Supplemental Material

Cooper *et al.*

Supplemental materials for
Research anxiety predicts undergraduate intentions to pursue research-related careers in science

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This supplement contains the following:

Table S1. Institutions represented in the final dataset by institution type and geographic region

R1 Public Universities
R1 Public University #1 (Southwest)
R1 Public University #2 (Northeast)
R1 Public University #3 (Southwest)
R1 Public University #4 (Southwest)
R1 Public University #5 (Midwest)
R1 Public University #6 (Midwest)
R1 Public University #7 (Midwest)
R1 Public University #8 (Southeast)
R1 Public University #9 (Northwest)
R1 Public University #10 (Northeast)
R1 Public University #11 (Southeast)
R1 Public University #12 (Southeast)
R1 Public University #13 (Midwest)
R1 Public University #14 (Southeast)
R1 Public University #15 (Southwest)
R1 Public University #16 (Northeast)
R1 Public University #17 (Midwest)
R1 Public University #18 (Northeast)
R1 Public University #19 (Northwest)
R1 Public University #20 (Southwest)
R1 Public University #21 (Southeast)
R1 Public University #22 (Midwest)
R1 Public University #23 (Midwest)
R1 Public University #24 (Northwest)
R1 Public University #25 (Southeast)
R1 Private Universities
R1 Private University #1 (Midwest)
R1 Private University #2 (Northeast)
R1 Private University #3 (Northeast)
R1 Private University #4 (Northeast)
R1 Private University #5 (Northeast)
R1 Private University #6 (Southeast)
R1 Private University #7 (Northeast)
R1 Private University #8 (Northeast)
R1 Private University #9 (Northeast)
R1 Private University #10 (Northeast)
R1 Private University #11 (Southeast)
R1 Private University #12 (Southeast)
Master's-granting Institutions
Master's-granting Institution #1 (Northwest)
Master's-granting Institution #2 (Northeast)
Master's-granting Institution #3 (Midwest)
Master's-granting Institution #4 (Northeast)
Master's-granting Institution #5 (Southeast)
Master's-granting Institution #6 (Midwest)

Master's-granting Institution #7 (Midwest)
Master's-granting Institution #8 (Northeast)
Master's-granting Institution #9 (Midwest)
Master's-granting Institution #10 (Southeast)
Master's-granting Institution #11 (Southeast)
Master's-granting Institution #12 (Northeast)
Master's-granting Institution #13 (Southwest)
Master's-granting Institution #14 (Southeast)
Master's-granting Institution #15 (Southeast)
Master's-granting Institution #16 (Midwest)
Master's-granting Institution #17 (Southeast)
Master's-granting Institution #18 (Midwest)
Master's-granting Institution #19 (Southwest)
Master's-granting Institution #20 (Northeast)
Master's-granting Institution #21 (Northeast)
Master's-granting Institution #22 (Midwest)
Master's-granting Institution #23 (Southeast)
Master's-granting Institution #24 (Southeast)
Master's-granting Institution #25 (Southeast)
Master's-granting Institution #26 (Midwest)
Master's-granting Institution #27 (Northeast)
Master's-granting Institution #28 (Northeast)
Master's-granting Institution #29 (Northeast)
Master's-granting Institution #30 (Southwest)
Primarily Undergraduate Institutions
Primarily Undergraduate Institution #1 (Midwest)
Primarily Undergraduate Institution #2 (Northeast)
Primarily Undergraduate Institution #3 (Southeast)
Primarily Undergraduate Institution #4 (Northwest)
Primarily Undergraduate Institution #5 (Midwest)
Primarily Undergraduate Institution #6 (Northeast)
Primarily Undergraduate Institution #7 (Northeast)
Primarily Undergraduate Institution #8 (Northeast)
Primarily Undergraduate Institution #9 (Southeast)
Primarily Undergraduate Institution #10 (Southeast)
Primarily Undergraduate Institution #11 (Southwest)
Primarily Undergraduate Institution #12 (Southeast)
Primarily Undergraduate Institution #13 (Midwest)
Primarily Undergraduate Institution #14 (Midwest)
Primarily Undergraduate Institution #15 (Northeast)
Primarily Undergraduate Institution #16 (Midwest)
Primarily Undergraduate Institution #17 (Midwest
Primarily Undergraduate Institution #18 (Midwest)
Primarily Undergraduate Institution #19 (Southeast)
Primarily Undergraduate Institution #20 (Midwest)

Copy of survey items analyzed

Attitudes Toward Research Anxiety Subscale (Papanastasiou & Zembylas, 2008)

Only questions 1-5 were used in the analysis for this manuscript.

