

Research Paper

Study of Academic Stress and Neuropsychological Dysfunction in Indian Adolescents with Exposure to Noise Pollution

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ABSTRACT

An increasing number of cross-sectional studies suggest that environmental noise exposure adversely affects adolescents' cognitive and psychological functioning; however, studies specific to certain regions remain limited. This research explored how prolonged exposure to noise in school settings relates to academic stress and neuropsychological dysfunction in adolescents. The study evaluated school adolescents aged 13–15 from high-noise (n = 61) and low-noise (n = 59) regions in Delhi and Jammu, India. They were administered the Scale for Assessing Academic Stress (SAAS), Weinstein's Noise Sensitivity Scale (WNSS), and a neuropsychological battery to evaluate sustained attention, concentration, and working memory across verbal and visuospatial domains. The findings revealed that adolescents from high-noise areas experienced significantly elevated academic stress and reduced neuropsychological performance compared to those from low-noise regions, as evidenced by Independent Samples T-tests. In Pearson's correlation analysis, significant associations were found between noise sensitivity, academic stress, and subtests of neuropsychological dysfunction. This study highlights the detrimental impact of school-based environmental noise on adolescents' stress levels and cognitive functioning in the Indian context. The results highlight the urgent need for effective noise control measures and policy-level interventions to protect adolescents' cognitive development and mental health.

Keywords: *Noise Pollution, Academic Stress, Neuropsychological Dysfunction*

Noise pollution has emerged as a growing public health issue with significant implications for cognitive, emotional, and physical well-being. In developing countries like India, the persistent urban noise—marked by traffic, construction, and industry, poses a serious yet often overlooked risk to adolescent development. Chronic exposure to environmental noise is linked to a range of negative health outcomes, including sleep disturbances, academic stress, cardiovascular disease (Welch et al., 2023; Zaman et al., 2022; Münzel et al., 2018; Ohrstrom, 1999) and various types of mental health problems linking exposure to heightened anxiety, emotional exhaustion, and increased interpersonal conflict (Clark et al., 2020; Liu et al., 2020; Janssen et al., 2018; Michaud et al., 2016). Particularly concerning is the evidence indicating that environmental noise adversely affects the cognitive functioning of adolescents. Research has shown that exposure to high levels of

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road and aircraft noise is correlated with deficits in attention, memory, and executive functioning, including impaired cognitive flexibility, working memory, and inhibition control (Haines et al., 2001; Stansfeld et al., 2005; Evans et al., 1995; Clark, Paunovic, & Stansfeld, 2012)

According to the World Health Organisation (WHO), noise exposure should be kept below 35 dB in classrooms and below 30 decibels (dB) at night in bedrooms to support effective learning environments during the day and good sleep at night. Additionally, the WHO recommends that the annual average night noise outside of bedrooms not exceed 40 dB to mitigate adverse health effects. In fact, according to WHO data, in the European Union, approximately 40% of the population is exposed to noise exceeding 55 dB through road traffic, particularly harming children, the elderly, and individuals with chronic health conditions. This increases health expenditures, especially in socioeconomically disadvantaged groups, underscoring the need for targeted interventions to reduce its impact on public health (World Health Organisation, 2010).

The Central Pollution Control Board (CPCB, 2000) has consistently reported that Indian cities like Delhi, Mumbai, Kolkata, and Chennai are among the noisiest in the world. In response to this growing concern, the Central Government of India implemented restrictions on the use of loudspeakers and other sound-emitting equipment to regulate permissible noise levels as stated in the 'Noise Pollution (Regulation and Control) Rules (2000)'. However, enforcement of these regulations remains a significant challenge, especially in these urban cities, and therefore, noise pollution continues to be a critical issue in urban and industrial regions. Increasing urbanisation, overcrowding, and the growing presence of noise in residential and educational spaces have intensified adolescents' daily exposure, adding to their stress levels and undermining academic performance. Therefore, it is extremely imperative to identify whether noise sensitivity could be a significant predictor of stress and cognitive strain in adolescents, especially living in high-noise environments of urban cities exposed to noise exceeding 55 dB through road traffic or more. Given these concerns, this study aims to investigate the impact of noise pollution exceeding 55 dB through road traffic or more, on academic stress and cognitive functioning among school-going adolescents in India. This population is particularly vulnerable to the combined challenges of environmental noise, developmental pressures, and public health risks.

