I. Cover Sheet

For each faculty member involved in the project, please include:

Name: **Steven A. Lloyd, Ph.D.**
Email address: **salloyd@northgeorgia.edu**
Department: **Psychology & Sociology**
Previously funded by CURCA? _**X**_*Yes* ____*No*

Additionally, include:

Title of Proposal: **Undergraduate Student Research in Behavioral Neuroscience and SoTL**
End date for proposed activities: **May 1, 2013**

Description of proposed research project or creative activities.
1. A behavioral neuroscience experiment. Mice given adolescent exposures to prescription stimulants drugs are used to model children who are misdiagnosed with ADHD or misusing/abusing this stimulant drug. The mice are tested in adulthood to assess the long-lasting effects of these developmental exposures. Behavioral testing ensues for 3-4 weeks with daily (5 days/week) training sessions in an automated learning chamber. After mice are trained to a specific criterion, they are run through an additional behavioral task. The animals' response to this new task allows us to measure alterations in behaviors such as impulsive and compulsive activity and motivation. These types of errors suggest permanent changes in the brain circuitry known to regulate these cognitions/behaviors and which are hypothesized to change as a result of an adolescent stimulant drug exposure. These types of errors also mimic those seen in several human conditions associated with impulse control (ADHD, addiction, etc.), aging (dementia), and over forms of disease and trauma affecting the same areas of the brain and highlight both potential susceptibility factors as well as disruptions of normal brain functioning that might arise from developmental exposures to drugs.

2. A science of teaching and learning experiment. Lab portions of 4 freshmen biology courses are used for the study. Students receive either a traditional set of laboratory experiences or a curriculum wherein some of the traditional laboratory experiences are replaced with a novel, semester-long, research-based module. The novel laboratory modules consist of a class-designed behavioral neuroscience experiment. Students work through all aspects of the research design from hypothesis development to experimental design to data collection and analysis to formal reporting. We hypothesize that this novel lab will produce increases in scientific literacy and student engagement without sacrificing course-specific learning objectives. The effectiveness of the novel labs are assessed for course-specific and general science literacy learning outcomes using the Experimental Design Ability Test (EDAT). Self-report data will also be collected using the Student Course Engagement Questionnaire (SCEQ) to track 5 subscales of engagement (Skills, Emotional, Participation/Interaction, and Performance). The EDAT and SCEQ will be administered at the beginning and end of the semester and compared across treatments (a mixed model design). New assessment techniques and instruments are piloted and adopted each semester and added to the repertoire (i.e., the SCEQ will be added this semester and another student-determined assessment in the Spring). There is a need for empirically-validated research-based exercises in the science education literature and there is a need for integrative and experiential exercises that engage students in the classroom laboratory.

Significance of the proposed work.
1. A growing number of adolescents are prescribed stimulant drugs (e.g., Ritalin) for the treatment of ADHD and still more misuse or abuse the drug due to its euphoric effects and ability to enhance concentration. This trend is coupled with the growing concern about the misdiagnosis of ADHD and unnecessary drug exposures that result. But are there lasting effects of these exposures on the developing adolescent brain? We hypothesize that Ritalin, which alters chemical messengers in the brain, will disrupt normal developmental processes that are regulated by these very same messages. During development, chemical messengers also direct the structural development of the brain. We hypothesize that disruptions of these neurochemicals will manifest as behavioral deficits that persist into adulthood. If such behaviors are identified in adult mice, it will suggest a permanent alteration in the structure and function of the brain areas that regulate such behaviors. The clinical implications of these findings are, at the same time, important for considering the potential impact of misdiagnosis of ADHD and the abuse/misuse of drugs that treat it as well as being informative for early diagnosis and treatment of those potentially affected. The data collected from this study will contribute to a larger dataset that we have built in our lab considering the effects of developmental stimulant exposure on the brain, behavior, and immune system. We have published and are in various stages of publishing several manuscripts in this area supported by previous CURCA funding.

