journals.unizik.edu.ng/jgcs ISSN: 1596-1141

JOURNAL OF GUIDANCE AND COUNSELLING STUDIES

THE IMPACT OF NOISE-INDUCED STRESS ON COGNITIVE DEVELOPMENT OF STUDENTS AND ITS IMPLICATION FOR ACADEMIC PERFORMANCE

Dr. GLADYS C. OWEISANA
gladysoweisana@alumni.york.ac.uk
(+2348032671491)

EDUCATIONAL PSYCHOLOGY, GUIDANCE AND COUNSELLING
FEDERAL COLLEGE OF EDUCATION (TECH.), OMOKU
RIVERS STATE, NIGERIA.

Abstract

Environmental noise pollution is a significant stressor with lasting consequence for cognitive development and academic performance. Previously dismissed as irrelevant, noise is now recognized for triggering physiological stress responses, mainly through the activation of the hypothalamic-pituitary-adrenal (HPA) axis, which result in increased cortisol levels and potential impairment of brain region responsible for memory and learning, such as the prefrontal cortex and the hippocampus. This paper explores the impact of noise-induced stress on cognitive development of students and its implication for academic performance. Drawing on recent research, the paper examines the various sources of noise in the school environment and how its impact contributes to stress response. It also explores the implications of noise-induced stress on cognitive abilities and performance outcome in academics. The paper finally, offered recommendations to mitigate noise-induced stress to foster healthy learning environment for optimum academic performance.

Keywords: Noise-induced Stress, cognitive, development, academic, performance

INTRODUCTION

Noise pollution is generally seen as a pervasive environmental stressor particularly in populated settings. Previously regarded as an annoyance, the impact of on human health particularly on cognitive and emotional wellbeing has garnered significant attention in recent years. Schools situated in areas with high traffic, construction, or other sources of environmental noise, present a setting where noise can have several negative effects on students' cognitive abilities and academic performance. While studies have documented links between chronic exposure to high levels of noise and various health challenges, including; hearing loss, sleep disturbance, hypertension and various cardio-vascular diseases, there is an increasing body of evidence suggesting that noise-induced stress causes significant cognitive function impairment, hinder memory retention, and generally reduce learning abilities in both children and adolescents (Stansfeld et al., 2020).

Research investigating noise-induced stress on brain activity and cognitive performance has been few (Jafari, et. al., 2019). Exposure to noise in both occupational and non-occupational environment has become a significant public health concern, as it affects psychological, behavioral and physiological processes (Liang et al. 2024; Tak, et. al., 2009). Studies demonstrate that noise causes oxidative stress in the brain, cognitive impairment such as cognitive and memory defects (Langguth, 2011).

Cognitive development describes the growth and maturation of a person's thinking processes and intellectual abilities (Kashyap & Minda, 2016). It is a foundational aspect of child development linked with decision-making, perception, memory, executive function, learning, reasoning, and language (Harvey, 2019), which are critical for successful academic performance. The definition

of cognitive development is important in understanding how children's intellectual abilities progress over time, making it a foundational aspect of human growth. As academic institutions remain one of the most crucial environments for children's cognitive development, it becomes essential to recognize the role that external factors, such as noise pollution play in shaping students' cognition and learning outcomes.

Studies show that noise trigger stress response in the body through the activation of the hypothalamic-pituitary-adrenal (HPA) axis, which results in elevated cortisol levels. As such, chronic exposure to such stress adversely affect brain structures involved in memory and learning, especially the hippocampus and prefrontal cortex (Liu et al., 2017). This physiological disruption can result in diminished cognitive functions, especially in children who are still in critical stages of brain development.

The implication of noise-induced stress for academic performance is extensive, in academics where focus, problem-solving, critical thinking, and creativity are essential for improved academic performance, noise-induced stress can negatively disrupt students' ability to perform optimally. Although, noise has been recognized as a significant contributor to low academic under-performance, much of the focus is centered on addressing noise levels in the classroom without an adequate understanding of the intricate relationship between noise, stress, and cognitive development. Given the importance of academic performance for students' future opportunities, it is imperatives that educators, researchers, and policy makers better understand the full scope of noise-induced stress on cognitive development and academic outcomes. Only by integrating this knowledge can the appropriate environment that support students cognitive and emotional well-being be fostered for an enhanced learning and academic performance.

