

Emotional Distress as A Predictor of Working Memory Efficiency Under Cognitive Load in Urban Adolescents

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ABSTRACT

Emotional distress is a prevalent issue among adolescent students, recognised for its disruptive impact on working memory through the depletion of attentional control resources; although, the precise effect on the underlying processes of working memory (WM) remains insufficiently understood. This study aimed to investigate the impact of emotional distress on cognitive performance, particularly in normal populations, using a computerised tool N-Back working memory task with two levels of cognitive load (1-back and 2-back). Grounded in Attentional Control Theory and Cognitive Load Theory, this research examines how internal psychological suffering may disrupt the balance between goal-directed and stimulus-driven attentional systems, particularly in relation to intrinsic task complexity. It is hypothesised that while high-load tasks naturally tax cognitive resources, the presence of emotional distress acts as a critical predictor of performance breakdown, as the total cognitive demand exceeds the finite capacity of the working memory 'buffer'. The current study examined the working memory efficiency under low load (1-back) and high load (2-back) conditions of n-back tasks. The sample consisted of 50 urban adolescents aged 14 to 18 years who completed the Anxiety, Depression and Stress Scale (ADSS-BSPSA). Mean of obtained scores were used to calculate the combined distress z-score. Students were divided into high and low levels of emotional distress as per median ($M_d=15$). Regression analysis found that higher level of emotional distress significantly predicts lower accuracy ($P=0.004$) on 2-Back task. As task difficulty increases, working memory performance declines, with increasing level of emotional distress.

Keywords: *Executive Functioning, Emotional Distress, Adolescence, Working Memory, Attentional Control*

Adolescence marks a pivotal stage of development characterised by various cognitive, physical, social, and emotional changes between childhood and adulthood (Spear, 2000). Throughout this phase, individuals go through rapid brain development while facing increasing environmental demands. Increased academic challenges, competitive educational environment, social dynamics, and constant digital engagement have together contributed to rising levels of anxiety, stress, and emotional instability among adolescents (Sebastian, Viding, Williams, & Blakemore, 2010). The National Mental Health Survey (2016) reported a 7.3% prevalence of mental health conditions among teenagers, with

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anxiety-related problems at 3.6% and depression-related conditions at 0.8%, particularly in urban areas. These results show the pressing needs understand how emotional distress affects developmental functioning during this vulnerable period.

Emotional distress represents a complex concept encompassing signs of stress, anxiety, depression, and related mood disturbances (Smith, Alloy, & Abramson, 2006). It refers to a state of emotional suffering where negative mood predominates while positive emotional experience diminish (Cohen & Pressman, 2006). Often used interchangeably with psychological distress, it typically reflects a subclinical yet pervasive emotional turmoil that can arise in both adaptive and maladaptive functioning (Mirowsky & Ross, 1989; Lerutla, 2000). Central to emotional distress are negative emotions such as sadness, fear, anger, guilt, and hopelessness, which can be associated with maladaptive coping, withdrawal, avoidance, and increased vulnerability to both mental and physical health complications (Andries, 2011; Charles et al., 2013). Extended exposure to these emotional states disrupts homeostasis and impair cognitive processes, including attention, memory, decision-making, and problem-solving (Watson, Clark, & Tellegen, 1988).

The close relationship between emotional regulation and prefrontal cognitive systems suggests that emotional distress can substantially disrupt executive functioning—processes that are fundamental to both academic achievement and broader developmental outcomes. Working memory (WM), a central executive function responsible for holding and manipulating information, is particularly susceptible to emotional interference. This cognitive system is essential in reasoning, comprehension, learning, and behavioural regulation.

Attention is central to working memory functioning, shaping how information is encoded, stored, and retrieved. As adolescents mature, notable developments occur in processing speed, short-term memory capacity, and reasoning ability (Fry & Hale, 2000). However, their capacity to maintain cognitive performance under emotional distress differs from that of adults. Adolescents typically lack fully developed emotional coping strategies, making them vulnerable to both internalizing manifestations (e.g., excessive worry, depressive mood) and externalizing expressions (e.g., irritability, disengagement) of distress. These emotional disturbances may undermine cognitive efficiency and academic performance, with potential consequences for long-term developmental trajectories (Hoyt et al., 2012).