	Strongly disagree (1)	(2)	(3)	(4)	(5)	(6)	Strongly agree (7)
1. Research makes me anxious							
2. I feel insecure concerning the analysis of research data							
3. Research scares me							
4. Research is stressful							
5. Research makes me nervous							
6. Research is complicated							
7. Research is difficult							
8. Research is a complex subject							

Open-ended questions probing what aspects of undergraduate research affect students' research anxiety

Reflecting on your research experience, please describe any aspects of your undergraduate research experience that **increased** your feelings of anxiousness.

Reflecting on your research experience, please describe any aspects of your undergraduate research experience that **decreased** your feelings of anxiousness.

Current intent to pursue research (Corwin et al., 2018; Estrada et al., 2011)

	Definitely will not 1	2 3 4 5 6 7 8 9	Definitely will 10
To what extent do you plan to pursue a science-related research career?			

Prior intent to pursue research (Corwin et al., 2018; Estrada et al., 2011)

	Definitely will not									Definitely will
	1	2	3	4	5	6	7	8	9	10
Prior to your first undergraduate research experience, to what extent did you intend to pursue a science-related research career?										

Demographic questions

I most closely identify as
- Woman
- Man
- Other, please describe
- Decline to state

I most closely identify as
- American Indian or Alaska Native
- Asian or Pacific Islander
- Black or African American
- Hispanic, Latinx, or Spanish Origin
- White/Caucasian
- Other, please describe
- Decline to state

I most closely identify as a
- First-generation college student whose parents' highest level of education is a high school diploma or less
- Non-first-generation college student (at least one parent has some college or a college degree)
- Decline to state

What is your grade point average (GPA)?

How long have you attended college while pursuing your undergraduate degree?
- 1 year or less (first-year student)
- 2 years (sophomore)
- 3 years (junior)
- 4 years (senior)
- 5 years or more
- I have graduated with my undergraduate degree

Table S1. Coding rubric for factors that increase student anxiety in research

Factors that increase student anxiety in research	Description
Failure and mistakes	Student describes feeling anxious about messing up an experiment or procedure. This category includes a student expressing fear of doing something wrong, failing, destroying samples, etc. Specifically, the student may describe that they work with hazardous chemicals or are afraid of causing harm to animals. If a student says that not getting results makes them feel anxious, that is coded here. If a student talks about limited reagents or samples, that is coded here.
Lack of preparation/ understanding	Student describes feeling anxious due to a lack of knowledge, understanding, ability, or experience. This category includes not understanding or needing to learn science, the purpose of something, a protocol, how to do a technique, etc. This category also includes if a student expresses concern about not being able to meaningfully or intellectually contribute to a project. If student mentions that learning is stressful, it is coded here. If a student mentions that performing unfamiliar experiments makes them anxious, it is coded here.
Time balance	Student describes feeling anxious due to trying to balance the time they're required to spend in research and other commitments including academics or other opportunities outside of lab. Additionally, if a student describes that research takes too much time or causes an increased workload it is coded here. If a student describes that it is hard to time experiments with coursework, that is *not* coded here. If a student mentions time but it is unclear that they are anxious about balancing their time, it is not sufficient to be coded here.
Insufficient guidance	Student describes feeling anxious because they do not have enough guidance or experience a lack of communication. If a student describes that they do not fully grasp what they are being asked to do, that is coded here. If a student describes that they are anxious to do something on their own or independently, this is coded here. If a student talks about feeling anxiety because they work alone, that is also coded here.
Presentations	Student describes feeling anxious about giving a presentation. This can include fear of any oral communication in front of the lab as a whole or a large group. If a student describes feeling anxious about asking or answering questions, that is *not* coded here.
Short deadlines	Student describes feeling anxious about having to do work/research/something (but *not* a thesis) in a short or unpredictable amount of time or having to learn something in a short period of time. If a student talks about the need to produce results in a certain period of time, that is coded here.
Lack of progress/product	Student describes feeling anxious because they are not making sufficient progress on their research. This includes worrying that they will not meet a long-term deadline such as doing the work for their thesis, or the work needed to produce a paper.
PI	Student describes feeling anxious because they are worried about getting a critique from the PI in response to something that they have done, being blamed for something, being yelled at, etc. This category does *not* include simply feeling nervous when the PI is watching.
Lab environment	Student describes feeling anxious because they do not feel like they fit in, feel different from, or don't belong in the lab. This category also includes a student feeling anxious because they do not know others in the lab, are not friends with others in the lab, or do not get along with others in the lab (*besides the PI*). If a student mentions being frustrated with people's behavior, that is coded here. If a student generally mentions that anyone in the lab makes the student anxious, that is coded here.
Negative response	Student describes feeling anxious because they are worried about getting critique from someone in response to something that they have done, being

