The University Of Sheffield.

MODIFYING CLASSROOM ACOUSTICAL ENVIRONMENT TO AFFECT SENSORY BEHAVIOURS AND LEARNING OF CHILDREN WITH ASD

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Abstract

This Study examines the correlation between classroom acoustical parameters, sensory response and on-task engagement behaviours of children with Autism Spectrum Disorder (ASD); these behaviours include ear covering, repetitive body movements, loud vocalisation and on-task engagement. The Study takes both qualitative and quantitative approaches. A purposive sample of four male students aged 9 to 11 years with a medical diagnosis of ASD was selected for the Study.

The quantitative approach uses Single Case Experimental Design (SCED) with ABA (Withdrawal Design) to investigate the effects of the long and short reverberation time (RT60). Participants were observed during two weeks of baseline (A1-phase), two weeks of acoustic intervention (B- phase) and two weeks of return to the baseline phase (A2- phase), i.e. removal of acoustic intervention.

In the qualitative Stage 1 Study, semi-structured expert interviews corroborated the manifestation of sensory response behavioural interlinkage with noise/ acoustics and on-task learning and engagement of children with ASD. In the Stage 2 Study, frequencies of delineated sensory response behaviours were calculated from video-recorded sessions of social group activity of 5 to 10 minutes long under existing and improved acoustical conditions. In the Stage 3 Study, the time of the participants' on-task was calculated in percentage using momentary time sampling from 5 to 10 minutes long video-recorded sessions under existing and improved acoustical conditions. Visual analysis was conducted to measure within-phase, between-phase characteristics and supplementary effect size measure and descriptive statistics were reported.

The outcome of the Stage 1 Study shows that noise/acoustics is a significant variable in a classroom environment affecting the sensory behaviours, learning and engagement of children with ASD. In the Stage 2 Study, when the RT60 of the classroom was decreased from 1.11s to 0.39s, the results indicated a positive correlative effect on the overall decrease of repetitive behaviour for all four participants. Ear covering behaviour, the outcome was largely positive; results were promising among three out of four participants, indicative of a positive correlation. Loud vocalising behaviour, the outcome for two out of four participants, was indicative of a strong impact of acoustic intervention across the three markers, visual analysis, non-overlapping percentage, and descriptive mean values, suggesting an overall decrease in loud vocalising behaviour during Phase B intervention. For two of the participants, the outcomes for loud vocalisation were indeterminate due to their idiosyncratic trend findings.

In the Stage 3 Study, overall, the results drew a strong positive co-relationship across the four participants under short RT (0.39s). Children's performativity depicted a significantly higher percentage increase in on-task intervals during 1:1 learning sessions under the improved acoustical condition.

The collated data analysis results were significantly suggestive through its validation that the sensory behaviour modulation of the participating children with ASD was considerably influenced by classroom environment acoustical modification through intervention which is an important factor in their learning and behaviour.

Keywords: Autism, Classroom Acoustics, Environment Design, Learning, Sensory Response Behaviours, Reverberation Time

To my parents, husband and children for their love and support

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Throughout my education and professional career, I have been passionate about creating safe and nourishing spaces for individuals. This has led me creatively apprehend and design environments specifically for people with special needs. My professional and educational career in architecture inspired me to undertake full-fledged doctoral research. This work is the culminating result of the existential plethora of experiences I have gathered as a human being. First and foremost, I would like to express my sincere gratitude to the professionals whose support enabled the completion of this work. I thank my supervisors, Dr Wen Shao, Dr Jian Kang and Dr Michael Phiri, for their indispensable guidance, imparting their specialist knowledge, patience, and unceasing support. This Study was supported by the Oasis School for children with Autism in Lahore, whose entire staff I am grateful for supporting this research, particularly Ms Samrina Anwar and Ms Ayesha Haroon, for permitting me to conduct this research at Oasis premises and anticipating its value.

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Declaration

I, the author, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means (www.sheffield.ac.uk/ssid/unfair-means). This work has not been previously presented for an award at this, or any other, university.

Signed: Ayesha Ghazanfar

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List of Abbreviations

ABA	Reversal/ Withdrawal Design
ABA	Applied behaviour Analysis
ANSI	American National Standard Institute
APD	Auditory Processing Disorder
ASD	Autism Spectrum Disorder
BB93	Building Bulletin 93 (British Acoustic Standards for schools)
CARS	Childhood Autism Rating Scale
CDC	Centre for Disease Control
dB	Decibel
dBA	A-Weighted Sound Pressure Level
DSM	Diagnostic and Statistical Manual
DV	Dependent Variable
EDT	Early Decay Time
Hz	Hertz
HPA	Hypothalamic–Pituitary–Adrenal
IDEA	Individuals with Disabilities Education Act
IV	Independent Variable
L max:	Maximum Sound Pressure Levels Recorded of a Measurement Period
L min:	Minimum Sound Pressure Levels Recorded of a Measurement Period
L90	Sound Level Equalled or Exceeded 90% of the Measurement Time
LAeq	Equivalent Continuous Sound Pressure Level with 'A' Frequency Weighting
PDD	Pervasive Developmental Disorder
PECS	Picture Exchange Communication System
RRB	Restrictive Repetitive Behaviours
RT60	Reverberation Time
SCED	Single Case Experimental Design
SD	Standard Deviation
SI	Speech Intelligibility
SNR	Signal to Noise Ratio
SPD	Sensory Processing Disorder
SPL	Sound Pressure Level
SSRD	Single Subject Research Design
TEACCH	Treatment and Education of Autistic and Related Communication Handicapped Children
Tmf	Mid Frequency Reverberation Times
WHO	World Health Organization
WWC	What Works Clearing House, Single Subject Study Design Standard

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CHAPTER 1: INTRODUCTION

This research underscores a holistic salutogenic environment for children with Autism Spectrum Disorder (ASD) diagnoses. It began from my earlier educational career in architecture, drawing inspiration from texts such as Richard Neutra's Survival Through Design. This built the foundational ideas for my research interests and professional aspirations towards a holistic approach to architecture encompassing intersectionality between the human brain, behaviours, and the built environment, particularly within the context of health, healing, and restoration of human beings. Thus, it was relevant to grasp the biological, cognitive, and behavioural sciences to envision design. In particular, to a group as heterogeneous as children with ASD. Human limitations of built environment design are the limitations of human growth and nowhere more conspicuous than the autism children and their struggles in the minutiae of their daily lives.

Consequently, the careful selection of methodologies in this research echoes the plight of human fragility in the learning environment. Children with ASD cannot be studied within the bounds of normalcy of the social sciences seeking blanket panacea and normativity, as each child is exceptionally distinctive being endowed with a unique mind, which depicts such levels of complexity in apprehending the world around them. I hope this small contribution will inspire not only research but develop the practical needs for learning of children with ASD through appropriately designed schools and classrooms which include therapeutic learning. In the Asian subcontinent, learning pedagogies are availed through ancient wisdom platforms; however, in the Twenty-First Century, the scale of Autism and its reach is truly mind-boggling. This necessitates a truly international outreach and collaboration to promote humane and purposeful architecture.

1.1 Setting the Context

This research is attentive towards drawing the intersectionality of seminal areas of Autism Spectrum Disorder (ASD) children's heightened sensorial dysfunctionality, the problem of noise, and the built environment. The integration of these disciplinary areas is vital in enhancing the development of an appropriate learning classroom environment for children with ASD. These aspects of discipline intersectionality are demonstratively attended to, laying out the profound ramifications of the spatial interiority of buildings on both neuro-typical and atypical individuals with different psychological challenges impacting their well-being and social communication. Although environmental factors affect all individuals to varying degrees, the evidence demonstrated a more significant adverse impact on neuro-atypical individuals.

Taking the crucial built environmental aspect into account, the research underlines the negative impact of the broad currently prevailing normative-traditional architectural practices, which are based upon heuristic and anecdotal modes, whose utility is negligible for the needs of the vast neuro-atypical populations (Martin, 2014). Two important issues arise in relation to these dominant anecdotally designed architectural practices. First, wherever the new built environment model standardised legislation is made requisite, these are largely not pursued. Secondly, where these legislations have been adhered to, the very nature of children with ASD, their acute heterogeneity makes the utility of these standardised legislated buildings questionable on account of their complexities which vary from individual to individual. On the contrary, systematic investigations have substantively demonstrated the workability and significance of a scientifically based model of research. It draws upon the relationship between the built environment and children with ASD's cognitive-educational and behavioural processing of their surroundings to be the most viable way to apprehend the sensory classroom design (Mullick, 2008). Therefore, despite the existing body of knowledge which highlights the fact that neuroscientific advances have led to a better understanding of children's ASD diagnostics, sensory aspects, and the environment, there is an implicit understanding that these advances would beneficially yield towards the direction of better classroom built Environment models, its applicability for architectural design remains minimal (Martin, 2014, Kanakri, 2014, Mostafa, 2008).

The research's point of departure drawn from the study area literature's important indicators depicts that an acoustical classroom environment modification is conducive and positively related to sensory disruptive behaviours, On-task learning engagement and its outcomes in children with ASD (Mostafa, 2008, Kinnealey et al., 2012, Kanakri, 2017b). This valuable pointer assisted in the development of the research's critical hypothesis built on noise acoustics/ as the significant variable which is studied closely. This research aspires to yield both theoretical and practical corollaries in its endeavour to investigate, assess, and treat, in the most scientific way, the optimal transformation of the classroom sensory environment for improved academic engagement On-task and sensory behaviour outcomes in children with ASD.

1.2 Critical Contextualisation of Autism in Pakistan

This research was set in Pakistan in the subcontinent of Asia. A critical contextualisation is necessary to provide a snapshot of Autism in the country. However, very few studies are carried out in this area despite the fact that greater awareness persists in the twenty-first century through academic research studies and international organisations highlighting the prevalent rates of Autism. This particular research is one of the rare studies undertaken in Pakistan. The problem underlying Autism in Pakistan reflects a tiered awareness. One, there is a fairly good understanding of the issue and its response in the small urban affluent social groups, which include, in some instances, international health bodies and non-governmental interventions through the way of assistance. Two, the vast majority of the population who live in rural settings have minimal awareness and facilities to aid children with ASD. This predicament is ascribed to a combination of factors such as the devolution of power, piecemeal legislature, lack of appropriate psychological-clinical diagnostic and educational facilities, non-existent familial or community support, and a complex cultural role which marginalises the ASD autism population and the national response to the challenge(Council, 2014) .

This lacuna underscores how vital it is to address the predicament of Autism in the country through academic research, governmental legislature, schools set standard guidelines, trained teachers' recruitment, educators and psychologists for developing any viable sound foundation for the education and well-being of children with ASD. This gap provides this research with a moral incumbency, the social and intellectual responsibility to undertake the Study, investigation, and avail the findings and outcomes to the public sphere for societal awareness.

The critical historical foregrounding of Pakistan as a country puts into perspective its political and historical context. Pakistan emerged as a nation-state upon the division of the South Asian subcontinent in 1947 through the British partitioning of its colony. The British colonial government established most educational institutions to serve the bureaucratic and civil infrastructure of the establishment predicated upon the control of the machinery and governmentality. The post-independence era witnessed incremental factors, including population increase, underdeveloped economic, social, and educational structures, unreformed agrarian sector, vestiges of feudal-based land ownership, capitalism and globalisation, and regional instability, which have hampered consecutive governments' ability to develop into an exemplary modern state.

The de-prioritisation of Autism ASD left uncoordinated responses to its multi-fronted challenges. A radical inclusive educational programme was initiated in 1986 through the National Policy for the

Rehabilitation of the disabled, integrating principles of learning and diversity and calling for specialised education in Pakistan. However, Pakistan's last few tumultuous decades did not witness any development towards child and adolescent psychiatry, including ASD. Major cities boast some child psychiatry departments and practitioners, but survey estimates depict non-existing sub-speciality fellowship or developmental disabilities. There exists only a single inpatient child and adolescent psychiatry established in 2012 at the King Edward Medical University in the city of Lahore. In terms of amenities, there exists a great rural-urban divide (Azeem and Imran, 2016).

Culture is one significantly dominant factor in which belief systems play a key role. This is reflected in widespread erroneous misconceptions in the public as well as the professional health services practices and attitudes towards the understanding of the causes, diagnoses, and treatment of ASD autism (Imran and Azeem, 2014). The cultural factor similarly depicts the prioritisation of traditional value beliefs and attitudes over scientific, objectively grounded medical research. It is further compounded by the lack of a Federal Government Legislature pertaining to Autism and developmental disabilities, with negligible or non-existent diagnostics available to the vast rural populations. The twentieth-century educational philosophy has evolved exemplarily towards value-based ethics by legislating educational provision for all irrespective of socio-economic, privilege, or power, affirming just-based n ms and rights of all physically or mentally challenged children. The Federal Government of Pakistan legislated the inclusion principle in the 1990s, whose implementation had proved difficult (Council, 2014).

The acute heterogeneity of children with ASD necessitates a radical negotiation of its multifaceted challenges in their behavioural outcomes and education. The worldwide assessment of the problem is apprehended in depth in Chapter 2, reflecting the immense task of working with quantifiable statistics for Autism. The entire measurement approaches for statistical quantification for ASD populations are rendered ineffective due to their heterogeneous nature. The recent Pakistan National Census, 2017, does not depict any statistics for its population with ASD. For practical purposes, in order to provide some perspective on the problem, this Study relies on the anecdotal reference of the 350,000 autism population reported in the National Dawn Newspaper. This figure is a close approximation of the general 1% - 2% of the prevailing rate of the continent of Asia is estimated to the present Pakistan population of 212 million people (http://www.pbscensus.gov.pk/,n.d.). The rural-urban divide, which refers to the disparity above, is further exemplified by the provision of psychiatric diagnostics, neurologists, psychologists, paediatricians, and speech-language specialists availed in the major urban cities. In contrast, a parallel cultural belief system is exemplified in rural areas where traditional religious healers play a key role. This significant factor has not been examined. This is further compounded by the fact that autism physical and cognitive-mental dysfunctionalities bear a cultural stigma which acts as an exclusionary factor for children with ASD to be admitted into schools or be accepted in communities. Pakistan's scale of socio-economic and cultural challenges, including what opportunities could be availed, is contingently described by the fact that the ratio of trained psychologists and psychiatrists to the population is 1: 230,000, whose National GDP cost ranged between 4.9% - 6.3% (Council, 2014). A similar estimation by the World Health Organisation (WHO) Report concurs that there are 0.49 psychologists and psychiatrists for every 100,000. These estimates amplify the scale of the problem (WHO, 2008).

1.3 Aims, Objectives and Research Questions

The aim of this research is to bridge the knowledge gap and to investigate the intersectionality of the noise/ acoustics factor and sensory behaviours of children with ASD, entwined with building design. It is an interdisciplinary study of considerable relevance and immediacy for children with ASD.

This follows upon the nascent architectural designing, which has creatively thrust the focus to encompass neuroscientific domain conceptualisations whose research advances manifest exemplary paradigmatic shifts in understanding the inter-relational aspects of the human mind and the environment. This provides the research with a dynamically emerging approach to apprehend classroom design for children with ASD, taking into account their health and well-being as primary factors. Underscoring these principal factors for children with ASD adds the dimensions of an ideal classroom environment, which could have a healing effect on their constructive time spent in schooling (Martin, 2014).

The research's critical hypothesis and the framing, based upon the foregoing analysis, thus provide the pivot to the classroom environment as a critical feature which will factor in the ASD diagnoses, sensory environment, and their dysfunctionality. This rationale is evidenced by the fact that sensory stressors inhibited learning, and participation affected cognitive functioning and behaviour and children's educational achievement (Piller and Pfeiffer, 2016, Ashburner et al., 2008a). The examination of the literature review indicated overwhelmingly towards the classroom acoustical element, triggering auditory sensory dysfunctionality in children with ASD, which acted as an environmental stimulus leading to a behavioural response (Mostafa, 2008, Kanakri, 2017b, Howe and Stagg, 2016). This is corroborated in Chapter 2, Literature Review and leads to the research's investigation and testing of the hypothesis of noise/ acoustics and behaviour intersectionality of children with ASD in Stage 1 Study, represented in Chapter 4.

1.3.1 Aim and Research Questions

The overarching aim of this research is attentive to acute heterogeneous sensory response behaviours in children with ASD and their pedagogical on-task sustained learning impacted through classroom acoustics in the prevailing school built design. Through its theoretical framing, grounded upon experimental investigation, testing, and verification, the research is demarcated into three distinctive significant Stages, Stage 1 Study, Stage 2 Study, and Stage 3 Study. It draws upon the corollary that plausible classroom acoustical modification can ameliorate the children's sensory behavioural dysfunctions and attenuate their On-task learning performativity through enhanced engagement.

The purpose of this research is to develop a scientifically grounded academic research study which not only advances the awareness of the intersecting seminal factors of their sensory dysfunctional behaviours and restricted educational on-task engagement but also how this problem could be addressed through built environment design to assist the children's improved classroom behavioural and learning responses.

Research Questions

Three distinctive studies were outlined, which encapsulated specific methodological framing and enquiry that apprehended the research investigation:

Stage 1 Study: Is there a direct impact of the classroom environment's sensory stressor architectural elements upon the triggering behaviours of the participating children with ASD and restrictive input inhibiting their On-task learning?

Stage 2 Study: Is there a direct ramification of the Independent Variable (IV) RT 60, and the LAeq and LA90 correlates upon delineated sensory behaviours in children with ASD?

Stage 3 Study: Is there a direct impact of the Independent Variable (IV) RT60 and the LAeq and LA90 correlates upon 1:1 ratio on-task sustained performativity targeted behaviour in children with ASD?

1.3.2 Objectives

1: To interrogate discursively, through qualitative methodologies, the validity of noise/ acoustic as the significant Independent Variable (IV) in the research study with a positive correlation with sensory behaviours in children with ASD.

2: To interrogate empirically, via the Single Case Experimental Design methodologies, the ramification of the application of sensory interventional acoustic treatment and its co-relationship to sensory behaviours in children with ASD.

3: To investigate empirically via intervention, Single Case Experimental Design methodologies, the facilitation or inhibition of On-task engagement behaviour in children with ASD via classroom acoustic treatment upon their pedagogical focus.

1.3.3 Hypotheses

RQ 1: The hypothesis to research question 1 is that noise/acoustics is a significant detrimental variable that affects academic engagement and sensory behaviours in children with ASD in an educational setting.

RQ 2: The hypothesis to research question 2 is that there exists a significant correlation between the reduction of RT60 and the frequency of sensory behaviours in children with ASD.

RQ 3: The hypothesis to research question 3 is that the on-task performance of children with ASD would improve in a modified classroom acoustic environment with shorter RT60 and reduced LAeq and LA90 levels.

1.3.4 Research Significance

This research is premised on several integrated significances. Firstly, it relates to classroom noise/ acoustics and the built environment, which attests that most prevailing building designs are anecdotally and heuristically built. Second, this research investigation verifies that classroom RT60 is very significant. Its dynamics factor centrally in design, thus providing the intersectionality of sensory dysfunctionality of children with ASD, their education and well-being. This furthers the importance of an appropriately designed environment. Third, the research attests to the significance that it is plausible to implement cost-effective design modifications practically undertaken to address sensory noise/ acoustic measures. This will enable classroom designs for children with ASD for their learning nationally, regionally, and internationally. Fourth, the research is significant in being at the vanguard of empirically grounded studies in Pakistan which can assist in promoting far broader knowledge about sensory dysfunctionality, built environment, and learning of children with ASD.

The research findings contribute towards the identified research gaps, appropriately selecting a research design and framing interdisciplinary approaches and integrative methodologies. The results attest to the requisite need and emphasis for calibrated classroom design settings to attenuate the learning experiences of children with ASD. They also provide evidence of the need for acoustic design guidelines based on knowledge grounded on scientific investigation for the learning and well-being of children with ASD.

1.4 Methodology Overview

This section is to give an overview of the research methods employed in this thesis, research methodologies for each Stage (I-III) will be discussed in detail in chapter 3. This research is comprised of a pilot study followed by three-stage studies comprehensively undertaken at Oasis School in the city of Lahore, Pakistan. It carried out the research examination of four ASD diagnosed children (N=4) participants. The pupil's ages ranged between 9-11 years, and whose research was designed to enquire the plausible sensory modulation and integration affected by their sensory behaviours through the modification of classroom built environment. The research delineated the key primary factors, the noise/acoustics variable, children's complex heterogeneity, sensory dysfunctionality, and auditory processing, leading to the manifestation of behaviours with ramifications upon their on-task performativity, particularly the engagement span behaviour. The research framed various integrating theoretical modes and interdisciplinary approaches, evidentially drawing the deduction that the predominant noise/ acoustics sensory factor was one of the most significant stress factors impacting classroom behaviour and learning of children with ASD. The research's systematic enquiry and interrogation bordered upon this vital factor, by which the critical hypothesis was built and tested, as demarcated in the three-stage research studies.

It was imperative to apprehend the overall research delineated into Stage 1 Study, Stage 2 Study, and Stage 3 Study with integrated methodologies in order to achieve the overall aim discussed above. This entailed the possible negotiation of the critical hypothesis built around noise/ acoustics in the classroom sensory environment as the key Independent Variable (IV), and its manifested correlates examined. The critical hypothesis investigated and tested the impact of noise/ acoustics in order to validate the independent variable (IV) in the Stage 1 Study. Secondly, in Stage 2 Study and Stage 3 Study it was investigated by testing the impact of the IV upon selected participant children with ASD (N=4) sensory behavioural responses and On-task engagement span behaviour.

SCED Study A-B-A (Baseline-Intervention-Withdrawal Design) was employed in Three Phases, Base Line Data Collection; Intervention Phase included acoustical treatment method/ refurbishment by installing sound-absorbent wall panels and Return to Baseline Phase. This methodological and intervention modes tested the critical hypothesis and ramification of noise and acoustics on the participant's behaviours. Utilising the (SCED) methodology in the Three Phased A-B-A enabled to measure, evaluate, and quantify each participating children's heterogeneous apprehending of the sensory response behaviours and on-task engagement span behaviour. This methodological approach has important significance. One, it alleviates the sample size, providing each participant's performativity measurement within the classroom setting, responding to the task tailored with flexibility. It gives the research the possible measurement, evaluation, and quantification of each child and compares it with their relative performance at different stage levels. Built upon 1:1 ratio, this aided the individual child and teacher's pedagogical needs. This methodological approach provides the research's internal and external necessary validity and its grounding scientifically for the Study of the sample of children (N=4) (Horner, 2005, Kratochwill, 2010 -a).

The Stage 1 Study, represented in Chapter 4, encompassed the qualitative research aspect to glean personal reflections from multidisciplinary, international researchers/ experts employing semi-structured interviews, which gave them the requisite intellectual space to articulate their expert opinion. The qualitative research procedure led to the verification that noise/ acoustics was a predominant critical factor, acting as an environmental stress feature in the learning of children with ASD. Subsequently, it investigated that sensory responses of children with ASD, in particular, were affected by the auditory functions and had ramifications on children's behavioural responses and education.

The Stage 2 Study is represented in Chapter 5; it inquired into the Independent Variable acoustics and its behavioural and auditory ramification on participant children with ASD (N=4). The research's critical hypothesis was tested by interrogating the correlation between the reduction of classroom long and short RT60 from (0.1s to 0.39s) and correlates LAeq and LA90 and its ramification on specific behaviours and their frequency of occurrence in children with ASD. This was conducted in a specially designated and acoustically modified classroom to accommodate the participating children (N=4), boys aged 9-11 years diagnosed with ASD. The findings of the Stage 2 Study allowed the consecutive building of the research structure for the Stage 3 Study distinctively.