REVIEW OF LITERATURE

- **Eysenck et al. (2023)** propose attentional control theory (ACT), which posits that anxiety increases the influence of bottom-up over top-down attentional processes. Anxiety-related cognitions and worry exhaust attentional control resources, influencing critical executive functions and increasing demand for compensatory cognitive resources to make up for the effects of poor attentional control. ACT differentiate between **performance effectiveness** (e.g., accuracy) and **processing efficiency** (e.g., speed and cognitive effort), suggesting that anxiety may impair efficiency more than effectiveness due to compensatory coping effort allocation.
- **Delphin-Combe et al. (2016)**: studied the relationship between anxiety and cognitive performance in an elderly population. It was found that subjects with moderate to severe anxiety had worse performance (than subjects with no anxiety) in the storage and retrieval process of verbal episodic memory.

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- **Shafer et al. (2012):** Using fMRI, the study investigated the nature of emotion–cognition interactions in a perceptual discrimination task by manipulating both the emotional charges. Findings points that emotional processing could be both automatic and modulated by attention. This study also identified the neural correlates of responses reflecting the detrimental behavioural impact of emotional distraction.
- **Sweller et al (2011):** developed Cognitive load theory (CLT) as an educational framework suggesting that learning and performance face limitations by the restricted capacity of WM.
- **Neuro-cognitive models:** additionally indicate that emotional distress trigger activation of the limbic system, particularly in the amygdala and striatum regions, while reducing prefrontal cortex efficiency. This process weakens top-down regulation during cognitively demanding tasks. This imbalance is particularly relevant in teenage years, where the prefrontal control system continues developing alongside increased emotional reactivity.

Although widely cited, this research has seen minimal empirical follow up. Three gaps remain evident in the literature: (1) limited research focused particularly on adolescents; (2) an inadequate combination of emotional distress measures with systematically manipulated cognitive load; and (3) limited use of structured methodology to examine both accuracy and processing speed outcomes.

Addressing these gaps, the present study investigates the predictive effects of emotional distress on WM performance under low (1-back) and high (2-back) cognitive load conditions in urban adolescents using a computerised N-back task. By examining both accuracy and reaction time, the study aims to clarify whether emotional distress primarily affects performance effectiveness, processing efficiency, or both.

METHODOLOGY

Hypotheses

- **H0:** There is no relationship between working memory efficiency, effectiveness and level of emotional distress.
- **H1:** Increasing cognitive load (2-back) relative to 1-back will significantly reduce working memory accuracy.
- **H2:** Emotional distress will significantly predict working memory reaction time.

Objectives

1. To examine whether emotional distress predicts working memory accuracy (WM effectiveness) under varying cognitive load conditions in urban adolescents.
2. To examine whether emotional distress predicts reaction time (WM efficiency) during N-back task performance.
3. To examine whether higher cognitive load is associated with reduced processing efficiency (reaction time) and performance effectiveness (accuracy).

Sample

Participants included 50 healthy urban adolescents, selected based on random sampling at two coaching centres, aged between 14 and 18 years (56% female). Participants with sufficient language skills and without psychopharmacological medication were included in the study. Informed consent was obtained from each adolescent participant and additionally from a parent.

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Research design

The study employed a quantitative, predictive, cross-sectional research design with cognitive load as a manipulated task condition and emotional distress as an individual difference variable.

Statistical analysis

The data obtained was tabulated and analysed using SPSS 25 (IBM) to assess the findings of the study.

Variables

- The study considered independent variables as **Cognitive load levels (1-Back vs. 2-Back)** and **Emotional distress (combined score)**.
- The dependent variables included **Working Memory Accuracy (Percentage Correct)** and **Reaction Time (milliseconds)**.
- Separate regression analyses were computed for each dependent variable (Accuracy and reaction time).

Instruments

1. **Anxiety, Depression and Stress Scale-(ADSS-BSPSA)**: This assessment tool was developed by Pallavi Bhatnagar, Megha Singh, Manoj Pandey, Sandhya and Amitabh (English version). It served to assess emotional distress in participants. This scale measures three areas: anxiety, depression and stress. Raw scores were calculated for each domain. A combined score for emotional distress was calculated and z-scores obtained. For analytical purposes, participants were divided into two groups (based on Median=15):
 - **Low Emotional Distress Group** (scores below sample median)
 - **High Emotional Distress Group** (scores above sample median)
 - This grouping allowed comparison of cognitive performance across emotional distress levels.
2. **N-Back Task (Working Memory Task)**: Working memory performance and reaction time was assessed using a computerised **N-back tool**, consisting of two cognitive load conditions: The 1-back condition served as **low cognitive load**, whereas the 2-back condition served as **high cognitive load**. In the 1-back task, participants were required to respond when the current stimulus matched the immediately preceding stimulus. In the 2-back task, participant has to respond when the current stimulus matches the one presented two trials earlier, thus imposing greater working memory demand. Two dependent variables were recorded: Accuracy (percentage of correct responses) and Reaction Time (milliseconds).