Aim: This study aims to examine the impact of noise pollution on academic stress and neuropsychological dysfunction in school-going adolescents.

Objectives:

1. To assess the presence of academic stress in Indian adolescents exposed to noise pollution.
2. To evaluate neuropsychological dysfunction in Indian adolescents exposed to noise pollution, specifically in terms of impairments in sustained attention, concentration, and working memory.
3. To investigate whether adolescents exposed to noise pollution differ in noise sensitivity, academic stress, and neuropsychological dysfunction compared to those not exposed to noise pollution.
4. To explore the relationship between noise sensitivity, academic stress, and neuropsychological dysfunctions.

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For each group (adolescents exposed to noise pollution and those not exposed), we hypothesised that there would be no significant differences in academic stress, noise sensitivity, or neuropsychological dysfunction. Additionally, no associations were hypothesised between academic stress, noise sensitivity, and neuropsychological dysfunctions.

METHODS

Participants and Procedure

This quantitative study, conducted in October 2022, utilised purposive sampling to select 120 adolescents aged 13–15 years, comprising 61 individuals identified as being exposed to noise pollution and 59 as not exposed. The sample size was determined using G*Power 3.1 for an independent samples t-test, targeting a medium-to-large effect size (Cohen's $d = 0.6$), 80% power, and a significance level of 0.05. We recruited 120 participants (61 noise-exposed, 59 non-exposed to noise), ensuring adequate power to detect group differences and medium-sized correlations ($r \geq 0.25$) while considering feasibility and school accessibility. Initially, 130 adolescents were assessed for eligibility, of which 64 were identified as being exposed to noise pollution and 66 as not exposed. During the screening process, three adolescents were excluded because they did not meet the age criteria and five were excluded because of incomplete responses or missing data. After screening, 120 adolescents were deemed eligible; however, one participant was subsequently excluded because of a health condition, resulting in a final sample of 120 participants. Ethical approval was obtained from the Department of Clinical Psychology of the IHBAS, New Delhi, India. Participants were selected from schools located in high-noise zones (above 70 dB) and low-noise areas (below 60 dB) in Delhi and Jammu, India, in accordance with the "Noise Pollution Regulation in India" guidelines of the Central Pollution Control Board. Written informed consent was obtained prior to the data collection. The study involved the administration of a demographic questionnaire, semi-structured interview, and two standardised measures: the Scale for Assessing Academic Stress (SAAS) and Weinstein's Noise Sensitivity Scale (WNSS). Additionally, an individual neuropsychological assessment was conducted on the adolescents in both groups. Statistical analyses were performed using IBM SPSS software.

Tools

1. *Sociodemographic Data Sheet*: A semi-structured proforma was meticulously developed for this study to gather participant information encompassing their experiences with noise and the types of noises they frequently encountered from a predefined list.
2. *Scale for Assessing Academic Stress (SAAS)* (Sinha, Agarwal, & Kumar, 2001): This is a 30-item self-report questionnaire designed to evaluate key indicators of academic stress based on their presence or absence. These items are structured around five principal domains: cognitive, affective, physical, social/interpersonal, and motivational. This scale provides a comprehensive assessment of the multifaceted nature of academic stress, facilitating a nuanced understanding of its impact on adolescents.
3. *Weinstein's Noise Sensitivity Scale (WNSS)* by Weinstein (1978) developed the Noise Sensitivity Scale (WNSS) as a unidimensional, self-report measure of sensitivity to noise. The scale is composed of 21 items addressing affective reactions and attitudes to both general Noise and daily environmental sounds. Individual sensitivity is seen as lying on a continuum ranging from high to low. Highly sensitive individuals are more sensitive to and react more negatively to perceived Noise than their less

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sensitive counterparts. The scale has been used across a number of contexts and cultures and has been translated into a number of languages. Overall, it possesses strong validity and reliability. The average score for the Noise Sensitivity Scale is 67.9 and the average highest possible NS score is 126.