	blamed for something, being yelled at, etc. This category does *not* include simply feeling nervous when someone is watching.
Wanting to please	Student describes feeling anxious because they want to please their mentor, do not want to disappoint their mentor, or want to prove themselves. A student can also express that they are anxious about being inadequate, not meeting standards or expectations, or because they feel they are wasting lab time or resources. If someone describes that they do not want to let others down or that they are worried about failing someone, that is coded here.
Tasks or techniques	Student describes feeling anxious because they are charged with doing a complicated procedure, complex task, or working with a particular model organism.

Table S2. Coding rubric for factors that decrease student anxiety in research

Factors that decrease student anxiety in research	Description
Positive lab environment	Student describes that their anxiousness decreases because the lab environment is good, claiming they have friends/acquaintances in the lab. Student feels like they belong or that they are not alone in how they feel.
Positive relationship with mentor	Student describes that their anxiousness decreases because their mentor is nice, human, relaxed, approachable, or any evidence of more human behavior. This category also includes if the student mentions having a relationship with their mentor. If the student describes that the mentor is supportive, but it is not clear that they are supportive with in regard to the lab work, that is coded as sufficient guidance.
Sufficient guidance	Student describes that their anxiousness decreases because they feel like they can ask questions or seek help if they are stuck. Student feels as though they receive sufficient help or guidance. This includes feeling supported in their work or receiving feedback on their work. If a student mentions communicating or talking with a mentor and talking about the research or research process, that is coded here.
Praise from mentor	Student describes that their anxiousness decreases because their mentor provides positive reinforcement, encouragement, or praise.
Preparation	Student describes that their anxiousness decreases because they have practiced lab tasks or techniques. Confidence in knowledge or ability to do something or an increase in knowledge is also coded here.
Progress	Student describes that their anxiousness decreases when making progress on the research project. This includes getting results, doing something on their own, working independently, or that the science is working.
Norming research	Student describes that their anxiousness decreases because they realize something about research - e.g., how complex it is, that failure is normal. This can include that they realize that others struggle or have to figure out things. This also includes realizing that others make mistakes or others sharing stories of times that they have made a mistake.
Flexible scheduling/meeting	Student describes that their anxiousness decreases when the lab is understanding of the students' research/life (e.g., school, extracurriculars) balance. This includes mentioning when people are accommodating of schedules.

Table S3. Additional factors that increase student anxiety in the context of undergraduate research, reported by fewer than 10% of participants

Factors that increase student anxiety in research	Description	Example student quote	Example student quote	Percent of students who reported each factor (N = 1026)
Presentations	Student's anxiety increases because of having to give a presentation or speak publicly, often in front of more senior people in the field.	Student 206: I feel anxious when presenting my work in front of the entire lab.	Student 442: Presenting and speaking opportunities have also increased as a result of my research which also increases my anxiety, especially when talking to professionals in my field.	8.8%
Short deadlines	Student's anxiety increases because they have to do something (e.g., work/research/writing) in a short or unpredictable amount of time or they have to learn something in a short period of time.	Student 515: I was asked to learn a skill for my research in three weeks and felt anxious about whether or not I would be able to do it in time.	Student 616: The reasons I would feel anxious in the lab all resulted from meeting deadlines. (…) The pressure from deadlines attributed to much nervousness and anxiety.	8.6%
Lack of progress/ product	Student's anxiety increases because they are not making sufficient progress on their research. This includes worrying that they will not meet a long-term deadline such as doing the work for their thesis, or the work needed to produce a paper.	Student 85: I have also felt very anxious when a project was not moving forward and I had not accomplished anything because my work on the project depends on others completing previous steps.	Student 144: I only feel more anxious when I am unsure if this research will lead to anything, like a publication or presentation.	6.7%
Primary investigator (PI)	Student's anxiety increases due to an interaction with the PI, often because they perceive the PI as intelligent, skilled, or important.	Student 692: I highly respected my PI, and he is brilliant, organized and efficient. (…) I was paralyzed with fear about my poor mental math skills, which he would often quiz us on (a silly thing to be nervous about, but something that when I messed up I felt so, so small).	Student 526: At first I felt very anxious working with the PI because I had never discussed research before with someone so high up in a field.	5.8%
Lab environment	Student's anxiety increases because they do not feel like they fit in or belong in the lab. This category also includes a student feeling anxious because they do not know others in the lab, are not friends with others in the lab, do not get along with others in the lab, or are not treated well by others in lab (besides the PI).	Student 587: When my peers disrespected or ignored me and won't let me help with their experiments.	Student 522: Being in a lab environment where I consistently felt different from my peers because I was there more often but I wasn't close friends with any of them and they were all close-knit.	5.8%

