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Collegiate Recovery Brain Games: Establishing Internal Validity for the Perceived Stress Scale and Stroop Task as Measures of Substance-Use-Related Behaviors

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Introduction

Background. The Collegiate Recovery Brain Games study, conducted in the NEAARRD Lab at KSU, seeks to explore factors associated with substance use, including cognitive flexibility and stress, using externally validated psychometric measures. The study contains a total of 5 questionnaires and 6 cognitive tasks aimed at measuring psychometric properties and behavioral responses. Researchers in the NEAARRD Lab intend to continue collecting data for this study for later analysis using higher-order factor modeling to explore underlying attributes of the stable, long-term recovery uniquely observed in emerging adults.

Perceived Stress Scale (PSS). This study uses an adaptation of the original scale (Cohen et al., 1983) constructed by the New Hampshire Employee Assistance Program (2014), which includes 10 items concerning the frequency of stress-related thoughts and feelings within the past month. Participants rate each item on a Likert scale as follows:

0 = "Never"; 1 = "Almost Never"; 2 = "Sometimes"; 3 = "Fairly Often"; 4 = "Very Often"

With items 4, 5, 7, & 8 reverse-scored, the sum of responses constitutes overall PSS score. For this analysis, the median PSS score split participants into "Higher Stress" (*PSS > 22*) and "Lower Stress" (*PSS ≤ 22*) categories.

Stroop Task. The Stroop task presents participants with a series of color words ("red," "blue,", "green," "yellow") in either congruent font colors (color matches the word), or incongruent font colors (color does not match the word). Congruent trials include the stimuli **RED**, **BLUE**, **GREEN**, **YELLOW**, and incongruent trials include stimuli including, but not limited to **GREEN**, **BLUE**, etc. Participants view trials in a random order and must respond within 2000 milliseconds with either the font color or the word displayed, as instructed. Latency on incongruent Stroop trials commonly serves as an indicator for cognitive flexibility, and previous research suggests a negative correlation between substance use and cognitive flexibility.

Sample. Subjects completed a series of questionnaires and tasks aimed at measuring behaviors associated with SUD. Of the data collected, this analysis considered responses to the demographics survey, the PSS questionnaire, and the Stroop cognitive task. After cleaning, the data included a total of 1165 Stroop trials for 20 subjects. Both per-trial measures and subject averages underwent analysis. Ages ranged from 18 to 54 (*M = 32*), and PSS scores ranged from 18 to 30, with 11 subjects classified as "Higher Stress" and 9 classified as "Lower Stress". Only data for participants who fully completed all three tasks remained in the analysis.

Purpose. The current research aims to assess the internal validity of the Perceived Stress Scale (PSS) and the Stroop task for the initial pilot sample. Additionally, in pursuit of the overall goal of the NEAARRD Lab, this research includes preliminary analysis of the relationship between perceived stress and latencies on the Stroop task for both congruent and incongruent trials. These results will help inform further analyses and data collection for the duration of this ongoing study, and the study overall will add to the body of literature on the underlying behavioral structure of SUD recovery.

Methods

Exploratory Factor Analysis.

Correlation matrix. The initial step to determine factorability of the PSS items included creating a hierarchically clustered correlation matrix to visualize the factors (Figure 1). The distinct pattern provides a good indicator of factorability in the data.

Bartlett's test of sphericity. Bartlett's test of sphericity determined that the correlation matrix differed significantly from the identity matrix ($\chi^2(45) = 158.35$, $p < 0.0001$), providing more support for nonrandom relationships within the variables.

Kaiser-Meyer-Olkin test. The KMO test for sampling adequacy provided a third piece of evidence in support of factor analysis for this data (*MSA = 0.75*), indicating that the underlying data structure includes at least one factor to extract.

Parallel analysis. A parallel analysis and a subsequent scree plot suggested extraction of just one factor from the PSS data, but previous research suggests that these items load on to two factors ("positively-worded items", "negatively-worded items"). Due to the theoretical support for extraction of 2 factors, principal axes factor analysis proceeded as such.

Principal axes factor analysis. Factor analysis proceeded in extracting 2 factors from the PSS items using the principal axes method due to its greater fitness for small sample sizes than maximum likelihood.

One-Way ANOVA. Visualizing the distribution of all per-trial Stroop response latencies revealed outliers common to response-time-based behavioral data: nonresponses (*latencies > 1999 ms, n = 75*) and "quick-guesses" (*latencies < 250 ms, n = 3*). After removing outliers, a one-way ANOVA examined the predictive ability of Stroop trial congruency for latency. Two more one-way ANOVAs explored whether perceived stress levels predict subject average latencies over all trials and incongruent trials.