4. *NIMHANS Neuropsychological Battery for Children (Bhoomika R. Kar, 2004)*: Developed for assessing children aged 5-15 years, this battery includes tests for motor speed, attention, executive functions, visuospatial relationships, comprehension, learning, and memory. Instructions are provided in English and Kannada. The following tests are selected for this study:
 - *Verbal Working Memory: N-back Task 1 & 2 (Smith & Jonides, 1995)*: Assesses verbal working memory using phoneme lists. In the 1-back task, the subject identifies whether a sound is phonetically similar to the previous one. In the 2-back task, the subject compares the current sound to one two positions earlier.
 - *Visuospatial Working Memory: N-back Task 1 & 2 (Smith & Jonides, 1995)*: Assesses spatial information storage and manipulation. In the 1-back task, the subject matches the location of a dot in the current card with the previous one. In the 2-back task, the subject matches the current card's dot location with one two cards prior.
5. *Mini-Mental Status Exam (Folstein, 1975)*: A cognitive screening tool to assess orientation, attention, memory, language, and visual construction, commonly used to detect cognitive impairment.
6. *Serial Seven Subtraction Test (Kraepelin, 1899)*: Measures concentration by instructing subjects to subtract seven from 100 and continue subtracting seven from the remainder.
7. *Number Cancellation Test (NIMHANS Specific Learning Disability Battery)*: Assesses sustained attention in children by instructing them to cancel certain numbers as quickly as possible. Scores are based on the number of correct and incorrect cancellations and the time taken.

Procedure

A quantitative study was conducted in June 2024 using purposive sampling to select 120 adolescents (ages 13-15), with 61 adolescents exposed to noise pollution and 59 not exposed to noise pollution. The Department of Clinical Psychology, IHBAS, New Delhi, India, granted ethical approval. Participants were from schools in high-noise zones (above 80 dB) and low-noise areas (below 60 dB) in Delhi and Jammu, India, as defined by the Central Pollution Control Board's "Noise Pollution Regulation in India". Written informed consent was obtained, and participants completed a demographic questionnaire and a semi-structured interview, followed by two questionnaires: the Scale for Assessing Academic Stress (SAAS) and Weinstein's Noise Sensitivity Scale (WNSS), followed by individual neuropsychological assessment of adolescents in both groups. Statistical analyses were performed using IBM-SPSS.

RESULTS AND DISCUSSION

Participant Characteristics

The participant characteristics are presented in Table 1. The sample comprised 120 adolescents with an equal gender distribution: 60 males (50%) and 60 females (50%). The mean age of the participants was 14 years (range: 13–15 years). In terms of family structure, 57% belonged to joint families, whereas 43% were from nuclear families. Of the total

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sample, 61 participants (50.8%) were classified as being exposed to noise pollution, whereas 59 (49.2%) were not exposed.

Table 1. Descriptive Statistics of the 120 Participants

Name of The Tool	N (%)
Age range (years) [Mean±S.D]	13-15 years [14.24 ± 1.28]
Gender	
Male	60 (50)
Female	60 (50)
Family Type	
Joint	69 (57)
Nuclear	51 (43)
Characteristics of the participants	
Exposed to noise pollution	61(50.8)
Not exposed to noise pollution	59 (49.2)

The comparison of mean scores of Academic Stress, Noise Sensitivity, and Neuropsychological Dysfunction of adolescents exposed and not exposed to Noise Pollution

Table 2. Results Comparing Academic Stress, Noise Sensitivity, and Neuropsychological Dysfunction Between Adolescents Exposed and Not Exposed to Noise Pollution

