

INTRODUCTION AND PROJECT OVERVIEW

The NSF-funded project *Neurons in Action Version 2: Understanding the Behavior of Normal and Abnormal Neurons* (NIA2) was designed to extend, disseminate and evaluate the prototype tutorial and simulation package *Neurons in Action Version 1* (NIA1). Many of the neuroscience concepts addressed in NIA1 and NIA2 have historically been difficult for post-secondary students (and sometimes instructors) to fully understand and explain. As stated in the NIA2 NSF proposal project description,

The subject of neurophysiology is often intimidating to students who fear electrical circuitry and cannot easily relate concepts such as conductance and capacitance to their general understanding of biology and physiology. Yet with the subject of neuroscience expanding in so many directions, it seems essential that the neurobiologist have a grasp of the fundamental principles of neuronal function and an appreciation of how the field can be aided by computational tools. (p. 1)

These concepts have traditionally been covered in graduate level courses. However, NIA2 provides a dynamic environment based on computational models that allow undergraduate students, at different levels in their neuroscience education, to perform neuronal simulations, observe what happens, and think about the underlying principles that explain what they saw. This active-learning approach is designed to give students the opportunity to have ownership of these concepts and build their own rich, interconnected knowledge structures.

NIA1 is a set of 17 tutorials that were based on the professional simulator NEURON (<http://neuron.duke.edu/>). NEURON was initially designed and used only for research purposes. However, the introduction of HTML programming and web-browser interfaces gave the perfect support structure to call on NEURON for educational investigations. Since NIA1 debuted in 2000, further advances have been made in NEURON's capabilities, as well as computer speed and functionality. The needs and vision of undergraduate neuroscience education have also expanded and evolved. Thus, the ideas for significant restructuring and further development of NIA1 were consolidated into a National Science Foundation proposal and NIA2 was born.

The objectives of this proposal, funded in February 2005 (DUE CCLI Award # 0442748), are as follows:

Specific Aim #1. To restructure, refine, and add features to the existing tutorials.

Specific Aim #2. To extend the range of NIA downward to the chatter of single channels and upward to the behavior of simple circuits.

Specific Aim #3. To add new tutorials to the original prototype.

The following evaluation report is divided into four major sections. The first section gives a brief overview of the evaluation team's history with this project and outlines all of the various data collection methods used for the project evaluation. The second section focuses on the three

Specific Aims stated above and compares and contrasts the changes that were planned by the PIs (as outlined in the NSF proposal) to the currently published contents of NIA2. The third section focuses on the project's larger impact on the neuroscience educational community, both faculty and students. This section includes case studies from five different undergraduate institutions. The fourth and final section offers suggestions for future directions and concluding comments.

DATA COLLECTION METHODS AND EVALUATION OVERVIEW

We, evaluators Mary E. Searcy (Mary Beth) and Jill E. Thomley, began working on the *Neurons in Action Version 2* (NIA2) project in the summer of 2007, as it was nearing the end of its official three years of funding. The PIs had initially contracted with another evaluation team at the time the proposal was submitted; however, due to extenuating circumstances, this team was unable to fulfill their obligations to the project.

PI Ann Stuart was able to obtain a project extension to allow further time to implement and evaluate NIA2. This allowed us approximately a year and a half to design and implement an evaluation program that was primarily summative in nature. A variety of complementary data collection methodologies were used. Some methods focused on the materials themselves. Other strategies provided us with data that gave us snapshots of the project materials in action in a variety of educational contexts. Information gathered from all data collection methods described in this section were combined and synthesized to evaluate the three project objectives listed above. Many of the explicit details and individual student or instructor quotes are given in this report, as well as several summaries, to assist the program director(s) and principal investigators in making their own assessment of the outcomes of the grant and planning future endeavors.

Data Collection Method 1: Review of project materials.

Both evaluators reviewed all of the project materials (in print and on the NIA2 CD) as well as the contents of the project web site (<http://neuronsinaction.com/home/main>). Since neuroscience is not our area of expertise (Mary E. Searcy is a mathematics educator and Jill E. Thomley is a statistician), we contracted a biology consultant (Mark Venable of Appalachian State University) to help us evaluate the materials. We compared our observations to those made by Ann Stuart in her 2006 and 2007 Progress Reports to NSF. We also attended the first week of the 2008 Marine Biological Laboratory's (MBL) *Summer Program in Neuroscience, Ethics & Survival* (SPINES) where PI Ann Stuart taught graduate students with the NIA2 materials. We spent many hours during this week investigating the concepts covered in NIA2 as novice neuroscience students in addition to our evaluator activities. This extensive material review provided a framework within which we could analyze various user comments and subsequent field observations. Finally, we received extensive notes made by a UNC-Chapel Hill undergraduate who worked through all the NIA2 tutorials and provided feedback to PI Ann Stuart.