This article seeks to explore the impact of noise-induced stress on cognitive development in students, focusing on how noise exposure impacts attention, memory, emotional regulation, and overall academic performance. By reviewing current research on noise and its effects on brain function, this paper examines the broader implications of noise for educational practices and policies.

Noise and its Sources in Educational Settings

Noise pollution is generally characterized by sound that disrupts daily activities, impairs cognitive functions and causes physical discomfort. World Health Organization (2018), defined noise pollution as any environmental noise that is negatively impacts health, particularly when it exceeds a 65 decibel, and persists for long periods. Noise pollution considered as a nuisance is a significant environmental stressor with detrimental effects on human health, particularly in learning environments like schools. Although, noise is a general issue in urban settings, its impact is particularly concerning in an academic environment, where concentration, cognitive development, and mental clarity are critical for improved academic performance and success. In an educational context, noise pollution not only leads to difficulty in concentration, but it can also lead to hearing impairment and increased stress levels.

Primary Sources of Noise in a School Environment

The major sources of noise in schools can be generally categorized into external and internal sources, each of these sources contributes uniquely to the overall noise burden experienced by students in the environment. A good understanding of these sources will help identify strategies to mitigate the impact and improve the quality of the learning environment.

External Sources of Noise

External sources of noise are those that originate from outside the school building but still have a significant impact on the individuals within the school environment. External noise, also known as physical noise or environmental noise, encompasses any sound or disturbance that originates outside the listener and can disrupt or interfere with the effective transmission and reception of a message (Stansfeld et al., 2020). These include but not limited to: **traffic noise**, construction noise, **aviation and airport noise.**

Internal Sources of Noise Pollution in Schools

Internal sources of noise are those that emanates from within the school environment itself. While these sources may be more controllable, they still contribute significantly to the overall noise levels students experience within the school environment. Some of the most common internal sources of noise in schools include; **classroom noise, school bells and announcements**, **cafeteria and hallway noise, school activities and extracurricular noise.**

Impact of Noise-Induced Stress on Cognitive Brain Regions

Chronic exposure to environmental noise has been reported to dysregulate the brain's stress response systems. Over time, this could lead to structural and functional changes in certain brain regions that are responsible for learning, memory, attention, and emotional control. The three most affected areas are the hippocampus, prefrontal cortex, and amygdala.

Hippocampus: The Memory and Learning Center

The hippocampus is an important brain structure located in the medial temporal lobe, responsible for converting short-term memory into long-term memory and it plays a crucial role in spatial navigation and contextual learning (Liu et al., 2017). This region is particularly sensitive to cortisol, the main stress hormone released during HPA axis activation.

With chronic exposure to noise, resulting in repeated stimulation of the stress response and elevated cortisol levels, over time, the hippocampal functioning may be impaired. Studies have showed that high cortisol levels reduce neurogenesis, disrupt synaptic plasticity, and can even cause atrophy in hippocampal tissue (Liu et al., 2017). These effects directly limit the brain's capacity to encode, store, and retrieve information, which is especially detrimental in academics where students are expected to retain large volumes of content, perform in assessments, and engage in complex problem-solving activities.

Prefrontal Cortex: The Seat of Executive Function

The prefrontal cortex (PFC), is located at the front of the brain. It is integral to executive functions including attention regulation, reasoning, decision-making, working memory, and goal-directed behavior (Hughes et al., 2019). The PFC functions like the brain "control center", enabling people to focus, regulate impulses, and manage distractions, coordinate thoughts and actions in accordance with internal goals.

A major challenge the PFC faces in today's world is environmental noise exposure. Noise exposure interferes with the function of the PFC in various ways. The need to constantly filter out

irrelevant background noise consumes cognitive resources and reduces the brain's ability to focus on the task at hand. Studies shows that even low levels of ambient noise can lead to significant reductions in working memory performance and task persistence (Hughes et al., 2019). This effect is particularly detrimental in classroom settings where attention and mental organization are crucial.

Furthermore, exposure to chronic noise can weaken functional connectivity within the PFC and between other brain areas involved in cognitive control. This can lead to diminished capacity for sustained attention, poor organizational skills, difficulty shifting between tasks and increased mental fatigue (Miller & Cohen, 2001). For students, these impairments can translate into experiencing difficulties staying on task, decreased ability to plan and complete assignments effectively, and increased susceptibility to distractions. The PFC as the center of executive function, is very sensitive to environmental stressor such as noise. Hence, protecting learning environment from irrelevant noise is essential not just for comfort but also for preserving students' cognitive function, promoting mental wellbeing, and supporting general academic performances.