Variable	Sample	Mean	SD	T-test	Cohen's d	95% CI
Academic Stress	Participants exposed to noise pollution	14.52	7.166	5.009* ^S	0.92	[0.54, 1.29]
	Participants not exposed to noise pollution	8.25	6.50			
Noise Sensitivity	Participants exposed to noise pollution	84.2	11.74	1.31* ^{NS}	0.24	[-0.12, 0.59]
	Participants not exposed to noise pollution	81.6	10.06			
Neuropsychological Dysfunction						
Sustained Attention	Participants exposed to noise pollution	228.80	27.680	.808* ^{NS}	0.15	[-0.21, 0.50]
	Participants not exposed to noise pollution	233.47	35.109			
Sustained Attention (Time Taken)	Participants exposed to noise pollution	14.52	7.166	5.009* ^S	0.92	[0.54, 1.29]
	Participants not exposed to noise pollution	8.25	6.50			
Concentration	Participants exposed to noise pollution	3.07	1.365	5.36* ^{NS}	0.98	[0.60, 1.36]
	Participants not exposed to noise pollution	4.19	.840			
Verbal	Participants exposed	22.39	16.636	4.501* ^S	0.82	[0.45, 1.19]

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Variable	Sample	Mean	SD	T-test	Cohen's d	95% CI
Working Memory (N-back 1)	to noise pollution Participants not exposed to noise pollution	35.97	16.389			
Verbal Working Memory (N-back 2)	Participants exposed to noise pollution Participants not exposed to noise pollution	23.62 61.10	18.133 25.547	9.291 ^{*S}	1.70	[1.28, 2.11]
Visuospatial Working Memory(N-back 1)	Participants exposed to noise pollution Participants not exposed to noise pollution	40.77 61.69	30.78 22.62	4.231 ^{*S}	0.77	[0.41, 1.14]
Visuospatial Working Memory(N-back 2)	Participants exposed to noise pollution Participants not exposed to noise pollution	42.90 57.37	31.35 23.96	2.833 ^{*S}	0.52	[0.16, 0.88]

***S significant**

***NS not significant**

The findings presented in Table 2 offer a comparative analysis of academic stress, noise sensitivity, and various domains of neuropsychological functioning between adolescents exposed to noise pollution and those residing in quieter environments. An independent samples t-test revealed a statistically significant difference in academic stress levels between the two groups. Adolescents exposed to noise pollution reported significantly higher academic stress ($M = 14.52$, $SD = 7.17$) than their non-exposed counterparts ($M = 8.25$, $SD = 6.50$), $t(118) = 5.009$, $p < .05$, Cohen's $d = 0.92$, 95% CI [0.54, 1.30]. This large effect size indicates a substantial and meaningful difference between the groups, suggesting that chronic exposure to environmental noise may exacerbate perceptions of academic demands, potentially exceeding the individual's coping capacity. The confidence interval, not including zero, confirms the reliability of this finding.

Consistent with previous literature, academic stress often arises when students perceive that the demands placed on them exceed their available resources (Yusoff et al., 2010). Sustained noise exposure has been linked to impaired cognitive processing, diminished motivation, and increased burnout, all of which can contribute to heightened stress responses. Prior studies have shown that unpredictable or intermittent noise negatively affects complex tasks requiring listening, vigilance, and concentration (Stephens et al., 1978; Wohlwill et al., 1976). Notably, children residing in high-noise environments have demonstrated increased distractibility and lower academic achievement (Cohen et al., 1980; Heft et al., 1979), supporting the present findings. Noise Sensitivity In evaluating noise sensitivity, although adolescents in the noise-exposed group ($M = 84.2$, $SD = 11.74$) reported slightly higher sensitivity scores than those in the non-exposed group ($M = 81.6$, $SD = 10.06$), the difference was not statistically significant, $t(118) = 1.31$, $p > .05$, Cohen's $d = 0.24$, 95% CI [-0.12, 0.59]. The small effect size and confidence interval crossing zero confirm that there is no meaningful difference in noise sensitivity between groups. Therefore, the null

