50) Ben-Shahar Y, Thompson CK, Hartz SM, Smith BH, Robinson GE (2000). Differences in performance on a reversal learning test and division of labor in honey bee colonies. *Animal Cognition*. 3: 119-125.
- 51) Daly K, Durtschi M, Smith BH (2001) Olfactory-based discrimination learning in the moth, *Manduca sexta*. *J. Insect Physiology* 47: 375-384. PMID: 11166302
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* Fulker Award from the Behavior Genetics Association for the best paper published in the journal of Behavior Genetics Vol. 31, 2001
- 54) Daly K, Chandra SBC, Durtschi ML, Smith BH. (2001) Generalization of olfactory-based conditioned response reveals unique but overlapping odour representations in the moth, *Manduca sexta*. *J. Experimental Biology*. 204: 3085-3095. PMID: 11551996
- 55) Shafir S, Waite TA, Smith BH (2002) Context-dependent violations of rational choice in honeybees (*Apis mellifera*) and gray jays (*Perisoreus canadensis*). *Behav. Ecology Sociobiology* 51: 180-187.
- 56) Wright GA, Skinner, B.D., Smith BH. (2002) Ability of honeybee, *Apis mellifera*, to detect and discriminate odors of varieties of canola (*Brassica rapa* and *Brassica napus*) and snapdragon flowers (*Antirrhinum majus*). *J Chem. Ecol.* 28:721-740. PMID: 12035922
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- 58) Alqarni AS, Smith BH, Cobey SW (2003). Performance Evaluation of Naturally Mated and Instrumentally Inseminated Honeybee (*Apis mellifera* L.) Queens in Field Colonies. *Pak. J. Bio. Sci.* 6: 17, 1476- 1481.
- 59) Wright GA, Smith BH. (2004) Variation in complex olfactory stimuli and its influence on odour recognition. *Proceedings of the Royal Society London c*: 147-152. PMID: 15058390
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- 61) Daly KS, Wright GA, Smith BH (2004) Molecular features of odorants systematically influence slow temporal responses across clusters of coordinated antennal lobe units in the moth *Manduca sexta*. *J. Neurophysiology*. 92, 236-254. PMID: 14985411
Link: <http://jn.physiology.org/content/92/1/236.full.pdf+html>
- 62) Daly KC, Christensen TA, Lei H, Smith BH, Hildebrand JG (2004) Learning modulates the ensemble representations for odors in primary olfactory networks. *Proceedings National Academy Science (USA)*. 101: 10476-10481. PMID: 15232007
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- 63) Borisyuk A, Smith BH (2004) Odor interactions and learning in a model of the insect antennal lobe. *Neurocomputing* 58-60: 1041-1047.
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- 64) Farooqui T, Vaessin H, Smith BH (2004) Octopamine receptors in the honeybee (*Apis mellifera*) brain and their disruption by RNA-mediated interference. *Journal of Insect Physiology*. 50: 701 – 713. PMID: 15288204
- 65) King L, Horine FM, Daly KC, Smith BH (2004) *IEEE Transactions on Instrumentation and Measurement* 53 (4), 1113-1118, 2004
- 66) Shafir S, Menda G, Smith BH (2005) Caste-specific difference in risk sensitivity in honeybees, *Apis mellifera*. *Animal Behavior*. 69: 859-868.
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Published abstracts

3-4 published abstracts for poster presentations per year through, for example, the Association for Chemoreception Sciences (*Chemical Senses*) and the Society for Neuroscience (meeting abstracts).

Books Reviewed

"Neurobiology and the Behavior of Honeybees" (R Menzel and A Mercer, eds) *Quarterly Review of Biology*.

"Interindividual Behavioral Variability In Social Insects" (RL Jeanne, ed.) *Quarterly Review of Biology*.

"The 'African' Honey Bee" (M Spivak, DJC Fletcher, and M Breed, eds). *J. Insect Behav.*

"A Primer of Invertebrate Learning: The Behavioral Perspective" (C.I. Abramson) *American Psychological Assn.*

"The Dance Language Controversy" (A. Wenner and P. Wells). *Animal Behaviour*.

Professional background

My specialty can be broadly defined as mechanistic and comparative analyses of Animal Behavior, focusing on sensory ecology and behavioral plasticity. My research since beginning my Ph.D. studies in 1978 has involved a consistent trajectory toward integrating new technologies into my research program on odor-guided behavior, which together with collaborators in other disciplines has allowed me to ask questions at different levels of biological analysis. I joined the faculty in the School of Life Sciences at Arizona State University in July 2005, after having spent 15 years on the faculty at Ohio State University. I began working in Chemical Ecology for my graduate studies by analyzing the chemical signals social bees use to recognize nestmates. My work involved isolating and analyzing chemical signals bees used in this important form of social communication. At the time my colleagues and I speculated about how the brain processes and learns about complex chemical signals. This interest led to my move to Berlin, Germany to work with Prof. Randolph Menzel, and then to Prof. John Hildebrand in Arizona, which was the start of my training in Neuroscience. Those moves ultimately placed me on the trajectory toward my current NIH-funded research program on olfactory coding and behavioral plasticity with honey bees, which involves electrophysiology, bioimaging, computational and molecular investigations of olfactory processing and learning. More recently I have reached out to integrate work with fruit fly and mouse models to test hypotheses derived from the work with honey bees. Finally, researchers in my laboratory are now working with colleagues who treat Parkinson's patients and manage a bank of brains from autopsies of these patients. We are testing models derived from our work with insect and mice of how alpha-synuclein affects processing in the olfactory bulb.

