

**Applicant:** Arun Rajarajan

**Note:** Fully addressing these questions is required for approval. Please work with your mentor to complete any aspects you are unsure of.

### **Literature review/Introduction**

Your literature review/introduction should address each of the following questions. You can either answer each question as a “line item” or in a narrative/paragraphs format.

- 1) What is the big picture question of your study? (how would you explain it to someone who is not in your field?)
  - a. Does anxiety have an influence on value-directed learning? That is, does anxiety influence what items we prioritize learning/remembering, items with positive value or items with negative value? Do people group items in a particular way, such as remembering the positive high-value words?
- 2) What does the existing literature say about this question? Include at least 5 relevant citations.
  - a. Stimulus-reinforcement-based decision making and anxiety: Impairment in generalized anxiety disorder (GAD) but not in generalized social phobia (GSP). (DeVido)
    - i. “patients with GAD committed a significantly greater number of errors compared to both the patients with GSP and the healthy comparison individuals”
  - b. Probabilistic Learning by Positive and Negative Reinforcement in Generalized Anxiety Disorder (LaFreniere)
    - i. “Results showed that those with GAD learned the correct probabilistic choices at a slower rate over time and to a lesser degree than control participants regardless of reinforcement type”
  - c. The Relationship of Anxiety and Stress With Working Memory Performance in a Large Non-depressed Sample (Lukasik)
    - i. Negative association between working memory and anxiety
  - d. Anxiety and selective attention to threat in tactical decision-making (Matthews et al.)
    - i. “Trait anxiety was associated with a bias in information search, favoring sampling of information about possible losses, but only with a neutral mood induction. Anxiety may not be associated with a general, automatic bias towards threat on”
  - e. Castel et al (2002)
    - i. young adults were better at recalling more words than older adults as we might expect; older adults were more selective and strategic of the higher-valued words despite their reduced general memory
  - f. Murphy & Knowlton (2022)
    - i. as far as I can see from my research so far, this study is the only one that has utilized a loss manipulation albeit using a between-subjects design whereas mine will be within-subjects; they found that the effects weren’t huge but there was still some evidence that individuals were more responsive, that is they were more selective towards higher-valued words when their goals were framed in terms of gains as opposed to in terms of losses
- 3) What is the gap in knowledge that your study will address?
  - a. The effect the possibility of loss has on the value-directed learning paradigm is largely unstudied, and furthermore, the potential effects anxiety may have on prioritization strategies utilized in value-directed learning is unstudied as well.

- 4) What are your specific hypotheses? If you are doing an exploratory study to establish a domain of knowledge (too early to have hypotheses) what knowledge will your study contribute and how might this advance future research?
- a. Individuals with anxiety will show poor overall recall and will show worse selectivity for higher-valued items compared to healthy controls.
  - b. More specifically, individuals with anxiety will have overall disrupted reward and punishment systems and therefore not demonstrate any priority towards recalling positively-valenced words over negatively-valenced words or vice-versa; additionally, they will not demonstrate priority towards recalling higher-valued words over lower-valued words.

## Research design

*Participants:* How many, who they will be, how recruited/obtained. If possible, include a power analysis justifying the sample size. If secondary data analysis describe the source of the data.

Participants will be adults who do or do not self-identify as having anxiety. (This is a screening question that is part of their Prolific profile.)

The relative novelty of this study (to our knowledge there has been no within-subjects comparison of loss- vs gain- valuations on value-directed learning even in healthy participants, and we are not aware of any studies of anxiety and value-directed learning) makes it difficult to estimate effect sizes for a formal power analysis. My current plans are to recruit 90 participants (45 Anxiety group and 45 Control group) online through Prolific who will then access the experiment through Prolific.

Using G\*Power 3.1.9.7 (Faul et al., 2007, 2009) and the default estimates of correlation between repeated measures (.5) and nonsphericity correction (1), power of .80 to detect a within-between interaction would require a total sample size of 24 at a medium effect size ( $f = .25$ ), and a total sample size of 138 at a small effect size ( $f = .1$ ). A sensitivity analysis indicates that with a sample size of 90 (45 per group) we have power of .80 to detect an effect size of .124

*Methods:* What tasks, surveys, biological assays (including neuro) or other measures will you be using to collect your data? You don't have to give all the details (# of questions etc.) – just provide a sufficient description to allow someone who is not in your lab to understand how your measures map onto the concepts central to your research (e.g., “To measure proactive control, I will use the AX-Continuous Performance Test (AX-CPT, Braver et al., 2007). This test measures proactive control by....” In addition to describing the data collection tools (tasks, etc.), describe the steps the participants will go/have gone through from start to finish as if you were writing a recipe.