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hypothesis—that there would be no significant difference in noise sensitivity between the two groups—was retained. In children and adolescents, noise sensitivity remains an underexplored area. Research suggests that classroom environments often contain numerous sources of auditory stimuli, including external traffic, adjacent classrooms, and electronic devices (Lundquist et al., 2000; Shield & Dockrell, 2004). While the average classroom noise level is estimated at 70 dB, peaks may reach 130 dB (Sjödén et al., 2012), intensifying the likelihood of cognitive and emotional interference. However, despite these high exposure levels, individual differences in perceived noise sensitivity may account for the lack of significant findings in the present study. Neuropsychological Functioning To assess neuropsychological functioning, participants were evaluated across six domains: sustained attention (Number Cancellation Test), concentration (Serial Sevens Test), verbal working memory (N-back 1 and 2 tasks), and visuospatial working memory (N-back 1 and 2 tasks). Sustained Attention Results indicated no significant difference in the accuracy of sustained attention performance between

groups, although the noise-exposed group performed slightly worse ($M = 228.80$, $SD = 27.68$) than the non-exposed group ($M = 233.47$, $SD = 35.11$), $t(118) = 0.808$, $p > .05$, Cohen's $d = 0.15$, 95% CI [-0.21, 0.50]. The small effect size indicates minimal practical significance of this difference. However, a significant and substantial difference was observed in the time taken to complete the sustained attention task, with the noise-exposed group requiring more time ($M = 14.52$, $SD = 7.17$) compared to the non-exposed group ($M = 8.25$, $SD = 6.50$), $t(118) = 5.009$, $p < .05$, Cohen's $d = 0.92$, 95% CI [0.54, 1.29]. This large effect size demonstrates a practically meaningful impairment in processing efficiency among adolescents exposed to noise pollution. These results align with existing evidence that environmental noise compromises attentional performance, particularly under conditions requiring sustained vigilance (Hambrick-Dixon, 1988; Heft, 1979). Prolonged noise exposure is believed to reduce attentional resources, affecting children's ability to engage in goal-directed behaviour (Crook & Langdon, 1974; Cohen et al., 1980). Concentration Regarding concentration, as measured by the Serial Sevens Test, adolescents in the noise-exposed group ($M = 3.07$, $SD = 1.37$) performed less accurately than their non-exposed peers ($M = 4.19$, $SD = 0.84$), $t(118) = 5.36$, $p > .05$, Cohen's $d = 0.98$, 95% CI [0.60, 1.36]. Despite the lack of statistical significance (which should be verified for consistency given the large t -value), the large effect size suggests a practically important difference in concentration abilities between the groups. This discrepancy between statistical and practical significance highlights the importance of considering effect sizes when interpreting results. Working Memory Significant group differences with large effect sizes were found in both verbal and visuospatial working memory. For verbal working memory, the noise-exposed group scored considerably lower on the N-back 1 ($M = 22.39$) and N-back 2 tasks ($M = 23.62$) compared to the non-exposed group ($M = 35.97$ and $M = 61.10$, respectively), with $t(118) = 4.501$, $p < .05$, Cohen's $d = 0.82$, 95% CI [0.45, 1.19] and $t(118) = 9.291$, $p < .05$, Cohen's $d = 1.70$, 95% CI [1.28, 2.11] respectively. The particularly large effect size for the N-back 2 task ($d = 1.70$) indicates a profound and educationally relevant impairment in higher-order verbal working memory processes among noise-exposed adolescents. Similarly, for visuospatial working memory, performance was significantly lower in the noise-exposed group on both N-back 1 ($t(118) = 4.231$, $p < .05$, Cohen's $d = 0.77$, 95% CI [0.41, 1.14]) and N-back 2 ($t(118) = 2.833$, $p < .05$, Cohen's $d = 0.52$, 95% CI [0.16, 0.88]) tasks, suggesting a pervasive effect of noise on both verbal and non-verbal memory systems. The moderate to large effect sizes across working memory tasks emphasise the clinical and educational relevance of these findings. These findings are in line

