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Perceived Stress as a Mediator between Episodic and Semantic Memory in Hypertensive and Normotensive Individuals: A Neuropsychological Perspective

Maryum Anees and Aisha Tauqeer

Abstract

Background: Hypertension is not only a leading cardiovascular risk factor but also significantly influences cognitive functioning, particularly episodic and semantic memory. Dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, leading to heightened perceived stress, has been linked to neurocognitive impairments. Despite growing evidence, the interplay between episodic memory, perceived stress, and semantic memory remains underexplored, particularly in hypertensive populations

Method: This cross-sectional, comparative study included 200 participants (100 hypertensive, 100 normotensive), recruited through purposive sampling. Data collection occurred between October 1, 2024, and January 4, 2025, at the Cognitive and Neuroscience Lab, Foundation University School of Science and Technology (FUSST), and the Cardiology Department at Fauji Foundation Hospital, Rawalpindi, Pakistan. Episodic memory was assessed using the Rey Auditory Verbal Learning Test (RAVLT) and Picnir Scales, semantic memory via the Semantic Memory Scale, and perceived stress through the Perceived Stress Scale (PSS). Correlational and mediation analyses were conducted.

Results: The results of this study demonstrated that perceived stress significantly mediated the relationship between episodic and semantic memory in both normotensive and hypertensive groups. Moreover, people with normal blood pressure had better memory when they felt less stress. However, in people with high blood pressure, stress had a stronger effect on memory, showing that they may be more mentally vulnerable. Additionally, moderation analysis revealed a more robust direct effect of episodic memory on semantic memory in normotensive participants compared to their hypertensive counterparts.

Conclusions: These findings highlight perceived stress as a critical neuropsychological mediator influencing memory systems, particularly under hypertensive conditions. Integrating stress-reduction strategies into cognitive interventions may help mitigate neurocognitive decline in hypertensive populations.

Keywords: Hypertension, episodic memory, semantic memory, perceived stress, cognitive function, neuropsychology, HPA axis, stress mediation

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Background

Hypertension, defined as chronically elevated arterial blood pressure, remains a leading global health concern due to its widespread prevalence and its role in promoting cardiovascular, cerebrovascular, and cognitive dysfunction (Pacholko & Iadecola, 2024; WHO, 2023). Beyond its systemic effects, accumulating evidence has demonstrated that hypertension is associated with structural and functional alterations in brain regions critical for cognition, particularly those underlying episodic and semantic memory (Feng et al., 2020; Zúñiga Salazar et al., 2024). These memory domains are essential for autobiographical recall, factual knowledge, reasoning, and adaptive behavior in daily life (Tulving, 2002; McManus et al., 2020).

Recent neuropsychological studies suggest that the mechanisms linking hypertension to memory impairment are multifactorial, with chronic stress emerging as a key contributing factor (Antypa et al., 2022; Kim & Kim, 2023). Chronic psychological stress activates the hypothalamic–pituitary–adrenal (HPA) axis, resulting in elevated cortisol levels that disrupt neural homeostasis, particularly in hippocampal and prefrontal structures involved in memory encoding, consolidation, and retrieval (Younan et al., 2020; Schwabe et al., 2022). Stress and hypertension thus appear to act synergistically, producing a compounding effect on cognitive decline through vascular, endocrine, and neuroplastic pathways (Arif et al., 2024; Kulshreshtha et al., 2023).

Episodic memory, which supports the recall of specific experiences and temporal-spatial contexts, and semantic memory, which governs the retrieval of factual and conceptual knowledge, both rely heavily on hippocampal–cortical interactions (Zhu et al., 2022; Weist et al., 2024). These systems are particularly vulnerable to damage from sustained hypertension and HPA axis hyperactivity. Indeed, neuroimaging studies reveal hippocampal atrophy, disrupted connectivity, and impaired synaptic plasticity in hypertensive individuals, especially when stress is present (Feng et al., 2020; Parandiyal et al., 2023). These neurocognitive disturbances not only diminish memory performance but also undermine executive function and prospective memory, further impairing adaptive decision-making and quality of life (Moraes et al., 2020).

Despite the growing body of research on stress and hypertension as independent risk factors for cognitive impairment, the interactive role of perceived stress in mediating the relationship between episodic and semantic memory in hypertensive populations remains insufficiently explored. Some studies, such as Elsaid et al. (2021), suggest that stress exacerbates working memory deficits in individuals with elevated blood pressure, while others emphasize the modulatory role of environmental buffers such as exposure to green spaces (Lega et al., 2021).

