***Research Aim 1***

To establish the efficacy of utilizing response time models with quantitative assessments of attention, executive control, and working memory.

**Hypothesis 1.** I hypothesize that response time distributions from the data will fall within a 95% highest density ratio (HDI) of the posterior predictive distribution.

Hypothesis 1A: The response time distribution from the Attention Network Test data will fall in 95% of the posterior HDI based on the shrinking spotlight model.

Hypothesis 1B: The response time distribution from the Dual N-Back Task data will fall in 95% of the posterior HDI based on the Linear Ballistic Accumulator model.

Hypothesis 1C: The response time distribution from the Open-Source Anticipated Response Inhibition data will fall in 95% of the posterior HDI based on the BEESTS-CV model.

***Research Aim 2***

To utilize response time modelling to assess changes in the cognitive measures throughout the last four weeks of a semester.

**Hypothesis 2.** I hypothesize that response time modeling will capture valid, ecological changes in participant cognition at the end of the semester, as measured by posterior estimates of the relevant regression coefficients having greater than 95% of the probability in the appropriate direction.

Hypothesis 2A: There will be a 95% or higher posterior probability increase in the interference time parameter across the four weeks.

Hypothesis 2B: There will be a 95% or higher posterior probability increase in the stop-signal reaction time parameter across the four weeks.

Hypothesis 2C: There will be a 95% or higher posterior probability decrease in the workload capacity parameter across the four weeks.

***Research Aim 3***

To evaluate the impact of end of semester stress on performance for the three cognitive function assessments.

**Hypothesis 3.** I hypothesize that the data will be at least three times more likely under hierarchical mixed-effect models including stress as a factor impacting cognition than under models that do not include stress (as predicted by Bayes factors).

Hypothesis 3A: The hierarchical mixed-effect model for interference time that includes stress scores will be at least three times more likely to explain the data than the model that does not include stress.

Hypothesis 3B: The hierarchical mixed-effect model for stop-signal reaction time that includes stress scores will be at least three times more likely to explain the data than the model that does not include stress.

Hypothesis 3C: The hierarchical mixed-effect model for workload capacity that includes stress scores will be at least three times more likely to explain the data than the model that does not include stress.

**CHAPTER 3: METHOD**

**Participants**

The 15 participants that will be included in this study will be drawn from the psychology community at the University of Texas at San Antonio (UTSA). To be included in this study, an individual must be a UTSA psychology student. An individual will be excluded from this study if they are unable to respond to visual and auditory stimuli. Additionally, all participants will be required to complete the tasks in-person during the last four weeks of the semester, so an individual would be excluded from this study if they will be unable to travel to campus during the data collection time frame.

**Recruitment**

To recruit for this study, flyers will be placed on bulletin boards throughout campus buildings. Additionally, a summary of the study design and criteria will be emailed to graduate students within the psychology department. Participants will receive a $15 gift card for each of the four times they complete the experiment, with an additional $20 gift card given to the participants who complete the assessment at all four timepoints. There are no projected costs of completing the experiment, beyond the time necessary to complete the assessments, which should not surpass one hour per week.

**Measures**

***Demographics***

The only demographics that will be recorded for this study are age, gender, ethnicity, and race. No identifying information will be collected.

***Attention: The Attention Network Test***

The Attention Network Test (ANT; Fan et al., 2002) was designed to assess three areas of attention: alerting, orienting, and executive function. In this computerized task, participants are presented with a string of arrows (e.g., < < > < <), and are instructed to press the corresponding arrow key on their keyboards to select which direction the central arrow is pointing. The central arrow can be flanked by arrows pointing the same direction (congruent trials), arrows pointing the opposite direction (incongruent trials), or by squares (neutral trials). Throughout the task, the string of arrows will appear at the top or bottom of the screen. Participants may be primed to look towards the location the arrows will appear with the image of a square. There are four types of priming throughout the experiment: central cue, spatial cue, no cue, and dual cue. In central cue trials, a square briefly appears in the center of the screen before the arrows are presented. In spatial cue trials, the square will flash in the location the arrows will next appear (either the top or bottom of the screen). In no cue trials, no square will appear before the arrows. In dual cue trials, a square will appear at both the top and bottom locations, regardless of where the arrows will appear next. Altogether, there are 48 combinations of stimuli (2 arrow directions x 3 flanker conditions x 2 screen locations x 4 cue conditions). The response time and accuracy for each trial is recorded.