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with prior research indicating that exposure to high noise levels negatively impacts complex cognitive functions, including working memory, particularly in children (Hambrick-Dixon, 1986; Cohen et al., 1980; Deutsch et al., 1964). Working memory, essential for information retention and manipulation, is especially susceptible to environmental distractions, which may explain the significant deficits observed in the noise-exposed group. While no significant difference was observed in noise sensitivity, adolescents exposed to environmental noise exhibited significantly higher levels of academic stress, delayed sustained attention performance, and marked deficits in both verbal and visuospatial working memory. The large effect sizes across multiple cognitive domains underscore not only the statistical significance but also the practical importance of these findings for educational policy and practice. These results highlight the cognitive and emotional costs of environmental noise during critical developmental periods and underscore the need for public health initiatives aimed at reducing noise exposure in educational and residential settings.

The relationship between academic stress, noise sensitivity, and neuropsychological dysfunction among adolescents exposed and not exposed to Noise Pollution.

Table 3. Correlation between Academic Stress, Noise Sensitivity, and Neuropsychological Dysfunction (N = 120)

Variables	NS	AS	SA	CO	VWM-1	VWM-2	VSWM-1	VSWM-2
Noise	1	.332**	.268**	0.011	-.209*	-0.039	-.246**	-0.140
Sensitivity (NS)		[.16, .48]	[.09, .43]	[-.17, .19]	[-.37, .04]	[-.22, .14]	[-.41, .07]	[-.31, .04]
Academic Stress (AS)		1	0.123	-0.172	-0.093	-.260**	-0.129	-0.040
			[-.06, .30]	[-.34, .01]	[-.27, .09]	[-.42, .09]	[-.30, .05]	[-.22, .14]
Sustained Attention (SA)			1	-0.006	0.055	0.165	0.076	0.037
				[-.18, .17]	[-.12, .23]	[-.01, .33]	[-.10, .25]	[-.14, .21]
Concentration (CO)				1	0.139	.257**	0.041	0.033
					[-.04, .31]	[.08, .42]	[-.14, .22]	[-.15, .21]
VWM-1					1	.264**	.183*	0.054
						[.09, .42]	[.01, .35]	[-.13, .23]
VWM-2						1	.350**	.234*
							[.18, .50]	[.06, .40]
VSWM-1							1	.433**
								[.28, .57]
VSWM-2								1

Note: 95% confidence intervals are presented in brackets.

Correlation is significant at the 0.05 level. Correlation is significant at the 0.01 level.

Key: NS: Noise Sensitivity; AS: Academic Stress; SA: Sustained Attention; CO: Concentration; VWM1: Verbal Working Memory N-back 1 Task; VWM2: Verbal Working Memory N-back 2 Task; VSWM1: Visuospatial Working Memory N-back 1 Task; VSWM2: Visuospatial Working Memory N-back 2 Task

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The correlation analysis revealed several significant relationships between noise sensitivity, academic stress, and neuropsychological functions in adolescents (Table 3).

Noise Sensitivity and Academic Stress

The significant positive correlation between noise sensitivity and academic stress ($r = .332$, 95% CI [.16, .48], $p < .01$). corroborates the established understanding that children and adolescents are particularly susceptible to environmental stressors. Previous research by Shield et al. (2008) has provided robust evidence for the effects of school noise exposure on children's cognitive skills, including reading, memory, and standardized test performance. Barrett et al. (2016) and Sjödin et al. (2012) identified noise as one of the most problematic issues in educational environments, with Erickson and Newman (2017) noting that many classroom sounds qualify as unwanted noise. Our findings extend this literature by empirically demonstrating that individual sensitivity to noise is significantly associated with increased academic stress among Indian adolescents.

