

## ARTICLE

# How to Successfully Incorporate Undergraduate Researchers Into a Complex Research Program at a Large Institution

**Rebecca B. Weldon & Valerie F. Reyna**

*Human Neuroscience Institute, Department of Human Development, Cornell University, Ithaca, NY 14850.*

One feature of the Laboratory for Rational Decision Making at Cornell University is the integration of a large number of undergraduate students into a relatively elaborate research program. We describe our thorough screening process, laboratory structure, and our expectations for undergraduate researchers in our lab. We have a structure in place that helps maintain organization and enhance productivity, including scheduled weekly and monthly meetings, and selecting undergraduate and graduate team leaders to lead each research project. We discuss how it

is important to encourage students to aim high and have a good attitude toward learning and problem solving. We emphasize that both initiative and teamwork are important in a large research laboratory. We also discuss the importance of giving students responsibility in connection with research projects—our undergraduate researchers engage in data analysis, interpretation of results, and have a high-level understanding of theory.

*Key words: undergraduate students; research program; structure; professionalism; teamwork; initiative*

Undergraduate involvement in scientific research is valuable for students. Undergraduates who gain experience in research have higher grade point average and higher rates of acceptance to graduate programs (Bauer and Bennett, 2003; Fechheimer et al., 2011). Graduate students and faculty members who mentor undergrads on research projects report greater quality of work and life (Dolan and Johnson, 2010; Webber et al., 2013). However, some argue that including undergraduate students in research projects can be challenging for faculty members with limited time and resources (Eagan et al., 2011; Harvey and Thompson, 2009). Others contend that a systematic approach to including undergraduate researchers can be very effective (Hunter et al., 2006; Thiry et al., 2012).

The Laboratory for Rational Decision Making (LRDM) at Cornell University is one example of a laboratory that has been consistently successful in incorporating undergraduates into a relatively complex research program. The LRDM is housed in the Department of Human Development in the College of Human Ecology. In the LRDM, we examine decision making across many different domains, including law (e.g., jury decision making), medicine (e.g., decisions to vaccinate), and development (e.g., risk taking in adolescence). Our research methods include measures of self-report, behavior, and neuroscience. We conduct basic and applied research to answer questions about decision making.

The LRDM is also part of the Human Neuroscience Institute (HNI), which is comprised of several laboratories in the Department of Human Development. The HNI research investigates the neural mechanisms of human behavior across the life span. Current topics of HNI research include memory, imagination, emotion, and decision making.

The LRDM neuroscience research focuses on the

neural underpinnings of risk preference and risk taking across development. Our predictions go beyond traditional dual-process theories and suggest that gist-based intuition plays a fundamental role in higher-level decision making (Reyna et al., 2011; Reyna and Huettel, 2014; Reyna et al., 2015). Our current research has important implications for risky decision making during the vulnerable period of adolescence. This type of research is pivotal in ultimately developing educational interventions that can reduce poor health decisions such as unhealthy eating or unprotected sex.

In the following article, we describe how the LRDM involves undergraduates in research. We describe the lab structure, screening and recruiting process, and expectations for undergraduate researchers. We discuss fundamentals for making a relatively large lab run efficiently, including weekly and monthly team meetings. Finally, we discuss how a great deal can be achieved with hard-working student researchers who value teamwork, taking initiative, and having a positive attitude.

## Multiple levels of organization promote structure and increase efficiency

The LRDM is arranged in an organized structure with different levels of lab leadership roles. The laboratory is divided into four research teams: a medical decision-making team, a memory and law team, an adolescent risky decision-making team, and a neuroscience team. The total number of graduate and undergraduate students fluctuates somewhat from semester to semester, but the general structure is that each team has one or two graduate team leaders and an undergraduate team leader and is comprised of approximately 6-10 undergraduate students (see Figure 1 for an illustration of this set-up). A postdoc may help lead a team with the graduate team leader.