This study seeks to address this gap by examining how perceived stress mediates the association between episodic and semantic memory in hypertensive and normotensive adults. This study aim to contribute to a more integrated neuropsychological model of memory function that accounts for physiological and psychological stressors by exploring this dynamic interplay,. This research not only enhances theoretical understanding of stress-memory interactions but also informs the development of targeted cognitive and behavioral interventions for populations at risk of hypertension-related cognitive decline (Aqeel et al., 2024).

Method

Research design

This study utilized a cross-sectional, comparative, and correlational design with purposive sampling to examine the relationships among episodic memory, semantic memory, and perceived stress in normotensive and hypertensive adults. Two clinically distinct, demographically matched groups were compared to assess cognitive and emotional functioning. The design enabled analysis of group differences and tested perceived stress as a mediator and hypertension as a moderator in memory relationships, enhancing understanding of neuropsychological alterations associated with hypertension.

Objectives

1. To investigate the associations among perceived stress, episodic memory, and semantic memory in hypertensive and normotensive individuals.
2. To compare levels of perceived stress, episodic memory performance, and semantic memory retrieval between hypertensive and normotensive groups.
3. To evaluate the mediating role of perceived stress in the relationship between episodic and semantic memory across hypertensive and normotensive individuals.
4. To examine the moderating role of health status (normal vs. hypertensive groups) on the relationship among perceived stress, episodic and semantic memory.

Hypotheses

1. Perceived stress will be negatively associated with episodic and semantic memory performance in both hypertensive and normotensive individuals.
2. Normotensive individuals will exhibit significantly better episodic memory and semantic memory performance compared to hypertensive individuals.
3. The negative association between perceived stress and memory performance will be stronger in hypertensive individuals than in normotensive individuals.
4. Perceived stress will mediate the relationship between episodic memory and semantic memory across hypertensive and normotensive individuals.

Sample

A purposive sampling technique was used to recruit 200 participants aged 20–60 years, including 100 normotensive and 100 hypertensive individuals. The sample size was determined using the WHO sample size calculator, based on an expected medium effect size, 95% confidence level, and 80% power. Normotensive participants were recruited from the Cognitive and Neuroscience Lab at the Foundation University School of Science and Technology

(FUSST), Rawalpindi, and hypertensive participants were recruited from the Cardiology Department of Fauji Foundation Hospital, Rawalpindi, between October 1, 2024, and January 4, 2025.

Hypertensive participants met the inclusion criteria of a clinical diagnosis of hypertension (systolic BP ≥130 mmHg and diastolic BP ≥90 mmHg), absence of neurological (e.g., stroke, dementia) or psychiatric disorders (e.g., schizophrenia, major depression), and no use of medications known to impair cognitive function (e.g., benzodiazepines, antipsychotics). Exclusion criteria included uncontrolled hypertension, severe medical conditions (e.g., heart failure, chronic kidney disease), or sensory/motor impairments affecting assessment.

Normotensive individuals had BP within the normal range (systolic <120 mmHg and diastolic <80 mmHg), with similar inclusion and exclusion criteria applied to control for confounding variables. This approach ensured a well-defined and comparable sample for investigating group differences and relationships among perceived stress, episodic memory, and semantic memory.

PsychoPy Software

This cross-sectional study employed *PsychoPy* (version 2.3), a robust open-source software widely used in experimental psychology and cognitive neuroscience, to administer standardized cognitive and psychological assessments. Episodic memory was evaluated using the Rey Auditory Verbal Learning Test (RAVLT) and the Pictorial Novel Image Recall task (PICNIR), while semantic memory was assessed through the Semantic Memory Scale (SEM) and the Semantic Probability Task (See Figure 1). Perceived stress was measured using the Perceived Stress Scale (PSS). All stimuli were presented in white Arial font (3 cm height) on a blank screen, ensuring uniform visual clarity across both hypertensive and normotensive participants. PsychoPy's high temporal precision in stimulus delivery and response capture (Peirce et al., 2019) ensured the generation of valid and reliable data. Its flexibility and experimental control rendered it particularly suitable for investigating the dynamic interaction between episodic and semantic memory retrieval under varying stress levels and physiological conditions in a cross-sectional framework.

