EDITORIAL
Active Learning for Students and Faculty

Bruce R. Johnson

Department of Neurobiology and Behavior, Cornell University, Ithaca, NY 14853.

In addition to introducing new issue content, an objective of my *JUNE* editorials is to highlight educational papers from other journals that may be of interest to our readers. A series of papers on active learning caught my attention recently. A survey of college teaching practices found that traditional faculty lecturing is still the main method of instruction in North American Universities (Stains et al., 2018). This is despite evidence that active learning activities can produce more effective learning. For example, Freeman et al.'s (2014) metanalysis of 225 studies compared courses in STEM disciplines which included a variety of active learning activities (laboratories, group problem solving, worksheets, tutorials, personal response sessions) with those where lecturing alone was the teaching method. They showed that students in courses with active learning earned slightly higher grades and had lower failure rates than students in courses with lecturing alone. The paper discusses interesting implications of their results, including the estimate that reduction of STEM course failure rates by active learning activities could save students $3.5 million in tuition costs. There may be more pressure for active learning in college classrooms once parents with college-age children hear about this.

One of the authors of the Stains et al. (2018) and Freeman et al. (2014) papers encourages faculty to develop new teaching material for publication in peer review journals (Smith, 2018). Smith argues that faculty who develop and publish new teaching materials increase resources for active learning activities and are more likely to use them in their own courses. In addition, Smith suggests that publishing teaching articles encourages collaborations with colleagues and students, gives us feedback on our teaching creativity, and is evidence for tenure committees (and students' parents) of our quality and commitment to teaching. The Smith article reminded me that working through the process of developing, assessing, refining, presenting and publishing our creative teaching activities is also a form of active learning that promotes our professional development as educators.

This brings me to the contents of the new Spring issue of *JUNE*. This issue is rich with two editorials besides this one, 10 full articles, a new case study, a statistical review, two technical papers, and six new contributions to our Amazing Papers in Neuroscience series.

In the editorial section, Neuwirth et al. argue that teaching neuroanatomy in a historical context adds depth to the subject and can supplement courses lacking resources to support cadaver labs. The historical story telling of early neuroanatomists, their ideas and creative approaches, was well received by their students. They preferred neuroanatomy presented through historical vignettes over other learning methods such as reading text books, listening to anatomy lectures, and virtual lab assignments.

This *JUNE* issue presents a trio of statistical articles. The second editorial continues a running statistical perspective series that Bob Calin-Jageman started in the Fall 2017 *JUNE* issue (Calin-Jageman, 2017). The new perspective focuses on "effect sizes," presenting a tutorial to address the next question after finding a statistically significance effect: what is the practical significance of a statistical result? A full article in the new *JUNE* issue describes a method to compute Bayes factors for ANOVA and independent sample t-tests (Faulkenberry). The Bayes factor indexes how much observed data supports a hypothesis, as an alternative to *p*-values. The third statistical piece is a review of multivariate and data mining methods as applied to neuroscience data (Smith). It provides a brief guide to techniques like linear discriminant analysis, principal component and factor analysis, cluster analysis, multiple linear regression, and other methods. This article follows a review also by Smith (2017) in the Fall issue of *JUNE* covering statistical methods in neuroscience. The articles are building an excellent core of statistical resources for neuroscience educators.

There are seven full or shorter technical articles describing lab exercises, techniques and low-cost methods for undergraduate teaching and research labs. Two articles describe the construction of low-cost equipment for student research and teaching with rodents. Gallivan and Schmitzer-Torbert present a Morris water maze design for memory and learning studies. They show its ability to test the cognitive abilities of rats in diet-induced obesity trials. Fox et al. designed a home-made elevated plus maze for anxiety research as part of a neuroscience methods course. Students were engaged in the planning, design and construction of the maze as an applied critical thinking and real-world problem-solving project. Another report illustrates the construction of an eye model made from very simple, everyday materials (Wood and Dayal). This model teaches students the role of different extraocular muscles in eye movement, and pathological conditions that affect rotational eye movements.

Four laboratory exercises highlight the creative lab activities FUN members are developing. Pokala and Glater present an elegant optogenetics program for students to study the neural basis of behavior. Serotonergic neurons in wild type and (mystery) mutant strains of *C. elegans*, are engineered to be activated by light through channelrhodopsin to examine neuromodulation of movement in these nematodes. A

classical conditioning exercise with bees using simple equipment is described by Van Nest to teach principles of learning. The honey bees learned quickly to associate a simple order with a food reward, and this association could be extinguished. Continuing this series of invertebrate model systems for teaching learning and memory, Pavin et al. also use an associative learning theme in their *Drosophila* lab exercises. Their students condition fly larvae to associate sweet and bitter taste stimuli with a neutral order to examine aversive and appetitive behavioral responses. Protocols run with animals with mutated synaptic proteins demonstrate the importance of specific proteins in synaptic plasticity and learning. Ending this lab exercise series, Pemberton et al. present a student (and instructor) guide for using ImageJ to analyze neurite outgrowth. They build upon an earlier paper in *JUNE* by Catlin et al. (2016) to guide the procedures that help make ImageJ functionally useful in the student lab.