Participants will begin the experiment by reading through the details of the study and will be asked to give informed consent. After this, they will go through a calibration task because I want to discourage any potential cheating such as writing down the words by running these calibration trials to see how quickly they can make a judgment about the word as I am planning on doing this as an online study. So, participants will be shown a list of 10 words and for each word they must press the letter corresponding to its first letter as quickly as they can. I am including the calibration task because I am planning on doing

this as an online study and I want to discourage any potential cheating such as writing down the words by. To measure anxiety, I will use the State-Trait Anxiety Inventory (STAI, Spielberger et al., 1983) with the State Anxiety portion of the survey being administered after the calibration trials. This survey is a self-report asking participants to read through a series of statements that may describe how they are feeling *in the moment* and then rank how accurate the statement is to how they're feeling currently using a 4-point Likert scale. Afterwards, they will read instructions for the Learning task which explains that the task consists of a list of 40 words that participants must read through, each with a point value associated with it. The cue with the value comes up for 2 seconds and can be positive or negative 5 or positive or negative 10 with the negative values appearing in a red color and the positive values appearing in a green color. The word will show up after that for 3 seconds and will appear in the same color as the preceding value to reinforce the connection between the two. Once again we're going to ask them to press the first letter so we know they're actually completing the task. After the 3 seconds, there will be a blank screen displayed for 1.5 seconds before the next value cue is presented. In order to help participants learn the words and develop a strategy, they will see the list 3 times. Participants will then complete a free recall test after completing the questionnaire on Qualtrics. They will be given 5 minutes to write down as many of the words as they remember.

Participants will then complete the State Anxiety portion of the STAI again after the Recall task. The Trait Anxiety portion will then be administered afterward which asks participants to rate how a series of presented statements accurately reflects how they feel *generally* using a 4-point Likert scale. Upon completing the STAI State and Trait surveys, participants will then complete the General Anxiety Disorder-7 (GAD-7, Spitzer et al., 2006) questionnaire to measure the severity of anxiety that participants have which will confirm that the participants have correctly self-identified as having anxiety for the Anxiety group or as not having anxiety for the Control group. Then the participants will complete the Patient Health Questionnaire-9 (PHQ-9, Kroenke, K. & Spitzer, R.L., 2002) which assesses the degree of depression severity based on the participants' responses to the questions. After completing the PHQ-9, participants will be asked three questions: 1. What strategies, if any, did you use when LEARNING the items you were trying to remember? 2. What strategies, if any, did you use when trying to RECALL the words on the final memory test? 3. Do you have any comments, questions, or things you would like to tell us about your participation today? Answers to these questions will help me to determine any clustering strategies that participants used to both learn and recall the words. After answering, participants will be thanked and given monetary compensation for their participation.

### **Statistical Design/Analysis Plan**

Note: Many theses include more than one method (e.g., both an experimental manipulation and a correlational analysis within groups; or correlations on quantitative data plus a qualitative analysis of written or verbal responses) In that case give the relevant information for each analysis. *The most important thing is that your reader can understand how your data analysis will address the hypotheses/questions you put forth in the last section of your literature review/introduction*

*Experimental studies:* What are your independent and dependent variables? What tests will you use to examine relations between them? (t-test, anova, etc) Be sure to indicate how the results will relate to/test your hypotheses. (e.g., "If my hypothesis that time-management strategies reduces stress is correct, an 2 x 2 ANOVA (Group (training, no training) X Time (beginning of semester, end of semester) will show that people who successfully complete the training and implement the strategies will show smaller increase on the College Student Stress Scale (Feldt, 2008) over the course of the semester than will those who do not")