Amygdala: Emotional Processing and Stress Regulation

The amygdala is an almond-shaped small structure deep within the brain's limbic system, mainly involved in the processing of emotions, specifically fear, threat detection, and stress responses. Although the activation of the amygdala is a normal part of the body's defense mechanism, constant or prolonged activation due to chronic noise exposure can lead to severe emotional sensitivity and stress reactivity (Evans & Cohen, 2021).

Noise stimulates the amygdala even when an individual is not consciously aware of it, particularly when the noise is unpredictable or intrusive. This constant state of alertness can result in increased levels of anxiety, irritability, and emotional dysregulation (Evans & Cohen, 2021). In an educational setting, this emotional hyper-reactivity may interfere with students' ability to focus, participate in classroom discussions, or manage interpersonal conflicts.

Cognitive Effect of Noise-Induced Stress on Students

Noise generally has a profound and multifaceted impact on students' cognitive abilities, especially during formative academic years when the brain is undergoing significant development. Research has shown that continuous exposure to unwanted environmental noise impairs cognitive abilities including; memory retention, attention regulation, reading comprehension, problem solving, and language processing.

The Munich Airport study is a popular study by Hygge, et al., (2002), that examined the cognitive performance of school children before and after relocation of an airport. The study found that chronic exposure to aircraft noise result in significant delays in memory performance and reading comprehension among students. Also, Shield and Dockrell (2003), studied the effect of classroom noise in primary school in London the study found that increased levels in classroom noise were associated with low performance in mathematics and reading. This study suggested that noise both disrupts students' ability to hear and process verbal instructions and also their ability to remain focus and organize thoughts, which are key elements in literacy and numeracy development. The study concluded that constant background noise in a classroom, including those emanating from

nearby traffic or poorly insulated interiors, creates a cognitive demanding environment, that increases the mental efforts required to perform learning tasks.

This disruption occurs because noise consumes limited cognitive resources. Cognitive load theory propose that individuals possess limited amount of attentional capacity at any given time (Sweller, Ayres, & Kalyuga, 2011). When a classroom is always noisy, students involuntarily redirect part of their attentional capacity to filter out the unwanted sounds, thereby leaving fewer resources available for learning-related activities. This results in higher incidence of cognitive fatigue and reduced working memory efficiency, particularly in younger students who are still developing effective self-regulation strategies (Klatte, et, al. 2013).

According to Klatte, et al. (2013). Chronic exposure to noise at critical developmental phases, such as early childhood and pre-adolescence is very critical because it may disrupt maturation of critical executive functions, impulse control, goal-setting behaviors, and task switching. These executive functions are critical not only for academic performance but also for broader life outcomes, indicating that unwanted noise may have implications that extends beyond the classroom.

Basically, when environmental noise is allowed to persist without control in a learning environment, it impedes students' ability to process information efficiently, sustain concentration, and retain new knowledge. Leading to poor academic performance and in some cases long term developmental delays. This occurs because chronic environmental noise is a pervasive stressor that can significantly interfere with students' cognitive development and by extension their academic performance. This form of noise-induced stress is both a distraction and also a source of

psychological and physiological strain that interferes with brain functions essential for learning (Klatte, et al.,2013)

The impact of stress-induced noise on the cognitive abilities of students are both substantial and enduring. Classroom environmental noise constitutes a major threat to learning, especially for young and vulnerable students. It negatively impacts memory, interferes with attention abilities, disrupts language acquisition, and increases cognitive fatigue. All of these can potentially hinder academic performance. To foster effective learning environments, it is important that schools prioritize acoustic design and implement strategies to mitigate noise in school environments.

Implications of Noise-Induced Stress for Academic Performance

The cognitive interference caused by noise-induced stress have both direct and far-reaching implications for academic performance. Students who learn in a noise prone environment will doubtless experience difficulty in recalling information, think critically, and are likely to struggle while completing assignments, performing well on tests, and maintaining motivation in school. The impact of noise on academic performance can manifest in several ways:

1. **Poor Grades and Test Scores**: Students exposed to chronic noise tend to experience a decline in academic performance and overall academic achievement. This can manifest in lower grades and poor test scores, especially in subjects that requires high levels of concentration and cognitive reasoning. A study by Stansfeld et al., (2005), showed that children living in noisy environments near airports performed significantly poorer on reading comprehension and memory tasks compared to their peers in quieter environments. Over time, the continuous intrusion of noise can lead to mental fatigue,

elevated stress levels, and reduced motivation to study, all of which contribute to diminished academic performance (Tanimowo, 2017). As such, students may struggle to keep up with their coursework, effectively complete assignments, or perform very well in standardized tests and classroom exams. This decline in academic performance is often reflected in consistently poor grades and low-test scores, highlighting the profound impact of environmental noise-induced stressors on educational outcomes.