2. Experiential and integrative learning are known components of effective pedagogy and undergraduate research is a well-established high impact practice. We have created a novel, integrative, research-based laboratory sequence to be used in a freshman biology course. We have also designed an empirical assessment of its effectiveness in enhancing learning outcomes and enthusiasm for learning. The results of this study will inform the education literature and will provide valuable materials for faculty to adopt in their classrooms, especially at under resourced institutions. This study is firmly grounded in pedagogy and supported by the SoTL and science education literature. Its impact will be immediate given the relative scarcity of empirically tested laboratory experiences in this context. Finally, these studies were, in part, designed to meet the needs of students interested in pursuing science education as a career. The student researchers who conduct these studies develop valuable experience in the classroom, the lab, and in the research environment. They learn how to develop and empirically assess educational experiences, and we hope they will carry that over to future educational and career pursuits. We will publish the results of this

study in an education-oriented journal. We have published 3 other SoTL articles using the same model of student-driven science education research embedded in the classroom for the immediate benefit of NGCSU students and the long-term benefit of the larger community of science teachers.

Goals and expected products.

1. Poster presentations at regional conferences: Southeastern Psychological Association and Association of Southeastern Biologists.
2. Presentations at NGARC Conference on campus.
3. Submission of UR travel and research grants to regional and national organizations. Student leaders produce very detailed research proposals before starting their projects, which provide most of the necessary information for submitting small travel and research grants. Our students have a history of applying for and securing these types of awards and external funding.
4. Continued development of datasets to contribute to several manuscripts currently in preparation. Each of the projects associated with this proposal are components of larger projects and a much larger system of student development.
5. All data collected in these projects will also contribute to applications for external funding. To date, we have submitted several grant applications. While these submissions have not been successful, we have received positive feedback and are encouraged to submit more, especially if we have a larger body of preliminary data as would be collected here. We have targeted NSF and NIH R15 grant mechanisms.

Plan for involvement of undergraduates in the project or activity.

Our lab employs a tiered system of student involvement. At the initial levels, some students are learning the very technical methods employed in the lab. For example, they are training in animal care, management, and husbandry in accordance with federal guidelines. They are training in experimental techniques to employ in pharmacology studies or to teach freshmen students. They are conducting semester/year long experiments (e.g., on animal behaviors in a learning study or on the effectiveness of a novel laboratory experience in a freshmen biology lab course). At the highest levels, some students have become leaders in the lab. At this level, students have mastered techniques employed in the lab and now engage in a much higher level of research. They design and manage their own projects. To this end, students write detailed proposals outlining the research they will conduct and, more importantly, the fully referenced rationale for conducting the experiment (a task which proves to be both extremely difficult, but also extremely valuable for the students' development). By the time students begin writing a proposal, they are knowledgeable of both the technical details and scientific literature associated with their projects and are then tasked with proposing all aspects of their novel project. Proposal writing is iterative with much guided feedback for the students. This continues until we are satisfied with the theoretical and practical aspects of the research proposed, how well the student understands the project's "big picture" ideas, the benefit to the student of the proposed project, and how the project fits into a larger body of research conducted in the lab. At this point, the we become consultants who ensure that projects are running smoothly, but not interfering if they are. The mentor provides expertise and guidance where needed – the mentor is not "hands off". The student leader is responsible for developing, conducting, analyzing and reporting on all aspects of the research project.

Another goal of student involvement in research is for them to gain experience and develop skill in leadership through managing a project and group of trainees in the lab. The projects described in this proposal require a tremendous daily effort over an extended period of time, which is best handled through a team of capable hands. The student leaders train team members on the protocols being employed and organize and manage their daily responsibilities. All student leaders are expected to produce a primary product. While at the very least they are expected to a present at a scientific conference, projects always contribute to larger datasets and projects with an end goal of publication in a peer-reviewed journal with student co-authors. As seen below, these models of undergraduate involvement have been extremely successful in the past. In addition to involvement in a primary research experience, our students support campus-wide and external efforts in promoting undergraduate research. In the recent past, our students have presented to the NGCSU Board of Trustees, The Lumpkin County Rotary Club, and the QEP-Steering Committee. They have also presented at a national Leadership Conference, promoted CURCA through student fellowship positions, and are in process on a publication in a journal focused on Undergraduate Research and Mentoring. We actively seek out and encourage these types of experiences for our students. Our students are truly involved in all facets of the research process and our research program and agenda is 100% student-focused, with a singular question driving all major pragmatic decisions – is this going to be good for this student's development and future career/academic goals?