I have had continuous federal funding to study olfaction from NIH, NSF-CRCNS and now the Human Frontiers Science Program since 1991. My Google Scholar profile with relevant citation statistics is available online. I am a AAAS Fellow, I have received funding from the German Academic Exchange Service, and I am currently a Senior Fellow of the Zukunftskolleg at the University of Konstanz in Germany.

Expertise

My core expertise lies in investigating what animals know, how they know it and what are the rules for translating that knowledge into behavior. These studies are crucial for understanding how odors are represented, discriminated and classified in the CNS. My laboratory performs detailed analyses of the mechanisms that are involved in odor-guided behavior. I have developed nonassociative and associative conditioning paradigms, mostly with insects (fruit fly, moth and different bee species). But I have also published work with birds, rats and now mice. Since 1986 this work has integrated behavior with electrophysiology, bioimaging, molecular genetics and computational modeling to understand the neural mechanisms that underlie odor discrimination and plasticity. My research has extended to studies of operant conditioning (e.g. signaled avoidance), categorization/classification, and multimodal integration of odors with contextual cues from other stimulus modalities. Finally, I have published studies that integrate economic models of rational choice comparing insect and bird foraging behavior.

My original interest, which brought me to study olfaction, lies in analyzing natural odor signals, which are almost invariably complex mixtures of many chemical elements. My recent interest has turned to analyzing the 'scene' statistics of the natural stimulus space. My laboratory, for example, is now using behavioral, electrophysiological and imaging experiments with synthetic blends of odors designed to mimic the composition and variation of natural odors. This is an area that is poorly understood in olfaction, relative to visual and auditory processing, where much more effort has been devoted to understanding the physical properties of the stimulus space. By this I mean that we need a multidimensional analysis of how odor objects that have the same meaning vary (variance, skewness, kurtosis) in both space and through time. This is in my opinion one of the central challenges that must be addressed in order to understand how and why the CNS has evolved to process odors.

Contributions to Science

The insect Antennal Lobe is the analog to the mammalian Olfactory Bulb, and several lines of evidence indicate that the networks of the AL and OB process olfactory sensory information in the same way. Over the years my laboratory has adopted or developed the means to record activity in the AL and more central brain regions using bioimaging and electrophysiology in such a way that awake, behaving conditioned and naïve animals can be compared. More important, we have developed hypotheses about the function of the plasticity for olfactory coding and perception.

Daly KC, Christensen TA, Lei H, Smith BH, Hildebrand JG (2004) Learning modulates the ensemble representations for odors in primary olfactory networks *Proceedings National Academy Science (USA)*. 101: 10476-10481. PMID: 15232007

Fernandez PC, Locatelli FF, Rennell N, Deleo G, Smith BH. (2009) Reinforcement tunes spatiotemporal dynamics of early olfactory processing. *J Neuroscience* 29: 10191-10202. PMID: 19692594.

Locatelli FF, Fernandez PC, Villareal F, Mezzinoglo K, Huerta R, Galizia CG, Smith BH. (2013) Nonassociative plasticity alters competitive interactions among mixture components in early olfactory processing. *European J Neuroscience*. 37:63-79. Epub 2012 Nov 21. PMID: 23167675

Locatelli FF, Fernandez PC, Smith BH. (2016) Learning About natural variation of odor mixtures drives plasticity in early olfactory processing. *J Exp Biology*. pii: jeb.141465. [Epub ahead of print]

My research program has developed the means to identify via QTL analyses genes that affect behavior and then manipulate targeted neuromodulatory pathways (biogenic amine receptors) using pharmacological and now molecular genetic (RNA interference) techniques. We have used this ability to evaluate causal relationships between modulatory pathways in the brain and behavior.