The Stage 3 Study is represented in Chapter 6. It investigated the impact of noise/ acoustics primary Independent Variable (IV) upon the Dependent Variable (DV) On-task engagement behaviour of children with ASD. This entailed the SCED methodology, A-B-A Baseline, Intervention, and Withdrawal Baseline Return Three Phases.

1.5 Thesis Outline

The current research focuses on how the built environment could be adapted in very particular ways to assist children with ASD positively. Due to the effect of human brain activity and auditory sensory dysfunctionality, this research underscores how children with ASD are adversely affected by environmental stressors. Through the Three Stages of Study, this research aims to indicate the critical parameters of an effectively designed environment, which is carefully tuned, calibrated, and responsive towards children with ASD, thus enabling them the opportunity to develop their potential to become valuable members of the communities. This research study is divided into 7 chapters which are outlined below:

Chapter 1 Introduction

Chapter 1 introduces the research, descriptively analysing the nature of the Study, and its interdisciplinary modes, discursively explicating the important intersectionality of ASD diagnosed children, the built environment, and sensory dysfunctionality. It highlights the aims and objectives, the theoretical and methodological framing which requisites the Single Case Experimental Design and setting out the critical contextual parameters in Pakistan. The Chapter also briefly introduces neuroscientific and environmental theoretical concepts; the understanding of ASD as a Spectrum Disorder, underscoring its acute heterogeneous nature, sets out to explicate the evidence-based interlinkages between children's auditory dysfunctionality, classroom sensory environment and behavioural responses.

Chapter 2 Literature Review

Chapter 2 offers a critical analysis of the research's Literature Review. It navigates the extensive studies taking into account paradigmatic shifts in neuroscientific and environmental concepts, which provide the research's pathway for apprehending the intersectionality of children's Autism, the built environment, and classroom design acoustics entwining them through an interdisciplinary framework. It proceeds with the analytical exploration of the major factors in three sectional areas. Section 1 probes into examining Autism, Aetiology and Symptomology. Section 2 critically outlines and identifies important emergent theoretical and conceptual non-deterministic shifts. These anticipate the seminal Section 3, where the significance of neuroscientific advancement is discursively apprehended and particularly delineating its impact and relevance on neuro-architecture, Noise and the built environment. In sum, the critical navigation of the literature identifies and demarcates the gap which the research apprehends. This provides the research with a platform and point of departure on the justification of appropriating diverse methodologies to investigate dysfunctionality, heterogeneity, and education of children with ASD.

Chapter 3 Methodology

Chapter 3 focuses on the critical appraisal of the seminal research methodologies. It seeks methodological relevance, validation, rationale principle, and justification criteria, thus leading to its appropriation for the current research. The Methodology Chapter paves the way for the research's distinctive Three Staged Studies (I-III) encapsulated and distinctively pursued in Chapter 4, Chapter 5, and Chapter 6, respectively. These studies investigate the ramification of sensory and auditory dysfunctionality in children with ASD entwined with the core noise/ acoustical variable. The objective is to build the critical hypothesis and seek its validation based on the noise/ acoustic variable and children's auditory dysfunctional aspects through appropriate research methodologies.

Chapter 4 Stage 1 Study: Classroom Environment, Behaviour and Learning

Chapter 4 seeks the identification, validation and prioritisation of Architectural stressors in a classroom environment affecting on-task learning and sensory behaviours in children with ASD. It represents the Stage 1 Study of the research which apprehends the noise/ acoustics factor as the Independent Variable (IV) attested through the qualitative enquiry methodology. The Study aids the development of the critical hypothesis encapsulating noise/ acoustics within the classroom environment as the key Independent Variable (IV) for furthering the research enquiry construction and testing in the Stage 2 Study and Stage 3 Studies.

Chapter 5 Stage 2 Study: Modifying Classroom Acoustical Environment to Effect Sensory Behaviours in Children with ASD

Chapter 5 represents the Stage 2 Study of the research, interrogates and examines noise/ acoustics Independent Variable (IV) verified in Stage 1 (Chapter 4) as a significant critical classroom environment stressor leading to disruptive behaviour outcomes in children with ASD. The research methods road map for this stage is provided in Figure 5.1, on Pg. 91. The examination is framed by the appropriately justified Single Case Experimental Design and the Three Phased A-B-A, Baseline, Intervention, and Return to Baseline investigation phases. This allowed the Study to verify the Independent Variable, the classroom noise/ acoustics RT60 and the correlates LAeq and LA90 Levels to experimentally test the hypothesis relation between noise/ acoustics and its effect upon each participant's delineated triggered behaviours. The data results are analysed through visual analysis and supplementary descriptive statistics method, and effect size is interpreted to identify the children's engagement span behaviour patterns within and across the Three Phases.

Chapter 6 Stage 3 Study: On-Task Learning and Classroom Acoustic Modification

Chapter 6 represents the Stage 3 Study of the research. The research methods road map for this stage is provided in Figure 6.1, on Pg. 146. The point of departure of this research directed the enquiry into the classroom noise/ acoustics the RT60 and the correlates LAeq and LA90 Levels and the impact upon the participating children's performativity upon on-task behaviour span with 1:1 teacher ratio pedagogy. This research framed by the Single Case Experimental Design Three Phased A-B-A, Baseline, Intervention, and Return to Baseline investigation phases. The Three Phased approach allowed testing each participant's on-task span under the existing classroom sensory noise conditions in Phase (A). In the Intervention Phase (B), it tested the hypothesis during the sensory modulated design installation of sound-absorbent elements combined with the declination of the RT60 pressure levels from (Tmf 1.11s) to (Tmf 0.39s). Lastly, tested the hypothesis upon the Return to Baseline Withdrawal Phase (A). The data results are analysed through visual analysis and supplementary descriptive statistics method, and effect size is interpreted to identify the children's engagement span behaviour patterns within and across the Three Phases.

Chapter 7 Conclusion

Chapter 7 discursively evaluated and explicated the summative nature of the research. It draws upon the significant findings of the research in the three Stages (Chapter 4 Stage 1 Study), (Chapter 5 Stage 2 Study), and (Chapter 6 Stage 3 Study), respectively. It critically weighs the strengths and limitations of the research.

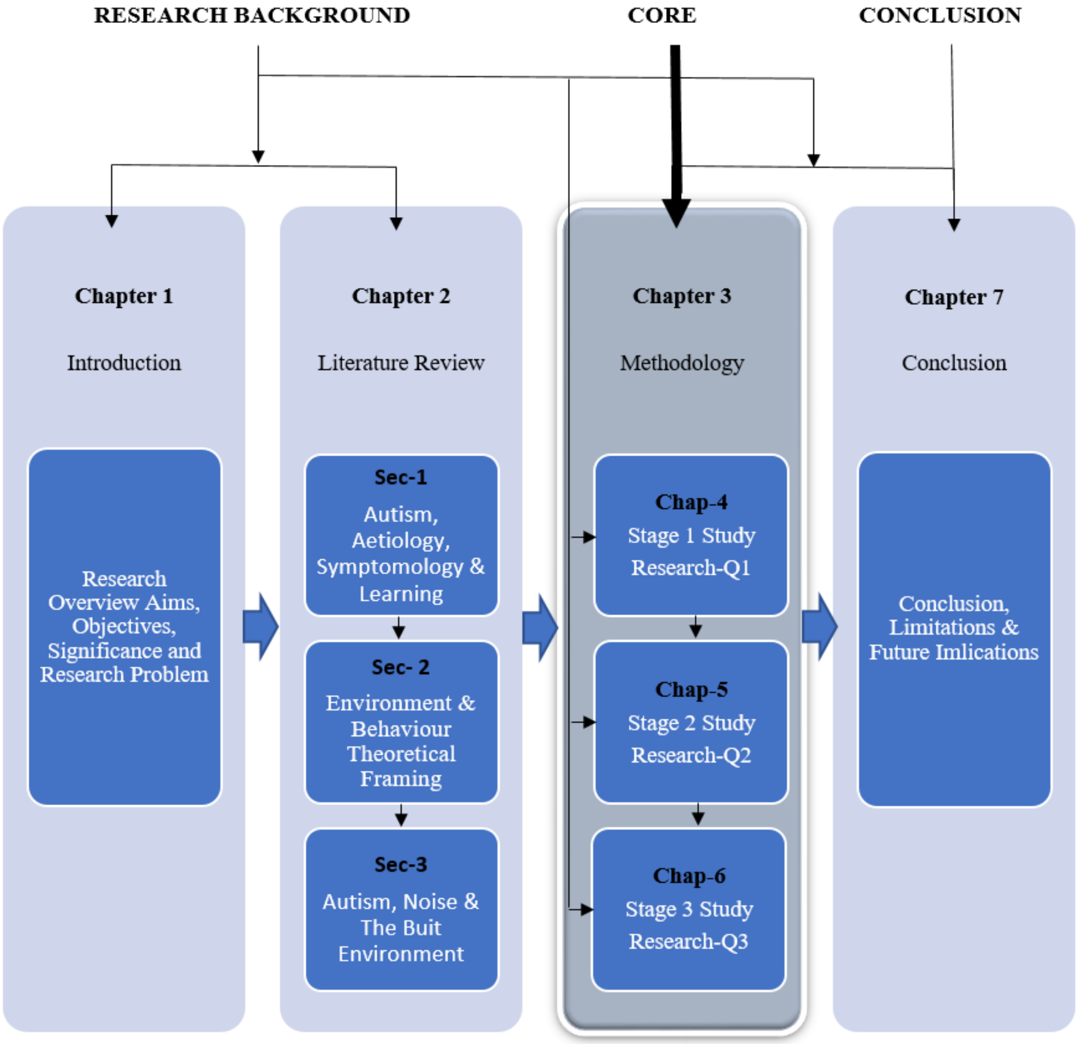

Figure 1.1: Structure of the Thesis

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CHAPTER 2: LITERATURE REVIEW

Recently, with increased attentiveness towards neuroscientific advances, academic disciplines developed a persuasive body of evidence through enquiry, framed through non-deterministic re-conceptualising of the environment through prisms which enable a more comprehensive understanding of its complexity and multi-faceted nature. This radical shift involved more nuanced, interdisciplinary and holistic modes of analysis involving the socio-biological, psychological, and experience sensory domains. The chapter is divided into three major sections. Section 2.1 focuses on the nature of Autism, surveying its aetiology, symptomology, and its impact on children's learning. Section 2.2 presents the theoretical framework and recent emerging theories, whose conceptualisations demonstrate paradigmatic shifts. Section 2.3 maps out how the noise factor is correlated to sensory and behavioural responses in children with ASD, which provides the rationale for enquiring and engaging with built environment design. Figure 2.1 depicts the analytical framing of Chapter 2

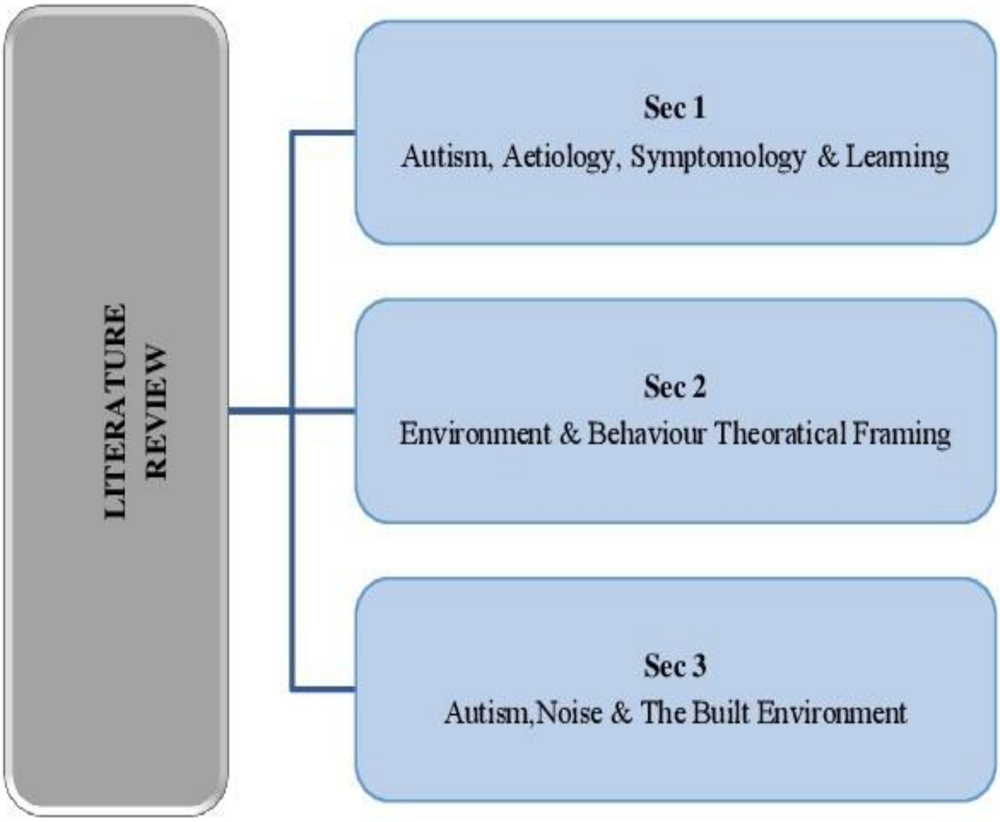


Figure 2.1: Chapter Structure

2.1 Autism: Aetiology, Symptomology and Learning

An important definition of Autism is offered by the American Psychiatric Association (APA), which underpins the broad manifestation of socio-psychological and behavioural conditions. These included the variegated sensory and complex dysfunctionality of the individual's operational levels, a triadic symptom diagnosis exemplifying the lack of socio-communication, and social adjustability, factors which assert Autism's behavioural disorder and had central relevance to this Study. In technical psychiatric aspects, this condition was considered a spectrum disorder which reflected the wide-ranging scale of atypical behaviours with inhibiting social correspondence, asocial with atypical singular interests (American Psychiatric et al., 2000).

The Individuals with Disabilities Education ACT- IDEA, USA, provided a succinct definition of Autism as referenced through educational terms. In this category, Autism was considered as identifying the child's developmental disability through evidence, the effect of verbal and non-verbal communication and social interactional adverse performativity reflected before the age of three. Autism behavioural characteristics were marked by stereotypical and repetitive movement traits which showed confrontation and resistance to change in environment and the normalcy of each day prompted by unusual sensory experience responses. These manifestations were the focus of the research in Chapter 5.

From the foregoing analysis, it is deduced that the autism human mind condition reflected in children did not have a single diagnostic template nor any singular medical treatment. It was manifested through acute heterogeneity with social, familial, school and educational ramifications attested in several studies depicting the resultant complex social, health, cognitive and clinical aspects. Defined 'symptomology' in children with ASD within clinical observations explicated a set of variegated and ambiguous symptoms, which on account of this peculiarity, were prone to easy diagnostic misidentification. Sensory processing dysfunctionality was the most common predicament in 90% of children diagnosed with Autism which attested resultant unconventional stereotypical behavioural patterns and rigid traits such as the repetitive flapping of arms, spinning, and rocking (Lathe, 2006, Baker et al., 2008).

2.1.1 Prevalence of Autism

The global incidence rate of Autism Spectrum Disorder is estimated to be 1 in 160, according to the world health organisation (WHO). The prevalence estimated that 1% of the United Kingdom's population, approximating 500,000 family households, were affected (Khare and Mullick, 2014). The estimations for the United States of America reflected that 1.5 million children and adults were diagnosed with Autism, whose repercussions were felt by 15 million people, including families and health and professional workers. The American Centre for Disease Control and its Department of Autism Developmental Disabilities Monitoring (ADDM) provided a ratio for children diagnosed with Autism under the age of 8 years of 1:150

in the USA (ADDM, 2007). The study was also suggestive of a world-approximated prevalence ratio of 1:500. When this was applied to Asian countries with substantive populations, the autism population of India was approximately 2 million, for China 2.65 million, and for Pakistan 400,000.

The ASD gendered categorical analysis depicts a ratio of 1:252 for females and 1:52 for males, showing a highly skewed fivefold male prevalence (Prevention, 2012). These statistical estimation ratios emphasise the problematic nature of assessing the scale of autism prevalence in world populations. This was clearly demonstrative in the Centre for Disease Control 2010 estimates which depicted an exponential leap of 1600% ASD diagnosed percentage of individuals between the ages of 6-22 years when their respective adjustments took into account recent diagnostic methods and estimation procedures (Martin, 2014). When drawing perspectives from the standpoint of principles of social justice, equanimity, educational optimisation and psychological and medical provision, and familial support, the scale and prevalence of Autism reflected daunting implications worldwide and for individual countries, societies, and families.

Drawing upon the Centre for Disease Control and Prevention (CDCP) worldwide prevalence rate of 1:68, it can be deduced that Autism was not confined to any particular part of the world, but its prevalence was spread extensively worldwide, affecting all ethnic groups, cultures, and societies (Mostafa, 2014).

2.1.2 Autism: As a Spectrum Disorder

The American Psychiatric Association referred to Autism Spectrum Disorder (ASD) as the complexity of neurodevelopment disorders. The 'spectrum disorder' denoted both the severity of the symptomatic and heterogeneity traits reflected in differential levels of impairment in two broad areas in the DSM-V. The first entailed the social-communicational and interactional area, which depicted a socio-emotional reciprocal deficit, including non-verbal communicational behaviours and hampering the development and stability of the understanding and enacting of social relationships. The second important area referred to the restrictive repetition of behaviour patterns, and restricted interests or activities which depicted repetitive movement. It also importantly includes how objects and speech were used, familiarity was insisted upon, routines were adhered to inflexibly, the verbal articulation and nonverbal behaviours reflected ritualisation patterns, interests which were fixated and highly restrictive with an abnormality in the focal intensity, and hypersensitivity or hypo-sensitivity sensory conditions to sensorial input from the environment (Association, 2013a).

The Complexity and Heterogeneity of ASD Disorder in Children

The sensory integration processing dysfunctionality leads to a broad-spectrum continuum of behavioural disorders in children with ASD, which manifests in all regardless. However, it appears more pronounced in children with high-functioning Autism, whose effects were depicted through acute heterogeneous personalities and behavioural responses. Specifically, in the individual's high-functioning case, each child manifested an erratic representation compounded by varying responses to the environment. Several researchers have examined, analysed and established the nature of high-functioning sensory integration dysfunctionality and its multi-faceted heterogeneous characteristics evidenced and pointed towards complex personalities and behavioural responses (Gabriels and Hill, 2002). This dysfunctionality was similarly attested in children's medical and educational aspects. However, the very nature of autism dysfunctionality complexity has led to no commonly consensual agreement upon questions of its constitution whose understanding could lead to a generic application of evidence-based effective treatment for the entire social group with ASD (Mesibov and Shea, 2011).

2.1.3 Theories of ASD, Mind and Heterogeneity

In the foregoing analysis, the case of ASD heterogeneity is critically discussed, and its worldwide prevalence is examined in length. This research primarily refers to the underscoring of three salient cognitive-mind formulations which are framed by neuroscience. This aid the explication of the neural-cognitive dysfunctionality of the mind specifically providing a descriptive dimension to comprehend the unique ASD mind, which is significant and relevant to understanding the acute heterogeneity of individuals.

2.1.3.1 Cognitive Theories

The Theory of Mind posited that ASD individuals were devoid of the capabilities of an individual mind, which could assign mental states such as emotions and thoughts to other people. This factor is explained and lent towards the ASD child's cognitive and social-interactional problems, i.e. the inability to participate and interact in the important sphere of social engagement necessary at crucial levels, including linguistic and educational (Baron-Cohen et al., 1985). The Theory of Central Coherence postulated that ASD individuals demonstrate an embodied cerebral mechanism impairment which interferes with the major functions of human learning and meaning. A typical human mind is able to confer coherence to the range of environmental stimuli received and important for human existence but particularly for learning, interpreting, and making meaning (Frith and Happé, 1994). The Theory of Executive Functions postulated the absence of the governing of the vital functions of individuals, which act as a catalyst towards an array of stereotypical and repetitive behaviours (Turner, 1999). The normal human mental and cognitive functions, e.g. attention, concentration, and planning necessary for human performance of various socio-biological and mental tasks, appeared inadequately governed by the executive system in the mind of individuals with ASD (Hill, 2004).

In addition to the foregoing descriptive analysis of the human mind and resultant heterogeneity, new conceptual insights were reflected in significant studies. An important redefined conceptual terminology, 'downstream effects', posited these behavioural level findings, which suggest how the individual's nervous system cope and adapts within the challenging variegated environments, their unpredictability, and unreliable peripheral inputs (Brincker and Torres, 2013). These studies explicated that uncoordinated and non-centralised processing of the environment in children with ASD burdened their sensory systems and thus hampered their autonomous control. Over time duration, it led to an individual's unsettling of the mind's prediction and anticipation, and simultaneously altered the neural wiring. These theoretical explanations regarding the heterogeneity, the mind and its functionality were central to Chapter 6, which examined on-task classroom engagement behaviour in children with ASD.

2.1.3.2 Sensory Integration Theories

Sensory environmental stimuli are captured through sensory receptors in our bodies representing tactile, auditory, visual or olfactory senses. These sensory receptors convert the signals from the environment into sensory information, which is then transmitted to the brain and is decoded into specific behavioural responses (Galiana-Simal et al., 2020). Ayres introduced the sensory integration (SI) theory which is essentially the neurological process and organisation of sensory information from the environment and allows an effective response to external stimuli (Ayres, 1974.). Some scholars have divided the sensory integration process into four distinct phases; the first phase is the registration when the brain receives the sensory information; the second phase is the modulation which allows the calibration of the stimulus intensity; the third is the discrimination when the stimulus from the environment is organised and construed, and the last phase is the response which generates a specific behavioural or a motor movement reaction after the final integration and processing of the stimuli. Sensory Integration Dysfunction (SID), also known as Sensory Processing Disorder (SPD), is a disorder in which one or more of the SI phases are disrupted, resulting in abnormal behavioural responses (Galiana-Simal et al., 2020). This dysfunctionality is a key neurodevelopmental feature of Autism, which resultantly manifest in a complexity of diverse traits in individuals.

The consequential gaps manifested in the social-communicative, and interactional deficiencies were reflected in the common restrictive traits such as repetitive behaviour patterns and interests, restriction-induced hyperactivity or heightened sensory stimuli engagement (Varni et al., 1979). According to Bogdashina (2003), human experiences were based on the mind's cognitive-based ability and vital integrative modes acting upon the environmental stimuli; this integrative functionality was disrupted in children with ASD. This function was conceptually referred to as the "Sensory Perceptual Issue" (SPI), which explained the rupture of the organising sense information stemming from the human intelligence based upon all major senses, e.g. the sense of smell, taste, touch, sight, sound but also included the human vestibular movement, and proprioceptive muscle and joint receptors.

Sensory dysfunctionality in children with ASD affects the reception of stimuli signals in degrees of severity and simultaneously obstructs the natural modes of the mind's categorical processes, response, and organisation (Bogdashina, 2003). This predominant diagnostic dysfunctionality identified is highlighted and underlined in this research. Two distinctive studies examined two unique characteristics of sensory integration dysfunctionality in children with ASD, emphasising and highlighting their different aspects. The first Study examined integration difficulty, which demonstrated the range of its occurrence between 42% - 88% of children (Baranek et al., 2014), whereas the second Study examined sensory cohesion problem, which occurred between 40% - 88% of children (Killoran, 2011). Not only was heterogeneity in the sensory dysfunctionality emphasised, but also the resultant integration difficulties and sensory cohesion were heightened during the children's interaction with the environment.