***Executive Control: The Open-Source Anticipated Response Inhibition Task***

The Open-Source Anticipated Response Inhibition Task (OSARI; He et al., 2022) is a computerized task designed to measure executive control. During this task, participants will hold a button to fill a bar to the point of a threshold that is indicated by arrows. These trials, which constitute 75% of the experimental blocks, are called GO trials. STOP trials make up the remaining 25%. In STOP trials, the bar will randomly stop filling, and the participant must continue to hold the button for the expected amount of time. The accuracy and response times are collected, and the data is analyzed with a Bayesian form of ex-Gaussian modeling (Matzke et al., 2013).

***Working Memory: The Dual N-Back Task***

The Dual N-Back (DNB; Heathcote et al., 2015) assessment for this study is a computerized task, testing a participant’s working memory capacity by requiring the participant to remember two pieces of information about a series of stimuli. In this task, the participants will receive visual and auditory cues, and will need to remember the visual and auditory cue from 2 items before the current cue, throughout a steady stream of new stimuli. For each set of stimuli, the participants will be required to make a go/stop decision, and the response times are recorded. By assessing a participant’s workload capacity coefficient, this task can be utilized to evaluate changes in working memory.

***Stress: The Perceived Stress Scale-10***

The Perceived Stress Scale-10 (PSS) was developed by Cohen and Williamson (1988) to assess stress perception. This scale consists of ten 5-point Likert scale items, that are scored from zero (“Never”) to four (“Very often”). The PSS is one of the most widely used self-report assessments for stress, and is considered reliable (α > .7; Lee, 2012). Importantly for this study, the PSS has been used to predict inflammatory responses, and is linked to an increase in IL-6 (Cohen et al., 1999). The current study received permission to use the printed version of the PSS (Mapi Research Trust, Lyon, France, https://eprovide.mapi-trust.org).

**General Procedures**

***Participant Enrollment***

Individuals will be able to enroll in the experiment until five weeks before the end of the fall 2024 semester. When participants sign up for the experiment, they will be randomly assigned to complete one of the three cognitive tasks (with five participants per cognitive task). Participant enrollment will end when all 15 openings are filled, or when data collection begins.

***Data Collection***

This study will be completed in-person, with data collection occurring once a week, for the last four weeks of the semester. During the first week, participants will be provided with an informed consent, and the researcher will explain the cognitive task. If the participant consents to the study, they will be assigned a unique, random word, which will be used as their participant identification. The participant will then begin the experiment by completing a paper version of the PSS. Next, the participant will be shown to the computer where they will complete the cognitive task. The cognitive assessment will take roughly 30 minutes to complete. The task will end with a prompt to report their demographics and random word. Once the participant has completed the data collection for the day, they will be given a $15 gift card, and will be reminded to return the following week. For the next three weeks, the participants will complete the same cognitive task (and the PSS), with a $15 gift card given each time. If the participant returns for all four weeks, they will receive an additional $20 gift card.

***Data Cleaning***

The data cleaning procedure will be the same for all three cognitive tasks. First, a participant’s will be removed if they exited the experiment before completing the task. Next, all practice trials will be removed. Then, trials will be removed if the response was faster than 250 ms, or if there was no response. If this cleaning procedure results in more than 15% of the trials missing, the participant will be excluded. If there is less than 15% of the trials missing, Bayesian imputation will be used to simulate the missing data.

***Model Fitting***

**Attention**. The ANT will be fit with a modified version of the drift diffusion model, the shrinking spotlight model (White & Curl, 2018). This model was created specifically for flanker tasks, and is comprised of six parameters: boundary separation, perceptual strength, non-decision time, starting point, spotlight width, and shrinking rate. Spotlight width and shrinking rate trade off with each other, so they are evaluated as a ratio, which is referred to as interference time (White & Curl, 2018). This interference time provides an indicator of attentional control, and will be the parameter of concern for the attention construct in the current study. Thus, after the data has been cleaned, Stan-based Bayesian estimation will be used to fit the shrinking spotlight model to the ANT data.

