Vulnerability of Key Executive Functions Under Acute Stress at Different Stages of Adolescence

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BACKGROUND

Executive functions (EF) are critical for learning outcomes. However, studies have demonstrated that stress strongly impacts the performances of some key executive functions.

Previous research have shown that different EF develops at different stages of adolescence, however, none of them shows the sensitivity or vulnerability of different EF under stress. This research, therefore, is looking at the vulnerability of selected executive functions under acute stress in adolescence. According to a meta-analysis, stress impaired working memory (WM) and cognitive flexibility, whereas it had nuanced effects on inhibition (Shields et al., 2016), therefore, this research mainly focused on the performance of WM and cognitive flexibility (shifting). The data here is collected from 46 participants using *Aquapressure* produced by MIT, a game-based assessment of executive functions.

METHODOLOGY

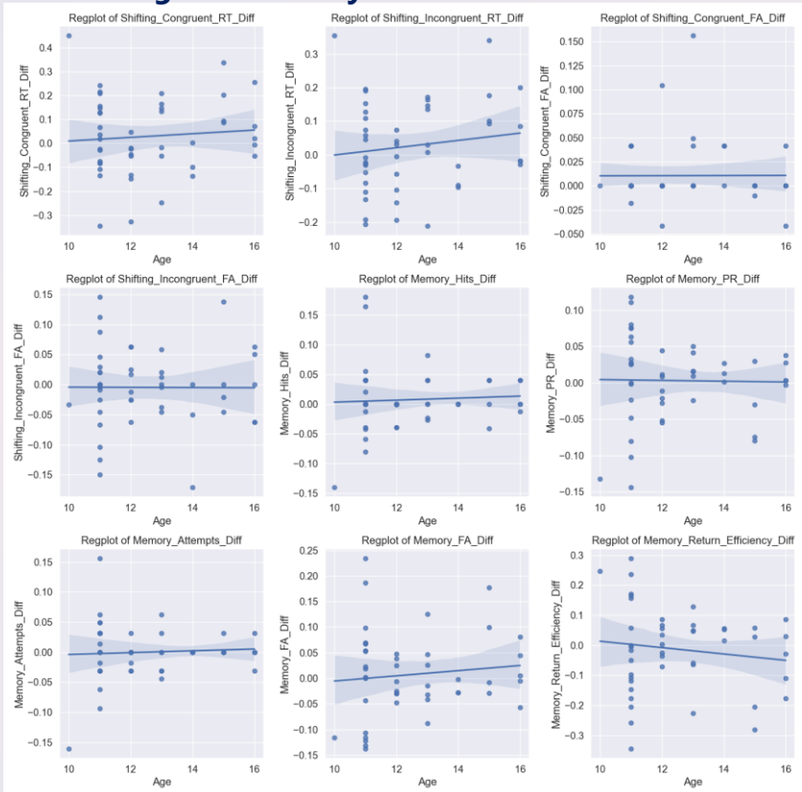
A Within-Subject Experimental Study :

1. Collect EF data from 46 participants under two different stess levels (low/no stress : the “cold” mode; and high stress: “hot” mode)
2. Compare the difference value (substraction) of certain cognitive data (Working memory & shifting) between the two modes at different age levels
3. Compare the results across different stages.

Participant Demographic:
Age: 10-16
Female: 24 Male: 22

DATA ANALYSIS

Linear Regression Analysis



ANOVA Analysis

Variable Name	F-statistic	p-value
Shifting_Incongruent_FA_Diff	5.072	0.029
Memory_PR_Diff	4.186	0.047
Memory_FA_Diff	3.198	0.081

CNN Prediction Model

We developed a neural network model to predict the "Working Memory FA" target variable based on age and gender inputs. The model consists of three fully connected layers with ReLU activation and a dropout layer. The model achieved low errors, with mean squared error of 0.0163, root mean squared error of 0.1278, and mean absolute error of 0.1133. The training process demonstrated good generalization performance, with the model performing well on both training and validation data. This corresponds with our previous linear regression and ANOVA analyses, indicating the effectiveness of age and gender features in predicting Working Memory FA.

RESULTS

Among all aspects of executive functions measured in this research, there are three different correlation pattern to acute stress:

1. Positive: the difference of Shifting Reaction Time (both congruent and incongruent) and the WM False Alarms are getting higher as one grows older, meaning they are more sensitive to acute stress in later adolescence.
2. Negative: the difference of WM Return Effeiciency is getting lower as one grows older, meaning they are less sensitive to acute stress in later adolescence.
3. None: Shifting False Alarms, WM PR, Hits and Attemps are not sensitive to the effects of stress over time.

DISCUSSION

The results parallel with existing literature regarding the influence of stress on the performance of executive functions, and specifically further investigate the impact of acute stress on EF of adolescents and their different levels of vulnerability during human developments. Future research could aim to investigate the underlying mechanisms that contribute to age and gender differences in EF, as well as the potential for interventions to minimize EF vulnerability under stress.

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