Ayers (1972) suggested a sensory integration therapeutic model based on a triad: neural plasticity allows for brain change, active involvement is required for neural synaptic changes, and enriched calibrated settings are required to promote and guide neural changes. This neuroscientific informed sensory model which focused upon the functions of the human mind and its integrative modes and dysfunctionality, was integral to this research's bridging of learning and behaviours in children with ASD. This led to the research addressing the sensory built environment.

ASD Sensory Processing Disorder

A significantly high proportion of ASD diagnosed individuals (95%) reflected varying degrees of sensory processing dysfunctionality, suggestive of its strong correlation. This has been designated by psychologists as the key diagnostic feature (Baker et al., 2008, Tomchek and Dunn, 2007, Association, 2013a). Sensory processing is particularly referred to as how an individual is able to apprehend through the nervous system functionality through the sensory stimuli in daily life routine responses and adaptability (Baker et al., 2008, Dunn and Bennett, 2002). Sensory processing dysfunctionality had far-ranging consequences, which affected abilities in cognitive attentiveness, social play or sustained social-interactional objectives. This significant aspect of the mind, sensory processing deficiency SPD, was attributed to being the underlying cause of children's social disengagement, discordant off-task behaviours as well as On-task (Greenspan and Wieder, 1997). Moreover, under the sensory processing dysfunctionality, there are hypersensitivity and hyposensitivity, two conditions of Autism that occur due to the failure of sensory integration. This lack of integration results in either a lack of responsiveness to the environment, known as hyposensitivity or an over reactivity to the environment, known as hypersensitivity (Boyd et al., 2009).

Auditory Processing in ASD

Evidence indicates that the most significant element in any sensory environment for the population with ASD is acoustics (Mostafa, 2014). Furthermore, Ashburner et al. (2008a) indicate an overpowering factor in the learning process of children with Autism is sound. Children's behaviours were considered to be of an avoidance nature which was generally associated with hypersensitivity. These were attributed to auditory stimuli, due to which verbal instructions and classroom focus attending were rendered difficult in their performativity (Ashburner et al., 2008a).

Individuals with ASD have shown a remarkably improved focus and ability to process sensory data when the present auditory stimulus is simpler while showing difficulty in focusing in the presence of complex auditory stimuli (Bonnel et al., 2003) (Heaton, 2003). The findings from the Ashburner et al. (2008a) Study indicated that learning and focus on the task at hand in the pupil with ASD is affected by auditory processing problems. This Study further indicates the significant role of acoustics in achieving academic competency for children with ASD. In the face of all the aforementioned studies, it is safe to say that acoustics is one of the most significant environmental variables that affect the learning engagement and attention span of pupils with ASD. Children with ASD also have been known to suffer from hyperacusis, a condition which elicits extreme negative reactions and behaviours. This, being a usual trait in children with Autism, is a matter of concern and therefore, it is of extreme importance to build a suitable environment for such children (Stiegler and Davis, 2010).

2.1.4 History of Autism and Its Status in the World of Education

A brief contextual history of Autism was accounted for, framing the important intersectionality of psychology, education, and its reference relevance specifically for children with ASD today. The historical account was useful to envision and spell out pathways for Autism in the twenty-first century's globalised and environmental challenges for ASD pertaining to children worldwide. Kanner (1943), in the 1940s, systematically advanced general comprehension through psychological investigation and identification of the psychiatric symptoms of sensory dysfunctionality and the disordered nature of the human mind coining the terminology of Autism. His earlier observations and symptomology diagnostics were invaluable today, importantly the classification of hyposensitivity and hypersensitivity. Recent advances have further illuminated Kanner's earlier classification by revealing and affirming an acute state of heterogeneity in individuals with Autism. Whereas this typology was initially considered to refer separately to individuals, it was now evidenced that both hyposensitivity and hypersensitivity sensory could be co-present concurrently in one individual (Baron-Cohen et al., 2009).

The American Psychiatry Association's Autism Definitional Manual DSM-5 (2013) Current edition stands as a testament to these endeavours. Its alignment of ASD symptomology, the depicted sensory dysfunctions and manifestation in variegated ways is a major defining tool feature for ASD diagnosis. In contrast, Autism was earlier designated in medical terms with limited behavioural explanation (Kerns et al., 2016) and later explicated and associated with the psychiatric condition schizophrenia (Dvir and Frazier, 2011). For researchers who associated Autism with schizophrenia or other psychiatric disorders, Autism was simply a disease which needed to be cured. However, recent studies have proven that Autism is not a disease, but a genetic variance, which makes it difficult for individuals with ASD to perceive data the way neuro-typical people do. It is a neurodevelopmental disorder which affects the social and behavioural faculties of individuals with ASD (Association, 2013a).

The genetic and neuroscientific advances leading to the understanding of the human mind have enabled putting Autism into various perspectives, thus aiding in their educational goals, justice and rights, and particularly throwing focus upon a conducive built environment relevant for children with ASD (Tufvesson, 2007). During the 1960s, there emerged the progressive ethos which considered important educational shifts in viewing inclusionary and mainstreaming as societal necessities. However, these ideas proved to be of limited significance for children with ASD as greater awareness affirmed their acute heterogeneity, which necessitated the focus on innovative and individual educational practices, curricula and pedagogies (Segal, 1967).

2.1.5 ASD, Education and Learning

The progress of Autism charted above historically, framed by psychological and medical nature discoveries, had a positive impact on education through awareness of consolidating new methodologies and curricula. Furthering the understanding of Autism and the mind, neuroscience aided the field of education generally and in particular for children with ASD. Following these research breakthroughs, several countries legislated educational statutes leading to the protection of children with disabilities and Autism through the provision of statutory rights. These were, however, circumscribed largely to countries with advanced economies where evidence-based research was initiated. In contrast, in emergent countries such as Pakistan, there existed a huge gap in establishing the necessary legislation nexus between Autism and education.

The United States of America and the European Union had exemplary advances in contemporary research in education for children with ASD. They were at the forefront of championing the inclusionary integration of children with ASD into mainstream schools. In 1975, the USA Congress legislated the Education for "All Handicapped Children Act" with significant later amendments. In 2001, the USA Congress passed the "No Child Left Behind Act", which enabled the integration of children with ASD and students with disabilities into mainstream schools. The merits of public-school inclusion for children with ASD had been deliberated by legislators, educationists, academicians, neuroscientists and psychologists weighing the strength of corroborating research evidence. However, it was increasingly realised that heterogeneity and the neuro-atypical nature of children with ASD underlined their unique educational and sensory dysfunctionality, which necessitated differential learning needs, including grading and educational achievement. This culminated in the 2004 AHCA Amendment Act explicitly affirming the children's heterogeneous needs (Baron-Cohen and Bolton, 1993). For this research, it was important to underscore the vitality of such legislature for emerging countries like Pakistan to advance the cause and safeguard nuanced education for children with ASD.

Table 2.1: Historical Context, Medical Advances and Legislations

Year	Historical Context
1943:	Leo Kanner first labelled the condition "infantile autism" in his publication describing 11 children he observed. He noticed significant similarities between their behaviour, obsession with objects, or resistance to change.
1944:	Austrian paediatrician Hans Asperger first defined Asperger's Syndrome and underscored a genetic connection for autism prevalence.
1970s:	Lorna Wing proposed the view of Autism as a spectrum condition with a "triad of impairment" in Social communication, interaction and creativity
Year	**Medical Advances/ Beliefs**
1949:	Leo Kanner claimed that parents who are distant and frigid are to blame for Autism, and he gave it the term "refrigerator mothers".
1952:	In the first version of DSM-1 of the Diagnostic and Statistical Manual of Mental Disorders, children with autism symptoms were labelled as having paediatric schizophrenia(Despert, 1938).
1964:	The "refrigerator mother" theory was debunked in Bernard Rimland's book Infantile Autism, and he presented the idea of neurological underpinning for autism prevalence (Cowie, 1965).
1964:	Ole Ivar Lovaas started developing his hypothesis for using Applied Behavioral Analysis (ABA) therapy on children with Autism (The Lovaas Center. Lovass ABA Treatment for Autism).
1977:	Folstein and Rutter (1977) published the first investigation on twins and Autism. The Study underscored and concluded that genetics is a significant risk factor for an autism diagnosis.
1980:	For the first time, the Diagnostic and Statistical Manual of Mental Disorders (DSM-III) provides criteria for diagnosing infantile Autism.
1998:	The Lancet publishes Andrew Wakefield's article in which he claims that the MMR vaccine causes Autism. Numerous epidemiological studies thoroughly refute the idea, which was subsequently retracted (Sathyanarayana Rao, 2011).
2013:	The DSM-5 classifies autism spectrum disorder as a combination of Autism, Asperger's syndrome, and childhood disintegrative disorder and includes sensory dysfunction as one of the diagnostic criteria.
2020:	Centre for Disease Control and Prevention provided a prevalence rate for Autism, suggesting one out of every 54 children has autism spectrum disorder (ASD).
Year	**Legislations/Policies, Education/Support**
1965:	A group of the parent body with children with Autism founded the Autism Society of America.
1975:	"The Education for All Handicapped Children Act" was passed to support the rights and needs of exceptional children. Most of these children previously were either not given admission or supported at school.
1990:	The Individuals with Disabilities Education Act (IDEA) recognised Autism as a disability and made it easier for children with Autism to get special education services.

2.1.5.1 Academic Engagement

The analysis of the preceding legislation, adopted by several countries and promoted by the World Health Organization, was a highly significant development in the history of autism in recent times. Underlying these developments was the awareness that children with ASD were idiosyncratically unique in their apprehending of academic engagement and learning processes in heterogeneous ways. Therefore, Academic Engagement for children with ASD was significantly different than the standardised normalcy of schools, which underlined the ability to perform rigorous educational tasks. This necessitated classroom enactment routine of teacher's instructions, engagement and attentiveness, and the essential cognitive grasp and processing, which demanded valuable social time and control (Sparapani et al., 2016).

The relevance and validity of the normative structure and academic engagement as a critical component function for children with ASD had to be interrogated in light of their acute heterogeneity, sensory dysfunctionality, and stimuli responses. However, this academic engagement function of schools remained a dominant educational model entailing a routinized and normalised learning for neuro-typical social groups, which could not be presupposed as a generic panacea for all social groups but specifically for children with ASD.

The discursive analysis of the theory of the human mind, explicated in the foregoing analysis of the Three Theories of the Mind, had specific relevance for children with ASD due to the functioning of the mind, which entailed classroom spans of attention, experience, and responding to the environmental stimuli. This was pivotal because the researchers underlined a significant gap in evidence-based studies on children with ASD, seeking to correlate how their minds engaged in their performativity upon more imaginative and tested curricula and pedagogies particularly tailored for them, including learning which involved therapeutic aspects approaches. The identification of this research gap was based on the evidence of the classroom aberrations due to the sensory processing in children with ASD, which entwined with their academic engagement challenging the notion of the advocacy and relevance of conventional educational pedagogies. The research's point of departure was to examine the plausible conducive tailored idiosyncratic pedagogies which catered for each child through understanding their unique differential sensory processing abilities (Baker et al., 2008).

The classroom noise had been discursively apprehended in the Literature Review and was particularly focused in research stage 1(Chap 4), which was critically central to the problematic academic engagement of children with ASD. Drawing from the seminal research, a significant positive co-relationship was drawn between classroom noise and children's learning, subsequently impinging upon their sensory processing, leading to cognitive and behavioural stress factors. The dynamics of the multi-faceted aspect of noise, as the principal factor that predominantly affected the child's on-task learning, educational performativity, and emotional and sensory behaviour, is discussed in the next section.

The Literature Review demonstrated, importantly, that children's experiences of classroom noise acoustics impacted their auditory sensory processing in complex and heterogeneous ways and was the key factor in their learning hindrance and competency (Ashburner et al., 2008a, Kanakri et al., 2016). Supplementary research similarly interlinked sounds and auditory processing with children's academic engagement and learning. Their findings illustrated that when children's auditory stimulus became facile, their ability to focus and process sensory data was amply demonstrated to increase. Contrarily, the complex auditory stimuli made their engagement, concentration, and processing of data more difficult (Bonnel et al., 2003, Heaton, 2003). It became significantly important to stress the complex issue of noise. The noise/ acoustics was compounded when it persistently accumulated as ambient noise through the classroom's unfiltered spaces. This ambient Background Noise impacted the academic engagement of children with ASD, particularly viewed through their retraction of the necessary focus on the teacher (Sparapani et al., 2016).

From the preceding discursive analysis of noise, the noise factor was positively entwined with learning, sensory response, and emotive behaviour in children with ASD. This aspect of noise affected, in particular, children's emotional regulatory behaviours by which a child depicted challenges in the alignment of patterns of behaviours in concert with emotions.

ASD and Learning Environment

Three important factors, namely, the cognitive and attention span, the sensory dysfunction and the overriding noise variable, were articulated above regarding the academic engagement of children with ASD. These factors underscored the question of what conducive type of learning environment was appropriate for children with ASD. It was a truism that for all children notwithstanding, an appropriate educational learning environment, i.e. the classroom is vital. This fact had more urgency to attend to due to the cognitive and emotive impairments in children with ASD, which were associated with their neurological disorder and sensory dysfunction, further demonstrated by the effect of the physical learning environment constraining their behaviour (Pilar Arnaiz Sánchez, 2011). The building environment was an embodiment of educational learning spaces, encapsulated vital classroom features, such as noise, light and space.

Recent studies have designated that the spatial bounds of architecturally designed spaces affect the sensitivity levels of both neuro-typical and children with ASD. This co-relationship between design and human emotions was explored in depth in the theoretical framework below. Earlier, it was demonstrated that the lesser the conducive nature of the learning environment, the higher the exertion extolled on children's disposition towards learning and behaviour. Consequentially, children with ASD confronted limited productivity learning because of the continually expended proportion of time on making sense of their learning environment and surroundings. If this predicament were reversed with an appropriate alternative environment, particularly designed with limited stressors, children's cognitive focus would be enhanced upon the learning on-task engagement (Pilar Arnaiz Sánchez, 2011).

The research also drew evidence regarding the complexity and heterogeneous nature of children with ASD, which affected their hearing and vision senses, and was critically investigated in Stage 1Study 1Chapter 4 (Bogdashina, 2003). Aspects of a neuroscientific theory which enquired and explicated sensory integration were suggestive that the human mind was capacious and processed and organized all data acquired from the environment, including sound, touch, smell, sight, and taste, converting it into functioning utilitarian information. A critical entwining of the environment, the human mind, and education underscores the pivotal nature of gathering sensory information, interpretation, and the import of learning. When humans were availed of various opportunities and configured this input through their enhanced sensory perception, it resulted in a positive causal relationship with the individual's behavioural modification and learnability (Ayres, 1974). For this research, these insights were relevant as they had a bearing on individuals with ASD and their genetic sensory deficiencies. These insights interrogated the consideration of learning, the type of learning environment prevailing, the nature of their sensory functionality and its integration, and the educational modes of interventions possible which were discussed in the following Chapter 3.

The extension of neuroscientific conceptions lending towards modifying the learning environment had been established to have a positive condition for the neuro-typical and children with ASD social groups. Studies have evidenced that employing multisensory room for neuro-typical children led to an enhancement of plasticity-dependent experiences with considerable positive outcomes not only upon their learning but also their social development and enhanced wholesome and conducive experiences-(Stephenson and Carter, 2011, Baines, 2008). In one particular research, the dynamic interplay between the teacher-instructor, and pupil, with an ambient sensory spatial classroom physically structured, was demonstrative of rendering a transformative educational for learning of children with ASD. This approach included the entwining of bold, innovative, and creative pedagogies and holistic learning, which combined learning effects with spatial and visually sensitive environments which resulted in enhanced learnability, incremental attentiveness and reduce visual distractions (Kopec, 2006, Bavelier et al., 2006, Chen et al., 2006).

The centrality of a conducive learning environment was argued above, underlining the fact that ambient noise apparently created the most disruption in the classroom, but besides noise, the light was another significant factor which led to hypersensitivity of children with ASD. In particular, it was importantly evidenced that such ambient noise-sourced from fluorescent lights, rotational fan blades, and air-conditioners, was proven to be the primary source for inducing commotion and thus acted as distracting stimuli which led to elicited sensory disruptions (Choi and McPherson, 2005).

In framing the research's investigation, high-visual complexity and auditory sensitivity in children with ASD were key factors to take into account in relation to enhancing their learning. The literature evidenced the possibility of educational enhancement evidenced by optimal transformation through unique pedagogies which focused on individual learning-teacher interaction rather than group learning. It was significantly proven that an appropriate spatially and innovatively designed environment specifically for children with ASD mitigated the auditory and sensorial distractions effect, thus easing learning processes and further enhancing pedagogies which curtailed children's visual and auditory interference. This was significant in assessing an appropriately justified research design, aided by constructing well-grounded methodologies for testing the impact of elements and individual learning pedagogy, sensory classroom environment design which would reduce the children's distractions and be dealt with in-depth in the Methodology Chapter 3 Research Design Section (Hochhauser and Engel-Yeger, 2010).

In contrast to the dominant model of learning in mainstream education, this research critically assessed evidence-based studies in the literature, which underscored the categorical importance of an appropriate learning environment and the application of individual pedagogies and learning for effective education for children with ASD. The pedagogical factors kept in focus were the elimination of noise, unique curriculum, and individual teaching, preferably a small ratio of teacher to pupil facilitating children's sensory processing and enhancing their learning. These evidenced indicators were examined in depth, including optimizing learning and a calibrated classroom sensory environment, discussed in the next Chapter 3.

2.1.6 Design Criteria, Built Environment and Autism Spectrum

The foregoing analysis leads to the establishment of the consideration of an appropriate learning environment drawing the critical nexus between the physical classroom sensory environment and the learning of children with ASD. It raises the vital issue of built environment designers taking into account the children's dysfunctionality and how to respond to design elements which would assist in the amelioration of the sensory functioning responses to learning by minimizing the aggravation from the environmental stimulus. Such a shift entails a systematic re-evaluation of architecture conceptualisation and design, particularly the interior spatial classroom elements and their necessity for children with ASD.

Despite this growing awareness of educational and sensory problems underpinning their learning, the design practices were largely based on heuristic assumptions. These included recommendations by teachers and caregivers upon which the design modes for learning environments were based (Delmolino and Harris, 2012). These design models were ill-rendered and could not be considered adequate architectural design for children with ASD considering their complex dysfunctionality.

Compelling evidence has established on how crucial it is for learning of children with ASD to have an attenuating environment which frees their levels of stimuli stress through an appropriate sensory environment (Gaines et al., 2016). The consequences of the lack of such an environment were demonstrated in the dominant model of normalcy of schools which pursued random, procedural, and rigorously controlled nature of examinations where children with ASD were negatively impacted. This environment was purported to be an inappropriate one in which children on the spectrum with acute heterogeneity and multiple levels of complex sensorial makeup and diagnostic shortfalls were not the beneficiaries of achieving educational goals (Mesibov and Shea, 2011).

The research built the nexus between the critical criteria of designing an environment for a heterogeneous group of children with ASD; the focus needs to be an enabling environment that caters to sensory differences, maximizes independence and skill acquisition and builds on their existing strengths. Moreover, it focuses on the factors that can potentially affect the health, well-being and learning of ASD children. Design recommendations for a sensory supportive classroom environment are provided in Appendix A.

2.1.7 Concluding Remarks on Section 2.1

The Introduction section above established the widespread prevalence of autism afflicting huge populations worldwide with an estimated prevalence rate of 1% -2% internationally. The case of Pakistan, with 350,000 estimated, exemplified its extensive nature. The import of the psychological and neuroscientific theoretical formulations was significant in the research to explicate ASD as a developmental, sensory dysfunction with complex heterogeneous nature, whose understanding was vital. Recent psychological and neuroscientific advances depicted the manifested complexity as referenced above in Autism Spectrum Disorder represented in the DSM-5 Manual of Diagnostic Tools.

The Neuroscientific theoretical and conceptual grounding were drawn upon, particularly the Theory of Mind, Theory of Coherence, and Theory of Executive Function, to explicate the nature of the human mind, the brain's disposition and dysfunctionality of its vital executive operations whilst underlining the possibilities. It particularly underscored the cognitive dysfunctionality leading to the lack of the integrative and governing functions of the mind depicted in the cerebral mechanism impairment, leading to learning and meaning disjuncture. Juxtaposed with these three theories, the Sensory Perceptual Issue (SPI) elucidated the predominant failure of ASD individuals to receive and organise categorical signals from the environment (Bogdashina, 2003). Its impact was felt in the high visual and auditory sensitivity and in learning where academic engagement, which necessitated attention and cognitive competence, was disrupted due to the significant noise acoustic factor. Resultantly, the acute heterogeneity and auditory and sensory dysfunctionality in children with ASD led to a vast array of complex atypical behaviours and stereotypical and repetitive movements (Stiegler and Davis, 2010).

It contrasted the largely prevailing architectural design and practices based upon belief, opinion, and anecdotal approaches, with the research's central pivot that neuroscientific advances, entwined the human mind, education, and the environment relationally had impacted contemporary architectural designs which acknowledge scientific conceptual approaches. Apprehending the classroom spatial sensory design model was requisite, which addressed the heterogeneity of the children and their dysfunctionality. Whereas the efficacy of the commonplace heuristic, the anecdotal architectural designed classroom was interrogated due to persistent learning hindrances, which were features underscored for relevance for this research. This research highlighted how vital it was to address the building environment with integrated sensory related elements to facilitate children's learning. Based upon the rationale of the validity of Sensory Built Design and its empirical grounding, this research bifurcated research into two different empirical study stages. The Stage 2 Study and Stage 3 Study, Chapter 5 and Chapter 6, respectively, dealt with the testing of the research's critical hypothesis through the application of the sensory design intervention upon its ramification on the participating children's stimuli responses and sensorial behaviours and their sustained On-task engagement.

2.2 Environment and Behaviour

In this Section, the research drew upon important theoretical constructs whose underlying concepts attempted to explain the vital interlinkages between children with ASD, learning and classroom environment. These theoretical constructs aided in the understanding and developing of the framework central to the research's Stage 1 Study, Stage 2 Study, and Stage 3 Study dealing with sensory behaviours and attenuated education performativity classroom On-task behaviour in children with ASD.

The significance of the Theory of Neuroplasticity was profound as it explicated a new understanding of the human mind in terms of plasticity. This entailed that the brain was a constantly transforming organism with proven flexibility and adaptability towards the environment, a principle which was very important for the education of children with ASD (Eriksson et al., 1998). Lewin's People Environmental Theory explains that human behaviour, productivity, and health which assist an individual in realising their full potential, were fundamentally determined through meaningful interaction with the environment (Neufeld et al., 2006).

It was plausible that the learning processes of children with ASD could be heightened and attenuated when applied to the theoretical prisms of the 'sense of coherence' construct as formulated in the Salutogenic Theory (Antonovsky, 1987). The fundamental theoretical presupposition of this theory was that it did not consider ASD autism as an illness but a human condition which could be constantly improved with appropriate transformations. In this manner, a holistic approach to apprehending children's education was possible, which would allow the attenuation of the effects of auditory and sensory disruptions and learning in the classroom environment.

Drawing upon the above theoretical constructs, two major design approaches, the atypical inclusionary approach and the sensory design approach, were pertinent to exploring the learning environment for children with ASD. These two design approaches were brought in to examine, contrast, and seek justification for this research and its framing.