**Executive Control**. The OSARI task was built to be modeled with Bayesian Estimation of Ex-Gaussian Stop-Signal (BEESTS) model (He et al., 2022). This model estimates the three ex-Gaussian parameters (mean, standard deviation, and exponential tail) for both the GO and STOP distributions. As the goal of the OSARI is to test a participant’s anticipated response inhibition, the parameters of most concern for the OSARI task are the mean and tail parameters for STOP trials. In specialized BEESTS models (Context-Independence Violation BEESTS models, or BEESTS-CV models), the mean and tail parameters can be combined to create a stop-signal reaction time (SSRT) parameter (Matzke et al., 2021). As these calculations are non-trivial, the authors provided an open-source software (the BEESTS software package), to fit OSARI data with the BEESTS-CV models, and provide parameter estimates (Matzke et al., 2013). Thus, BEESTS software will be utilized for model fitting of the OSARI data from this study.

**Working Memory**. The DNB task data will be fit with linear ballistic accumulator (LBA) models, using Stan-based Bayesian estimation. The main LBA model parameters are drift rate, response caution, and non-decision time (Donkin et al., 2011). Rather than relying solely on the model parameters (as planned for the ANT and OSARI data), the LBA modeling will be used in conjunction with systems factorial technology (SFT). SFT is an alternative to parametric evidence accumulator models, can evaluate response times and accuracies in theoretically meaningful interpretations of the underlying processing architectures (Townsend & Wenger, 2004; Cox & Criss, 2017). Recent research has illustrated that SFT can be incorporated into the analysis of accumulator models (such as the LBA), to provide an estimated workload capacity for DNB tasks (Eidels et al., 2010; Heathcote et al., 2015). As working memory capacity is a specific concern for CRCD, the current project will utilize this technique of combing LBA and SFT to analyze the DNB response time distributions. Thus, when evaluating changes in cognition across time (as planned for Experiment 2 and Experiment 3), the workload capacity coefficient will be the parameter of interest.

**Specific Procedures**

***Data Analytic Plan for Experiment 1***

The first experiment will evaluate the efficacy of response time modeling in representing the participant data for each of the three tasks (addressing Research Aim 1). To accomplish this, the participant data for each task will be compared to predictions from the corresponding model. The participants’ data will be fit with the appropriate response time model. Then, posterior predictive distributions will be generated from the model. Finally, the distribution of posterior distributions will be compared to the participant’s observed response time distribution at five quantiles (0.1, 0.3, 0.5, 0.7, 0.9). The model will be deemed acceptable if the observed distribution falls within a 95% high density interval (HDI) of the posterior predictive distribution. This process will be identical for each of the three cognitive assessments.

***Data Analytic Plan for Experiment 2***

The second experiment will evaluate changes in the cognition parameters across the four weeks (addressing Research Aim 2). This change will be assessed with Bayesian hierarchical mixed-effect models. The change in the parameter will be considered substantial if…

**Attention.** The attention model will evaluate the factors that impact changes in the interference time parameter. The model will include the time point and participant identification as random factors. A coefficient for condition will also be included.

**Executive Control.** The executive control model will evaluate the factors that impact changes in the stop-signal reaction time parameter. The model will include the time point and participant identification as random factors.

**Working Memory.** The attention model will evaluate the factors that impact changes in the workload capacity parameter. The model will include the time point and participant identification as random factors.

***Data Analytic Plan for Experiment 3***

The third experiment will build on the models created in Experiment 2, with the addition of the PSS scores to account for the impact of stress. A Bayes factor will be calculated comparing the model including stress to the model that does not include stress, for each of the three parameters. The impact of stress will be considered substantial if the Bayes factor indicates that the data is three times more likely under the model that includes stress.

**Risks and Mitigation**

The largest risk of this study is participant drop-out. In an attempt to prevent this possibility, each participant will be offered $80 for completing the study. Participant data will still be included, as long as they complete the tasks at least two times. Due to the longitudinal component, participant data will be excluded from experiments 2 and 3 if they only attend the experiment for the first week.