Measures

In this study, four standardized measures were employed: the Rey Auditory Verbal Learning Test (RAVLT), Picture Naming and Identification Recognition (PICNIR), Semantic Memory Scale, and Perceived Stress Scale (PSS). Episodic memory was the primary predictor, semantic memory the secondary outcome, and perceived stress was examined as a potential mediator between the two memory systems.

Cognitive Tasks

The Semantic Memory Task

The Semantic Memory Task, originally developed by Krieger-Redwood and Jefferies (2023), was translated and culturally adapted into Urdu for the current study. This word-association paradigm was designed to assess semantic memory retrieval across 304 stimulus items, categorized by emotional valence into positive, negative, and neutral associations (e.g., *popcorn_ability*, *budget_economics*, *thief_dishonesty*). Each item was presented for a fixed duration of 3 seconds, during which participants were required to recognize or recall the correct semantic association. Response accuracy and reaction time (RT) served as primary performance indicators, with non-responses within the 3-second window recorded as incorrect. Stimuli presentation and response logging were conducted using PsychoPy software, ensuring precise timing and data capture. A standardized scoring key was employed by trained research assistants to evaluate accuracy. Reaction time and accuracy data were aggregated and analyzed using Excel pivot tables to compute mean scores, enabling comparative analyses of semantic memory performance between hypertensive and normotensive groups.

Rey Auditory Verbal Learning Test (RAVLT)

The Rey Auditory Verbal Learning Test (RAVLT), originally developed by Rey (1941) and later standardized by Schmidt (2004), is a widely used neuropsychological measure of verbal learning and episodic memory. It assesses key cognitive processes such as encoding, retrieval, retention, proactive and retroactive interference, and subjective organization. The task involves the auditory presentation of a 15-word list (List A) at a rate of one word per second, followed by immediate free recall. This procedure is repeated over five learning trials to evaluate acquisition. Subsequently, an interference list (List B) is presented, followed by immediate recall of List B and then delayed recall of List A. After a 20-minute delay period, participants are again asked to recall words from List A (delayed recall), followed by a recognition trial in which they identify List A words from a mixed list. The RAVLT is normed for individuals aged 16 to 89 and is considered a sensitive tool for detecting verbal memory deficits in both clinical and non-clinical populations.

Picture Naming and Immediate Recall (PICNIR) Task

The Picture Naming and Immediate Recall (PICNIR) task, adapted from Bartos (2023), is a two-part cognitive measure designed to assess semantic memory, lexical access, and short-term episodic memory. In the first phase, participants label 20 black-and-white images with single-word responses, evaluating naming accuracy, spelling, and semantic retrieval. In the second phase, following a brief distraction, participants are given one minute to freely recall and write as many image names as possible, assessing immediate recall.Errors are classified as anomia (omitted responses), semantic/phonemic paraphasias (incorrect labels), confabulations (items not presented), and repetitions. Scoring is based on the number of correctly named and recalled items, with culturally relevant adaptations made to the image set and accepted responses

Psychological instrument

Perceived Stress Scale

Perceived stress was assessed using the 10-item Perceived Stress Scale (PSS-10; Cohen et al., 1983), translated and adapted into Urdu by Tahira and Kausar (2013). The scale measures the degree to which individuals perceive their lives as unpredictable, uncontrollable, and overloaded. Participants rate each item on a 5-point Likert scale ranging from 0 (never) to 4 (very often), reflecting stress levels experienced over the past month. Items 4, 5, 7, and 8 are reverse scored. Higher total scores indicate greater perceived stress. In the current study, the PSS-10 demonstrated acceptable internal consistency (Cronbach's α

= .78), supporting its reliability for use in both hypertensive and normotensive groups.