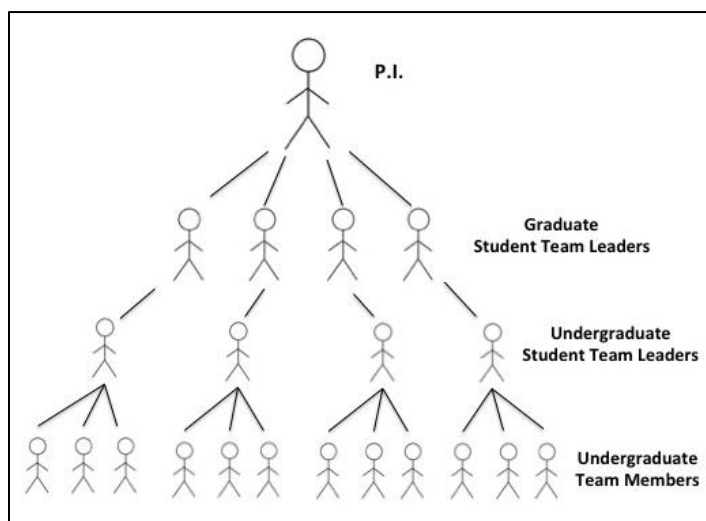


Figure 1. The LRDM lab structure.

### Initial screening of potential undergraduate research assistants: Making sure it is a good fit

We receive applications from an extremely high caliber of students at Cornell University. However, despite the fact that most of our applicants are very bright, hard working, eager students, we want to make sure that we select only those who seem like the best match for our lab. Therefore, there are certain criteria that students must meet to be selected for our lab.

The first step in recruiting is making sure that we are vigilant about any opportunity to find students interested in being a part of scientific research. We often meet students at a research recruiting day in the Human Development department. We also have one person (typically a graduate student or postdoc) attend a Cornell University Research Board dinner at the beginning of each fall semester, in which first and second year students are paired up with faculty members who conduct research that may be of interest.

We then send an initial screening survey to any interested students. The survey asks basic questions about the student, such as year and major. Several different academic majors are represented across our four research teams. We typically have several students from Biology, Psychology, and Human Development. We have students majoring in Economics, Classics, Policy Analysis and Management, and Philosophy. We have Mathematics and Engineering students. The neuroscience and medical decision-making teams typically have several students who are pre-med, while there are usually several pre-law students on the memory and law team. The medical decision-making team and adolescent risky decision-making team both attract students who are interested in public health or nutrition.

The initial survey also asks questions about career ambitions and extracurricular activities. We also ask for a short paragraph about why the student thinks that he or she will be a good fit for one (or more) of our research

teams and our laboratory.

A couple of graduate students will then talk with the student to get a better sense for whether this student is a good match for the lab, and whether the lab is a good match for the student's interests. We ask questions about the student's academic interests, current career ambitions (although we are cognizant that these will likely change over the course of the college years), and what draws the student to our lab. We also ask for previous examples of situations in which the student had to deal with a challenge or problem to solve in an academic or work setting. Scientific research does not come without its challenges, and we want to make sure that the student will be willing to persevere and have a good attitude about solving a problem.

If the undergraduate still seems like a good fit for the lab, the undergraduate student will then meet with a few graduate students and VFR. VFR will listen to the graduate students' recommendations about why the student seems like a good fit, and will then provide the final evaluation of the student. The purpose of such a thorough screening process is to weed out those who lack professional attitude and dedication. We want to make sure our lab is a good match for the student, from both our perspective and from the student's perspective.

It is also important to us that the lab continues to be a good fit throughout the student's time at Cornell. Over the course of four years, an undergraduate's interests may change, or he/she may realize that research is not for him/her. We make sure that our undergraduate and graduate team leaders have a talk with the student as soon as there are unexcused absences or sub-par work. In some cases, this sub-par work is due to an overloaded schedule, but in some cases, it reflects a diminished interest in lab. We recognize that our lab is not for everyone, and thus, think that it is important to communicate with a student when things are not working out.

### Weekly and monthly lab meetings encourage communication and productivity

The undergraduate team leaders have a weekly meeting with the graduate students and postdocs. During this time, each undergraduate team leader presents what each undergraduate member of the research team has accomplished that week. The undergrad team leaders are generally chosen after having been lab members for some time. These are students who consistently demonstrate leadership, character, perseverance, and dedication to the lab. These are also students who work especially well with all undergrads on the team, graduate team leaders, and VFR.