Negative response	Student's anxiety increases when they experience or anticipate experiencing getting critiqued, yelled at, reprimanded, or blamed in the lab.	Student 586: The faculty member blamed every wrong thing on me. Also, the students I worked with took advantage of the fact that I didn't know some things and blamed me for every mistake.	Student 607: I am anxious when I first get to the lab, the staff members who work with me tend to put the blame on the undergraduates even in situations that were out of the control of us. I am nervous that when I get to the lab I will get yelled at or put down for something that I did not do wrong.	5.6%
Wanting to please	Student's anxiety increases because they want to please their mentor, do not want to disappoint others in the lab, or want to prove themselves. This also includes when a student's anxiety increases because they feel inadequate, are not meeting standards or expectations, or because they feel they are wasting lab time or resources.	Student 449: I felt like I needed it to be perfect or I would let down the grad student.	Student 544: I feel as though my lab puts a lot of pressure on success. This is a good and bad thing, but I am constantly worried about disappointing members of my lab.	4.4%
Tasks or techniques	Student's anxiety increases because they are charged with doing a complicated procedure, complex task, or working with a particular model organism.	Student 158: During my work in the field, we worked with large sharks and many high-stakes situations.	Student 155: Having to perform certain tasks with mice alone made me anxious, such as having to remove them from the testing chambers (they usually jumped out or were unpredictable - I also was bit hard enough to bleed with a certain mouse), having to scruff them (puts them in a lot of stress), etc. Almost all behavioral work with mice made me feel anxious at some point.	4.3%

Table S4. Additional factors that decrease student anxiety in the context of undergraduate research, reported by fewer than 10% of participants

Factors that decrease student anxiety in research	Description	Example student quote	Example student quote	Percent of students who reported each factor (N = 1037)
Norming aspects of research	Student's anxiety decreases because they realize that research is complex, that failure is normal, or that everyone makes mistakes.	Student 215: Stories of my graduate student's mistakes early in their career (we're all human).	Student 618: My mentor explained that there's always a possibility that I could have done everything right, and things just don't like to work out. (…) I would also feel better when I saw [my mentor] mess up, because then I know it isn't just me making mistakes.	8.1%
Flexible scheduling/ meeting	Student's anxiety decreases because people in the lab are flexible with their schedule or understand that they have other commitments (e.g., school, extracurriculars). Additionally, students may appreciate that the type of research they do allows for their research schedule to be flexible.	Student 487: [My PI] was understanding that I am a student first right now and worked around my schedule as much as she could, and I worked around her schedule as much as I could. There was a lot of mutual respect for what we were each doing.	Student 279: The flexibility in lab schedule is very helpful in this regard. As long as I am able to come to the lab for the amount of hours I am assigned to, it does not matter the exact times I came in.	5.4%

EFA on half of sample: 2-factor solution

Round 1:
Factor Analysis using method = wls
Call: fa(r = efa_samp, nfactors = 2, rotate = "oblimin",
max.iter = 500,
    fm = "wls")
Standardized loadings (pattern matrix) based upon correlation
matrix

```
     WLS1  WLS2   h2   u2 com
AQ1  0.85 -0.04 0.70 0.30 1.0
AQ2  0.62  0.10 0.45 0.55 1.1
AQ3  0.83 -0.05 0.65 0.35 1.0
AQ4  0.54  0.29 0.52 0.48 1.5
AQ5  0.91  0.01 0.84 0.16 1.0
AQ6  0.04  0.89 0.82 0.18 1.0
AQ7  0.09  0.79 0.69 0.31 1.0
AQ8 -0.12  0.82 0.59 0.41 1.0
```

```
                       WLS1 WLS2
SS loadings            3.02 2.25
Proportion Var         0.38 0.28
Cumulative Var         0.38 0.66
Proportion Explained   0.57 0.43
Cumulative Proportion  0.57 1.00
```

 With factor correlations of
```
     WLS1 WLS2
WLS1 1.00 0.45
WLS2 0.45 1.00
```

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