Procedure

The study was conducted in collaboration with the Cognitive and Neuroscience Lab, Department of Psychology, Foundation University School of Science and Technology (FUSST), Pakistan. Ethical approval was secured from the institutional ethics review board in accordance with the guidelines of the American Psychological Association (APA, 2017) and the Declaration of Helsinki (2013). Prior to participation, all 200 participants received a detailed information sheet outlining the purpose, methodology, potential risks, and benefits of the study. Participants were required to provide both verbal and written informed consent, ensuring voluntary participation and full understanding of the research protocol. The experimental paradigm, implemented using PsychoPy software (version 2.3), consisted of computerized tasks designed to assess episodic memory, semantic memory, and perceived stress. Tasks were administered in a controlled laboratory setting to ensure consistency in stimuli presentation, environmental conditions, and response recording. All assessments were supervised by trained research assistants to provide standardized instructions and monitor participant responses. Confidentiality of participant data was strictly maintained through anonymized coding and secure data storage. Participants were informed of their right to withdraw from the study at any point without penalty. To ensure psychological safety, debriefing sessions were conducted immediately following task completion. Additionally, participants showing signs of distress were offered immediate psychological support through on-site mental health professionals. No participant experienced any lasting adverse effects, and ethical integrity was maintained at all stages of data collection and analysis.

Analysis Plan

Data analysis was conducted using IBM SPSS Statistics (Version 25). Pearson product-moment correlation coefficients were calculated to examine the relationships among episodic memory, semantic memory, and perceived stress across hypertensive and normotensive groups (Field, 2018). Independent samples t-tests were employed to compare group differences on cognitive and stress variables. To test Hypothesis 1 (perceived stress mediates the relationship between hypertension and memory performance) and Hypothesis 2 (hypertension moderates the effect of stress on memory), Hypothesis 3, which posits that perceived stress significantly predicts memory performance, was examined using multiple linear regression analysis. For Hypothesis 4, which assesses perceived stress as a mediator specifically within the hypertensive group, subgroup mediation analysis was conducted using the SPSS (Field, 2018).All statistical tests were two-tailed, with a significance threshold set at $p < .05$. Effect sizes were reported using Cohen's *d* for mean differences and standardized beta coefficients (β) for regression models, in accordance with APA reporting guidelines (Field, 2018).

Results

In table 1, the reliability analysis indicated that all scales demonstrated acceptable to excellent internal consistency, with Cronbach's alpha values ranging from .50 to .96. The Semantic Memory scale showed excellent reliability (α = .96), while the Perceived Stress Scale (PSS) displayed good reliability in both normotensive (α = .87) and hypertensive (α = .74) groups. The RAVLT and PICNIR scales demonstrated adequate reliability, with slightly lower values in the normotensive group.

Correlation analysis revealed significant positive associations between semantic and episodic memory (RAVLT and PICNIR) in both normotensive and hypertensive participants, though the relationship was stronger and more consistent in the normotensive group. Perceived stress was significantly negatively correlated with all memory measures across both groups, with stronger negative correlations observed in the hypertensive group. These findings suggest that while semantic and episodic memory are closely linked, elevated stress levels particularly in hypertensive individuals are associated with impaired memory performance.

Pearson correlation analyses revealed that the DHI total score was significantly and positively correlated with its subscales: Vestibular Handicap (r = .98, $p < .001$), Vestibular Disability (r = .94, $p < .001$), and Visuo-Vestibular Disability (r = .95, $p < .001$). The DHI was also positively associated with the Tinnitus Handicap Inventory total score (r = .38, $p < .001$) and its subdomains: Functional (r = .35, $p < .001$), Emotional (r = .37, $p < .001$), and Catastrophic (r = .35, $p < .001$).

The findings presented in Table 2 reveal statistically and clinically significant differences in cognitive performance and perceived stress between normotensive and hypertensive individuals. Specifically, participants in the normal (normotensive) group demonstrated superior performance across all cognitive domains assessed. Semantic memory performance, as measured by the SEM scale, was markedly higher in the normotensive group (M = 169.66, SD = 30.37) relative to the hypertensive group (M = 124.05, SD = 25.76), yielding a highly significant result ($t(198) = 11.45$, $p < .001$) and a large effect size (Cohen's $d = 1.62$), indicating a robust difference with practical relevance. The 95% confidence interval (CI) for the mean difference ranged from 37.76 to 53.46, further confirming the strength of this effect.

Similarly, episodic memory recall, measured via the Rey Auditory Verbal Learning Test (RAVLT), was significantly better among the normotensive participants (M = 46.12, SD = 10.26) compared to the hypertensive group (M = 31.94, SD = 7.69), with a very large effect size (Cohen's $d = 1.56$, $t(198) = 11.05$, $p < .001$, 95% CI [11.65, 16.71]). This finding indicates that hypertension is associated with a notable decrement in memory consolidation and retrieval abilities. In the domain of episodic memory recognition (PICNIR), although the overall mean scores were close, the normotensive group still performed significantly better (M = 19.78, SD = 0.64) than the hypertensive group (M = 19.01, SD = 1.45). The difference was statistically significant ($t(198) = 4.844$, $p < .001$), with a medium effect size (Cohen's $d = 0.67$, 95% CI [0.456, 0.884]), suggesting subtle but meaningful impairment in recognition processes in the hypertensive group.