Budget

Category	Description	Project	Price	Total
Mice	*Per diem for 9 months (food, bedding, caging supplies, and animal facility maintenance fees)	**1:~50 2:~100	3.82 per diem (9 months)	1031.40
Syringes	This study requires daily injections.	2	134.91 (case)	269.82
Gloves	Animal handling is a component of all projects.	1-2	126.08 (case)	756.48
Drugs	Methylphenidate (Ritalin) + processing, shipping and licensing fees.	1-2	573.21	573.21
Materials	Various supplies to build apparatus for class projects.	1	200.00	200.00
Supplies	Supplies for printing posters for presentations.	1-2	200.00	200.00
TOTAL				3030.91

*** Per diem costs** - inclusive of all costs associated with maintaining the animals including food, bedding, caging supplies, cleaning supplies, and other animal facility maintenance fees. Please note that this per diem is well under national averages.

**** Project 1** – Assessment of novel, research-based laboratory module.

Project 2 – Analysis of adolescent exposure of psychostimulants on adult executive functions.

Project 1-2 – All animal needs are based on the number of experimental animals needed as well as those needed for breeding these animals and maintaining the colony.

*****Psychostimulants for Project 2** – Please note that all of the psychostimulants used in these studies are scheduled compounds, which require special processing and purchasing procedures as well as State and Federal licenses. The budget request is inclusive of these fees. Please note that all studies require drug or saline administration via intraperotineal injection. Adolescent exposures require 11 days of injections (from Postnatal Day 22-31 and again at 2-3 months of age).

Timeline

1. Behavioral Neuroscience Experiment: Cohort 1 (~20 animals); Cohort 2 (~20 animals)
    - Animal breeding: 7/28 – 8/30; 12/15 – 1/15
    - Adolescent exposure to Ritalin occurs 22 days after birth for 10 days.
    - Training occurs 2-3 months of age (~10/30 & 3/15) and usually lasts for 3-4 weeks.
    - 5CSRTT at completion of training (~11/30 & 4/15).
    - Remainder of the semester is spent analyzing the results of the study and preparing it for presentation.
    - 3 potential presentations (SEPA, ASB, NGARC) are planned stemming from this project in Spring 2013 and a manuscript will be prepared for publication by the end of summer 2013.

2. SoTL Study: Cohort 1 (n = 4 classes); Cohort 2 (n = 4 classes)
    - Research, compile, pilot and train on assessments (8/1-8/28; 12/15-1/15)
    - Help students in the class with the lab experiment deliverables (various points throughout the semester).
    - Administer pretest and posttest assessments (first week of classes and last week of classes).
    - Remainder of the semester is spent analyzing the results of the study and preparing it for presentation.
    - 3 potential presentations (SEPA, ASB, NGARC) are planned stemming from this project in Spring 2013 and a manuscript will be prepared for publication by the end of summer 2013.

*Note: The projects described in this proposal are underway, but need funding to continue. Given the nature of the animal research, we would not have enough time to conduct the studies otherwise.

As described above, all student leaders submit their own, individual project proposal complete with a project timeline. We work closely with the students to ensure that their project and the product it produces are completed within a given semester. Of course the larger projects continue indefinitely and the students often stay in the lab working on them for subsequent semesters. Each step of the experiment is carefully planned with the student leader to avoid other time conflicts (school, holiday, work, etc.) and to be completed within a given semester.

Productivity from previous CURCA funded projects (Lloyd/Shanks Collaborative Efforts).
During the past 3½ years, CURCA funding has supported my direction of 43 independent study projects. These projects have resulted in 55 student presentations at national (2), regional (33), and local (20) research conferences. Furthermore, 6 invited presentations at research and leadership conferences have involved the direct participation of these research students. The high level of research these student-focused projects entail is evidenced by the awards and honors these students have received. These include selection for the highly selective CUR Posters on the Hill, 6 student authored research grants from the ☐☐☐ national biolog
honors society awards at the Southeastern Psychological Association Conference, 2 ☐☐☐ awards at
of Southeastern Biologists Conference, 2 awards at the Georgia Academy of Sciences meetings, and multiple awards at NGCSU. The list below represents the presentations and awards supported by last year's CURCA funding along with 2 student co-authored peer-reviewed manuscripts published this past year (* represents NGCSU students):

Peer Reviewed Publications:
1) Shanks RA, Anderson J*, Taylor JR*, **Lloyd SA** (*in press*). Amphetamine and methamphetamine have a direct and differential effect on BV-2 microglia cells. *Bulletin of Experimental Biology and Medicine*.
2) Shanks RA, Southard EM*, Tarnowski L*, Bruster M*, Wingate SW*, Dalman N, **Lloyd SA** (*2012*). A vodcasted, cross-disciplinary, behavioral neuroscience laboratory exercise investigating the effects of methamphetamine on aggression. *Bioscene, 37*(2): 10-17.