Results

Figure 1: Correlation Matrix for PSS Item Responses

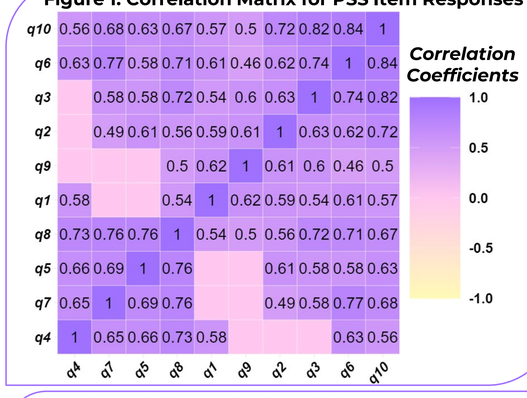


Figure 2: Scree Plot for PSS Item Responses

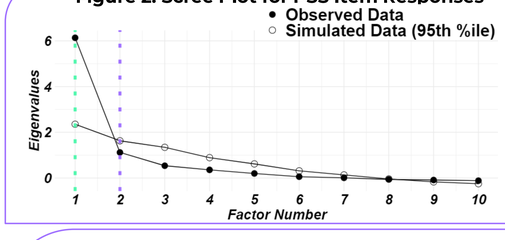


Figure 3: Factor Loadings for PSS Items

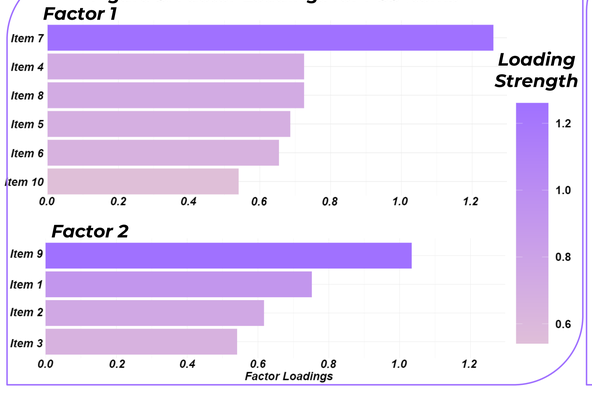


Figure 4: Principal Axes Factor Loading Network

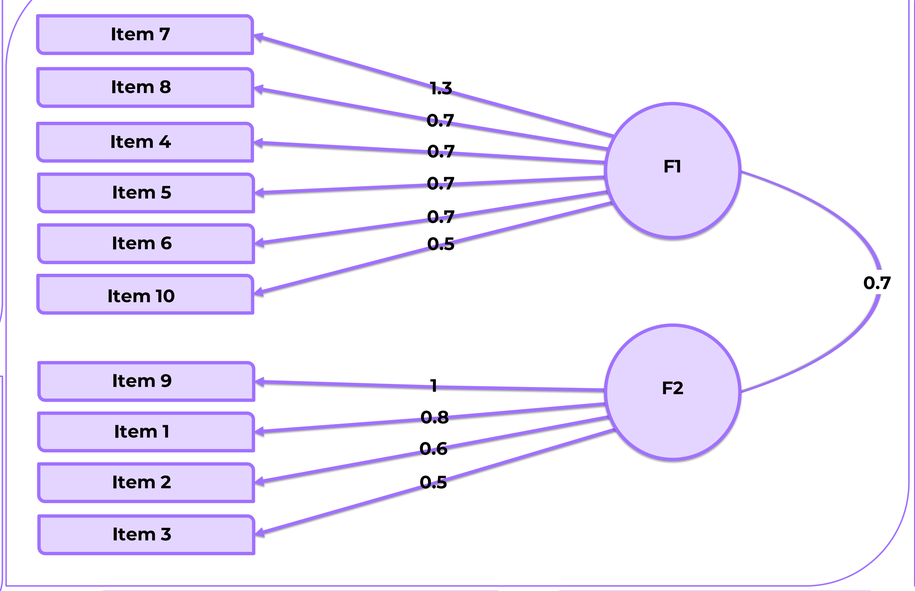


Figure 5: Distribution of Per-Trial Stroop Latencies

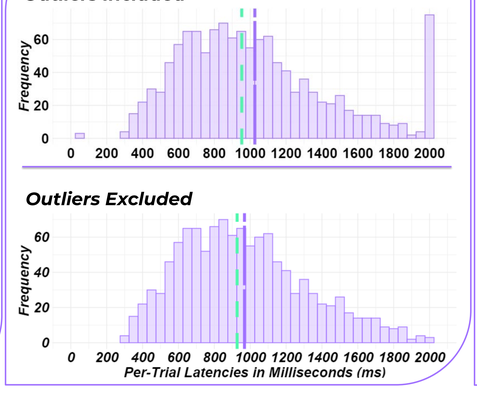


Figure 6: Per-Trial Stroop Latencies by Trial Congruency

ANOVA Results
F(1, 1163) = 24.34
*p < 0.0001****

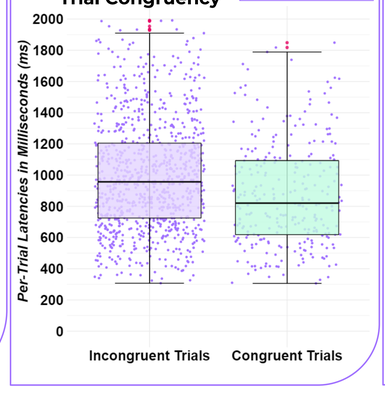


Figure 7: Subject Average Stroop Latencies by PSS Level

ANOVA Results
F(1, 18) = 4.717
*p < 0.0435**

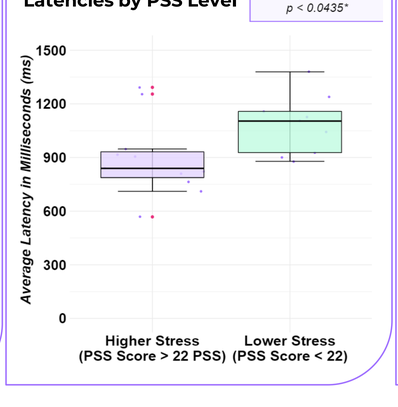
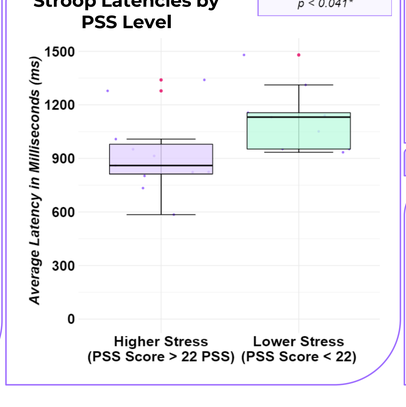


Figure 8: Subject Average Incongruent Stroop Latencies by PSS Level

ANOVA Results
F(1, 18) = 4.844
*p < 0.041**



Conclusions

Does the PSS adequately measure the underlying structure in this sample? Bartlett's test of sphericity produced a significant result, ($\chi^2(45) = 158.35$, $p < 0.0001$) indicating that the correlation differed significantly from a random matrix. The KMO statistic suggested that the data's structure included at least one latent variable to extract, (*MSA = 0.75*). Parallel analysis and a subsequent scree plot suggested retaining only one factor, but this analysis followed previous research using the PSS questionnaire, which suggests two factors underlie the data. Due to the sensitivity of the maximum likelihood method to small samples, factor analysis applied the principal axes method, with Promax variable rotations. Principal axes factor analysis revealed that two factors explain 71% of the variance in the PSS item responses. All items produced salient factor loadings for only one factor, producing an internal reliability of 0.878 *(90% CI = 0 – 0.229)*, and a mean item complexity of 1.3. This suggests that the PSS items explain a significant proportion of variance in their respective factors, and they do not explain a significant proportion of variance in the unassociated