These theoretical insights were highly relevant and could be further extended for their application to this research's investigation of the impact of classroom environment and its factors upon children with ASD. As the classroom incorporates the built environment, it entails education, healing, and productivity. The environmental design was plausible, where the principle of altering optimal was used to the point that the child was in harmony with the classroom environment. The following Fig 2.1 represents the contextual framework.

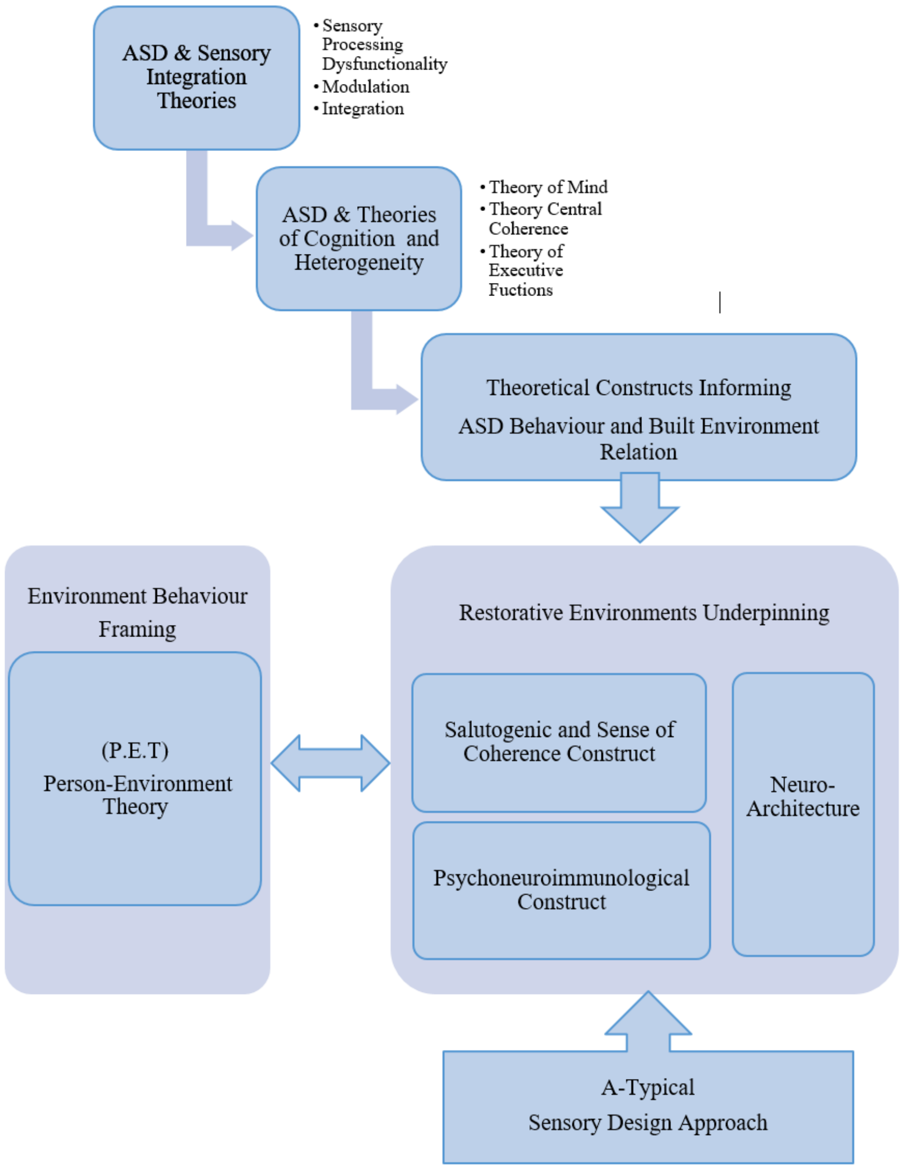


Figure 2.2: Contextual Framing Road Map

2.2.1 Theoretical Context

Person Environment Theory

In the recent development in the field of social psychology, emergent conceptual shifts explicated how individuals negotiated and interacted with the environment (Lewin, 1947). It underscores the functionalist concept of engagement with the environment, determining a person's behaviour, productivity, and health through achieving equational congruency, which was deemed vital for children with ASD and their learning. The Person-Environment Theory (P.E.T) presupposes the adaptability and intersectionality of an individual's full potentiality and its tenets with the field of environmental design. This conceptual adaptability and intersectionality could be employed as a methodological and analytical explicating of how individuals processed specific subjective characteristics whilst adjusting to the environment through assessing commensurable properties in the objective world.

One significant approach suggested that the built environment proposed the scaffolding of an individual's existing strengths by optimising one's potential through the design environment (Neufeld et al., 2006). Proponents of the Person-Environment Theory (P.E.T) underscored the plausibility of emphasising aspects which enabled psychologists and medical professionals to shift attentiveness towards the environmental horizon for healing and capacious productivity. Within the emerging environment theory, the conceptualization of the environment had significant positive psychological and educational implications. They aided the optimization of the environment and design, particularly for children with ASD, interrogating the manner in which modification could be advocated based upon precepts of the person-environment conceptualisation.

From this theoretical prognosis, implications could be drawn for facilitating children's education, particularly in reference to the academic engagement of children with ASD. This concept of congruency with the environment and healing allowed possibilities for better negotiating, participatory, and evaluative practices in the classroom. The dialectical negotiation between the child and the environment was relational, had mutuality of understanding, and arrived towards a reconciliatory point through adjusting to the learning environment. Once the child reached some semblance with the environment, the pedagogical basis for evaluation was made possible by monitoring children's feelings and responses towards the altered environment to maintain positive behavioural outcomes.

A Salutogenic Approach to Learning and Sense of Coherence Construct

The necessity for an empathetic approach was profoundly relevant as it rejected the notion of autism as a disease or disability designated as signified specifically on the Spectrum. Identifying with the salutogenic theory, this study upholds the argument that the ASD pupil is not diseased or disabled; instead, certain levels of health and well-being are defined as a continuum on which the ASD pupil may fall somewhere (Antonovsky, 1987). Parallel to this is the theory of sense of coherence construct, also introduced by Antonovsky (1987), asserting that a coherent, manageable view of the world can help the ASD pupil manage stressful situations and events and improve their overall health, well-being and coping mechanism. Drawing upon this Golembiewski (2010), in his paper "Applying a salutogenic model to architectural design", is of the view that a sense of coherence is an essential construct in the process of healing, emotions of comprehensibility, meaningfulness, and manageability have architectural implications and can help to strengthen the sense of coherence in the healing process.

Conjoining The Theory of Salutogenic and the Sense of Coherence Construct, this thesis insinuates that the ASD pupil be viewed as an individual capable of learning the way any other neuro-typical individual would, given the proper environment and physical stimulus. In an environment where such strategies and interventions are introduced, the ASD pupil would thrive, drawing from their own specific abilities.

The purpose of inspecting this theory is to examine the connection between learning, health, emotional well-being, physical healing and the built environment. There is an established connection between the physical space and its effects on behaviour and physical and emotional well-being (Sternberg, 2009). Even though each ASD pupil is heterogeneous and the severity of the disorder varies from pupil to pupil, understanding how the brain functions and reacts to certain stimuli within the built environment can provide a primary starting point for the research.

Psychoneuroimmunology

Drawing upon the health and well-being of an individual in a person-environment relationship, it is imperative also to comprehend the mind and physical body connection which is critical to understanding the health and wellness consequences of person-environment interactions. The emergent studies depict human psychological and physiological connectivity with psychical-immunology considered within the nexus of environmental responses of an individual's stress in encountering environmental stimuli (Suresh et al., 2006). According to Owen (2001), psychoneuroimmunology (PNI) studies mind-body associative relationships, considering the mind's interactions with the neuroendocrine and immunological systems. Its primary premise is that a person's mental health impacts their immunological response, i.e. the physical body may be more prone to illness if the mental/emotional health of the individual is compromised.

Ulrich (1984), a pioneer in advocating the notion that our physical systems are affected by the physical surroundings and settings, his research demonstrated that providing a restorative physical immediate surrounding environment to patients can shorten the length of stay in hospitals. This implies that an individual's mental well-being is required for their physiological well-being and that the built environment is accountable for it in multiple ways.

Combining neuroscientific understanding, Psychoneuroimmunology demonstrated through the examination of enabling individuals coping with stressors and healing in which the emotive influence of immunological functions negatively impacted the immune system and explained heightening or inhibition through the environmental stimuli through the subconscious mind reaction through five senses responses resulted in anxiousness or sereneness (Starkweather et al., 2005, Rubert et al., 2006).. Taking this as a frame of reference, it can be argued that the SCED methodology and strategies used for this study claim both contextual and functional suitability.

Neuro-Architecture

The generic conceptual construct of the environment is deeply and profoundly an integral part of human lives, so nuanced and subtle that its impact is felt inconspicuous and yet of seminal importance to life and existence. It is neither felt nor registered in the human daily mundane routine, behaviour, performativity and actions. In ASD diagnosed children, it affects varied minutiae experiences of life circumnavigating around school institutions, home, and the general communal or natural environment. This navigation of daily life, grappling to make meaning at every turn, is taken for granted.

This dimensionality becomes more significant when considered in simultaneity with an individual's being and habitat in singular or multiple places and natural or human-made habitat. The practices of human inhabitancy result in reactions and interconnectivity at complex conscious and subconscious levels. This underscores that human beings are dependent socio-psychologically on physical spatial surroundings for their individualised development and well-being because human experiences are grounded and inseparable from their physiological and psychological systems (Rapoport, 1990).

Neuroscience is a rapidly growing sphere of research which recognizes the relationship between the built environment and its effects on the physical and emotional well-being of people. It is essential to understand the neuro-architectural nature of the environment concerning children with ASD as it has numerous implications for environmental and behavioural disorders (Eberhand, 2009). By understanding the neuro-architectural environment, one hopes to understand the relationship between the children's emotions, perceptions and environmental design. An architectural endeavour rooted in the neurological workings of the children on the spectrum thus hopes to become a more beneficial learning experience and a healing environment. This understanding of neuro-architecture forms the premise for choosing this study's most appropriate sensory environmental variable.

In the scope of this study, insights from neuroscience/ architecture are employed to inform the theoretical framework of this research to create transformational design that promotes healing, well-being and learning of the children with ASD. Therefore, a spatially designed built environment entailed ameliorating a habitat environment in which an individual found coordinated alignment, heightened motivation, and reduced pessimist emotions affected by the mind. Apprehended in this manner, Neuro-Architecture could be viewed as a built environment design framed within the neuroscientific principles of sensation and perception, which enabled the spatiality to inspire memory, ameliorate cognitive ability, and deter stress whilst stimulating the mind (Eriksson et al., 1998).

An understanding of the neurobiological aspects linked to autism might lead to more effective therapeutic approaches and new insights into the disorder's genesis. In his regard, an important first study by Rance et al. (2017) investigated listening-related stress in school-going children with ASD by studying neurobiological marker cortisol stress hormone levels in correlation to auditory intervention remote ear microphone usage. The findings suggest improved listening, social participation, communication and reduced salivary cortisol stress levels with auditory intervention. As such, auditory/acoustic interventions that reduce stress may be beneficial to the well-being of children with ASD, an area which is only marginally explored needs to be investigated in school's natural settings with acoustic modifications affecting auditory-related stress (Dargue et al., 2021). Although the stress response is adaptive for temporal responses to stresses in the immediate environment, however, sustained activation of the hypothalamic-pituitary-adrenal (HPA) axis due to prolonged exposure to a stressful environment or chronic stress can have negative consequences such as neuroendocrine dysfunction and compromised immune system (Sternberg and Wilson, 2006) as discussed in the previous section.

According to Sternberg and Wilson (2006) environmental variables stimulate a number of neurological and physiological reactions that can contribute to emotions of comfort, anxiety and agitation. Architectural designs that include these neuroscience ideas are well-informed and are expected to improve the creativity, cognition, and comfort of individuals living, working or studying in such settings.

Building upon the above nexus, Ayres introduced a neuroscience-informed sensory integration disorder intervention paradigm discussed earlier in detail (section 2.1.3.2), based on a triad: neural plasticity allows for brain transition, active involvement is needed for neural synaptic changes, and enhanced attuned calibrated environmental conditions are required to stimulate and steer neural changes (Ayres, 1974). This neuroscientific-based sensory model, which centred on the workings of the human mind, its integrative forms, and dysfunctionality, was crucial in this study's bridging behaviours and learning of children with ASD. As a result, the study focused on the sensory built environment. This understanding forms the undercurrent of the research in apprehending the research's studies in Stages 2 and 3, where the classroom environment is used as a transformative design environment to impact sensory behaviours and learning.

2.2.2 Design Approaches

In the foregoing analysis of the three theories of mind, the theoretical framing of this research evoked the integration of neuroscientific concepts undergirding the mind, coupled with non-deterministic environmental theories, which provided directions in this field. This theoretical ascription threw sharp relief on Sensory Environment as a key which became the overarching integrating factor at the intersectionality of education and children with ASD.

Two design approaches were critically evaluated in light of the foregoing discussion pertaining to the Sensory Environment. Both were examined upon their particular set of criteria, justification, and conceptual grounding with largely bifurcated outcomes. The Sensory Design Approach was conceptually built upon Sensory Environment and was fundamental in understanding transformative processes of sensation, perception and behaviour. The Sensory Design drew upon the implications of designing spatial areas for children, which affirmed that the environment served as a pivotal composite experience for people through their surroundings (Scott, 2009).

Neuro-typical Approach

Two predominant Sensory Design paradigms were examined to apprehend design research for autism. Firstly, the “Neuro-typical” model, which proposed the principle of immersion and integration of individuals with ASD in the general environmental arena designed for neuro-typical social groups. The rationale for this conventional design approach pre-empted the limitations of time and expense, bridging the urban-public axis for ASD individuals, based upon the rationale that it would lead to brisk discovery of optimal simulation, adaptation, and functionality in the world context, which was presupposed to be universal. Its social validity was sought under the precept of the inclusionary principle that immersion led to individuals becoming part of the reality of the externally lived world. However, this rationale was strongly contested whether high stimuli environment was conducive for unique ASD sensory conditioned individuals for facile adaptation to the universal environment taking into account their given skills development and sensory environment facilitation. Furthermore, although this model appeared alluring, it was more conjectural rather than verified empirically. With any sensory paradigm, spatial designing demanded a highly specific purview for individuals with ASD, which entailed time, expense, and thorough consideration of numerous sensory factors and environmental variables (Pomana, 2014, Marion, 2006).

Sensory Design Approach

The Sensory Design Theory paradigm proceeded with the fundamental stipulation that ASD sensory behaviour could be ameliorated by altering the sensory environment via an appropriately constructed learning environment. The theory advocated the creation of a controlled Sensory Environment to facilitate children’s skills, participation and learning acquisition, taking into account their learning dysfunctionality and sensory issues. It proffered using a flexible, low stimulus environment for ASD children centring on skill acquisition (Mostafa, 2008). Hence drawing upon the sensory design approach, a sensory environmental modification to facilitate children with ASD is an intervention carefully calibrated and attuned in its proximity and complexity to affect one or more sensory variables in the ambient physical environment surrounding the child to improve functioning and participation (Bodison and Parham, 2018).

The Sensory Design Theory was informed and conceptually predicated upon the principles of the Theory of Sensory Integration which underpinned the neuroscientific conceptualization explained above in depth (section 2.1.3.2). It underlined the mind’s ability to organize, consolidate, and make a meaningful response to the environment and information through the senses.

The paradigm apprehended the intersectionality of Sensory Design Theory and principles of Sensory Environment simultaneously. It was mindful of the deficiencies and sensory dysfunctionality of perception, which lead to the child’s hyposensitivity and hypersensitivity behaviours reflected across the

Spectrum, which altered visual and sensual experiences, including acoustics, texture, light, and colour. This paradigmatic approach drew implications for Building Design. It adopted criteria to account for dysfunctions in order to enhance the learning and academic engagement of children with ASD and aid more profound experiences and knowledge of the Environment (Scott, 2009).

Summing up from the critical perspective of this research, the "Neuro-Typical" paradigm lacked the principles of mindfulness and empathy, an approach exerting cognitive toil on learners, whose time was primarily invested in sensory processing, de-energized in the pursuit of learning routines and sapping concentration, thus delimited.

In sum, a sensory design approach or supportive sensory environment necessarily means adapting to a child's sensory processing demands rather than attempting to adjust a child's sensory processing threshold. The models offered by several researchers underscore this approach (Mallory and Keehn, 2021). Sensory Design Theory was an empirically verified paradigm employed as a conduit to design conducive altered sensory environments for positive and constructive learning for children with ASD standing in sharp relief against the neuro-typical model (Mostafa, 2008). Its theoretical framework was scaffolder upon sensory environment conceptualisations allowing for flexible and adaptable architectural design criteria. This approach was evidentially relevant in applying children's complex levelled abilities corresponding with their stimulus zones, reflecting differential responsivity in their activities and skills levels.

2.2.3 Concluding Remarks on Section 2.2

This important section 2.2 demonstrates the complexity of learning, healing, and the built environment for education dimensions for children towards their wellbeing. The multidisciplinary fields drew upon the conceptions of the environment, neuro-architecture, design approaches, and, additionally, the salutogenic theory, which provided the possible ground for healing components in the research. An important added dimension of the healing phenomenon drew upon the nexus of human psychical-immunology entailing the neuroscientific understanding of psycho-neuro-immunology, which assisted in understanding how individuals coped with the stress of the environmental stimuli both through conscious engagement and the subconscious aspects of the mind.

In the theoretical context and design approaches section, the intersectionality of the neuroscientific theoretical frameworks, the theory of neuroplasticity, and the people's environment theory provided fundamental concepts which underpin this research's rationale towards aiding an appropriate calibrated built environment design entwining sensory design principles.

2.3 Autism, Noise, and The Built Environment

The literature revealed that noise was a predominant factor in learning and sensory behavioural problems in children with ASD. The examination of this factor is discussed below.

2.3.1 Effects of Noise

The predominance of noise/ acoustics as a critical, significant factor in relation to children with ASD and the built environment in the research literature has been established. However, for this research and studies in the area, it was important to explicate the scientifically based component of noise and its ramification on individuals as, in lay terms, its impact on human subjects was generically considered unwanted or causing a disturbance.

Empirically assessed noise findings substantiated and underscored that it had a dual causal impact, both auditory and non-auditory. Upon an individual's subjectively exposed to noise exceeding the level which crosses the normal range, it produces adverse health effects. This was particularly evidenced in occupational manufacturing, where exposures exceeded the considered normal range; this results in a negative impact on the workers' health and leads to hearing loss (Stansfeld et al., 2000).

Cumulative-continual impact of noise was considered to lead towards impairment. Although there were widespread studies on occupational noise, an increasing number of researchers have broadened their scope, which now encompasses the social source of noise and environmental types emanating from enclosed bars, headphone music, vehicles, and construction. The studies have reflected the negative interfering aspect of noise stemming from environmental pollution, severely impeding the human comprehension abilities of ordinary normalised speech, leading to individual disabilities, deterrence, and behavioural changes (Basner et al., 2014, Goines and Hagler, 2007).

2.3.1.1 Physiological and Psychological Effects

The salutogenic theory of learning and coherence construct discussed in Section 2.2.2.4 explicated that individuals must be viewed both from physiological and psychological dimensions, not in one binary, which was relevant for children with ASD. There were types of prominent environmental noise levels which negatively impacted an individual's health physiologically and psychologically and consequently affected blood pressure, heart rates, muscle reflexes, and sleep patterns. It led to hearing loss when an individual sustained continuous exposure to a very high frequency of noise at 85 Decibels (dB), whereas excessive prolonged noise interfered with subjective tasks, startled response, freezing, muscle tensions and risks of aggressive behaviour (Suter, 1989). However, it was the psychological effects which endured and prevailed longer. These were manifested in agitation, anxiety, antagonism, and restive behaviour, which affected an individual's perception and concentration, reflecting a significant co-relationship between human stress and noise levels. (Atmaca et al., 2005).

A resultant condition termed stress was a significant aspect of various effects, including noise. It was the consequence upon individuals who were imposed with several demands necessitating adjustments and enactment with several sources. Several sources-inducing stresses were regulated through heat, chemical pollutants, and noise-triggered physiological reactions. One very significant aspect of noise was ambient noise, which in general, was considered irrelevant. However, for this research, it was the key stressor feature in the classroom and of central focus in the three stages of this research. It will be addressed in the research design and throughout the whole thesis. When noise was evaluated as negative and unwanted, it pertained to an individual's subjective and internal state of mind. Individuals demonstratively indicate unique idiosyncratic and differential responses to the same auditory stimuli, conditionally assessed sound as noise-induced anxiety, which was linked to one's stressfulness (Halpern and Gullickson, 1996).

The empirical noise findings evaluations demonstrated its multifaceted variation and were also dependent upon age. For example, an aircraft noise factor impacted both adults and children (aged 9-11 years) in similar patterns on the exposure-annoyance curve. In comparison, the frequency level of traffic noise affected adults more than children (aged 8-14 years) (Van Kamp and Davies, 2013). This research draws essential deductions from the analysis of noise and its implications.

Noise, viewed in this study deemed to have an intensified effect on human physiological and psychological distress but demonstrated empirically made differentials when age, experiences, and perceptions were considered. However, although the noise sensitivity factor positively correlated with human physiological functions of heart, blood pressure, and skin resistance, the findings cannot be deemed consistent or conclusive. Noise acted through high complexities and nuances upon human functionality, which had significant implications and relevance for this research on children with ASD (Kanakri, 2017a).

2.3.3 Classroom Acoustics and Children with ASD

The theoretical and conceptual formulations of the two major disciplines were a significant focus for this research to understand how classroom acoustics influence the learning of children with ASD. The research underscored the conceptual shifting from genetic and environmental determinism by bridging neuroscientific conceptual breakthroughs, which aided the understanding of how the autistic mind, ASD and environment was relationally interlinked.

In the discussion of the classroom sensory environment, the predominant factor of noise/acoustics was descriptively apprehended to demonstrate how inadequate the prevailing architectural designs were for learning, retention of knowledge, linguistics and verbal skill development of children with ASD. These normative anecdotal designs did not address the acoustics and sensory built environment design, which was crucial for children's auditory response, and for developing their speech intelligibility (Dockrell et al., 2004). As a result of the children's acute heterogeneity, which was demonstratively depicted in Section 2.1.1, their sensory stimuli response straits were highly idiosyncratic, and their outcomes were complex and indeterminate.

The sound was a reflective stimulant for noise from all directionality, sources, and classroom effects and surfaces, including walls, furniture, whiteboards, and ceiling. It was explicitly evidenced that a compact or solid surface reflected and caused more noise. Furthermore, two distinctive sources, i.e. environmental and children's noise, were earmarked as noise inducers in classrooms (Dockrell and Shield, 2006). In addition, and more significantly, researchers had evidenced first-hand accounts of the centrality of classroom acoustics.