The Association of Southeastern Biologists Conference, Athens, GA.
1) Bryant S*, Schulz J*, Tavares C*, Doyle HH*, Shanks RA & **Lloyd SA** (2012). Effects of adolescent methamphetamine exposure on methamphetamine sensitization in adult mice.
2) Phillips B*, Herdliska A*, Shanks RA & **Lloyd SA** (2012). An assessment of a novel behavioral neuroscience laboratory exercise.
3) Pass J*, Gonzalez E*, Helton A*, Herdliska A*, Shanks RA & **Lloyd SA** (2012). The effects of adolescent methamphetamine exposure on executive functions in adult mice.
4) Helton A*, Schulz J*, Shanks RA & **Lloyd SA** (2012). The effects of methamphetamine on PRX antioxidant proteins in a cultured microglia cell line and a mouse model.

The Annual Meeting of the Southeastern Psychological Association, New Orleans, LA.
1) Schulz J*, Tavares C*, Shanks RA & **Lloyd SA** (2012). Adolescent methylphenidate leads to methamphetamine cross-sensitization in adult mice.
2) Tavares C*, Schulz J*, Bryant S*, Shanks RA & **Lloyd SA** (2012). Adolescent d-amphetamine leads to methamphetamine cross-sensitization in adult mice.
3) Bryant S*, Schulz J*, Tavares C*, Doyle HH*, Shanks RA & **Lloyd SA** (2012). Effects of adolescent methamphetamine exposure on methamphetamine sensitization in adult mice.
4) Phillips B*, Herdliska A*, Shanks RA & **Lloyd SA** (2012). An assessment of a novel behavioral neuroscience laboratory exercise.
5) Pass J*, Gonzalez E*, Helton A*, Herdliska A*, Shanks RA & **Lloyd SA** (2012). The effects of adolescent methamphetamine exposure on executive functions in adult mice.
6) Bruster M*, Shanks RA & **Lloyd SA** (2012). The effects of methamphetamine on aggression.

The Annual North Georgia Academic Research Conference, Dahlonega, GA
1) Schulz J*, Tavares C*, Shanks RA & **Lloyd SA** (2012). Adolescent methylphenidate leads to methamphetamine cross-sensitization in adult mice. *****Oral Presentation Award**
2) Tavares C*, Schulz J*, Bryant S*, Shanks RA & **Lloyd SA** (2012). Adolescent d-amphetamine leads to methamphetamine cross-sensitization in adult mice.
3) Bryant S*, Schulz J*, Tavares C*, Doyle HH*, Shanks RA & **Lloyd SA** (2012). Effects of adolescent methamphetamine exposure on methamphetamine sensitization in adult mice. *****Poster Presentation Award**
4) Phillips B*, Herdliska A*, Shanks RA & **Lloyd SA** (2012). An assessment of a novel behavioral neuroscience laboratory exercise.
5) Pass J*, Gonzalez E*, Helton A*, Herdliska A*, Shanks RA & **Lloyd SA** (2012). The effects of adolescent methamphetamine exposure on executive functions in adult mice.
6) Bruster M*, Shanks RA & **Lloyd SA** (2012). The effects of methamphetamine on aggression. *****Oral Presentation Award**
7) Helton A*, Schulz J*, Shanks RA & **Lloyd SA** (2012). The effects of methamphetamine on PRX antioxidant proteins in a cultured microglia cell line and a mouse model.

BBB Honors Society ☐Undergraduate Research Grants:
1) Helton A*, **Lloyd SA**, Shanks RA. " The effects of methamphetamine on PRX antioxidant proteins in a cultured microglia cell line and a mouse model " **Total Award: $355**
2) Pass TJ*, **Lloyd SA**, Shanks RA. " The Effects of Adolescent Methamphetamine Exposure on Executive Functions in Adult Mice " **Total Award: 350**