Conversely, perceived stress levels, measured using the PSS, were significantly elevated in the hypertensive group (M = 26.04, SD = 5.56) relative to the normotensive group (M = 17.34, SD = 7.36). This inverse pattern ($t(198) = -9.427$, $p < .001$) with a large negative effect size (Cohen's $d = -1.33$, 95% CI [-10.52, -6.879]) underscores the substantial psychological burden associated with hypertension. Collectively, these results underscore the deleterious impact of hypertension on both memory-related cognitive functioning and stress perception. The consistent large effect sizes suggest not only statistical significance but also clinical importance, highlighting the need for early cognitive screening and stress management interventions in hypertensive populations.

Mediation Analysis

In table 3, The mediation analyses revealed that in both normal and hypertensive groups, perceived stress significantly mediated the relationship between episodic memory (RAVLT and PICNIR) and semantic memory retrieval. Specifically, episodic memory was positively associated with semantic memory and negatively associated with stress, while perceived stress negatively impacted semantic memory across all models. Particularly, effect sizes were stronger among normotensive individuals, suggesting more efficient memory integration and lower vulnerability to stress-related disruptions. In contrast, the hypertensive group exhibited attenuated direct effects of episodic memory on semantic memory, but stronger negative associations between stress and semantic memory retrieval, suggesting that stress exerts a greater disruptive effect in this population.

The moderation analysis demonstrated a significant interaction between group status and episodic memory (PICNIR) in predicting semantic memory retrieval ($\beta = -1.165$, $p < .001$), indicating that the beneficial impact of episodic memory on semantic memory retrieval is significantly diminished in hypertensive individuals. The overall model explained 48.9% of the variance in semantic memory performance ($R^2 = .489$).Together, these results highlight that perceived stress is a key cognitive-affective mediator, and hypertension moderates the cognitive relationship between memory systems. The findings suggest targeted stress reduction may enhance memory consolidation, especially in hypertensive populations at risk of cognitive decline.

Discussion

This study examined the complex interplay between episodic memory (both recognition and recall), semantic memory, and perceived stress, with a specific focus on the moderating role of health status (normotensive vs. hypertensive individuals). The findings align with and extend prior research by demonstrating both the mediating role of stress and the moderating effect of hypertension in memory processes. As hypothesized, hypertensive individuals exhibited significantly poorer performance in episodic memory (both RAVLT and PICNIR) and semantic memory tasks compared to normotensive participants. These results are consistent with prior neuropsychological research, such as Feng et al. (2020) and Zúñiga Salazar et al. (2024), which highlight the vulnerability of hippocampal and cortical structures to the deleterious effects of vascular pathology. Given that episodic memory is highly dependent on hippocampal function, and semantic memory relies more on distributed neocortical networks, the observed deficits suggest widespread cognitive impairment among hypertensive individuals.

A key objective of this study was to investigate the mediating role of perceived stress in the relationship between episodic memory and semantic memory. Across both groups, stress significantly mediated this relationship. Stronger episodic memory (PICNIR and RAVLT) was associated with reduced perceived stress, and lower stress, in turn, was linked to better semantic memory performance. These findings align with the stress-memory framework (McManus et al., 2020; Zhu et al., 2022), which suggests that chronic psychological stress impairs memory consolidation and retrieval by altering the functioning of the hypothalamic-pituitary-adrenal (HPA) axis and elevating cortisol levels. The present findings support this theory by demonstrating the indirect influence of episodic memory on semantic memory through stress levels, particularly in the normotensive group.

Notably, the mediation effect of stress was more pronounced in hypertensive individuals. While episodic memory still predicted semantic memory, this relationship was significantly attenuated due to the stronger influence of stress. Hypertensive participants exhibited higher levels of perceived stress, which in turn more substantially impaired semantic memory retrieval. This is supported by evidence from Elsaid et al. (2021) and P & Jose (2021), who highlighted the compounded effects of hypertension and psychological stress on cognitive systems. These findings suggest a compounding effect of hypertension and stress on memory functioning, particularly in processes that depend on the integration of episodic traces into semantic frameworks.