2. **Decreased Motivation and Engagement:** A continuous exposure to uncontrolled noise in an educational setting, can affect students' motivation and engagement in learning significantly. Noise acts a stressor that interferes with mental focus, emotional stability often resulting in irritability and frustration (Clark & Paunovic, 2018). With time, this constant psychological strain reduces students' intrinsic motivation to learn. When students constantly experience noise or are distracted by noise in the classroom, they may experience difficulty processing information efficiently, retain what has been learned. This normally would result in cognitive overload where the brain is burdened by background noise to effectively focus on academic tasks. Such overload often contributes to academic disengagement and potentially academic underperformance (Klatte et al., 2013).

3. **Mental Health Challenges**: Prolonged exposure to environmental noise has been significantly linked with mental health challenges among children and adolescents. According to Stansfeld and Clark (2015), exposure to persistent uncontrolled noise can significantly manifest in psychological conditions, including; heightened arousal,

irritability and restlessness. These are early signs of emotional strains, and when sustained, can result in the development of clinical anxiety or depressive symptoms, especially in vulnerable individuals or students with limited coping mechanisms (Evans & Hygge, 2007). These mental health challenges are not isolated, they have direct impact on cognitive functions like; memory, attention, and executive processing, all of which are essential for learning.

As students experience reduced cognitive capacity under mental stress over time, they may start experiencing difficulties in participating in classroom activities, carrying out academic tasks, poor performance on test and assignments (Basner et al., 2014). Essentially, environmental noise does not only impede momentary concentration, it can also have lasting psychological consequences. Addressing mental health challenges in schools, therefore, requires environmental considerations, including noise reduction strategies, especially in high-density urban areas where children are most at risk

Recommendations for Mitigating Noise-Induced Stress

Given the significant impact of noise on cognitive development and academic performance, it is imperative to implement measures that helps reduce noise exposure in educational settings. The following recommendations are proposed to mitigate noise-related stress and optimize learning environments:

1. **Classroom Design and Acoustic Treatment**: Schools authorities should invest in the design and renovation of classrooms to ensure they are acoustically modified for learning

Schools located in noisy areas, such as near airports or high ways, should consider using double-glazed windows or noise barriers to reduce external noise intrusion.

2. **Quiet Zones and Study Areas**: Apart from classroom interventions, schools should designate quiet zones for independent study or group work. These spaces, should be free from disruptive background noise (Shield & Dockrell, 2008).
3. **Sound Monitoring and Regulation**: Noise level should be regularly monitored and regulated within the school classrooms, libraries, and other academic spaces in the school. Noise level indicators, such as decibel meters, can be used to maintain the noise levels below thresholds that cause stress or distraction (Shield & Dockrell, 2008).
4. **Promotion of Stress Management Techniques**: Introducing stress management techniques such as mindfulness, deep breathing exercises, and relaxation strategies into the school curriculum can equip students with appropriate skills to manage the psychological effects of noise-induced stress. This approach would teach students how to regulate their emotions, manage anxiety, and maintain focus without been distracted even in noisy environments (Evans & Cohen, 2021).
5. **Increased Awareness and Community Engagement**: Raising awareness on how detrimental noise is on academic performance is an essential, yet often overlooked aspect of educational and community development. To mitigate this, schools should engage in **campaigns** targeting students, parents, and community members. Schools can collaborate with environmental agencies, local government bodies, urban planners to advocate for **zoning laws or noise ordinances** that protect school zones from excessive noise. By integrating these efforts into school and local governance, academic institutions can play a

crucial role in fostering environments that support cognitive development and equitable learning opportunities for all students.

Conclusion

Noise-induced stress is recognized but yet a frequently underestimated factor that significantly impede academic performance. Persistent noise exposure within an academic environment, can have lasting effects on students' cognitive performance. Empirical studies has consistently demonstrated that noise interferes with crucial cognitive functions such as concentration, memory retention, and problem-solving skills. Over time, these impairments would not only lead to lower academic performance but also to heightened levels of anxiety, irritability, and other mental health challenges.