Data Collection Method 2: Surveys

In Fall 2007, we sent out a survey (hereafter referred to as the Initial NIA2 Survey) to gauge reactions of educators to the newly released NIA2 as well as assess how various individuals contributed to the creation/editing of NIA2 and/or were using it at the time. The Initial NIA2

Survey was sent to anyone mentioned in the NIA2 NSF proposal or other NIA2 literature in some sort of advisory role, as well as to any instructors we knew of who were currently using NIA2 in their classrooms (this list of instructors was given to us by PI Ann Stuart). A Student Feedback survey was sent out to several instructors during Fall 2007 and Spring 2008. Three instructors chose to give the survey to their students. We also had an undergraduate student from another institution (who used NIA2 in one of her 2007-2008 undergraduate courses) fill out the survey during Summer 2008. We created and administered the SPINES 2007 and SPINES 2008 Surveys to the graduate (and one undergraduate) students who used NIA2 during these MBL-sponsored programs. NIA2 materials were not particularly aimed at graduate students, we were particularly interested in the SPINES students' reactions because (1) they had been instructed by one of the NIA2 PIs, and (2) they had either been Teaching Assistants in undergraduate neuroscience-related courses or would possibly be undergraduate instructors in the future.

Data Collection Method 3: Communications with Principle Investigators

We feel that we are very fortunate to have the opportunity to work with PIs who are so willing and eager to engage in an ongoing dialogue with us and the neuroscience education community about their project. During the course of our involvement in the project, we have interacted with Ann Stuart via telephone interview, extensive e-mail, and in-person informal interviews at Woods Hole. Ann also provided us with her notes from the 2007 SPINES education program (where she introduced the just-released NIA2 to approximately 20 graduate students), and we have been following her blogs on the Sinauer NIA2 website. Finally, we had the pleasure of meeting and talking to PI John Moore at Woods Hole. His stories about his first attempts to visualize neuroscience concepts with oscilloscopes and relatively primitive flip-book style "movies" was utterly fascinating. It is obvious from these rich data sources that this project is not the result of some passing educational fad. Rather, it is the product of a lifetime philosophy (older than either evaluator) that neuroscience concepts need to be experienced and visualized to be truly understood. NIA2 is their vehicle for passing along their adventures in uncovering these concepts for themselves and others.

Data Collection Method 4: Site Visits (including classroom observations, interviews, and artifact collection) of institutions using the materials with undergraduate (and graduate) students.

The evaluation team visited educational institutions in three different states during Spring 2008 and Fall 2008 (Texas, Massachusetts, and Georgia) to observe the NIA2 materials being used in five different undergraduate classes. We also participated in a week's worth of SPINES classes at MBL in Summer 2008. During these site visits we interviewed nine different instructors and four teaching assistants who played various roles in developing and teaching these courses. We also interviewed an instructor at the University of Texas who had used NIA1 at two previous institutions and who planned to create a new UT course that would involve NIA2. The site visited represented a diversity of educational settings in which the materials could potentially be used. A detailed description of all sites is included later in this section.

During classroom visits the evaluation team observed project materials in use, participated in classroom group activities, and in some cases had informal discussions with students about their

experiences. At all but one site the evaluation team interviewed the instructors about their prior and current experiences with teaching the materials, as well as plans for future use (the other instructor's schedule didn't permit time for an interview). The site visits lasted one to two days each. Extensive and independent field notes were taken by each member of the evaluation team, and when possible the handouts and teaching materials used by the instructors were collected.