Chandra SBC, Hosler JS, Smith BH (2000) Heritable variation for latent inhibition and its correlation to reversal learning in the honey bee, *Apis mellifera*. *J. Comparative Psychology* 114: 86-97. PMID: 10739314

Farooqui T, Robinson K, Vaessin H, Smith BH (2003) Modulation of early olfactory processing by an octopaminergic reinforcement pathway in the honeybee. *J. Neuroscience*. 23: 5370-5380. PMID: 12832563

Mustard JA, Pham PM, Smith BH. (2009) Modulation of motor behavior by dopamine and the D1-like dopamine receptor AmDOP2 in the honey bee. *J Insect Physiol* 56: 422-430 PMID: 19945462

We have now identified mechanisms of non-associative and associative plasticity in the AL and central brain. We have shown how these mechanisms are integrated into a decision-making process. I have also always worked with mathematicians to implement our findings in computational models of the AL and central brain, which have always help shape new hypotheses.

Strube-Bloss M, Herrera-Valdez MA, Smith BH (2012) Ensemble response in mushroom body output neurons of the honey bee outpaces spatiotemporal odor processing two synapses earlier in the antennal lobe. *PLOS One* 7(11):e50322.

Bazhenov M, Huerta R, Smith BH (2013) A computational framework for understanding decision making through integration of basic learning rules. *J Neuroscience*. 33: 5686-5697. PMID: 23536082.

Locatelli FF, Fernandez PC, Villareal F, Mezzinoglo K, Huerta R, Galizia CG, Smith BH. (2013) Nonassociative plasticity alters competitive interactions among mixture components in early olfactory processing. *European J Neuroscience*. 37:63-79. Epub 2012 Nov 21. PMID: 23167675

Chen J-Y, Marachlian E, Assisi C, Huerta R, Smith BH, Locatelli F, Bazhenov M (2015) Learning modifies odor mixture processing to improve detection of relevant components. *J Neurosci*. 35: 179-197

We have studied processes of transduction of odors and subsequent coding that allows for discrimination of a large number of odors. Recent funding from the Arizona Alzheimers Consortium has now extended this work into mouse and to humans. One important part of the work involves a statistical analysis of odor

scenes (recent NSF award). And the implication of this work will be a better understanding of how the olfactory system fails in humans who have neurodegenerative disorders that can begin in the olfactory system (e.g. Parkinson's Disease).

Stopfer M, Bhagavan S, Smith BH, Laurent G. (1997) Impaired odour discrimination by desynchronization of odor-encoding neural assemblies. *Nature*.390: 70-74.

Szysaka P, Gerkin R, Galizia CG, Smith BH. (2014) High speed odor transduction and pulse tracking by insect olfactory receptor neurons. *Proc National Acad Sci* 111 (47): 16925-30

Chan HK, Hersperger F, Marachlian E, Smith BH, Locatelli F, Szyszka P, Nowotny T (2018) Odorant mixtures elicit less variable and faster responses than pure odorants. *PLoS Computational Biology* Dec 10;14(12):e1006536. doi: 10.1371/journal.pcbi.1006536. eCollection 2018 Dec. PMID: 3053214

Zhou Y, Smith BH, Sharpee TO. (2018) Hyperbolic geometry of the olfactory space. *Science Advances*. *Sci Adv*. 2018 Aug 29;4(8):eaq1458. doi: 10.1126/sciadv.aaq1458. eCollection 2018 Aug. PMID: 30167457

We have adapted several techniques used in basic research to apply more broadly to pollinator health. All species of honey bees are used all over the world for honey production and pollination, and their contribution to agricultural productions are irreplaceable. Yet in many areas the health of honey bees has been threatened by many factors. We have shown how the behavioral and physiological measure we employ for basic research can be applied to assess and understand how factors such as toxins (heavy metals, pesticides, fungicides) and environmental stressors (humidity and temperature) have important sublethal effects on honey bees. I have taught workshops on these techniques to academic researchers and beekeepers in the US, Chile and Saudi Arabia, and I have now workshops planned in China.

Hladun KR, Smith BH, Mustard JA, Morton RR, Trumble JT (2012) Selenium toxicity to honey bee (*Apis mellifera* L.) pollinators: effects on behaviors and survival. *PLoS One*. 2012;7(4):e34137. Epub 2012 Apr 13. PMID: 22514621.

Burden CM, Smith BH. (2014) The Proboscis Extension Response (PER) procedure for investigations of behavioral plasticity in insects: Applications to basic, biomedical and agricultural research. *J Visualized Expts* Sep 8;(91):e51057. doi: 10.3791/51057.

Ali H, Alqarni AS, Owayss AA, Hassan AM, Smith BH (2016) Osmotic concentration in three races of honey bee, *Apis mellifera* L. under environmental conditions of arid zone. *Saudi J Biological Sciences* online 23 Dec 2016

Burden CM, Elmore C, Hladun KR, Trumble JT, Smith BH. (2016) Acute exposure to selenium disrupts associative conditioning and long-term memory recall in honey bees (*Apis mellifera*). *Ecotoxicol. Environ. Safety* 127: 71-79.

Ali H, Alqarni A, Smith B. Two manuscripts are currently in preparation showing adaptations of local honey bee species to climate conditions in Saudi Arabia and Pakistan.