Basically, recognizing the dual impact of noise as both an environmental and psychological stressor, and taking deliberate steps to mitigate them, academic institutions can better support their student's cognitive development. This not only improves immediate academic outcomes but also contributes to the long-term cognitive and emotional development of learners. Ensuring that every student has access to a calm, focused, and supportive learning environment is not just beneficial, it is critical for equitable and effective learning.

References

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S. & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *The Lancet*, *383*(9925), 1325–1332.

Clark, C. & Paunovic, K. (2018). WHO environmental noise guidelines for the European region: A systematic review on environmental noise and cognition. *International Journal of Environmental Research and Public Health*, *15*(2), 285.

Evans, G. W. & Cohen, S. (2021). Environmental stress. In D. Stokols (Ed.), *Handbook of environmental psychology* (2nd ed., pp. 571–610). Wiley.

Evans, G. W. & Hygge, S. (2007). Noise and mental health in children and adolescents: A review. *Journal of Children's Services*, *2*(4), 30–38.

Harvey, L. (2019). *Child development: A thematic approach* (7th ed.). SAGE Publications.

Hughes, R. W., Hurlstone, M. J., Marsh, J. E., Vachon, F. & Jones, D. M. (2019). Cognitive control of auditory distraction: Impact of task difficulty and semantic relatedness. *Journal of Experimental Psychology: Human Perception and Performance*, *45*(4), 499–512.

Hygge, S., Evans, G. W. & Bullinger, M. (2002). A prospective study of some effects of aircraft noise on cognitive performance in schoolchildren. *Psychological Science*, *13*(5), 469–474.

Jafari, M. J., Akbari, J., Khavanin, A., Salehnia, M. & Yekaninejad, M. S. (2019). The effect of occupational noise exposure on blood cortisol and auditory system of workers in a central oil company. *Noise & Health*, *21*(100), 43–50

Kashyap, H. & Minda, J. P. (2016). Cognitive development and executive function: Current perspectives. *Journal of Cognitive Psychology*, *28*(5), 530–544.

Klatte, M., Bergström, K. & Lachmann, T. (2013). Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in Psychology*, *4*, 578.

Langguth, B. (2011). Tinnitus: The causes and treatments. *The Lancet Neurology*, *10*(9), 920–930.

Liang, Y., Fang, L., Guan, Y. & Hu, X. (2024). Noise pollution and brain health: A systematic review of recent neuroimaging and cognitive studies. *Environmental Research*, *238*, 117807.

Liu, L., Shen, J., & Chen, T. (2017). Effects of chronic noise exposure on hippocampal structure and function in rats. *Environmental Toxicology and Pharmacology*, *56*, 59–64.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*, 167–202.

Shield, B., & Dockrell, J. E. (2003). The effects of noise on children at school: A review. *Building Acoustics*, *10*(2), 97–116.

Shield, B., & Dockrell, J. E. (2008). The effects of environmental and classroom noise on the academic attainments of primary school children. *The Journal of the Acoustical Society of America*, *123*(1), 133–144.

Stansfeld, S. A., & Clark, C. (2015). Health effects of noise exposure in children. *Current Environmental Health Reports*, *2*(2), 171–178.

Stansfeld, S. A., Clark, C., Cameron, R. M., Alfred, T., Head, J., Haines, M. M., ... & Hygge, S. (2005). Aircraft and road traffic noise and children's cognition and health: A cross-national study. *The Lancet*, *365*(9475), 1942–1949.

Stansfeld, S., Haines, M., & Brown, B. (2020). Noise and health in the urban environment. In M. Nieuwenhuijsen (Ed.), *Exposure science in the 21st century: A vision and a strategy* (pp. 295–312). Springer.

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. Springer.

Tak, S., Davis, R. R., & Calvert, G. M. (2009). Exposure to hazardous workplace noise and use of hearing protection devices among US workers—NHANES, 1999–2004. *American Journal of Industrial Medicine*, *52*(5), 358–371.

Tanimowo, N. B. (2017). Effect of noise pollution on students' academic performance in urban areas: A case study of selected schools in Ibadan, Nigeria. *Nigerian Journal of Environmental Sciences and Technology*, *1*(1), 45–52.

World Health Organization. (2018). *Environmental noise guidelines for the European Region*. WHO Regional Office for Europe. https://www.who.int/publications/i/item/9789289053563