We stress giving concrete educational tasks to the undergraduate team members so that progress can be easily assessed and monitored. Examples of concrete educational tasks include running specific data analyses (e.g., run a correlation between sensation seeking score and proportion of risky choices) or finding a certain number of recent articles on a certain topic (e.g., create a

spreadsheet that includes 10-15 articles on fMRI studies of adolescent risky decision making). The key is that they are concrete tasks (specifying exactly how many articles to find or which data analyses to run). The more that *specific instructions* are given for a task, the more likely it is that the researcher will receive a product that he/she can work with, which will enhance productivity for the research team as a whole.

Each research team (graduate and undergraduate team leaders, and undergraduate team members) also meets once a week. During this time, the team members cover progress since last week's meeting, any problems with subject recruitment or data analyses, and next assignments. We often use these meetings to discuss relevant journal articles or rehearse for an upcoming presentation. Regular and scheduled follow-up with undergraduates is essential to completing tasks and moving projects forward.

The graduate students and postdocs also meet with VFR once a week. During this time, the graduate students are encouraged to bring any undergraduate student issues to VFR's attention, which may include problems (e.g., missed meetings or overdue assignments) or accomplishments (e.g., an undergraduate is accepted to graduate or medical school). Communication between the graduate students and VFR is key.

The entire research team (VFR, graduate students and postdocs, and undergraduate students) meets once a month. At each of these "full lab" meetings, one of the four research teams presents their research project to the entire lab. These formal lab presentations are helpful for several reasons. Given the size of the lab, it is important that students understand what is happening with the other teams in the lab (e.g., an undergraduate on the neuroscience team may learn more about what the memory and law team is working on). Presenting in front of the lab help students develop more confidence in their public speaking skills and in explaining a scientific research study to an audience. These presentations usually generate stimulating discussion about the research findings and broader implications of the research, which is enjoyable for everyone, and provides high-level training for the undergraduate students.

### **Completing tasks in advance will work in everyone's favor**

Any professor who heads a large lab like VFR's will be extremely busy (this is the nature of the job!). Therefore, the LRDM lab manual stresses that it is extremely important to turn things in for VFR's review well ahead of deadlines – 30 days in advance is our general lab guideline. This applies to letters of recommendation, grant applications, papers, and presentations. The graduate and undergraduate team leaders emphasize these organizational requirements, so that everyone is working to make sure all team members get things done in time. We try to avoid as many "my dog ate my research paper"

situations as possible by having things due a month in advance.

### **A lab manual outlines expectations for undergraduate and graduate research assistants**

All undergraduate and graduate research assistants receive a copy of the LRDM lab manual as an initial introduction to the lab. As the manual states, the expectations described in the manual (e.g., being on time, responding to email, initiative, positive attitude, independence, ability to work on a team) are all characteristics that the person recruited for the team most likely already embodies. However, it is important that these are explicitly laid out in a lab manual. Further, this helps with a smooth transition for new students, so that we do not have to reinvent the wheel each time a new student joins the laboratory.

### *Grading policy*

Most undergraduate students receive course credit for their participation in the lab. We make sure to outline the grading policy in the first few pages of the lab manual, as one would in a syllabus. The performance of the student is evaluated based on six areas of performance: responsibility, competence, teamwork, knowledge, initiative, and following instructions (e.g., meeting deadlines for tasks assigned). Undergraduate researchers typically dedicate regular hours each week to working in our lab. Undergraduate researchers typically work 10 hours per week in our lab (although this may vary depending on number of lab research credits). We also stress that points may be deducted for unexcused absences, if a student is disrespectful of others in the lab, or if the product is not accurate. We treat time in the lab like a class, and expect students to take their research projects and lab responsibilities seriously.

### *A good attitude is extremely important!*

Scientific research comes with its challenges, and it is a world that can be especially intimidating to someone who has never set foot in a lab before. There are myriad of things to know about the research process, and with it comes a large swath of new literature to immerse oneself in, programming challenges, and advanced statistics. One token of advice that we like to give in the LRDM lab is that a good attitude is extremely important. Regardless of level of experience, as long as a student is willing to work hard and take on challenges, the student will be extremely successful in our lab. Further, the LRDM lab seems to have a propensity for selecting some very likable grads and undergrads to work in lab, which makes the laboratory environment that much more enjoyable. Kind, hard-working, dedicated people abound!