A significant contribution of this study lies in identifying the moderating role of health status in the episodic–semantic memory relationship. The moderation analysis revealed that the strength of the relationship between episodic recognition (PICNIR) and semantic memory was significantly weakened in the hypertensive group. This finding underscores the idea that hypertension disrupts the neural and vascular mechanisms necessary for efficient encoding, consolidation, and transformation of episodic memory traces into semantic knowledge. This result aligns with theoretical models such as the encoding specificity principle (Tulving & Thomson, 1973), and empirical evidence from Pacholko & Iadecola (2024) and Arif et al. (2024), who reported that hypertension alters cerebrovascular integrity and neural network dynamics during memory processing. The significant interaction effect found in this study confirms that hypertensive individuals not only perform worse on memory tasks but also show a weaker integration between episodic and semantic memory systems. This suggests a potential breakdown in the neurocognitive architecture linking hippocampal and cortical networks, further exacerbated by chronic stress and vascular burden.

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Table 1

Correlation Matrix, Cronbach's Alpha Reliability, Means, and Standard Deviations for Normotensive (n = 100) and Hypertensive (n = 100) Groups.

Variable	*α(N)*	*α(HP)*	*M (N)*	*SD (N)*	*M (HP)*	*SD (HP)*	***1***	***2***	***3***	***4***	***5***
1. SEM	.96	.80	418.95	41.14	464.49	33.60	-	-.76**	-.27**	-.53**	.30**
2. SEM.PROB	.96	.76	168.67	30.37	124.05	25.76	-.70**	-	.31**	.48**	-.21*
3. RAVLT	.77	.73	46.12	10.26	31.94	7.70	-.16	.25*	-	.37**	-.31**
4. PICNIR	.50	.60	19.78	0.65	19.01	1.45	-.02	.19	.28**	-	-.32**
5. PSS	.87	.71	17.34	7.37	26.04	5.56	.28**	-.46**	-.23*	-.55**	-

Note. N = Normotensive group*; HP* = Hypertensive group, Values below the diagonal represent correlations for the normotensive group, while values above represent correlations for the hypertensive group, SEM = Semantic Memory Retrieval Score; SEM.PROB = Semantic Memory Retrieval Probability; RAVLT = Rey Auditory Verbal Learning Test (episodic memory scale); PICNIR = Picture Naming and Recognition Test (semantic memory scale); PSS = Perceived Stress Scale. $p < .05$, $p < .01$, $\boldsymbol{p} < .001$.

Table 2

Independent Samples t-test Comparing Semantic Memory, Episodic Memory, Picture Recognition, and Perceived Stress for *Normotensive (n = 100) and Hypertensive (n = 100) Groups*

	Normal (n=100)		Hypertension (n=100)				95% CL		
Variables	*M*	*SD*	*M*	*SD*	*t (df)*	*p*	*LL*	*UL*	*Cohen's d*
Semantic Memory Retrieval	169.66	30.37	124.05	25.76	11.45(198)	0.00	37.76	53.46	1.62
Episodic Memory	46.12	10.26	31.94	7.69	11.05(198)	0.00	11.65	16.71	1.56
Picture Naming and Recognition	19.78	0.64	19.01	1.45	4.84(198)	0.00	0.45	1.08	0.67
Perceived Stress Scale	17.34	7.36	26.04	5.56	-9.42(198)	0.00	10.52	6.87	1.33

Note. *M* = Mean; *SD* = Standard Deviation; *t* = *t*-statistic; *df* = degrees of freedom; *p* = significance value; LL = lower limit; UL = upper limit; Cohen's *d* = effect size. Confidence intervals represent 95% CI. $p < .05$ indicates statistical significance.