Schools and Instructors Visited

- The University of Texas at Austin, Austin, TX (Nace Golding, Jennifer Morgan): According to the Carnegie Foundation, the University of Texas at Austin is a public Research (very high research activity) University. It has 2900 faculty and more than 50,000 students, the majority of whom are undergraduates. In Spring 2008, we observed the BIO 365L Neurobiological Laboratory course, which is an elective for the BS in Biology with a specialization in Neurobiology. There were approximately 20 students in the course. All of them had already taken Introduction to Neurobiology. Although UT Austin does not have Neurobiology major per se, it does have a Section (i.e. department) of Neurobiology in the School of Biological Sciences. Dr. Nace Golding, the instructor for BIO 365L, is an Associate Professor in the Section of Neurobiology. His research interest lies in the mechanisms that shape synaptic activity in dendrites. We also visited with Jennifer Morgan, an Assistant Professor in the Section of Molecular Cell and Developmental Biology. Jennifer's research is in exploring the molecular mechanisms underlying both synaptic maintenance and plasticity. Although she has not used NIA2, she previously used NIA as a UNC-Chapel Hill graduate student and as an instructor at two other post-secondary institutions. She currently plans to use NIA2 in a new course she is developing.
- Amherst College, Amherst Massachusetts (Steve George): Amherst College is a private Baccalaureate College with approximately 1600 undergraduate students and 194 faculty. It was the first institution to offer a Neuroscience major (established in 1973). In the fall of 2008, we observed two lab sections (approximately 15 students in each section) of the BIOL-35 Neurobiology course. BIOL-35 is one of three core courses taken by all Neuroscience majors. The instructor for this course was Steve George, the chair of the Neuroscience Department. He started out in mathematics and physics, but shifted his focus during his career as he discovered that he truly enjoys applying this knowledge to understanding how the nervous system works. His current research interests are the visual system and channel structure changes that underlie the opening and closing of voltage-sensitive ion channels. Steve was off campus at a meeting when we observed his laboratory sections, which were led by undergraduate teaching assistants. We were able to interview him later in our visit about his Neurobiology course.
- Williams College, Williamstown MA (Steve Zottoli): We first became aware of Williams College as a prospective evaluation site when PI Ann Stuart sent us an e-mail Steve had written to her about using NIA2 in his courses. Steve was one of the SPINES program faculty and we met with him in person when we attended SPINES 2008. Steve told us that he used NIA2 for the first time in his BIOL 304 Neurobiology course the previous year. One of his former BIO 304 undergraduate students was helping Ann Stuart as an NIA2 teaching assistant during Ann's part of the SPINES educational program. Williams is a private, Baccalaureate College whose population is primarily composed of undergraduate students. Current enrollment is approximately 2000 students, and there are a little over 300 faculty.

Steve Zottoli is a member of the Biology department, which offers a BS in Biology with a concentration in Neuroscience. Steve Zottoli has also used NIA2 in NEURO 201 (a required course) and the above-mentioned BIO 304 (an elective course). His area of research is in the study of startle response recovery in fish that have sustained spinal cord injuries. At the time of our Fall 2008 visit to Massachusetts, Steve had already completed the NIA2 labs in his current NEURO 201 course and the BIO 304 course was not offered in the fall. However, we were able to informally interview faculty, students and teaching assistants who had been involved while at Williams College.

- Emory University, Atlanta, GA (Astrid Prinz, Dieter Jaeger): Like University of Texas at Austin, the Carnegie Foundation classifies Emory University as a Research (very high research activity) University. However, Emory is a private institution with almost 13,000 students and over 3,600 faculty. Emory has a Neuroscience and Behavioral Biology major that is housed in the Biology Department. In the fall of 2009, we observed an elective lab course for this degree program, BIO 360L/NBB 301L: Neurobiology Simulation Lab. There were approximately 25 students in this course. Dieter Jaeger, a Biology faculty member, was teaching this meeting of the course. Dieter's research interest is computational neuroscience, particularly understanding algorithms of information processing taking place in the cerebellum and in the basal ganglia. We also visited with Biology faculty member Astrid Prinz, who co-teaches the Simulation Lab course with Dieter. In her research, Astrid uses a variety of techniques, including computational brute-force explorations of high-dimensional spaces, to study how cellular and synaptic properties shape the output of a neural network, and how neural circuits manage to function reliably in spite of ongoing molecular turn-over and developmental or environmental changes.
- Agnes Scott College, Atlanta, GA (Karen Thompson): While in Atlanta during Fall 2008, we visited Agnes Scott College, a small private Baccalaureate College. It was founded in 1889 as an independent national liberal arts college for women. Currently there are about 850 students and 83 full-time faculty. Although small, Agnes Scott has its own Neuroscience major. There are four faculty members for the Neuroscience program, three in psychology and one in biology. The biologist, Karen Thompson, taught the Biology/Psychology 250 Foundations of Neuroscience 1: Excitable Cells and Synapses course in which NIA2 was used. Karen's research interest is in neural circuits. There were four students in the Foundations of Neuroscience 1 course, and we observed the students giving their individual final NIA2 project presentations. At the end of the class we informally interviewed Karen and her students about their NIA2 experiences.