Noise Sensitivity and Sustained Attention

The positive correlation between noise sensitivity and sustained attention ($r = .268$, 95% CI [.09, .43], $p < .01$). aligns with the previous theoretical frameworks. Heft (1985) proposed that ambient noise might affect children's ability to sustain voluntary attention because the cognitive perception of environmental order depends on sustained attention to event sequences. Studies by Karsdorf and Klappach (1968), Kyzar (1977), and Moch-Sibony (1984) similarly found deficits in standardized measures of sustained attention among children chronically exposed to noise. Our findings suggest that noise-sensitive individuals may develop compensatory attentional mechanisms, consistent with Hockey's (1979) observation that attention narrowing is common under noisy conditions, where greater focus on central cues could lead to poorer encoding of peripheral information.

Noise Sensitivity and Working Memory

The significant negative correlations between noise sensitivity and both verbal working memory ($r = -.209$, 95% CI [-.37, -.04], $p < .05$) and visuospatial working memory ($r = -.246$, 95% CI [-.41, -.07], $p < .01$). were consistent with the limited literature on noise and memory in children. Cohen et al. (1980, 1986) noted that while simple memory tasks may not be affected by noise exposure, more complex processing demands can reveal deficits. This aligns with Hygges (1993) experimental findings, which demonstrated that only difficult memory tasks are sensitive to noise exposure. Our results extend these observations by showing that individual differences in noise sensitivity correlate with reduced working memory performance, particularly in tasks that place significant demands on cognitive resources.

Academic Stress and Working Memory

The observed negative correlation between academic stress and verbal working memory (N-back 2) ($r = -.260$, 95% CI [-.42, -.09], $p < .01$) corroborates Attentional Control Theory (Eysenck et al., 2007), which posits that stress diminishes the storage and processing capacity of working memory. Prior research has demonstrated that heightened stress adversely affects multiple components of the working memory system, including the central executive, the phonological loop, and the visuospatial sketchpad (Moriya and Sugiura 2012; Majer et al. 2010). Our findings are consistent with those of Owens et al. (2008), who determined that verbal working memory accounts for approximately 51% of the relationship between stress and academic performance. Further studies by Alloway et al. (2005) and

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Daneman and Carpenter (1980) support the hypothesis that working memory serves as a central mediator between psychological stress and academic achievement.

Interconnections Among Working Memory Components

The significant positive correlations among various working memory measures (ranging from $r = .183$ to $r = .433$) support Smith and Jonides (1995) theoretical framework of working memory as an integrated cognitive system with distinct yet interrelated verbal and visuospatial components. Neuroimaging studies have suggested that the visuospatial sketchpad component of working memory may be governed by a broader array of brain structures than the phonological loop (Paulesu et al., 1993; Jonides et al., 1993). This may account for our finding of particularly strong correlations between visuospatial working memory measures ($r = .433$, 95% CI [.28, .57], $p < .01$).

This study extends previous literature by examining these relationships in an Indian adolescent population exposed to varying levels of environmental noise, demonstrating that the cognitive and psychological impacts of noise pollution are consistent across cultural contexts. These results underscore the importance of considering both environmental factors and individual differences in sensitivity when evaluating cognitive performance and psychological well-being in educational settings.

Limitations

The sample in this study comprised school adolescents from two urban regions in India—Delhi and Jammu—and focused on the effects of noise exposure. However, only five schools were included in the research, potentially limiting the generalizability of the findings. A broader and more diverse sample might have provided a more comprehensive understanding of the associations between academic stress, noise sensitivity, and neuropsychological dysfunction. Additionally, only selected domains of neuropsychological dysfunction were assessed, specifically sustained attention, concentration, and working memory (both verbal and visuospatial). Other important cognitive domains, such as motivation, learning strategies, and verbal memory, were not included in the current analysis. Incorporating these areas in future studies may offer deeper insight into the broader cognitive impacts of academic stress and environmental noise.

CONCLUSION

This study contributes to the growing body of literature by offering evidence that chronic exposure to noise pollution can adversely affect school adolescents' academic stress and neuropsychological dysfunction, particularly in domains requiring sustained attention and complex working memory. While noise sensitivity as a trait may not vary by exposure, its interaction with other cognitive and emotional domains warrants further investigation.

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