Table 3

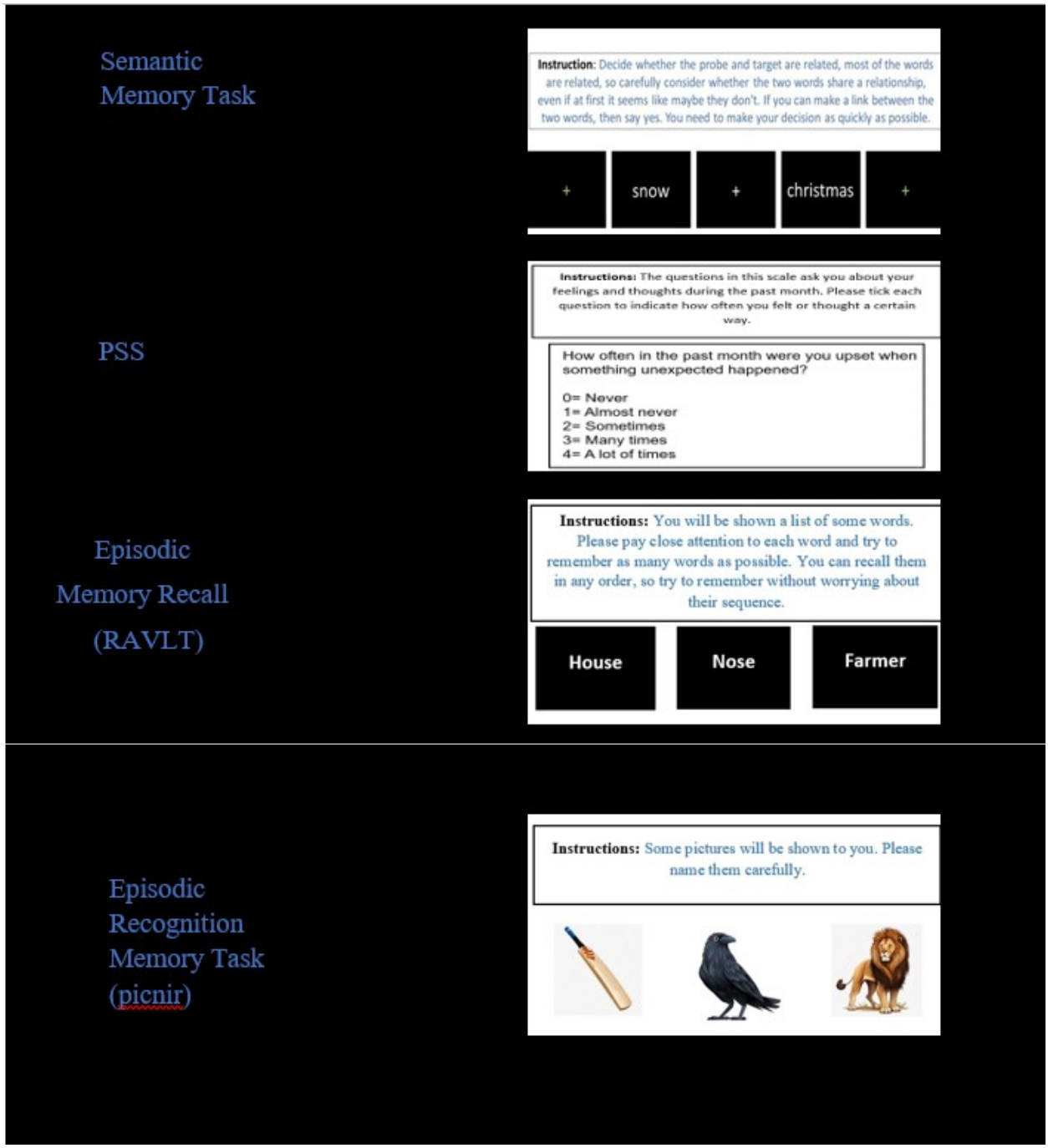
Mediation and Moderation Analyses of the Relationship between Episodic Memory and Semantic Memory, with Perceived Stress as a Mediator and Group Status as a Moderator (N = 200)