The independent variables of my study are *anxiety* which will be between-subjects as participants will self-identify as having anxiety or not, while *valence*, which will be positive or negative where points are gained for remembering or lost for forgetting, respectively, and *value*, which will be low or high, will be within-subjects. The dependent variables we will measure are the overall recall of the words and the selectivity index to determine how good the participants are at prioritizing high-value words. We will also possibly do secondary analyses of clustering to determine how participants grouped what items to remember together. Initial plans are to analyze with a 2 (Group: Anxiety, Control) X 2 (Valence: gain, loss) X 2 (Value: high, low) ANOVA. If my hypothesis that individuals with anxiety will have lower recall overall is correct, there will be a main effect of Group on recall scores, with overall lower recall scores for the Anxiety group. If the hypothesis that individuals with anxiety also have less value-sensitivity overall is correct, there will be a Group X Value interaction (cross over interaction: controls remember proportionally more high-value and fewer low-value items than individuals with anxiety) for overall recall scores, and a main effect of Group (lower selectivity scores for individuals with anxiety) for selectivity scores. Predictions for the Valence manipulation are not as clear, but one possibility is that controls will prioritize gain words over loss words more than individuals with anxiety (Group X Valence interaction), and do so more for high-value words (3-way interaction). Additional secondary analyses may be conducted to help understand individual and group differences. For example, as anxiety and depression are often strongly correlated, if the Control and Anxiety groups differ in their depression scores, ANCOVA or regression will be used to determine if anxiety is still a significant predictor of performance after controlling for depression.

*Individual differences studies:* What are your predictor and outcome variables? What tests will you use to examine the relations between them? Be sure to indicate how the results will relate to/test your hypotheses. (e.g., "If my hypothesis that people who are more stressed are less likely to have the proactive control to successfully implement time-management strategies is correct, then I will first find a negative correlation between initial scores on the College Student Stress Scale (Feldt, 2008) and the number of times people successfully report using the strategies. In addition, subsequent mediation-moderation tests are hypothesized to show that this relationship is mediated by performance on the proactive control task described in Methods").

*Qualitative studies:* How will your data be summarized, how will themes be drawn out, etc? There are many different types of qualitative research and you should consult with your mentor on how to organize this section. However, in most cases your response should address each item under the "data analytic strategies" from APA <https://apastyle.apa.org/jars/qual-table-1.pdf>

### **Timeline and mentorship:**

1. Who are your mentor(s)? Describe the plan for getting their input and feedback on your progress and writing, including how often and in what format (email, in-person meetings, zoom) such meetings will occur.
  - a. Mentor: Dr. Cindy Lustig
  - b. Set up a time to meet weekly on zoom to discuss progress on writing and updates on data collection and analysis

- c. Also send updates through email, especially for small updates or questions that don't require a full-fledged meeting
2. If you do not already have IRB/IACUC approval, describe your plan/timeline for this component:
  - a. Have already received IRB approval
3. The thesis seminar will provide support for writing/revising sections of your thesis roughly on the timeline described below. If you will be actively following that timeline you can just say "following the seminar timeline". Otherwise, provide the alternative dates by which you will complete each section. **NOTE THAT A FULL ROUGH DRAFT OF THE THESIS – FROM TITLE PAGE THROUGH REFERENCES – IS DUE THE FIRST FRIDAY OF MARCH.** (First Friday of November for students starting in Winter/graduating in Fall). Be sure to plan the steps of your thesis accordingly!
  - a. Following the seminar timeline

Thesis seminar support/writing activities

End of September: Methods outline/rough draft (do not yet need to have all the details yet)

Early October: Analysis plan outline/draft

End of October/beginning of November: Introduction first paragraph and outline

Nov-Jan: work on literature review and (if not already completed) data collection and analysis

3<sup>rd</sup> week of January: final/near-final draft of Methods

2<sup>nd</sup> week of February: Results outline/rough draft - if data collection/analysis is not yet finished, a list of likely tables and figures with "fill in the blank/mad libs" text is acceptable

3<sup>rd</sup> week of February: Discussion outline/rough draft; title and abstract draft

MANDATORY: Full draft due to Canvas and thesis mentor by first Friday of March.

March – poster draft; receive feedback from mentor and make revisions

MANDATORY: Final draft (i.e., for 2<sup>nd</sup>-reader evaluation and grading) of thesis and APA checklist due first Friday of April. Poster session end of April.