Procedure

Participants were administered ADSS and screened for high and low emotional distress levels corresponding to the median. To account for potential differences between groups on measures of emotional distress, adolescents filled in the Anxiety, Depression and Stress Scale (ADSS-BSPSA; Bhatnagar P, Singh M, et al.) (Cronbach's α ADSS present study = 0.981). A combined score was calculated to assess the distress level. Participants were divided into two groups- low emotional distress (n=26) and high emotional distress (n=24) based on the median score ($M_d=15$) and sign +/- of z-score.

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Each participant was administered n-back task, with low cognitive load (1-back task) and high cognitive load (2-back task) and their reaction time (in milliseconds) and accuracy (% correct) were recorded.

Data Collection

Participants were recruited through the coaching centres based on randomisation. ADSS was taken as a self-report measure survey. The N-back task was conducted using a computerised tool.

RESULTS

Data were analysed using linear regression to examine whether cognitive load (N-back level) and emotional distress predicted working memory accuracy (N=50). Two separate regression analyses were done:

1. Table 1: Dependent Variable – Accuracy in N-back tasks (% correct)

Model Summary (NBACK_SCORE)				ANOVA (NBACK_SCORE)					
	R	Adjusted R Square	Std. Error of the Estimate		Sum of Squares	df	Mean Square	F	Sig.
	.31	.10	.11	Regression	.13	2	.06	5.13	.008
				Residual	1.20	97	.01		
				Total	1.33	99			

The regression analysis indicated a statistically significant relationship. [$F(2, 97) = 5.13$] Statistical significance was evaluated at an alpha level of **.05 ($p=0.008 < .05$)**. The model explained **10% of the variance** in accuracy scores of high cognitive loads due to emotional distress.

2. Table 2: Dependent Variable – Reaction Time in N-back tasks (milliseconds)

Output — PSPPIRE Output Viewer

File Edit Windows Help

REGRESSION
 /VARIABLES= distress_level nback_level
 /DEPENDENT= RT
 /METHOD=ENTER
 /STATISTICS=COEFF CI R ANOVA BCOV TOL.

Model Summary (reactiontime)

	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.17	.03	.01	.47

ANOVA (reactiontime)

	Sum of Squares	df	Mean Square	F	Sig.
Regression	.65	2	.33	1.48	.233
Residual	21.48	97	.22		
Total	22.13	99			

Coefficients (reactiontime)

	Unstandardized Coefficients		Standardized Coefficients		t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta	t			Lower Bound	Upper Bound	Tolerance	VIF
(Constant)	1.34	.08	.00	16.68	.000	1.18	1.50	1.00	1.00	
distress_level	.05	.09	.05	.55	.586	-.14	.24	1.00	1.00	
nback_level	.15	.09	.16	1.63	.106	-.03	.34	1.00	1.00	

Coefficient Correlations (reactiontime)

	distress_level	nback_level
distress_level	1.00	.00
nback_level	.01	1.00

REGRESSION
 /VARIABLES= distress_level nback_level
 /DEPENDENT= RT score
 /METHOD=ENTER
 /STATISTICS=COEFF CI R ANOVA BCOV TOL.

Model Summary (reactiontime)

	R	R Square	Adjusted R Square	Std. Error of the Estimate

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Output — PSPPIRE Output Viewer

File Edit Windows Help

REGRESSION
/VARIABLES= distress_level nback_level
/DEPENDENT= RT
/METHOD=ENTER
/STATISTICS=COEFF CI R ANOVA BCOV TOL.

Model Summary (reactiontime)

R	R Square	Adjusted R Square	Std. Error of the Estimate
.17	.03	.01	.47

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Regression	.65	2	.33	1.48	.233
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Coefficients (reactiontime)

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(Constant)	1.34	.08	.00	16.68	.000	1.18	1.50	1.00	1.00
distress_level	.05	.09	.05	.55	.586	-.14	.24	1.00	1.00
nback_level	.15	.09	.16	1.63	.106	-.03	.34	1.00	1.00

Coefficient Correlations (reactiontime)

	distress_level	nback_level
Covariances		
distress_level	.01	.00
nback_level	.00	.01

REGRESSION
/VARIABLES= distress_level nback_level
/DEPENDENT= RT #score
/METHOD=ENTER
/STATISTICS=COEFF CI R ANOVA BCOV TOL.