The last four full articles in the *JUNE* Spring issue address interesting and novel programs or course activities. Synkowski et al. describe a clinical neuroscience immersion course created by a partnership between the Virgina Tech School of Neuroscience and Roanoke Memorial Hospital. Some of the many clinical activities undergraduates participate in include weekly clinical seminars, joining teams of neurosurgeons in operating rooms, hospital rounds and nervous system imaging facilities, and having 24 hour on-call experiences (including cognitive assessment after sleep deprivation). In another institutional collaboration, McCoy et al. describe a neuroscience internship program at Stonehill College for undergraduates to participate in research at the Laboratory of Neuroscience in the Department of Psychiatry at Harvard Medical School. The program is a model for small colleges with limited resources to give students a sophisticated, high tech research experience, and learn science in a community of research scientists. Spix and Brasier use multiple, short blog assignments in a systems neuroscience course to build student expertise in scientific reading and writing. The students reported increased confidence in their ability to analyze neuroscience research articles through their semester blog posts. A project-based learning project in an undergraduate neurobiology course is described by Zwick. Students worked in teams around the themes of neurotoxins, spinal cord injury and mechanisms of learning and memory to understand basic neuroscience concepts through team authored research papers and poster presentations.

We have one Case Study in the Spring issue of *JUNE*. Sawyer and Frenzel use epilepsy as a framework to discuss action potential generation and mutations in voltage gated sodium channels that affect excitability and influence excitatory and inhibitory networks. The case study used primary literature to increase quantitative reasoning and critical thinking skills while hypothesizing the effects of sodium channel mutations on neural activity. More details of the case study and the classroom implementation notes are available at cases.at.june@gmail.com.

Finally, we have 6 contributions to our "Amazing Papers in Neuroscience" series. In the first, Cleland highlights six seminal papers that are important for understanding the contributions of L- and T-type calcium channels to neuronal firing properties. This series has been weak in articles on neuronal excitability, and I hope the Cleland paper will inspire more contributions in this area. The other 5 papers in this series are an experiment. Stefan Pulver gave his students in the masters of neuroscience program at the University of St. Andrews, Scotland, an assignment to write an Amazing Papers article for *JUNE*. With the editorial help of Stefan and our Amazing Paper special editors Ian Harrington and Aaron Cecala, we present student written Amazing Paper reviews on the following topics: evolution of pain modulation (Thompson), split brain experiments (Rosen), protein phosphorylation in neural signaling transduction (Scurfield), HPA axis (Dunlavey), and the neuronal basis of face recognition (Febery). With proper academic and editorial supervision, our Amazing Papers in Neuroscience feature may be a new form of collaborative active learning for students and faculty.

REFERENCES

Calin-Jageman RJ (2017) After p values: the new statistics for undergraduate neuroscience education. J Undergrad Neurosci Educ 16(1):E1-E4.

Catlin R, Taylor A, Ditchek L, Burnett S, Khan S, Todd O, Adams M, Touhey E, Wynkoop A, Ryan J (2016) Using cultured mammalian neurons to study cellular processes and neurodegeneration: a suite of undergraduate lab exercises. J Undergrad Neurosci Educ 14(2):A132-A137.

Freeman S, Eddy SL, McDonough M, Smith MK, Okoroafor N, Jordt H, Wenderworth MP (2014) Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci U S A 111(23):8410-8415. doi.org/10.1073/pnas.1714936115.

Smith MK (2018) Publishing activities improves undergraduate biology education. FEMS Microbiol Lett 365(11): fny099. doi: 10.1093/femsle/fny099.

Smith PF (2017) A guerilla guide to common problems in 'Neurostatistics': essential statistical topics in neuroscience. J Undergrad Neurosci Educ 16(1):R1-R12.

Stains M et al. (2018) Anatomy of STEM teaching in North American Universities. Science 359:1468-1470.

Address correspondence to: Dr. Bruce R. Johnson, Department of Neurobiology and Behavior, S.G. Mudd Hall, 215 Tower Rd, Cornell University, Ithaca, NY 14853. Email: brj1@cornell.edu