### *Teamwork*

It is essential that the undergraduate researchers cooperate with their project leaders, other members of the

research team, and other members of the lab in accomplishing tasks. Cooperative learning is an effective way of working with others to achieve goals (Smith et al., 2005). We place emphasis on things like being respectful of team leaders and other members of the team, responding to emails and phone calls within 48 hours, and being responsible about attending meetings and being on time. Communicating frequently with members of the team is crucial to completing major tasks. Turning in an accurate product, whether it be data entry, data analysis, or a writing assignment, is a very important part of working on a team. We emphasize an “all hands on deck” approach, in which all team members help complete a task so that the project moves along in an efficient manner. Most importantly, we aim to maintain a friendly and supportive laboratory environment. Working closely with peers fosters friendships that extend beyond the laboratory.

### *Initiative*

As crucial as teamwork is, it is just as important that the student can work on his or her own to solve problems and move a project forward. Problem-based learning is a type of learning that occurs when one has to work towards the resolution of a problem on one’s own (Savery, 2006; Smith et al., 2005). The idea of problem-based learning is that it helps students develop the skills and confidence to solve problems they have never seen before. We encourage taking initiative in solving problems and checking work. We expect that students will not hesitate to ask questions if something is unclear. We tell students to report any problems immediately to their team leaders. We also encourage students to engage in critical thinking, and welcome creative ideas about any aspect of our research projects.

### *Professionalism*

We also communicate one of our most important lab goals in the lab manual, and that is to make sure that we uphold a high level of professionalism at all times. Given that we recruit a large number of research participants for our projects each year, it is especially important that our laboratory members are polite, friendly, responsive, and on time when communicating with and meeting our participants. The lab manual also emphasizes a high level of professionalism when interacting with students, faculty, and staff in the department.

### *Knowledge*

It is essential that all team members are very knowledgeable about the details of the research project (e.g., what each measure means and why it is being used, how to enter data). This facilitates training of new members and enhances productivity.

Further, much of the LRDM lab research has strong theoretical motivation. Our students are extremely bright and enjoy intellectual challenge, so we encourage a deeper level of thinking about the research in our lab and other related research. One of our goals as teachers and

mentors is that each undergraduate student leaves the lab with a sophisticated level of theoretical interpretation, critical thinking and writing skills, and new technical skills or analysis techniques. Another important goal is that we convey an appreciation for some of the major social, economic, and health problems through discussions about the real-life implications of our research.

### *Technology and tutorials*

Students in our laboratory begin with extensive education in the protection of human subjects and ethical guidelines, subject recruitment, and informed consent. The lab manual also outlines information about technology and tutorials for software we will be using in the laboratory (e.g., from how to log on to the lab server to how to access tutorials for statistical analyses in SPSS).

### *Graduate students manage each research team*

Planning and organization are essential when leading a research team. In our lab, graduate student team leaders and postdocs are responsible for making sure the team members are learning, making intellectual progress, completing their tasks every week, and meeting important deadlines. Graduate team leaders work with VFR to keep track of important details such as letters of recommendation requests from undergraduate team members. Together with VFR, we all complete mid-semester and final evaluations for all team members.

### **Giving a fair amount of responsibility to the undergraduates**

We believe that students are more successful in the laboratory environment when they are given more responsibility. We encourage active learning through involvement in data collection and analysis, rather than just reading articles and learning passively. Active learning approaches also tend to yield higher student satisfaction (Johnson, 2011). Therefore, it is important that each student has a sense of investment in the research study, and exposure to all aspects of the research process. For example, our undergraduate neuroscience students are involved in recruiting subjects and collecting data for our fMRI studies. They are involved in behavioral and fMRI data analysis, which involves learning new statistical software (e.g., SPSS and a Matlab-based fMRI software, SPM). We also encourage theoretical interpretation of results and discussion of how our results fit in to the current literature. It is essential that the student understands how his or her individual contribution is important to the success of the project as a whole.