Interventions Addressing Classroom Acoustic

For this research classroom sensory acoustic improvement, two available options were weighed. The first intervention was based upon the signal delivery implementation entailing the Frequency Modulation (FM) system, and the second was the Sound-field Amplification (SFA) system. The former evidentially proved highly effective in altering the classroom acoustics, particularly for children with special needs (Johnston et al., 2009). However, its single-person fitting benefitted only one child. Thus, it required costly individual personal fit and, therefore, was not cost-effective for a group of students, which was a major drawback (Crandell, 1992). The second system aided the teacher's verbal instructions by amplifying the single instructor's voice source to the entire classroom through multi-located speakers at critical points, which evidentially provided an improved signal-to-noise ratio (SNR) with a unitary sourced signal delivery(Palmer, 1998). However, it was also deemed to amplify the internally induced or extraneous classroom noise, which was a setback. Therefore, this research thesis considers using the SNR amplification of the signal above the ambient noise levels as the teacher's pedagogical tool. It was inferred that whilst it would ideally work for homogeneous social student groups or mainstream schools, its applicability for heterogeneous ASD diagnosed children was questionable.

Classroom Acoustics Parameters

Noise/ acoustics a predominant classroom factor, it was demonstrated to be a crucial environmental stressor which affected the auditory processing of children with ASD in a classroom setting (Mostafa, 2008, Kanakri et al., 2017, Howe and Stagg, 2016), impacting the dual psychological and physiological which was examined and underscored in sec 2.3.4. In consideration of the noise factor in the classroom, key parameters were essential to aid the empirically verifiable procedures to measure the specificity of noise/ acoustic levels in monitoring and control through the Built Environment design. The three primary acoustic parameters delineated in the Classroom Environment were the classroom Background Noise Level (BNL), the Reverberation Time (RT60) and the Signal to Noise Ratio (SNR) (Crandell and Smaldino, 2000). The BNL was the conceptual reference to the average of the actual multiple-combination of noise sources measured in the classroom setting (https://acousticalsociety.org). The statistical value assigned to Noise level, LA90, was gauged by the level at (90% > Time), the value 'A' being the weighted indicator measure depicted in the formulae L90 = 30 dBA.

The RT60 was the seconds' measurement of time the counting took to record the impulse sound, such as a robust hand-clap reverberation in the classroom, which gradually tapered off to the inaudible point. Positive Speech intelligibility was realised when the RT60 was lower, i.e. audible individual speech sounds were rendered to the end of blurring and minimised considerably (https://acousticalsociety.org). This was corroborated by the fact that the lengthier duration of the reverberation time in the classroom's social climate resulted in a more competitive, compromised atmosphere which was less comfortable for children (Persson et al., 2013).

To amend this classroom social-climate environment, the research employed requisite sensory designing, considered an essential feature that included fundamental changes such as acoustical panel wall coverings and carpet to reduce RT60 and other noise. The installation of sensory designing in practice in comparison with the anecdotal normative practices of architecture building would entail professional designers and consultants' assistance because the elimination of noise and distraction minimization, and transmission of the BNL and the support for audible speech necessitated technical aspects (Dockrell and Shield, 2006). For an appropriate classroom environment for Speech Intelligibility, it was significantly recommended that the differential account between Speech Level and Background Noise Level, also termed Signal Noise Ratio (SNR), be maintained at 15dB, and the 'A' weighted BNL should not exceed (35 dB>) (https://acousticalsociety.org). When classroom acoustic settings modification had the requisite acoustical measurement, at the point when BNL and RT60 had considerably ebbed, children demonstrated an enhanced word intelligibility test performance even in an environment active with peers talking (MacKenzie and Airey, 1999).

Classroom Acoustic Regulatory Standards

The significance of classroom acoustics was further evidenced in a study demonstrating a negative co-relationship comparing children's and adults' speech articulation and noise reverberations (Nelson and Soli, 2000). Acoustics had become an essential aspect of classroom design because learning relied extensively on linguistic verbal, and auditory communications in which acoustics was vital. As the classroom environment was an essential children's working centre, however variable and unpredictable, it demanded appropriate environmental settings that minimised the impact of noise on children working on educational activities (WH, 2015).

The observation of regulatory acoustics and noise standards were recommended for all schools, specifically maintaining the speaker's acoustic signal intensity of 15 dB and the cumulative BNL not exceeding 70 dB A, but ideally maintained at the level of 35 dB A (Nelson and Soli, 2000). These regulatory Standards were not practised in Pakistan; therefore, the research had to negotiate the empirical measurement and testing of the Classroom noise and acoustics in Study 2 and Study 3, which was descriptively explicated later.

Table 2.2: WHO Guidelines – presented ad verbatim (Shield and Dockrell, 2003)

Space	Noise level, dB LAeq	Reverberation time, seconds
Classrooms	35	0.6
Halls and Cafeterias	-	<1
Outdoor Playgrounds	55	-

The American National Standards Institute (ANSI) has undertaken exemplary Guidelines and Designing of Schools which entailed comprehensive Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools which assisted schools in the requisite consultation of respective design changes (ANSI S12.60-2010). It took into account all Heating, Ventilation, and Air Conditioning Systems HVAC considered a significant background noise source in a classroom learning setting, although not the only single directional source, including the suggestion that an expensive replacement was not the most viable alternative.

Table 2.3: Guidelines for ANSI presented ad verbatim (Shield and Dockrell, 2003)

Space	Background noise level, dB LAeq, 1 hour	Reverberation time, seconds
< 283 m2	35	0.6
> 283 m2 and ≤ 566 m2	35	0.7
> 566 m2	40	-

A comparative analysis of the ANSI and United Kingdom Guidelines was drawn up to highlight any significant variations. The U.K. Guidelines for an unoccupied classroom/ learning RT60 of 0.4> - <0.6 seconds requiring a maximum 45 dB A ambient sound-level frequency averaged time. The recommended Reverberation Time for children with undeveloped listening skills, hearing loss and/ or Auditory Processing Disorder, the optimal acoustic condition was 0.4s with ambient sound level <40 dB A weighted frequency. The United Kingdom Guidelines for indoor Ambient Noise Levels ANL and RT:

Table 2.4: Guidelines for the UK -presented ad verbatim (Shield and Dockrell, 2003)

	Indoor ambient noise level, dB, LAeq, 30min	Reverberation time, seconds
Primary school classrooms	35(40)	<0.6 (0.5-0.8)
Secondary school classrooms	35(40)	<0.8 (0.5-0.8)
Large (> 50 people) lecture room	30(35)	<1.0
Classrooms specifically for hearing-impaired pupils	30	<0.4

A third essential comparison was drawn from an important organization, the American Speech-Language-Hearing Association (ASHA) 1995, which worked mainly with children, the deaf and people with impaired hearing and had extended enduring prescriptive Guidance for classroom acoustics.

Table 2.5: Guidelines for ASHA -presented ad verbatim (Shield and Dockrell, 2003)

	ASHA (1995)
Background noise levels	30 - 35 dB(A)
Reverberation time	≤ 0.4 s
Signal to Noise ratio	≥15 dB

A significant nexus drawn in the research pertained to children with ASD and the classroom methodologies, a vital component of education which had immediacy for their education. The literature pointed critically to the noise/ acoustics in relation to enquiring about what pedagogical approaches could be more appropriate for the classroom (James, 2010). These were seminal aspects in the Three Stages Studies, whose examination was apprehended in Chapter 6, Study 3 of this research.

It was indicated that different pedagogical approaches were important for children with ASD and those with learning difficulties. However, gaps were shown in the required calibrated classroom modifications /methodologies for their educational acquisition. Most studies focused on the relationship between acoustics and children's speech intelligibility, perception, SNR, and the use of FM and Sound Field Systems. A vital approach was examining the aspects of the relevance of curriculum and an ideal classroom setup which accounted for the proxy of the teacher to the pupil at two meters distance whose impact could significantly reduce signal amplification (James, 2010). This method could be enhanced by acoustical noise modification aiding the internal RT60 dynamics.

Indicators drawn from the literature above showed that noise/ acoustics was the most significant environmental variable which adversely affected the learning of children with ASD. The research probed the possibilities of enhancing children's learning by addressing the attention span problem upon classroom on-task engagement, specifically through Sensory Design intervention. An important component of classroom pedagogy was the teacher's close proxy to the pupil, which assisted the conveyance of instruction and listening. The Three Stage Studies apprehended this vital aspect of education in Stage 2 and Stage 3 of this research. The architect's exploration of modes of sensory classroom design and acoustics, including classroom size, properties, and sound-absorbent elements, were considered (Stiegler and Davis, 2010).

2.3.4 Review of Research on Classroom Acoustics, ASD Sensory Response Behaviours and On-Task Learning

The selected literature review studies were essential to this research. They were discursively and critically apprehended to provide perspectives on the sensory behavioural response of children with ASD to classroom noise stimuli. The indicators from the critical review led to the systematic examination of relevant approaches in light of children's classroom learning, sensory acoustics environment, and design of the Built Environment. It also aided in the methodological framing and selection of the research design addressed in Chapter 3, Methodology.

In total, three Studies with diverse methodological approaches were selected. The rationale for the selection was their contribution to the study area and which reflected the concerns about the direction of this research and its intersectionality. These three Studies included a mixture of observational/ experimental, comparative correlational, and interventional were selected for the critical review. These studies are analytically summarized below.

Inclusion Criteria:

- Studies involved children with ASD.
- Classroom setting
- The intervention involved physical classroom acoustical modification
- Experimental, observational and co-relation studies
- Studies focused on sensory behavioural changes and learning as measured outcomes (e.g. reduction in repetitive behaviours, increased on-task attention span behaviour, On-task engagement, classroom participation).
- Studies published in the English language

Table 2.6: Critical Review Studies Table

Reference	Design, sample & ASD diagnostic procedure	Instruments and Measures	Setting	Intervention	Outcome Measures	Treatment Efficacy
Kanakri (2017)	Observational Study 42 children with ASD diagnoses by paediatrician/ psychologist	Noldus Observer XT software, video recorder, t-test & teacher questionnaire Behaviour observation in a quiet and noisy classroom	Classroom	N/A	Increased classroom performance	N/A
Kinnealey et.al (2012)	Mixed Method, Multiple Single Subject study, four males Students The diagnosis method of ASD was not mentioned. Sensory profile traced from Questionnaire	Observation of non-attending behaviours	Classroom	Acoustic treatment, sound-absorbent walls, halogen lighting	Increased frequency & stability of attentiveness, engagement, Improved classroom performance, mood &comfort	Effective, resulted in a positive hypothesis
Mostafa (2008)	Study in Two Phases. 1- Questionnaire Survey of 83 Children with ASD Caregivers. 2- Case-control Study. ASD diagnoses and profiles not elaborated		Speech Therapy room & classroom	Acoustical modification and spatial sequence segmentation	Positive behaviour outcome with an increase in on-task attention span and reduction in the response time	Highly effective. Hypothesis positive result.

Table 2.7: Study findings

Kanakri, 2017 Acoustic Design and Repetitive Speech and Motor Movement in Children with Autism	This quasi-experimental study examined the impact of classroom acoustics on repetitive behaviours in children with autism. It concluded from its observational findings that the incidence of repetitive behaviours in the 42 children with ASD decreased in classrooms with decibel readings 35 or below compared to classrooms with decibel readings above 35. Study findings were congruent with other studies affirming that classroom acoustics was an important environmental stimulus which was a key variable affecting behaviours and learning in children with ASD. Hence, an appropriate calibrated classroom acoustic environment is essential for ASD students' attention and learning in a classroom setting.
Kinnealey, 2012 Effect of Classroom Modification on Attention and Engagement of Students with Autism or Dyspraxia	This single-case experimental design study investigated the effect of physical classroom acoustic modification intervention on a mixed-age group of 4 students diagnosed with autism and dyspraxia. The sensory intervention involved sound-absorbent wall panels affecting the classroom's auditory environment and examined the impact on behaviours and on-task educational engagement. The study findings depicted that achieving a positive frequency and constancy in classroom acoustics impacted On-task attention and engagement with comfort and positive emotional response, which led to decreased frequency of non-attentive behaviours.
Mostafa, 2008 An Architecture for Autism: Concepts of Design Intervention for the Autistic User	The primary goal of the research was to develop an Architectural Design Guideline for spaces designed for children with ASD in Three Phase Study. The first Phase study questionnaire determined caregivers' views on the most significant architectural elements in the School's environment bearing upon acoustics. The Intervention's second phase entailed the observations and recording of specific behavioural indicators such as the on-task attention span, response time, and behavioural temperament of each child during the pre-intervention and post-intervention condition of the study group. The findings led to the devising of design strategies for ASD classrooms.

2.3.4.1 Discussion and Critique

The summative findings of the literature review selected summarized above exemplified the multi-faceted nature of the study area and its complex subject underpinnings. This leads to the discursive analyses of the studies, aiming to find the factors and identify the study gaps. The key factors drawn from the studies which underpin learning in children with ASD involved the diagnoses of their sensory auditory dysfunctionality and the significant impact of classroom noise/ acoustic, which directly affected their behaviours and learning. The classroom sensory environment and the various sensory modifications through various built environment was investigated.

The three studies reflected different methodological approaches and sample groups. One observational study drew important results of the direct correlation between classroom sensory noise/ acoustics and the impact on behaviours and learning. Two intervention studies significantly depicted the effect of noise/ acoustics on a mixed group and the positive impact of the sensory intervention on the results. These studies are discursively analysed below.

Kanakri's Study, "Acoustic Design and Repetitive Speech and Motor Movement in Children with Autism"

This significant recent study investigated the correlation of ambient noise levels on repetitive behaviours in children with ASD through observation methodology examined in two school settings (Kanakri, 2017a). It tested the acceleration of sound levels from 'quiet' to 'loud', reaching a peak of 70 dB. An analogous T-test was conducted between observations in the designated 'quiet' and 'loud' classrooms in both schools, whose findings indicated a positive correlation between sound level value in dB and children's behavioural and sensory responses.

As noise dB was increased, the correlational behaviours deteriorated, deducing that noise was a critical factor. The limitation of this study was that children with ASD in both schools were tested against the single noise variable and only one dB unit of measure, and it was a correlational study without any intervention. Moreover, a weighted average for the background noise may have provided a greater degree of empirical accuracy relevant to this research study and the general area of studies.

Kinnealey's Study, "Effect of Classroom Modification on Attention and Engagement of Students with Autism or Dyspraxia"

It combined the installation of sound-absorbent walls with halogen lights to examine the correlation between classroom acoustic design modification and the participant's educational impact. It furthered by examining the efficacy from the student's perspective vantage point. The study's sample included four male students aged between 13-20 years whose non-attentive education task behaviours were targeted.

The results depicted a positive correlation between the non-attendant learning behaviours in youth with ASD due to reduced ambient noise levels and the effect of light elements. The Study's delimitations were its methodological selection of the AB (B+C) design which did not consist of the Baseline Return Withdrawal. The study's selection of a sound level meter opted for generic reading and forewent more specificity meter reading which could not apprehend sound ranges and protocols (Kinnealey et al., 2012). This resulted in the restricted controls circumventing the rigorous, methodical detailing sound procedures, which delimited its replicability attested by the incapability of decibel reading to measure below (<50 dB A).

Mostafa's Study, "An Architecture for Autism: Concepts of Design Intervention for the Autistic User"

This important pioneer study apprehended the investigation through a control group design study, which involved a sample of 12 children with ASD divided into two groups of 6. It entailed acoustical intervention in the school-built environment (Mostafa, 2008). The two phases employed an online questionnaire of teacher and caregivers' perspectives which identified the architecture element as the most important architectural variable. Phase 2 of the study designed two interventions through acoustical modification and spatial compartmentalization to investigate the attention span, response times on tasks, and behavioural temperament in children with ASD.

This intervention approach, however, omitted the significant specificities regarding the acoustical measurement, the empirical measurement of the classroom environment, and its occupancy. It similarly did not provide the pre-intervention or post-intervention RT60 measurements. These data were surmised and conjecturally given based on broad statistical percentage estimations. Likewise, it did not include the sound levels meter readings of the classrooms where the studies were actually conducted. Instead of these protocols, generic noise level reading estimates were offered. This approach leant towards the normative, restrictive in the research's scientific conventions and academic rigours. Thus, its validity and replicability for contemporaneous studies were delimited.

The second major delimitation was the research's duration, which lasted one calendar year. For this area of study, with hindsight, this duration was perplexing due to the flux and the complexities and heterogeneous nature of the ASD participants. The constancy of the subject was assumed for very significant factors such as cognitive, physiological, biological and psychological changes and the factors of the teaching staff and caregivers, absenteeism etc. These discrepancies questioned the reliability of the findings, including the observation of the Control Group, which was supposed to have reflected no significant change. The findings of the hypothesis denoted negative results, which raised questions regarding its critical construction (Henry, 2014). The study remained highly significant despite its lax scientific and methodological rigours and duration. Its general approach and findings were vital breakthroughs in this emerging area of studies centred upon children with ASD and the Design approach departing from the heuristically normative.

2.3.4.2 Concluding Remarks on Selected Reviewed Studies

In this section, the research inquired critically into the selected three Studies from the literature to examine and weigh the various methodologies and approaches in order to consider the appropriate methodological and multidisciplinary framework and Research Design to apprehend this research at the intersectionality of children with ASD, their sensory responsiveness, and classroom environment design.

This important research stratagem was to envision creatively the most optimally valid, justifiable, and methodological appropriation to apprehend the research's aims in Stage 1, Stage 2, and Stage 3 studies.

The first important observational study critically examined investigated the correlation of noise upon children's repetitive and motor behaviours in two schools transitioning from 'quiet' to 'loud' peaking at 70 dB whose hypothesis proved positive of the results, but it was underlined that the observational methodology was delimited for broad scientific empirical application (Kanakri, 2017).

The second study investigated the correlation between the attention span of children with ASD on educational On-task learning through sound absorbent wall installation intervention combined with halogen lights employing the single-subject, mixed-method design AB(B+C), (Kinnealey et al., 2012). Its sample range of four youths was appropriate; however, the age ranges between 13 to 20 were too broad for the scientific study of heterogeneous groups whose sensory behaviours varied and were indeterminate from person to person. Significantly, it avoided the empirical measurement of the background noise and the ranges of sound levels in the classroom.

The third important study was an intervention-based two-phased study at a school whose investigation duration was one year. It apprehended the research through acoustical modification and spatial compartmentalization, correlating to ASD diagnosed children to attention span, response on tasks, and behavioural temperament (Mostafa, 2008). However, it significantly omitted acoustical empirical measurements of the classroom environment and its occupancy, not providing the measured RT60 before and post-intervention procedures which were central to this research. Its normative approach led to inferring percentage estimations instead of empirical sound level meter readings which lacked the precision scientific rigour procedures for noise protocols.

This discursive and critical analysis was of primary importance in seeking what optimal research design would be appropriate for this research based upon three stages which overcame these delimitations underscored. This assessment was apprehended in the following Chapter 3 Methodology in-depth for the most viable selection, which could be justified based upon research criteria. The Single Case Experimental Design, A-B-A Three Phased Baseline-Intervention-Return to Baseline, was deemed the most significant for its efficacy of investigation, simplicity and implementation

Chapter Concluding Remarks

This chapter framed the research's most significant aspects to contextualise the study area and the key intersectionality of children on the spectrum, their sensory behaviours and learning, and the Built Environment. It outlined autism's historical context, tracing its aetiology and symptomatic concerning learning in children with ASD. From earlier clinical studies to the ground-breaking neuroscientific advances, including genetics and the environment. This assisted in explicating a deeper understanding of autism framed through psychology and psychiatry explicating the nature of the human mind and environment, evidenced in the complex manifestation of acute heterogeneity exemplified in the Diagnostic tools DSM-V. This led to reconsidering the environment to cater to ASD brain complexity and its multifaceted nature relationally to the environment. The significance of neuroscience in understanding the human mind was significantly framed through the Theory of Plasticity, The Person-Environment Theory, to develop a plausible understanding of children's acute heterogeneity through the prism of the expansive mind. The holistic and therapeutic approaches of the Salutogenic were significant to envision autism as a condition, not a disease.

The prevalence of autism was discussed as it was highly significant to understand the repercussion and its physiological and psychological effects on vast populations but particularly the ASD groups, specifically in relation to education. Both the causes and manifestations of hyposensitivity and hypersensitivity responses were indeterminate. The understanding of non-deterministic environment had immediate relevance for considering classroom sensory environment and Built Environment bridged through the Sensory Design Theory, which was vital to the research. The above literature review highlighted three main thematic categories, which became the basis of the qualitative inquiry in chapter 4, study 2.

a) Classroom environment and behaviour responsivity
b) Environment context and pedagogical implementation
c) Enabling environment

Finally, the three staged Studies representative of the critical aspects of the study area and the methodologies were apprehended for the analysis of the research gaps, the methodological problematic, the selection and justification of the research design and its criteria. These aspects are examined in depth in the next Chapter 3 Methodology.

3

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The extensive literature review demonstrated that amongst various environmental stimuli, the acoustic variable within the classroom environment was the most common source that impacts sensory responses impinging upon their behaviour and learning in children with ASD (Kanakri et al., 2016, Mostafa, 2008, Kinnealey et al., 2012). As has been explained previously, this thesis aims to answer three research questions; hence, the whole research activity can be split into three stages. The Stage 1 Study explores the sensory factors of the classroom environment that affect children's responses and inhibit on-task learning in the classroom. In contrast, the Stage 2 Study investigates the relationship between the RT60, the LAeq and LA90 and the children's delineated disruptive behaviours. The Stage 3 Study focuses on the relationship between acoustic parameters in the second stage and the 1:1 on-task engagement span behaviour in children with ASD. This chapter offers detailed explanations of research methodologies used in this thesis to answer these research questions; Figure 3.1 schematises the methodological mapping.

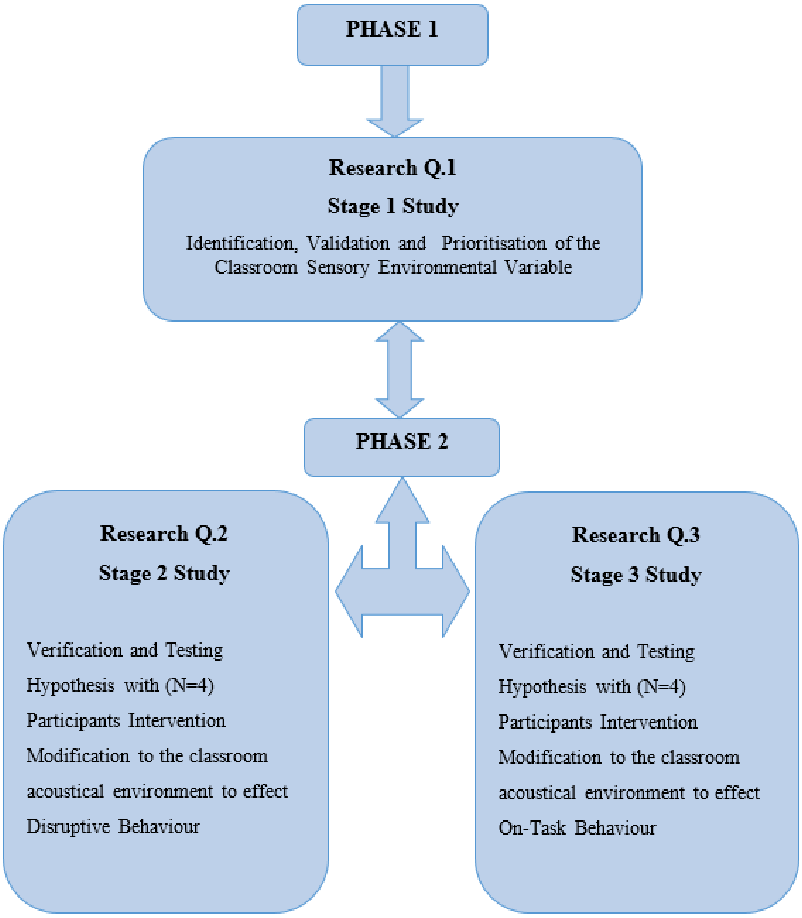


Figure 3.1: Methodological Framework

3.2 Conceptual Framework

Autism is a complex phenomenon whose understanding is linked to multiple bodies of knowledge discussed in sections 2.1 and 2.2. The research is delineated in three stages through the integrated framework underpinning the concept. It aimed to examine the impact of the classroom acoustical environment and its modification upon classroom behaviours and learning affected through auditory dysfunctionality in children with ASD.