Model Summary (reactiontime)

R	R Square	Adjusted R Square	Std. Error of the Estimate

The Cognitive load did not significantly predict reaction time. The regression analysis indicated a non-significant statistical relationship between emotional distress and working memory efficiency (reaction time) [$F(2, 97) = 1.48, p = .233$]. Statistical significance was evaluated at an alpha level of **.05** ($p = 0.233 > 0.05$).

DISCUSSION

The present study examined whether emotional distress predicts working memory performance under varying cognitive load conditions in urban adolescents using a computerised N-back task. Emotional distress was measured in participants, and the median ($M_d=15$) of the obtained distress z-score scores was used to divide participants into high and low levels of emotional distress. While the behavioural data were not sensitive enough to detect changes in emotion processing as a function of Load, such changes were identified. Regression analysis found that Higher cognitive load (2-back) significantly predicts lower accuracy (working memory effectiveness) ($P=0.008 < 0.05$). As task difficulty increases, working memory performance declines, with increasing level of emotional distress. However, when the overall regression model was examined for N-back reaction time, emotional distress did not emerge as a statistically significant predictor ($p=0.233 > .05$). These findings indicate that neither task load nor emotional distress significantly explained variability in processing speed within the present sample.

Also, Emotional distress did not show a direct relationship with performance at the group level, suggesting a relatively low overall correlation. However, when examined using regression analyses, emotional distress significantly predicted reduced working memory accuracy under higher cognitive load. This indicates that distress may not uniformly impair performance across individuals but instead functions as an individual-difference predictor that becomes pronounced when cognitive load increases.

This result suggests limited coping ability of teenagers in the context of high emotional distress and high cognitive load. These findings can be interpreted within the framework of

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Attentional Control Theory, which distinguishes between **performance effectiveness** (accuracy) and **processing efficiency** (speed and cognitive effort). This theory says that anxiety primarily impair attention by weakening goal-directed processing and increasing stimulus-driven hindrance. Although the theory often predicts greater impairment in processing efficiency than effectiveness, the present findings suggest that under higher cognitive load (2-back), emotional distress may compromise accuracy directly in teenagers. The level effect of cognitive load further supports this interpretation, as higher load was associated with lower accuracy overall. The absence of a significant relationship with reaction time may reflect task-related response expectations. Because the N-back task encourages rapid responding, participants may have maintained speed at the cost of accuracy.

Overall, the findings indicate that emotional distress contributes to working memory vulnerability in adolescents, particularly affecting performance quality under demanding cognitive conditions.

CONCLUSION

The present study demonstrates that emotional distress significantly predicts reduced working memory accuracy in urban adolescents, particularly under conditions of higher cognitive Load. However, emotional distress did not significantly affect reaction time, suggesting that performance effectiveness may be more sensitive to distress than processing speed in adolescents. This result suggests limited compensatory coping ability of teenagers in the context of elevated emotional distress and high cognitive load demand.

Future research incorporating neuro-physiological measures and a longitudinal research design would further clarify the mechanisms underlying emotional distress and executive functioning in adolescence.

Limitations of the Study

1. The taken small **sample size** (N = 50) may limit statistical power to detect small-to-moderate interaction effects between cognitive load and emotional distress. Future studies with larger samples would provide greater precision in estimating cross-level interactions and improve the external validity.
2. Participants include a normal urban population, limiting generalisation to broader teen populations, rural context, or clinically distressed groups
3. Emotional distress used a self-reporting tool, susceptible to response biases and may not capture real-time affect. Studies incorporating neuro-physiological tools or experimental distress manipulation can lead to objective measurement.
4. Using only two conditions (1-back vs. 2-back) may miss the complete range of cognitive load. Implementing variable load adjustments or flexible designs could reveal more detailed information about cognitive threshold points.
5. The research relied on **regression models** that did not explicitly model within-subject dependency through correlation frameworks. More advanced techniques would provide a better estimation of load-related performance changes across individuals.
6. The cross-sectional design prevents causal inference in long term. Longitudinal designs are needed to clarify directionality and developmental sensitivity.

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Conflict of Interest

The author(s) declared no conflict of interest.

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