factor. Theoretically, PSS items load onto factors constituting "positively-worded" items and "negatively-worded" items. While this analysis found that the positively-worded items loaded onto Factor 1 together, this factor also included items 6 and 10, likely due to the common theme of wording concerning feeling overwhelmed. Items 9, 1, 2, and 3 loaded onto Factor 2, likely due to their common themes of predictability or control over stressful feelings and circumstances. Uncovering these two latent measurements within the PSS scale will inform future higher-order modeling decisions as the study progresses.

Does Stroop trial congruency predict per-trial latency? After removing outliers due to nonresponse and "quick-guesses," a one-way ANOVA conducted on 1163 observations of individual Stroop task trials revealed a significant effect of trial congruency on latency, $F(1, 1163) = 24.34$, $p < 0.0001$. On average, incongruent trials produced higher latencies than congruent trials. This finding indicates that the task successfully measured the Stroop effect, establishing internal validity for the instrument on this sample.

Does perceived stress level predict subject average Stroop latencies? The previous analyses established internal validity for the two measures studied in this sample, enabling a meaningful one-way ANOVA for subject average latencies across levels of perceived stress. The analysis produced $F(1, 18) = 4.717$, $p < 0.0001$, indicating that, across all Stroop trials, participants in the "higher stress" category generally exhibited lower average latencies than "lower stress" participants. Taking a closer look, analysis for congruent trials only produced no significant effect for PSS level, $F(1, 18) = 2.737$, $p = 0.115$, but analysis for incongruent trials produced a significant result, $F(1, 18) = 4.844$, $p = 0.0435$. These initial results for the pilot data suggest a significant relationship between perceived stress and Stroop latencies, which correlate with substance use-related behaviors and neurological differences.

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