3.2.1 Methodological Rationale

The paradigmatic research shifts have opened the possibilities for more encompassing enquiries, which could assist researchers who examined and explicated the complex nature of studies needing methodological and theoretical integrative framing. This horizon allowed the construction of potential knowledge in challenging areas such as autism, children, and the ramification of the sensory and built environment upon children's minds. As this research deals with the variegated complexities and stimuli responses, the methodology selection is considered to eschew the sole empirical, methodological approach exacted from scientific positivism, which would not justify the heterogeneity of children with ASD. As it was argued in Chapter Two, Neuroscience advances have depicted that the human mind and the Environment are far more complex than to be able deterministically studied by empirical positivist methodologies. In the case of children with ASD, the complexes of the mind are far more extensive and more pronounced but not fully known.

Hence The Single Case Experimental Design (SCED) methodology and sensory intervention modes' approaches framed the studies in Stages 2 and 3, catering to the heterogeneity makeup of the children with ASD. The participants' behaviours were examined through the observations to validate the hypotheses.

The construction of this thesis' research design in the three stages was based upon the following criteria:

a) Heterogeneity in children with ASD
b) Suitability for special education and classroom settings
c) Listening to children with impaired or non-verbal communication

The mixed method design combined with the SCED was considered of critical relevance for the research design. These designs stand in sharp contrast to the Group Design, whose key proviso was the research's ability to examine and investigate from the observational vantage point, not in direct communication, social engagement, or participation with the subjects.

Mixed Method Design

The primary methodological significance of this thesis is enabling examination and validation of the research's independent variable, which is the noise/acoustics parameter in Stage 1. These are the most critical pillars for building the research hypothesis in this thesis and testing it distinctively. In Stages 2 and 3, one can deductively draw explications based upon the grounding of the enquiry. The apprehending of mixed methodological design in light of the theoretical backdrop mentioned above gave the researchers the scope to scaffold the investigation in Stage 1. This is one of the very few multifaceted research done alongside children with ASD, classroom physical environment and acoustics in Pakistan and globally, an area significantly underexplored (Dargue et al., 2021).

Single Subject Research Design vs Group Design

The adoption of the SCED allowed the investigation of sensory and on-task behaviours in children with ASD, quantification and comparison across phases, which embodied the functionality for one's control. This enabled contrast of each child's single performativity measurement to be evaluated and contrasted against previous performances (Horner, 2005). On the contrary, the Group Design research proved inefficient in testing the multileveled on-task engagement in children with ASD entailing severe fluctuating responses which contradict children's heterogeneous traits and learning nature and hence invalidated the research(Alnahdi, 2013). For this research, children's multileveled performativity measurement was the key objective; therefore, SCED was selected over the Group Design research method.

The SCED was the primary research design methodology in stages 2 and 3, whose salience was its reliability and as an enquiry tool examining the low-incidence children with ASD individual performativity bounded by an ethical frame of reference. This methodology permitted taking into account acute heterogeneity and indeterminate behaviours in children with ASD, leading to the integrated construction of stages 2 and 3 in this study (Kazdin, 2003, Hammond and Gast, 2010). This method prioritizes the individual as the unit of analysis, focusing on the individual data and analytics and thus enabling to measure the classroom intervention effectiveness in reference to the heterogeneity and the investigation of the frequency and occurrence of targeted behaviours and the learning span engagement (Louis et al., 2000)

The SCED is the research design that enables one to test the effect of an intervention on a small group of subjects. The methodology determines the visual analysis, i.e. graph reviews of dependent and independent variables. The behavioural observations of baseline vs treatment conditions were causally and functionally related in contrast to theoretically built verification of hypothesis through examination of the variable.

The other highly significant factor prioritises the requisite testing of children's multileveled on-task engagement through their variegated behaviours during the environmental phases change. In the social group sampling, activities presupposed those variations is a severe limitation in drawing up the variables for hypothesis testing for the enquiry. In comparison, the heterogeneity in children with ASD underlined by behavioural frequency occurring variances necessitated the individual comparative performance upon the task for analytical comparisons through empirically based trials, not presuppositions (Mesibov and Shea, 2011).

Single-Subject A-B-A Designs in Special Education

The adoption of the SCED (A-B-A) baseline, intervention, and withdrawal of intervention design was selected objectively for its utility to the children with ASD in this research. The A-B-A SCED allowed replication of intervention effect across participants, settings and behaviours. It was a suitable choice for reversible behaviours; a return to the baseline phase with the withdrawal of the intervention effect would not cause any harm to the participants (Barlow, 1984). The unit of analysis, as the sole data for examination, evaluation, and explanation, was salient for children with ASD and their multileveled sensory behaviours and on-task engagement (Cohen et al., 2000).

Experimental design with causal inference is evidence-based for intervention research. Still, this standard cannot always be achieved due to the study's limitations in a natural setting such as a classroom environment. Factors such as time constraints, unethical holding or withdrawal of the potential positive intervention can affect the efficacy of the research design (Kratochwill, 2010 -b). Therefore, the framing of the studies in Stages 2 and 3 meet the criteria of WWC (What Works Clearing House, Single Subject Study Design Standard) of three intra-individual replications within the limitations of the applied settings, congruently with the visual analysis supplementary effect size percentage NAP (Non-Overlap of All Pairs measurement) (Olive and Smith, 2005), and calculation of descriptive statistics.

The SCED A-B-A methodology was salient in consideration of the sample size in Stages 2 and 3, which was central for the investigation and testing of the hypothesis, achieved through accurately measuring the classroom noise/acoustics parameters such as RT60 and its correlated LAeq. It subsequently assisted the investigation of each individual's specificity and heterogeneity by testing these parameters' impact on the participant's sensory and educational on-task behaviours (Horner, 2005, Kennedy, 2006).

3.3 Background to Stage 1 Study

The stage 1 Study is represented in Chapter 4, which adopted the qualitative methodology approach. The utility of this particular approach was salient as it aids the validation of the classroom noise/acoustics environment as the key factor in the research with the conceptual elements of sensory design, built environment design attributes, and the multi-levelled children's indeterminate behavioural responses and on-task engagement. The qualitative approach involved semi-structured interviews of nine diverse, cross-cultural, international experts related to autism, underscoring the collaborative nature of this research work.

The findings were pivotal to providing the foundation for the subsequent examination and relevant import of these factors for the research stages. The general tendency of heuristic-designed normative practices in a prevalent built environment was critically discussed. Validating the critical Noise/acoustic variable and building sensory design was key to investigating the children's (N=4) subjective sensory experiences and classroom effects which were earmarked for further distinctive multi-investigation in the following Stages 2 and 3.

Heterogeneity in children with ASD was the key determining factor which eliminated any possibility of validating a singular concrete conceptual idea of design practice. This fact was attested and underlined earlier in Chapter 1 and Chapter 2 that the design practices were largely anecdotally informed, whose application was challenging to children's variegated sensory and educational needs (Delmolino and Harris, 2012). This research, therefore, foregrounds the available design principles by taking into account through investigation, verification, and assuring the appropriate value of these components for the well-being of children with ASD.

3.4 Background to Stage 2 and Stage 3 Study

As explained previously, the first part of the three stages involves qualitative investigation. The Stages two and Stage Three Studies adapt the SCED and the A-B-A Three Phased intervention methodology. It was considered based on the individual ASD child's sensorial response to the noise and relevant acoustics parameters. The heterogeneity in children with ASD and the classroom acoustic were the primary considerations in these two stages.

Stage 2 focused on the children's frequency occurrence of the identified behaviours in three-phased (A-B-A) investigations. This involved the testing of the impact of the modification of the classroom acoustical environment in Phase B. In Stage 3, the children's On-task engagement span behaviour was investigated. The justification and efficacy of the SCED were laid out in the methodological rationale section above.

3.4.1 Participant and Sampling

The sampling size of participants was evaluated on the criteria drawing upon the analysis of the literature review in Chapter 2. The salient perceptions considered the critical heterogeneous factor of the nature of autism, thus justifying the proposed limited classroom size of sample students for successful, manageable research. It, therefore, adjudicated the justification of a limited sample of four participants (N=4) as reasonable for this study.

The purposive sampling of four participants (N=4), children were selected from the Oasis School for Autism in the City of Lahore, Pakistan. All participants were certified with a medical diagnosis of ASD (Autism Spectrum Disorder) and presented delineated sensory behaviours. Gender boys delimited the participation eligibility criteria. An essential rationale for selecting all boy's gender was based on the evidence that the children's population with ASD configuration consisted of a 4:1 male-to-female ratio (Loomes et al., 2017). Therefore, all males were recruited due to only male students were part of the class.

The inclusion criterion verified the participating children's diagnoses based on standardized diagnostic tools, the Diagnostic and Statistical Manual, and Childhood Autism Rating Scale (CARS) (Association, 2013a) ,(Schopler et al., 1988) through the medical records provided by the school and further assessed by the school psychologist. The participant's post-selection outcome representative sampling depicted the age ranging between 9– 11 years. The socioeconomic evaluation of the participating children demonstrated the mixture of upper, middle- and lower-class strata of families from the city of Lahore in the Punjab Province. The ethnic, cultural, religious, or racial configuration make-up was composite, indicating no significant socio-cultural factor of diversity. The participating subject's linguistic and communicational disorders were assessed as ranging from impaired speech to non-verbal. Each Subject was designated with an acronym in lieu of their names to ensure their privacy and confidentiality, represented in the following Table 3.1.

3.4.1.2 Participant Student Profile

All four students were diagnosed with ASD and designated an acronym to maintain confidentiality and the sensitive nature of this study based on ethical considerations. The children's details are presented in the following section, and table 3.1 outlines the participant codes and characteristics.

Table 3.1: Participant Information Table

Subject Code	Age	Gender	Language Competence
ABD	10	Male	Non-verbal
IBT	10	Male	Echolalia
MOH	9	Male	Non-verbal
SHA	11	Male	Non-verbal

Student ABD (Male, Age 10)

Student ABD was a 10-year-old boy when the experiment was carried out, 1st born among the two siblings. According to his medical record maintained by the school, he was first diagnosed with DSM (Diagnostic and Statistical Manual) Criteria 299.00 (F84.0) Autism Spectrum Disorder through a standardised assessment based on the Childhood Autism Rating Scale (CARS) by a Neuro-developmental Paediatrician at the age of 5. According to CARS diagnostic assessment, he was moderately autistic. The sensory reflexivity challenges of ABD observed and noted were distractions by noise, transient sounds, and the particular aspect of other children's tantrums that affected him. That generally instigated ABD's getting up from his seat, wandering around, and required difficult convincing to settle down upon on-task work on hand and focus.

Similarly, ABD reflected attentional span problems and remaining seated. He depicted frequent stereotypical behaviours, e.g. jumping, moving in circles, flicking his fingers, covering his ears and creating loud noises. He would frequently gaze at the classroom ceiling, walls, and his fingers played with repetitive movements. He enjoyed playing with specific musical toys and did that repeatedly. He had limited social skills and no-verbal communication and would make loud vocal sounds spontaneously. He could make limited requests through PECS (picture exchange communication system).

Student IBT (Male, Age 10)

Student IBT was 10 years old boy when the experiment was carried out, 3rd born among three siblings. According to the school's medical record, he was first diagnosed with 299.00 (F84.0) Autism Spectrum Disorder by a clinical psychologist when he was 5 years old. The assessment was based on behavioural rating and developmental profile. IBT was extremely sensitive to loud noise. He tipped his chair, elicited loud noise, employed words repetitively and got distracted by toys and objects near and around him on his desk. He depicted challenging behaviours with the frequency of rocking, covering ears, making loud noises, and striking out at others. IBT needed high constancy and encouragement to get attentive and focused on-task. He reflected an obsessive tendency to hold paper and plastic bags. He had a unique trait of smiling, giggling and making eye contact. His limited verbal skills were reflected in functional limitation and echolalia with repetitive words, short phrases and making vocal sounds.

Student MOH (Male, Age 9)

MOH was a 9-year-old boy when the experiment was carried out, 2nd born among the three siblings. According to his medical record maintained by the school, he was first diagnosed with 299.00 (F84.0) Autism Spectrum Disorder through a standardised assessment based on CARS by a neuro-developmental paediatrician at the age of 5. According to CARS diagnostic assessment, he was severely autistic. He was acutely sensitive to noise from any source, such as music from toys, the crying of children, noise from objects thrown, or impulsive movements and shuffling of colleagues. He avoided social contact and group activity sessions and was rapidly prone to distraction, particularly behavioural issues stemming from fellow children, e.g. crying and meltdown. He would constantly wander in the classroom and depicted stimulatory behaviour such as rocking whilst seated, flickering fingers in front of the eyes, covering his ears and making loud noises. He required frequent prompting to be attentive to lesson sessions and on-task assignments. Occasionally MOH would withdraw from the group and lie down solitarily. Equally, he would be engaged in self-harm actions with meltdown, alongside loud crying and flinging himself on the floor. He preferred remaining barefoot and discarded his shoes occasionally. He would make eye contact on rare occasions, indicating he was pleased. He disliked and showed resistance to any change in his routine or environment. He loved building puzzles made of wooden pieces. He had very minimal verbal communication and made occasional sounds. His communication was circumscribed by limited requests through PECS.

Student SHA (Male, Age 11)

Student SHA was 11 years old boy at the time when the experiment was carried out, 3rd born among three siblings. According to his medical record maintained by the school, he was first diagnosed with 299.00 (F84.0) Autism Spectrum Disorder through a standardised assessment based on CARS by a neuro-developmental paediatrician at the age of 3. According to CARS diagnostic assessment, he was severely autistic. SHA had a tendency not to be able to sit or stay in his seat and focus on the given task, which disturbed other children. It would require constant urging and coaxing to complete the task being demanded. He frequently inserted toys into his mouth. He depicted persistent, energetic, impulsive on-the-spot jumping, rocking back and forth, and mouthing, which were observed and noted. He was fond of climbing furniture and doing puzzles. His limitations are reflected in his minimal social skills and no verbal communication. He made repetitive loud sounds through mouth-covering or without covering spontaneously. He was able to make limited requests through PECS.

3.4.2 Research Setting

The study was carried out in a specifically designated school for children in Lahore. The Oasis School for Autism is representative of very few establishments for children with ASD in Pakistan, whose proprietors acknowledge the importance of a built environment in treating and developing children with ASD. It was run through private funds, and the school was located on a university/medical premises in Sharif Medical Complex in the suburbs. The school was opened in 2010 in an exclusive building sanctioned to provide educational services and admit children diagnosed under the autism spectrum. The School was designed and tailored specifically to address the needs of these children but faced severe budget constraints. Oasis was partly funded by the Sharif Trust endowment and through the school's standing, fundraising, and by other resources. The school environment actively encouraged parents and collaborative community participation to work towards an inclusive environment. It catered to all socio-economic groups from high, middle, and low classes. The school comprises approximately 22 pupils with 55 teachers, including administration and support staff. The pupil intake ranged between 3 – 16 Years. The student-teacher ratio was 1:1, with a maximum of 6 pupils in one classroom. The school curriculum was modelled upon teaching pedagogies TEACCH (Treatment and Education of Autistic and Related Communication Handicapped Children), and PECS.

Research Classroom Interior

For this research, a classroom was selected with children with ASD whose ages ranged between 9 to 11 years. The staff-to-student ratio was 1:1, with TEACCH being the dominant teaching methodology employed in the classroom. Two classroom teachers and six assistants accompanied a total of 6 students. The classroom construction was made of brick from floor to windowsill and gypsum wallboard from windowsill to ceiling. The classroom interior had linoleum flooring, wooden doors, double-glazed glass and aluminium windows. The classroom suspension ceiling was made of gypsum board tiles 2'x4' Square Feet on a prefabricated iron truss system. Each child's desk in the study area was partitioned with flexible wood partitioning, with PVC chairs and study tables made of wood. In the social group activity area, a contrasting arrangement was set up in place, which consisted of a single large 'C' shaped PVC table, providing seating for the pupils and teacher in all six chairs. The designated study cubicles were colour-coded blue and green, and the group activity area layout visual-pictorial representational display was depicted in the following section. The classroom floor area measured 44.4 meters Square and 3.4-meter height.

Research Classroom Floor Plan Detail

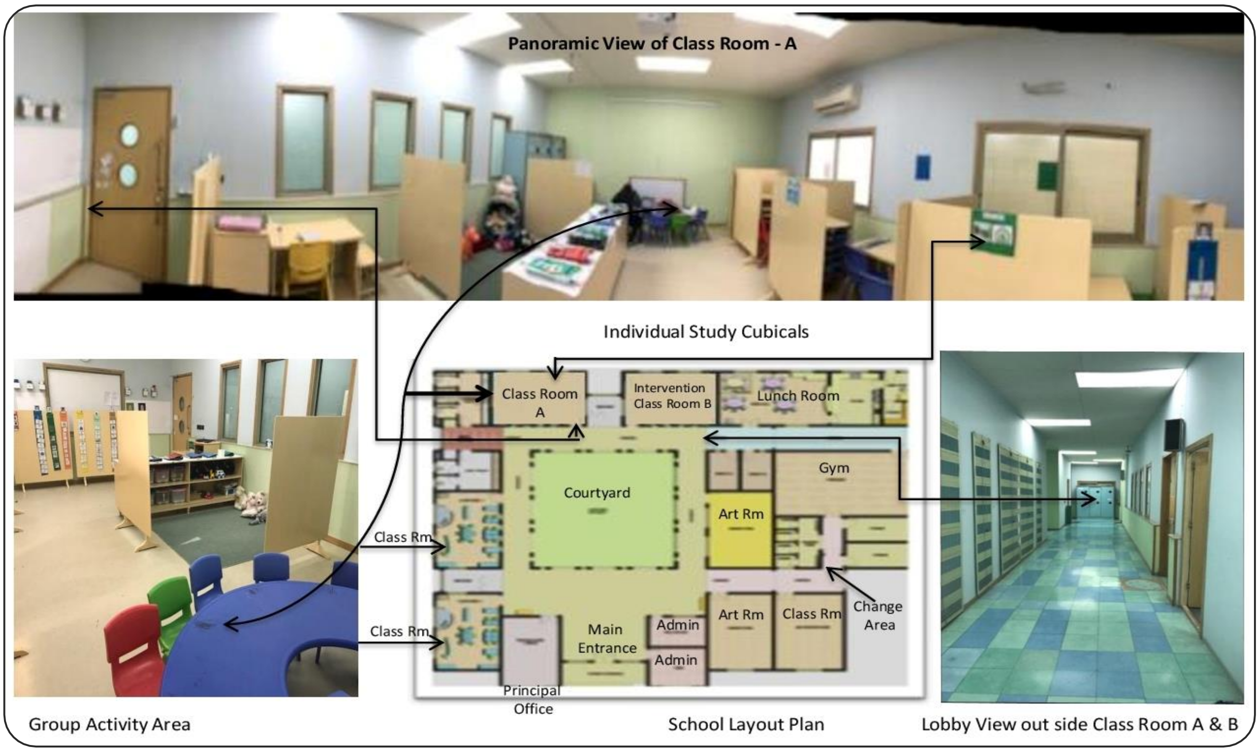


Figure 3.2: Classroom Before Acoustic Treatment

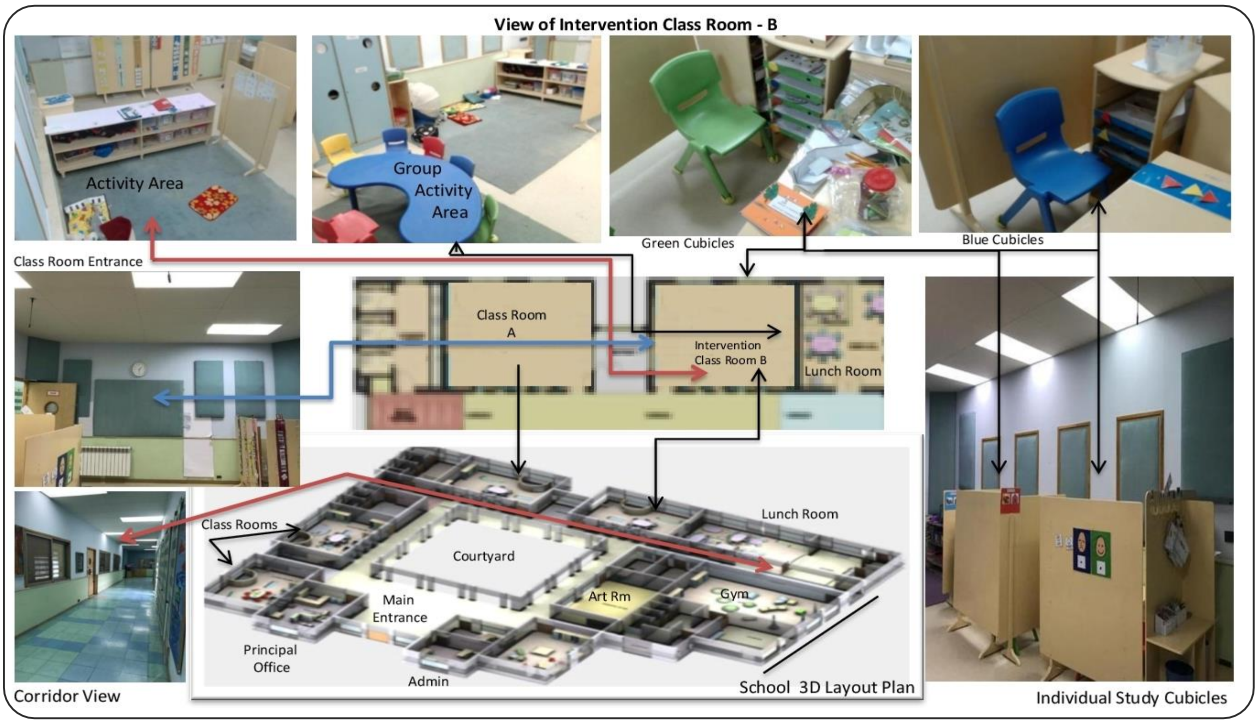


Figure 3.3: Classroom After Acoustic Treatment

3.4.3 Research Design

In Stages 2 and 3 Studies, the SCED was used and considered A-B-A three-phase procedures: baseline, intervention, and return to the baseline withdrawal. The study's primary purpose in Stages 2 and 3 was to investigate the impact of RT60 on delineated behaviours in children with ASD, calibrated through a fixed mode of architectural intervention in a classroom setting. This intervention was predicted to have a positive impact on behavioural outcomes and on-task learning in children with ASD. This approach was considered the optimal choice for the present research at the Oasis School designated classroom within the bounds of the timeline of the school semester and the fixed mode of architecture intervention. More importantly, this deductive priori approach subjected the researcher's integrity by not pre-empting projections by avoiding data-driven decisions or favouring results through preconceived expectations (Wicherts et al., 2016). The key variables were identified in the stage 1 study; these variables were subsequently treated as independent variables in Stages 2 and 3 studies. Stages 2 and 3 then investigate how these independent variables affect stereotype behaviour and on-task engagement in children with ASD.