### **All undergraduate researchers present their research to the entire research team**

At each monthly team meeting, the research teams take turns presenting. Student presentations help encourage a deeper understanding of the theoretical background, methods, and study results. Moreover, in the LRDM lab, students are taught the important skill of being able to

Topic	Comments from undergraduate students
General	<p><i>"The lab offers immediate, first-hand exposure to research methods and analysis as well as an implicit mentorship system."</i></p> <p><i>"Working in a neuroscience lab has been a highlight of my undergrad education."</i></p>
Skills learned	<p><i>"Even as an undergraduate, I've been able to participate in various facets of research, including data collection, data analysis, local participant recruitment, and scientific presentations."</i></p> <p><i>"As an undergrad in Dr. Reyna's lab, I've been given great opportunities to learn and use fMRI technology, complete data analyses with brain scans, and improve my public speaking skills through team and poster presentations."</i></p> <p><i>"I have gained skills in the areas scientific communication, project management, professional development, and in the practical application of neuroscience."</i></p> <p><i>"Through my work at the lab, I have learned a lot about statistical analysis and research methods. I have also learned how to use SPSS statistics, Qualtrics survey software and Microsoft Access - skills that can be beneficial in any field!"</i></p>
Mentorship in lab	<p><i>"I have learned a lot about the research process thanks to the extensive mentorship I have received while in lab."</i></p> <p><i>"Dr. Reyna has fostered a unique educational environment that has come to feel like "home" for me during my undergraduate years."</i></p> <p><i>"I feel very comfortable approaching all lab members with questions."</i></p> <p><i>"A benefit of being part of this network is the availability of advice from all sorts of perspectives, from graduate students to undergraduates, as well as alumni working in fields ranging from law school to consulting to health professions."</i></p>
Future endeavors	<p><i>"I know that all of these skills will help me immensely throughout and after college."</i></p> <p><i>"I applied to over 40 different programs for post-graduation (Masters of Public Health, medical schools, clinical and corporate jobs) and for every single one, a central component of my application involved my experiences in lab."</i></p> <p><i>"I have other volunteer and leadership positions on my resume, but the structure of student leadership under Dr. Reyna and the variety of tasks with specific accomplishments to cite makes it continuously the most relevant."</i></p> <p><i>"Dr. Reyna's lab has prepared me on the track to medical school by teaching me key problem solving and critical thinking skills."</i></p>

Table 1. Quotes from current LRDM undergraduate students.

communicate their scientific research to others (Brownell et al., 2013). These presentations are wonderful practice for this difficult but important skill. We encourage students to

think about the broader implications of their work. For example, how might sexual health interventions have implications for education and policy? Why is functional MRI research important, and what can it tell us about the way people make decisions? Being able to answer these questions and engage in intellectual debate are valuable skills to have as young scientists and scholars.

### Students are encouraged to aim high

We also encourage students to become involved in their research projects at a higher level. Students in the LRDM lab typically gain exposure to all aspects of the research process – the undergraduate research assistant role is not limited to subject recruitment and data collection. During their time in the LRDM lab, students progress to learning proper scientific methods, participating in data analysis and interpretation of results. We spend time critiquing the published literature (e.g., in neuroimaging and decision making), and understanding underlying causal theories of human behavior. We challenge students to engage in intellectual debate and to think and write critically. Each year, we have two or three senior undergrads in the lab that elect to write an honors thesis. We involve our undergraduate students in preparation of materials for presentation at regional and national scientific conferences, and, among the very best, co-authorship of scientific papers. Several undergraduate students have co-authored scientific journal articles (Reyna et al., 2014; Reyna et al., in press). LRDM undergraduates also tend to have an extremely impressive record of outcomes. Each year, we have several senior undergrads go on to graduate programs in medicine, law, public health, and business.

The lab experience is challenging, but we hope that it is also rewarding (quotes from current undergraduate members of the LRDM indicate that the lab offers a positive and productive experience ; see Table 1). We encourage students to find their niche in lab--to go after what really excites them. This may be something that aligns with their academic interests and career path, or our research may pique their interest in something entirely new. Our undergraduate researchers constitute a major part of the LRDM lab, and we strive to make sure their laboratory experience is enjoyable, productive, and intellectually fulfilling.

### Conclusions

Involving undergraduates in the research process may come with certain challenges, but we are confident that the following guidelines will result in success:

- Implement a thorough screening process to make sure the match is a good fit for student and researcher.
- Design a lab manual that outlines clear expectations for undergraduate researchers in the lab.
- Assign concrete laboratory tasks – the more specific, the better.
- Emphasize the importance of both teamwork and initiative.