Analysis Type	Group	Path	B	SE	β	p
Mediation	Normal (RAVLT)	RAVLT → PSS	-0.255	0.069	-0.313	.002
		RAVLT → Semantic Memory	0.921	0.284	0.311	.002
		PSS → Semantic Memory	-0.875	0.407	-0.212	.034
Mediation	Hypertensive (RAVLT)	RAVLT → PSS	-0.170	0.071	-0.235	.018
		RAVLT → Semantic Memory	0.836	0.327	0.250	.012
		PSS → Semantic Memory	-2.159	0.414	-0.466	.001
Mediation	Normal (PICNIR)	PICNIR → PSS	-3.754	1.090	-0.329	.001
		PICNIR → Semantic Memory	22.753	4.165	0.483	.001
		PSS → Semantic Memory	-0.875	0.407	-0.212	.034
Mediation	Hypertensive (PICNIR)	PICNIR → PSS	-2.125	0.322	-0.555	.001
		PICNIR → Semantic Memory	3.378	1.758	0.191	.058
		PSS → Semantic Memory	-2.159	0.414	-0.466	.001
Moderation	Full Sample	PICNIR → Semantic Memory	42.128	8.328	1.379	.001
		Group (Normal vs. HTN)	-35.550	4.066	-0.492	.001
		PICNIR × Group Interaction	-19.375	4.447	-1.165	.001
		Model R^2	-	-	0.489	-
		Model F(3,196)	-	-	62.590	.001

Note. B = Unstandardized coefficient; SE = Standard Error; β = Standardized beta; PSS = Perceived Stress Scale; RAVLT = Rey Auditory Verbal Learning Test (Episodic Memory Recall); PICNIR = Picture Naming and Recognition Test (Episodic Memory Recognition); Semantic Memory=Semantic Memory Retrieval Score; Group = Normal vs. Hypertensive (moderation variable); PICNIR × Group= Interaction between group and PICNIR(Semantic memory scale).

Figure 1

Illustration of the administration procedures for the Semantic Memory Task, Perceived Stress Scale (PSS), Episodic Memory Recall Task (Rey Auditory Verbal Learning Test; RAVLT), and Episodic Recognition Memory Task (PICNIR).



Novel Contribution

The present study makes several significant contributions. Theoretically, it deepens our understanding of how psychological (perceived stress) and physiological (hypertension) factors interact to influence episodic and semantic memory systems, moving beyond prior research that examined these variables in isolation. Clinically, the findings underscore the importance of integrated intervention strategies—combining hypertension management with stress-reduction techniques such as mindfulness, cognitive behavioral therapy, or vascular health programs—to prevent cognitive decline, particularly in aging populations at greater risk. Methodologically, the study is strengthened by the use of both recall (RAVLT) and recognition (PICNIR) tasks, validated instruments (PSS and Semantic Memory Scale), and standardized computerized assessments via PsychoPy, enhancing accuracy and consistency. Nonetheless, limitations include the cross-sectional design, which prevents causal inference; reliance on self-reported stress measures, which may introduce bias; and variability in participants' digital literacy, which could have influenced task performance despite standardized instructions and training.

Limitations and Future Directions

This study is limited by its cross-sectional design, which restricts the ability to draw causal inferences between perceived stress, hypertension, and memory performance. The use of self-reported measures for stress assessment may also introduce response bias and limit objectivity. Additionally, variability in participants' digital literacy may have impacted the accuracy of computerized cognitive assessments, despite the provision of standardized instructions and practice sessions. Future research should adopt longitudinal or experimental designs to establish causal relationships and track cognitive changes over time. Incorporating neuroimaging techniques (e.g., fMRI, DTI) may offer deeper insights into the neural mechanisms underlying the observed associations. Moreover, future studies should explore diverse populations with varying socioeconomic and cultural backgrounds to enhance generalizability and examine the potential role of additional psychological variables such as anxiety, resilience, or coping strategies.

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Conclusion

The present study provides robust evidence for the mediating role of perceived stress and the moderating role of hypertension in the relationship between episodic and semantic memory. These findings highlight the interdependent roles of stress and vascular health in cognitive aging and memory decline. Future research should employ longitudinal designs and incorporate neurobiological markers (e.g., cortisol, neuroimaging) to further elucidate the neural pathways underlying these effects. Addressing both stress and hypertension may be crucial for maintaining cognitive function, particularly in aging or at-risk populations.

Ethical Consideration

The study received ethical approval from the Cognitive and Neuroscience Laboratory, Department of Psychology, Foundation University Islamabad, Pakistan. Informed consent was obtained from all participants prior to data collection, and voluntary participation was emphasized. Participants were assured of confidentiality, anonymity, and their right to withdraw at any stage without penalty.

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Availability of data and materials

The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions/Author details

Maruam Anees conducted in the Cognitive and Neuroscience Laboratory at Department of Psychology, Foundation University Islamabad. Data collection was facilitated through affiliated clinical and hospital settings in Pakistan.

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