The withdrawal design's uniqueness was its ability to process, organise, and remove or insert an additional independent variable across the series of baseline and intervention (AB; ABA; A-B-A-B; BAB) and also controls history and maturation factor (Hitchcock et al., 2010). Within the brief particular intervention schemes, there was the possible occurrence of the independent variable to trigger some specific behaviours in children with ASD during the examination.

Limitations of Applied settings

The present research did not conduct Phase IV of the SCED design. This Study's outcome reflected that the experimental research, which was the criteria for data analysis and interpretation of the findings, was de-limited due to the application of applied settings which affected the resulting predictability, which is common in natural settings (Kazdin, 2003).

The present study was subjected to limitations of the applied settings, which included the school's strictures and its term semester timeline, which were affected due to political unrest in the country. An additional Phase was deemed to examine the solidity of results and effectiveness of the methodological intervention approaches, but it's not always possible. However, limited experimental control of the study design supported by supplementary data analysis methods, including descriptive and statistical parameters for solidity and predictability of the research outcome, provided analytical triangulation and greater confidence in the study outcome.

Nevertheless, A-B-A designs are recognised as the SCED prototype by Barlow DH ((2009)). Using this method, the researcher can assess if introducing the intervention had the expected impact on the target behaviour. It is possible to determine whether or not the target behaviour returns to baseline conditions when the intervention is eliminated by creating a second baseline phase after the intervention period.

According to Kazdin (2011), the second A phase in an A-B-A design serves two connected goals. The B phase's primary purpose is to forecast the target behaviour's future state if it continues receiving treatment. We can determine whether the target behaviour hasn't changed since the intervention phase by gathering data during the second A phase. If it doesn't and goes back to the first baseline level, the intervention may have had an impact. Second, the prediction generated using the data from the first baseline is confirmed if the desired behaviour during these second baselines returns to the level during the first baseline. In other words, that is how the desired behaviour would act if left untreated. In the first phase shift from A to B and the second phase change from B to A, the experimental control offers two chances to show the experimental effect(Evans and Axelrod, 2012).

This study provides preliminary empirical support to schools for the implementation of effective methods to modify classroom acoustics to support auditory sensory processing in children with ASD. At the culmination of the three-phased study, the acoustic panels were donated to the Oasis School. Following the Summer break, an exploration session involving the school principal, classroom teachers, and staff was conducted to gather pertinent research and subjective and critical reflections on the maintenance of the intervention. The findings gathered revealed overall positive feedback responses. Despite these delimitations, this research has contributed positively to the area of study, particularly in bridging the built environment, sensory environment, and learning in children with ASD.

3.4.4 Procedure

The ethical approval was obtained from the University of Sheffield, U.K. Ethics Review Board, prior to the research study's initial execution. Similarly, informed and signatory consent was achieved by all the participants in this study. The study took place over a period of six consecutive weeks, excluding the pilot study, covering the duration of the three phases: (a) baseline data collection phase, (b) intervention phase that included the installation of sound absorption wall panels and (c) return to baseline withdrawal phase. Each phase lasted two weeks, during which the children's daily routine activities were not interrupted to maintain their normalcy and regularity. The effect of confounding factors in the classroom was accounted for and ameliorated through a consistent staffing regime, unchanged routines for children, and consistency with classroom interiors such as furniture layout, lighting, noise, temperature, and the number of students present. Moreover, an additional two-day desensitising phase was implemented when shifting from classroom A to intervention classroom B.

The video recording and coding of all behaviours and on-task learning were systematically followed for the four participating subjects in the enquiry, observing and earmarking their relative progress within each phase and subsequently comparing across the phases in stages two and three.

Two separate activity settings were selected for the observation of behaviours: social group activity time and individual 1:1 teaching sessions. Observations were separately made both for behaviours elicited during the group activity and on-task learning one-to-one teaching sessions. For the stage 2 study, there were two group activity sessions every day, one in the morning and one in the afternoon, for approximately 10-15 min each. The morning session was documented for the study, but in case there was any change in schedule or cancellation, the afternoon session was documented. For the stage 3 study: individual 1:1 sessions were twice a day for each student, one in the morning and one in the afternoon. The first session was documented for each student, but in case the student was not available for the first session, then the second session was documented. It is very common for students with ASD to miss sessions due to bathroom breaks or any heterogeneous behavioural outburst. The classroom Activity Schedule is presented below for reference (see Table 3.2).

Table 3.2: Classroom Activity Schedule

Participant	On-Task 1:1 Activity	On-Task 1:1 Activity	Arts	Social Group	Social Group	Smart Board
ABD	9:00-9:30	12:30-12:45	11:45-1200	10:10-10:25	12:45-1:00	1:15-1:30
IBT	10:25-10:55	12:00-12:30				
MOH	9:30-10:00	11:30-11:45				
SHA	10:25-10:55	12:00-12:30				

Firstly, during baseline phase A, the existing classroom acoustic parameters, RT60 and correlates LAeq and LA90, were measured, analysed and compared with the BB93 (Building Bulletin 93, British Acoustic Standards for schools)) for examining and affirming the respective standard, low or high. The strength of the intervention acoustic wall panels was decidedly based on the acoustical results, which reduced the reverberation noise level to an effective point conforming to the standard. Simultaneously, behavioural reading was also conducted during the baseline phase to establish baseline stability. These readings were concurrently repeated during the intervention phase, in which acoustical intervention was implemented and RT60 and correlates readings were retaken. Upon the two-week completion of Phase B Intervention, the return to the baseline Withdrawal Phase A was implemented through the removal of acoustical intervention. The necessary acoustical and behavioural readings were taken earlier. The final data were gathered for descriptive statistics and interpretation, including visual analysis for the graphical presentations, which aimed to view identifiable patterns in multi-level behaviours and on-task responses and to draw the correlation between the IV (noise/acoustics) and DV (delineated behaviours) in Stages 2 and 3.

Pilot Study

Before commencing the pilot study, teachers filled out the requisite standardized teacher's school companion sensory profile questionnaire (Dunn, 2006) to provide insights and contextual information in relation to the four ASD students. In brief, it provided significant insights into the student's sensory makeup. A three-day pilot study was conducted involving 15 hours of observation before the start of the baseline data collection phase A1, the delineated sensory behaviours were observed in each ASD child, and observable operational definitions tailored to each individual child were finalised presented in Table 5.1 participant specific behavioural Topography of the three delineated behaviours. The pilot study provided the scope for the implementation and mechanisms involving stage 2 and 3 studies during three-phased video recordings, coding the observations of the participant's individual sensory behavioural responses and on-task engagement behaviour. The teacher provided a collaborative role, which was salient as the research sought the balance between the ranging swings of most tranquil to the highly energetic moments of the classroom sessions. This assisted in identifying the levels of the common occurrence of each child's relative hyped activity and behaviours recorded daily for 10 minutes, evidenced through each day's observations. This test shed light upon the demonstrated nature of social group activity time being the noisiest and concurrently the cause of intensive behavioural disruptions.

Data Analysis

Stages 2 and 3 study three Phased (A-B-A) investigations through the Single Case Experimental Design data outcomes were collated and transformed for the investigation's analysis and interpretation through visual analysis and supplementary descriptive statistics and percentage effect size measure.

Mangold Interac Software and Coding Procedures

Interac Mangold is a behaviour observation software that allows for data structuring and analysis of behavioural data. For this study individual, Interac Mangold Files were set up for the stage 2 and stage 3 studies with Data Groups and Data Sets representing the specific subject, phase, and date. For behaviour observation coding procedures, coding definitions were created, and the coding system was defined according to the behaviour dimension.

Video Recordings

Video recordings were first opened in OBS software and time-stamped, labelled, and organised in a folder for behaviour observation use by Interac Mangold software. Videos were then attached to the datasets in the Interac mangold for observations.

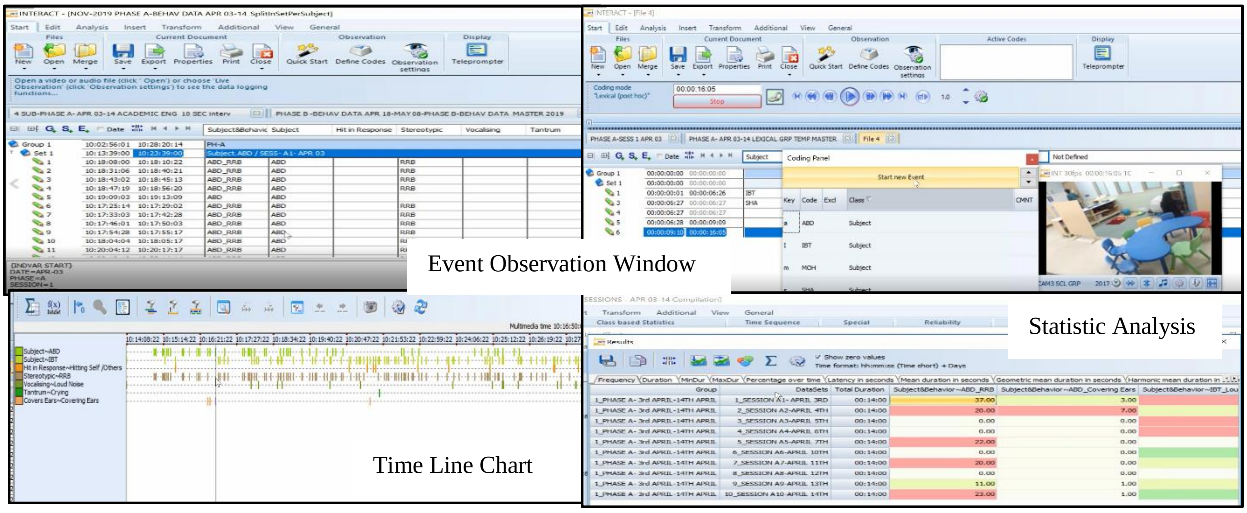


Figure 3.4: Interac Mangold Data Visualisation

Stage 2 Study, Social Group Activity

Two-tier Lexical coding system was used for the delineated sensory behaviours, ear covering, and repetitive and loud vocalising for group activity time; this made sure that Interact started and stopped an event as the specific behaviour was observed and waited until the subject class and behavioural codes were selected. The time frame for group activity sessions was set at +10 minutes, with time boundaries for group activity sessions. All students were observed individually per pass during the video observation sessions. Non-attending code was used for any time the student left the class or was unavailable.

Specific video observation steps were as follows:

Start observation, play the video, start and end the event as seen, and select the subject and code. For coding two behaviours during the same time frame, specific event recording was started again from the onset time to code the second behaviour. A behaviour observed twice within 3 sec of the first event observation was not coded again.

Stage 3 Study, On-Task Sessions

For on-task behaviours in the stage 3 study, time frames were set with 15-second intervals for a 10-minute video session: a total of 40 intervals per session for participant IBT, MOH and SHA; and 10-second intervals for a 5-minute time frame: 30 intervals per session for participant ABD. A standard, mutually exclusive coding system was used for coding procedures. If engaged at the end of the interval, the child was coded as on-task.

Analysis/Statistics

The analysis was split by subject/ behaviour across phases. The Interac Mangold timeline chart enabled the exact timeline of events and projected evaluation statistics for frequency, duration and percentage of each behavioural event code. These statistics were then exported to excel software for further analysis.

Visual Analysis

Visual analysis as the primary examination method was employed to analyse behaviours in children with ASD within the phase conditions and across the Phases. Therapy Science software was used to facilitate visual inspection and graphing of subject behavioural data. The aim of the graphical representation assisted in the evaluation of each participant's sensory behaviours and on-task performativity with reference to trends, level, stability and immediacy in the projected data pattern.

Additionally, following the benchmark for visual analysis, trend stability baseline data was marked steady, considering 80% of the data points were within the 25 % plus and minus range of the stability envelope (Lane and Gast, 2014). The trend stability data shows a range of deviations of the data points around the trend line to capture variability. It necessitates an evaluation of the data's overall image. Drawing a best-fit line between the data points can aid with interpretation. Variability may be regarded as low if many of the data points are near the line. However, if a large number of data points depart significantly from that line, then variability is substantial.

Supplemental Analysis

Complimentary methods of visual analysis to document efficacy and magnitude of effect size were implemented through specific objective measures of intervention in place to ensure the credibility of the results (Parker and Hagan-Burke, 2007).

NAP Non-Overlap of All Pairs

The non-overlap of all pairs (NAP) is a measure of the intensity of the intervention effect; through indicators such as the greater the non-overlap percentage, the stronger the effect, and vice versa. The NAP embodies superior metrics enabling it to compare all data points across baseline and intervention conditions. The percentage adjudication considered ranges between 50%-100% outcomes. Following this, the outcome at 50% is suggestive of accidental or no-effect; 65% non-overlap reflects a weak effect, whereas between 66% - 92% reflects a moderate effect, and above 93% depicts a strong intervention effect (Parker and

Vannest, 2009). In this study, NAP was used as the main supplementary effect quantifying method; however, where NAP reflected less effectiveness in the case of a pre-intervention trend in the desired direction, a slightly more numerical method was used. Tau-U (all paired comparisons across the baseline and treatment phases), criteria similar to NAP, was selected for systematically attesting the intervention effectiveness during the inter-phases. (Parker and Vannest, 2009) , (Parker et al., 2011).The NAP proved its suitability in marking the variability and stability of the data in the SCED and its implementation for quantifying the effective size (Manolov et al., 2016). It furthermore proved less sensitive to research procedures and any data outliers, providing the details for comparisons of the data pairwise across all baseline and intervention data points, calculated in percentage of the non-overlapping data drawn (Pustejovsky, 2016).

Tau-U, Criteria

Similar to the NAP, the Tau-U uses all paired comparisons across the baseline and treatment phases, aiding in the measurement of the effectiveness of single-case statistics size for the control of the baseline trend. During the phase of an individual's pre-treatment, measuring improving performativity poses challenges in the single-case experimental design. Therefore, it proves difficult to determine whether the improvement was due to treatment or a pre-existing baseline trend. The Tau-U was used in the present research, where the NAP proved less effective in determining the trend of the desired direction in the pre-intervention phase (Parker et al., 2011).

Descriptive Analysis

For each respective phase (A-B-A), descriptive statistics were generated as a supplementary method allowing differentiation of data and enabling comparative analysis across the Phases. Statistics mean, range and standard deviation representational for each individual ASD child's delineated behaviour were calculated for the overall relevance of evaluation.

3.4.5 Instruments and Measures

Independent Variable for Stages 2 and 3

The noise/ acoustics was verified as the Independent Variable (IV) through the data analysis content in stage 1, initially deduced from the literature review upon which the critical hypothesis of the research was built. This leads to the construction of the critical hypothesis for the development of stages two and three. It directed the hypothesis testing in stage 1, the correlation of the independent variable upon the ASD participant's multi-levelled behavioural response, which is considered a dependent variable (DV) in this research. The validation of the IV significantly led to the construction of the acoustic parameters in Stages 2 and 3, in which the two parameters tested and constructed the requisite acoustic transformation through measurement of the RT60 and the LAeq levels in the classroom. The intervention design was then instigated by employing an acoustic sensory wall panel installation to reduce noise/ambient and RT60 to appropriate levels for the research study investigations.

Intervention Investigated

In examining the interlinkages between children with ASD and the sensory built environment, the acoustic treatment had become the pre-eminent design classroom methodological practice for noise reduction. This was evidentially discussed in Chapter 2, concluding that the majority of architectural practices were bounded by anecdotal considerations (Dockrell and Shield, 2006, Shield et al., 2010). Therefore, for the intervention phase investigation in Stages 2 and 3, the requisite design treatment was chosen by installing acoustical sound-absorbing wall panelling materials. The economical materials, locally available, were customized and improvised through modification, enhancing the classroom acoustical environment through a transformative and efficacious mode of treatment.

The acoustic panels used in the study were made up of a 50mm thick yellow-coloured fibreglass wool sheet with silver backing. Panels were designed in varied sizes for placement in the classroom according to the available wall space. Glass wool was sandwiched in a 2-inch wooden frame and covered with breathable cloth for sound to pass through to the acoustic panel instead of reflecting it. Light blue colour cloth matching the classroom room interior was selected. Heavy-duty D-ring hanger hooks were installed on the wooden frame for mounting on the wall. One-inch air space was left behind the panel installation to effectively absorb low-frequency sounds and improve the overall sound absorbent performance. Quite a few of these panels were needed to bring the classroom acoustics to an effective level (see Fig 3.3).

Instruments

For the acoustics and noise measurement, the sound level meter NTI XL2 Acoustic Analyzer with M4260 Omni Directional Microphone was used to measure and record equal sound pressure levels LAeq and RT60. The RT60 was measured in an unoccupied designated classroom during all phases of study and observations. For the recording video aspect, four IP HD Logitech C90 Pro Webcams were installed in the observational classroom to record the four participant's behavioural and on-task learning responses. Additionally, video cameras covered children's individual working cubicle sections for the on-task and over the group session area. Two cameras were installed in the individual cubicles at 5 ft. height next to the wooden partition wall (see Fig 3.4). The webcam's video recording data were obtained initially from the OBS software, whose recording analysis was done by the Interac-Mangold Software. The sound data was coded and analyzed via NTI Data Explorer 365.

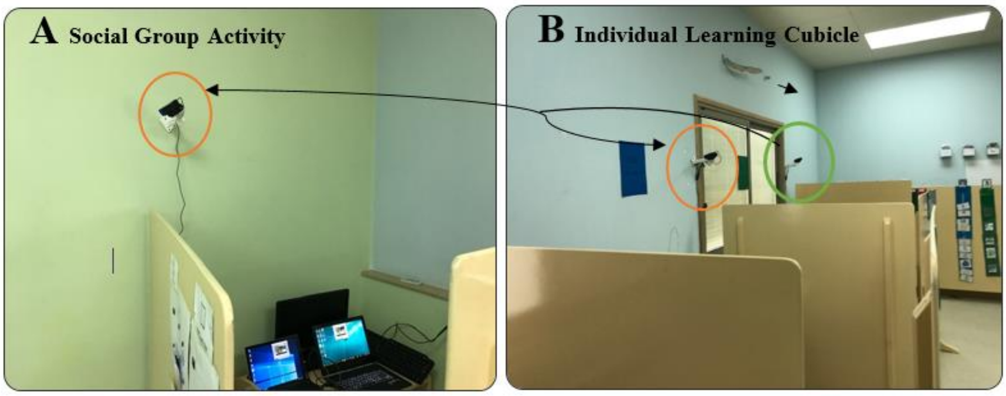


Figure 3.5: Class Room A Observational Camera Placement

3.4.6 Acoustic Parameters and Measurements

Reverberation Time

The Reverberation Time (RT60) was central in all stages of this study. It was explicated as the persistent and prolonged wave echo within the spatial confinement of an environment. The reverberating duration of the amount of noise was defined in seconds, measured from its high point until it decayed to an insignificant 60 dB. The RT60 was affected by several factors, which had to be considered in Stages 2 and 3. It included the internal cubic area of the room, the surface area, materials and finishing (Crandell and Smaldino, 2000, Kristiansen et al., 2016).

Measurement

The RT60 conceptualisation was relevant for conducting the three-phased study intervention in Stages 2 and 3. The process necessitated the testing of the acoustics of the classroom sensory environment for the research hypothesis investigation. The RT60 measurements were taken at three different frequencies, 500 HZ, 1000 HZ, and 2000 HZ, at selected five classroom focal points, the centre and four corners. The sound impulse was generated 25 dB above the background noise level of 35 dBA by clapping boards. The microphone was placed at a minimal distance of 1 meter from the reflective surfaces and from the floor, with only one person being present to achieve the optimal empirical readings. These readings were taken during the weekends only for precision, maintaining rigorous standards without interruptions. The five focal points measurement readings were averaged to estimate the RT60.

Equal Sound Pressure Levels A-weighted (LAeq)

The A-weighted equal sound Pressure Level recorded over a set length of time is referred to as LAeq. With 35dB – 40dB, it approximated the sound pressure resonating and perceived by people in a spatial setting. The NTI XL2 Sound Level Meter with Type 2 Microphone, explained previously, was used for the LAeq measurement of the research classroom environment. The sensory environmental noise pressure readings were taken in the designated classroom both during occupancy and non-occupancy time, whose empirical accuracy was essential. Any erroneous pressure level measurement could lead to data misrepresentation and jeopardize the outcomes in stages 2 and 3. The research used the Data Explorer 365 software with detailed data logging and analysis capabilities for NTI XL2 Sound Data. The A-weighted sound pressure of occupied and unoccupied classroom pressure conditions was measured. All possible fluctuations were monitored to maintain consistency in all the phases. The measurements were conducted with and without the HVAC (individual wall-hung heating and cooling unit) system, whose impact was explained in Chapter 2. These procedures were initiated during the pilot study readings to maintain the stability of the pressure level measurement, which was monitored for consistencies and fluctuations. During the initiation of the measurement of the classroom pressures LAeq, children's ages, details of classroom activities and occupancy, e.g. number of teachers, adults, and children, were meticulously recorded. Similarly, noise types and levels were identified and characterized.

Unoccupied Classroom Measurements

During the process of measuring the unoccupied classroom, classroom acoustic screening methods and procedures by Smaldino and C. d Jhonson were used. It was necessary to adhere strictly to the acoustics measurement standards for precision and accuracy, and thus the classroom doors were shut (Smaldino, 2010). However, noise from the external school environment, including corridors, the playground, and adjacent exteriors of classrooms or teaching spaces, was thinly audible. During unoccupied classroom measurements, standards were observed for precision, accounting for the interior space heating, ventilation, and light systems. The HVAC system fluctuation necessitated that two classroom measurements be undertaken for the discrepancy.

Occupied Classroom Measurements

The measurement was singularly attentive during children's classroom occupancy, whose procedures included shutting the classroom door during all measurement of noise readings. The audibility of noise from the external school environment, including corridors, the playground, and adjacent exteriors of classrooms or teaching spaces, was noted. This technique entailed identifying the classroom children and staff activities. The occupied classroom measurement standards were observed for precision and the interior space heating, ventilation, and light systems, to allow the HVAC system fluctuating discrepancy (Smaldino, 2010).

3.4.7 Experimental Controls

External Validity

The external validity was demonstrated through replication of the acoustic intervention effect across multi-level behaviours, educational activity settings and the participants (N=4) (Horner, 2005). These measurements were repeated for reliability and consistency through the standard averages assisted by a trained psychology evaluator blinded to the phase change.

Inter Observer Agreement

Before the actual study, the researcher conducted three training sessions with the second observer through video to explicate the operational definitions for the research, the specific children's targeted behaviours and the coding practices to establish the minimum threshold of 90%. Inter-observer data was collected for each phase condition A1-B-A2, and data observational rules were established for strict adherence to allowing the gathering of the 25% interrater agreement.

For the Stage 2 Study, the Inter-observer agreement (IOA) was recorded for each targeted behaviour during phases (A1-B-A2) for 25% of the sessions. The agreements for the behaviour event data recording were converted into percentages by the ratio: of smaller/ larger agreements. An IOA within the range of 87 % - 92% was established. For the Stage 3 Study, the IOA was recorded for on-task behaviour outcome during phases (A1-B-A2) for 25% of the sessions. The agreement for on-task time sampling data recording was calculated by converting the amounts of agreements and disagreements into percentages (agreements/agreements + disagreements x by 100) (Tawney and Gast, 1985). An IOA of 96% was established for on-task behaviour outcome.