- Encourage a positive attitude – and lead by example.
- Schedule regular weekly and monthly meetings to check in on progress, roadblocks, and accomplishments.
- Encourage students to aim high.

We also want to advise fellow researchers that these strategies should be effective regardless of the type of university. The college or university may be smaller. The college or university may not have graduate students. Other characteristics of the school or student body may present other unique challenges. Despite these differences, we are optimistic that these recommendations can apply to research at many different types of academic institutions.

## REFERENCES

- Bauer KW, Bennett JS (2003) Alumni perceptions used to assess undergraduate research experience. *J Higher Edu* 74:210-230.
- Brownell SE, Price JV, Steinman L (2013) Science communication to the general public: why we need to teach undergraduate and graduate students this skill as part of their formal scientific training. *J Undergrad Neurosci Educ* 12:E6-E10.
- Dolan EL, Johnson D (2010) The undergraduate-postgraduate-faculty triad: unique functions and tensions associated with undergraduate research experiences at research universities. *CBE Life Sci Educ* 9:543-553.
- Eagan MK Jr, Sharkness J, Hurtado S, Mosqueda CM, Chang MJ (2011) Engaging undergraduates in science research: not just about faculty willingness. *Res High Educ* 52:151-177.
- Fechheimer M, Webber K, Kleiber PB (2011) How well do undergraduate research programs promote engagement and success of students? *CBE Life Sci Educ* 10:156-163.
- Harvey L, Thompson K (2009) Approaches to undergraduate research and their practical impact on faculty productivity in the natural sciences. *J Coll Sci Teach* 38:12-13.
- Hunter A-B, Laursen SL, Seymour E (2006) Becoming a scientist: the role of undergraduate research in students' cognitive, personal, and professional development. *Science Education* 91:36-74.
- Johnson PA (2011) Actively pursuing knowledge in the college classroom. *J Coll Teach Learn* 8:17-30.
- Reyna VF, Chick CF, Corbin JC, Hsia AN (2014) Developmental reversals in risky decision making: intelligence agents show larger decision biases than college students. *Psychol Sci* 25:76-84.
- Reyna VF, Estrada SM, DeMarinis JA, Myers RM, Stanisz JM, Mills BA (2011) Neurobiological and memory models of risky decision making in adolescents versus young adults. *J Exp Psychol Learn Mem Cogn* 37:1125-1142.
- Reyna VF, Hans VP, Corbin JC, Yeh R, Lin K, Royer C (In press) The gist of juries: testing a model of damage award decision making. *Psychol Public Policy Law*.
- Reyna VF, Huettel SA (2014) Reward, representation, and impulsivity: a theoretical framework for the neuroscience of risky decision making. In: *The neuroscience of risky decision making* (Reyna VF and Zayas V, eds), pp 11–42. Washington, DC: American Psychological Association.
- Reyna VF, Wilhelms EA, McCormick MJ, Weldon RB (2015) Development of risky decision making: a fuzzy-trace theory neurobiological perspectives. *Child Dev Perspect* 9:122-127.
- Savery JR (2006) Overview of problem-based learning: definitions and distinctions. *Interdisciplinary Journal of Problem-based Learning* 1:9-20.
- Smith KA, Sheppard SD, Johnson DW, Johnson RT (2005) Pedagogies of engagement: classroom-based practices. *J Eng Educ* 94:87-101.
- Thiry H, Weston TJ, Laursen SL, Hunter A-B (2012) The benefits of multi-year research experiences: differences in novice and experienced students' reported gains from undergraduate research. *CBE Life Sci Educ* 11:260.
- Webber KL, Laird TFN, BrckaLorenz AM (2013) Student and faculty member engagement in undergraduate research. *Res High Educ* 54:227-249.

Received February 26, 2015; revised May 15, 2015; accepted May 20, 2015

Address correspondence to: Dr. Rebecca B. Weldon, Cornell University, Human Neuroscience Institute, Department of Human Development, Martha Van Rensselaer Hall, Ithaca, NY 14850. Email: rbw92@cornell.edu