Social Validity

In this study, the necessary ethical validation due to the four subjects' full cooperation and participation was substantively established. The ethics injunction was apprehended procedurally and availed for the intervening research for its acceptability, conformity, and objectivity (Horner, 2005, Wolf, 1978). The ethical requisition was an essential aspect of academic research practices. The study entailed educational investigation criteria in pursuing scientific rigours and goals, social appropriateness of protocols, and the social importance of the research's ending results. Culturally specific norms were observed and respected. The research was mindful of the school's educational context and ethos, maintaining its normal routines for seven weeks, including during the intervention Phases with sensitivity. Towards the termination of the research, the teachers involved in the study filled out the survey questionnaire entailing eight questions to provide their opinion regarding the significance and appropriateness of the research undertaking (Appendix – D)

Habilitative Validity

It was necessary to obtain the research's habilitative validity entailing the continuum and maintenance of the intervention treatment upon the study's completion (Kazdin, 2003). Towards this aim, the acoustic panels were donated to the School, and a follow-up was conducted after the long summer break in order to examine the status of the intervention maintenance. The school's principal confirmed the re-installation and maintenance of the acoustic panels in the very class, and a discussion was conducted to obtain the classroom teachers and staff regarding the efficacy of the acoustic intervention. The general anecdotal account through classroom observations reflected a consensus for the transformation of the calibrated classroom environment and the positively calming effect on the children with ASD. Their favourable responses underlined this research's initial recognition of the significance of sensory environment on children's behaviours and on-task performativity. The teachers further expressed the general increase in levels of group participation activity and overall declination in behavioural outbursts.

Ethical Consideration

The Sheffield University Ethics Review Board endorsed the proposal for conducting this experimentally based research at Oasis School (Reference No. 3556). The School Principal sent consent letters to parents of the selected children with ASD for the research study in Stages 2 and 3 (Appendix C), whose agreement was sought prior to the study. Informed consent was obtained from all nine experts interviewed for Stage 1 Study quantitative research semi-structured interviews (Appendix B).

3.5 Concluding Remarks

The chapter systematically laid down the rational criteria, selection, and justification of the research design weighing various design approaches. For stage 1, the qualitative design was deemed appropriate in order to deduce the critical hypothesis independent variable: the acoustic parameters in the classroom setting. It involves a collaborative research approach built on qualitative interviews with 9 international academics and experts in the field. For Stages 2 and 3, the efficacy of the vital three-phased SCED was underlined due to the heterogeneity and sensorial behavioural problems in children with ASD. This design was appropriate for the construction of the investigation of the hypothesis in the distinctive stages 2 and 3, the sensory behaviour response and on-task behaviour engagement, respectively. It investigated, through the classroom sensory modification, how the children's behaviour responses and on-task engagement would be affected by implementing the rigorous intervention employing the A-B-As three-phased mechanism of the research design. This entailed an empirical investigation of the noise/ acoustic parameters in the classroom and its sensory design principles transformation prompted through the installation, which required the investigation and measurement of the RT60 and correlates noise factors through appropriate tools.

4

CHAPTER 4: CLASSROOM ENVIRONMENT, BEHAVIOUR AND LEARNING

The aim of this chapter, Stage 1 Study, was to investigate how the classroom's sensory environmental factors, such as noise/acoustics, light, spatial layout, temperature and smell, may affect behaviours and learning in children with ASD. In particular, it inquired into demarcating, ranking, and validating key variables as emerging indicators, deduced in the Literature Review in Chapter 2 of the research. The examination identified noise/ acoustics as the significant environmental independent variable and the children's depiction of heterogeneous, idiosyncratic, and subjective behaviours correlated to the classroom sensory environment. The examination of these factors in this chapter, Stage 1 Study, led to the development of the critical hypothesis of the research to be tested in Stage 2 Study (Chapter 5) and Stage 3 Study (Chapter 6).

4.1 Background

The introduction delineates the complexities and intricacies of the human brain organism, and the mind's dysfunctionality is explored in depth in Chapter 2. It underscores a-typical sensory processing and auditory hypersensitivity with severe implications upon social communicational and learning performativity, specifically in cognitive semblance and memory attentiveness in children with ASD. Autism has significantly high prevalence rates in the world and is acutely heterogeneous (Gabriels and Hill, 2002) (Association, 2013a). This problem subsequently impinged upon the critical selection criterion of the research design and demographic sampling and the critical research question rationale. The research question, aims and objectives are premised upon interrogating how the physical built classroom environment design could affect the performativity of children with ASD based upon the person-behaviour-environment interaction. Content analysis was employed to descriptively analyse the qualitative data of the research. The ethical considerations were sanctioned by the University of Sheffield School of Architecture Ethics Committee.

The recent breakthroughs in the field of neuroscience were able to explicate the complexity and intricacies of the human mind organism demonstrating its manifold potentialities and limitations. In particular, the understanding of ASD primarily as a neurodevelopmental disorder, characterised in the main, by the lack of social-communicational skills and repetitive stereotypical behaviour impairments. Individuals typically depicted significant shortfalls in the form of aberration features regulating arousal, the modulation of sensory input, and atypical attention. Children with ASD depicted attentional abnormalities such as a lack of focus and obliviousness to all surroundings except their immediacy (Kanner, 1943). The Diagnostic and Statistical Manual of Mental Disorders defines autism as a pervasive developmental disorder whose diagnoses represent overtly sensitive reactions to the environment (Association, 2013a)

Communication Skills and Learning Implications

Children on the spectrum evidenced the resultant complex communication skills and learning effects. Those implications were demonstrated in their attention direction in both the social and non-social domains (Baranek et al., 2013). More significantly, autism's complexity and variegated nature had a profound influence on children's performativity and social development. This impact led to an overwhelming preoccupation with responding to the sensory stimuli and the inability to concentrate. These sensory processing patterns and auditory filtering, sensory under-responsivity, and sensory seeking resulted in determining their academic outcomes (Ashburner et al., 2008a).

A significant impact of these sensory-related effects made children with ASD less advantaged due to the under-developed socio-linguistic skills requisite for engaging with the social and natural environment. The differences were pronounced when correlated with an individual's abilities, the rhythm of development and linguistic characteristics due to the severity of sensory perception, which delimited their socio-linguistic and cognitive makeup(Amato and Fernandes, 2010). Therefore, the children reflected delayed understanding due to the lack of appropriate verbal language to identify or attend to information in the environment (Council, 2001). These sensory ascriptions cumulatively lead to heightened stress levels, anxiety, and depression in children with ASD.

Sensory Processing and Auditory Hypersensitivity

Sensory processing and hypersensitivity response to stimuli in children with ASD made them distinctively differentiated in comparison with typical normalised social peer groups (Baranek et al., 1997, Dunn and Bennett, 2002). A significantly high percentage, 95% of children with ASD, in a chart review study of 200 children on the spectrum depicted sensory modulating traits (Greenspan and Wieder, 1997). Children demonstrated a complex persevering engagement with stereotypical actions, which was a regulatory aspect of their sensory systems (Baranek et al., 1997). The effect of noise and auditory processing on the children led to linguistic representational difficulties, showing intent, and practical verbal and non-verbal communication resulting in delayed reception of classroom stimuli which impacted their multiple processing functions (Schopler and Mesibov, 1985, Frith et al., 1991).

Although the noise factor was a huge contributory factor in autism, very limited empirical studies established the educational and sensory problem and their impact on ASD (Dargue et al., 2021), leading to inadequate classroom sensory environment assessment (Martin, 2014). However, observation studies underscored the importance of design modification by employing sensory elements such as soundproofing walls and carpets which assisted in the overall noise-sensory classroom towards the attenuation of children's learning in a classroom setting (Kanakri, 2017a). It was critically identified as the most debilitating factor in the huge differential in autism populations (WHO, 2016). Children with ASD with prevailing sensory features were estimated to broadly range between 45% to 96% (Ben-Sasson et al., 2009).

ASD and Cognitive Semblance

Children with ASD indicated significant functional difficulties pertaining to cognitive semblance and memory attentiveness focus. This aspect affected their self-monitoring, planning and time management aspects of memory and orientation between visual, auditory, and spatial (Bjorklund and Causey, 2017) (Landry and Bryson, 2004). The cognitive semblance suggested how vital it was to attend to children's heterogeneous educational approaches, which bore upon these complexities. However, more fundamentally, it raised the necessity to address diverse architectural built environment Sensory Design approaches on the rationale that children with ASD demonstrated comparably high dissimilar sensory needs (Tola et al., 2021), which made it essential towards mindfulness in the design modification of the classroom sensory environment(McAllister and Maguire, 2012, Mostafa, 2008, Delmolino and Harris, 2012).

The manifestation of disruptive sensory behaviours in children with ASD was self-regulatory treatment stratagem modes evidenced in both the home and school sensory environments due to individual auditory dysfunctional reactions (Kanakri, 2017a, Brown and Dunn, 2010). In the classroom, children's sensory experiences had been demonstrated to negatively impact negatively on children's memory and attention; therefore, improved spatial designs reflecting the individual's subjective sensory quality were more appropriate than the predominant typical function zoning architecture (Pfeiffer et al., 2017).

In Chapter 2, the complex interrelatedness of human behavioural and the environment was established, underling that situational interaction was not binary but relational and was a fundamental characteristic of the human transaction (Mead, 1934 & Cronberg, 1975 in Khare & Mullick, 2008). Based upon this understanding, a conceptually enabled environment for each child through design that created the optimal calibrated functional congruency was plausible. The built environment design objective envisioned optimal performativity in children with ASD, which identified the stressors in specific spatial classroom settings to impact learning, behaviour, and emotional regulation (Mullick, 2008).

4.2 Research Questions and Objectives

The main aim of this chapter is to examine and verify the effect of the classroom sensory environment upon the triggering of disruptive sensory behaviours and on-task learning in children with ASD. It is not to discover the generalizable accuracies about children's behaviour and learning. It was more about examining sensory environmental variables in the classroom setting affecting behaviour and learning and developing a working hypothesis for the larger experimental Stage 2 Study (Chapter 5) and Stage 3 Study (Chapter 6), respectively. Therefore, this Stage 1 Study considers collaborative and consultative approaches in apprehending learning in children with ASD.

The overarching research question for this chapter is:

How are the sensory-related architectural elements within the classroom environment related to the inhibition/or facilitation of on-task learning and behaviour in children with ASD?

This can be further split into three sub-questions:

a) What specific classroom sensory feature elicits sensory disruptive behaviours in children with ASD?
b) What specific classroom sensory feature affects pedagogics and learning?
c) What could be a plausible classroom environment transformation to assist in ameliorating sensory disruptive behaviours and effective on-task engagement?

The above questions formulated specifically addressed the examination of the classroom environment features affecting on-task learning and behaviour in children with ASD. More particularly, affecting a child's levels of academic engagement and achieving decreased child engagement time on educational tasks.

The following main objectives outlined in this chapter are:

Objectives

a) To examine and validate how sensory environmental variables in the classroom setting affect behaviour and learning of children with ASD through semi-structured expert interviews.
b) To identify and rank independent variables (IV) in a classroom setting for intervention modification.
c) To collate, classify, and synthesize data for content analysis to develop a working hypothesis for the experimental studies.

Hypothesis

The hypothesis to the main research question in this chapter is that noise/acoustics is a significant detrimental variable that affects academic engagement and sensory behaviours in children with ASD in an educational setting.

4.3 Research Method

This chapter adapts the qualitative approach; it interrogates and establishes children's behaviours premised upon classroom sensory environment noise/acoustics deductively drawn from Chapter 2 literature review. The qualitative methodology approach allows the framing for the possibility of an informative conversation in which the experts developed horizons, viewpoints, and ASD issues were united across cultures and countries. It was initially conducted through a focus group interview with school staff and teachers, which provided the preliminary data for the information and framing of the design of the semi-structured interview. This focus group was not made a part of the study analysis but aided the design of the specific questions for the semi-structured interviews to probe the concepts and variables in the sensory design framework for children with ASD. The qualitative enquiry framing of the questionnaire was a highly effective communicational tool for both the researcher and the interviewee to elicit more concrete information (McMillan, 2001). The data demonstrated insights into children's classroom sensory environment, emotional sensory behavioural, and educational learning. For the integrity of this research, the optimal means and pathways were sought to attain information.

4.3.1 Demographic Sampling and Sample

I interviewed a non-random selection of a suitable sample, applying judgment sampling criterion selection for a professional body population with expertise in the knowledge field of autism, children with ASD, built environment and learning. This sampling technique assured the participant's active engagement and their relevance for eliciting well-considered deliberations upon the salient variables selected and framed in the semi-structured questionnaire and interviews in setting parameters for conducting the research. The non-random criterion selection does not delimit the number of participants nor conceptions drawn from theoretical formulations. In good judgement, 9 international professionals of high calibre academic expertise were selected (Tongco, 2007). The sampling criterion strictly adhered to the merit of expert knowledge fields and qualifications, which are seminal to the research for its development and validity. An international, intercultural, and global participating body of ASD experts with a wide range of experience (8-38 years) were interviewed as demonstrated in the following section Interviewees Profile Table 4.1.

Table 4.1: Interviewees' Profile Table

Interviewees	Years of Experience	Involvement with Children with ASD	Area of Expertise/Profession	Region
Interviewee A	15 Years	Special Educationalist, Private Consultant	Behaviour Therapist	North America
Interviewee B	38 Years	Evaluation of children with ASD	Professor, Psychologist, Researcher, Author, Editor	North America
Interviewee C	10 Years	Behavioural Assessment of Children with ASD	Educational Theory, Educational Policy, Educational Assessment	Middle East
Interviewee D	16 Years	Diagnosis	Clinical Psychologist	Middle East
Interviewee E	19 Years	Speech Language Hearing Specialist for Autism	Practitioner, Researcher, Writer and Trainer	Europe
Interviewee F	30 Years	Individual Intervention Planner	Special Educationalist	South Asia
Interviewee G	25 Years	Board Certified Behavior Analyst	Educator, University Professor, Disability Specialist, Teacher Trainer and Consultant	North America
Interviewee H	8 Years	Clinical Psychologist	Autism	South Asia
Interviewee I	10 Years	Environmental Design for Children with ASD	Architect for Health Care Design & Autism	North America

4.4 Procedure

A consent form prior to the interview was given to all the interviewees to ensure the regulatory and ethical procedures, guaranteed anonymity, and confidentiality. All interviewee-participants' sharing of views and expertise in the research was voluntary. They were adequately briefed about this research and its outlined parameters. Interviewees' names, locations and employers were kept confidential. An acronym was assigned to each participant to protect their privacy. The dominant mode of Interviews was the telephone, Skype and in person, which was facilitated by setting up a mutually convenient time. The cumulative interview time span was 30 minutes for each participant using the digital audio recording for reliability, whose collection was later transcribed for content analysis.

The structure of the Questions was pre-determined, open and closed, allowing leeway for prompting discourse which enfolded. It allowed the interviewers to explore and probe particular themes to elicit responses from the interviewee. The transcribed responses were systematized and interpreted to validate common, recurrent codes. The strategy of the interview was to stimulate the conceptual classroom environmental variables, built environment Sensory Design elements, teaching pedagogies and learning of children with ASD.

4.4.1 Data Analysis

The deductive qualitative, directed data content analysis of the interview transcripts was analytically apprehended for systematic classification under themes and codified for frequency patterns to prioritise variables for the investigation aspects of the research in Chapter 5 (Stage 2 Study) and Chapter 6 (Stage 3 Study) (Hsieh and Shannon, 2005). The priori coding scheme was based on the key theoretical sensory design construct to enable validation and prioritisation of the significant environmental variable for testing (Crabtree BF, 1999). The codification and classification of the content analysis method had significant utility for the communication aspect of the qualitative questions and their conversations (Babbie and Mouton, 2001). The resultant findings formulated the conceptual framework and identified factors intersecting children with ASD, sensory noise/ acoustics in the classroom environment and the built environment and Sensory Design perspectives.

Reliability

A research assistant (RA) with a Psychology background was employed to work on this project to transcribe the interviews and assist with content analysis. The RA and the author cross-checked all interview transcriptions prior to analysis to ensure data accuracy. Analysed data was classified under deductively drawn three main categories based on the literature review and identified research questions. To establish reliability, developed codes were cross-checked with the RA.

4.4.2 Ethical Considerations

All the interviewees were given lucid instructions on the research and their roles. Recorded interviewee's approval ensured that ethical guidelines were followed during the process of the interview. The consent forms used are included in Appendices sec (B). The research overview of the Stage 1 Study was conveyed both in writing and through verbal conversation. The interviewees became signatories only upon the full cognizance of the purpose of the research and their essential role within it. The Forms highlighted the obligation disclosure regarding their participation which allowed them the window of withdrawal should they choose, without hesitancy and partiality. Both prior to and post conducting the study, the interviewee's identities remained anonymous, and their academic confidentiality was safeguarded. The data collected was used solely for the purpose intended.

4.5 Results

As this chapter aims to elicit and rank the key variables, the results from the content analysis of the collated semi-structured expert interviews are presented. Semi-structured interview questionnaires delineated three main thematic categories and schematic coding. They reflect the key findings of ASD expert interviewees' opinions, experiences, and practices.

d) Classroom environment and behaviour responsivity
e) Environment context and pedagogical implementation
f) Enabling environment

These themes were drawn from the literature review in Chapter 2, which covered the enquiry categories, sensory environment and behaviour responsivity (Questions 1-3).

Question 1: In your opinion, do features or elements of the classroom environment stimulate any specific behaviours that may affect On-task learning? Explain.

Question 2: Which environment features noticeably triggered sensory behaviour in a classroom environment? Such as ear-covering, easily getting distracted, rocking, spinning etc.

Question 3: Which architectural variable in a classroom environment has the strongest effect on the On-task learning behaviour of children with ASD?

It intended to concomitantly calibrate the interrogation of children’s sensory responsivity to environmental features. The second category interrogated the impact of classroom environment on pedagogy and children’s behaviours (Questions 4-5), which enquired about the appropriate classroom variables that may enhance pedagogy and on-task attention span.

Question 4: Are the teaching methods such as ABA and TEECH affected by any significant architectural variable/s?

Question 5: Does the difficulty level of academic material appear to produce any off-task behaviours in a classroom environment?

The third category includes enabling environment, interrogated variables pertaining to the linguistic acquisition and communicational development, which were significant indicators (Questions 6-8) and then the noise/acoustics variable, the most significant variable necessitating the participant's specificity of considered responses (Question 8).

Questions 6 – 8:

Question 6: Which is the most important type of classroom accommodation that could be recommended to achieve sustained periods of attention on a learning task or activity?

Question. In your opinion, which classroom variables can play an important role in achieving better speech, language acquisition and listening?

Question 8: Which Acoustical Variable has the most significant impact in an ASD specific Classroom-learning Environment?

a. Signal to Noise Ratio SNR

b. Reverberation Time (Echo)

c. Background Noise BN

4.5.1 Classroom Environment and Behaviour Responsivity

This sub-section addresses: a) **What specific classroom sensory features elicit an ASD child's sensory disruptive behaviours?** It aimed to identify particular classroom environmental stimuli which impact behaviours. The category is divided into three central areas of focus thematically, classroom performativity, sensory triggers, and ranking of environmental factors.

Classroom performativity

All the nine participant interviewees underscored that classroom or generic environment played a major role in impacting children with ASD. Their responses specifically underline the classroom environment's significant impact on children's classroom performativity. This was further expressed by their endorsement of increased or decreased levels of participation hugely interfered with behaviour and functional response. The influence vastly ranges from overall academic engagement, including attention span, interests, and social school activities. Four out of nine interviewees underscored the physical environmental effect on concentration, performativity, and functioning of children with ASD. This led to the important deduction that the classroom interior was pivotal in educating children with ASD.

Sensory-Environmental Triggers

Child-specific

More than half of the interviewee participants (7 out of 9) mentioned noise reflecting auditory **sensitivity** as a dominant feature triggering disruptive behaviours in children with ASD. After the noise, four of the participants ranked light (not too bright or too dim) as the second most important factor, while three of the participants said that sensory behaviours are conditioned to the environment specifically. One of the participants also mentioned temperature as an element that stimulates behaviour in some children, it should neither be too hot nor too cold, but mild for children with ASD as their tolerance capacity is very less as compared to normal people.

Seven out of nine participants also underscored self-stimulatory behaviours in children with ASD accrued due to the sensory overload of responses to environmental stimuli. These were delineated as rocking, ear covering, shifting from seats, off-task, wandering about, and throwing things. There was a unanimous agreement that repetitive bodily movements such as rocking were the most common behavioural outcome. One participant explicated the fact that behaviour occurrence was a coping stratagem co-linked to stressful experiences resulting from potential adverse environmental stimuli, which reflected multiple stress correlates and stimuli overload.

Ranking of Environmental Factors

A majority, seven out of nine participants, underscored noise as the common significant environmental factor which prompted the on-task learning effect. The noise factor further amplified on-task learning stress induced through ambient noise, the clutter of chairs, furniture shuffle, children's screams, and classroom children's noise. One participant stressed that noise distraction overwhelmed children with ASD, less due to hypersensitivity than to experiencing for the first time un-conceptualised new sounds which were not earlier undergone, such as fire alarms and bell rings. Four out of nine interviewee participants indicated that the spatial layout of the classroom was significantly correlated with noise. They suggested appropriate classroom segmentation to attenuate noise, leading to the control of both noise and spatial variables.

Participants also underscored the importance of visual information in the enhancement of responses in children with ASD. The children were more responsive to details and depicted heightened ability of recollection and managing through visual memories. They recommended subdued and blended colours for spatial layout rather than bright colours, deemed distracting due to sudden attentive optical attraction. Interviewees considered light (4 out of 9), texture (3 out of 9), odour and smell/ olfactory (2 of 9 participants) as important factors in differential factorial importance.

4.5.2 Environment Context and Pedagogical Implementation

This sub-section addressed: **What specific classroom sensory features affect pedagogics and learning?** The theme pedagogical environment question embodied the most seminal aspects of the learning of children with ASD, which were not extensively studied. It interrogated how classroom environmental factors and delivery of teaching pedagogical methods correlated with specific classroom environmental factors affecting pedagogies and learning.

Teaching Method and Classroom Adaptation

Six out of nine interviewees underscored that respective teaching pedagogies for children with ASD were affected by the nature of architectural environmental variables in a classroom setting. More specifically, responses concurred that successful learning and optimal learning results were the outcome of attentiveness towards the correspondence between architectural variables and teaching methodologies. The salient stress was made on architectural prefiguration of the noise unit (5 out of 9 participants), and subsequently spatial layout (3 out of 9) and lighting (2 out of 9). Three out of nine interviewees specifically noted the significance of a dominant figure of a teacher or therapist who could command children's attention, in which case the environment was not a very important factor, such as in ABA teaching methodology. This was contrasted with teaching methodologies such as TEECH, which employed child-centred freedom where the environmental effects were more pronounced and thus played a significant role.

The pedagogical theme was extended to examine the impact of how the levels of difficulty of educational material prompted off-task behaviours in children with ASD in a classroom environment. The responses suggested that comprehending educational-curricula material was important, as it impacted a child in a multiplicity of ways. This had fundamentally differentiated results both on-task and off-task. The factoring of children's linguistic difficulty levels depended on how they understood the instructor's conveyance of On-task educational material. Consequentially, this resulted in off-task behaviours, which exhibited anxiety, restlessness, frustration, and the occurrence of aggression traits. The architectural environment was itself a source of distraction for some children as it desisted them from On-task attentiveness. The participants shed light upon the fact that a child's repeated disruptive behaviour was based upon the rationale that it culminated from the disinclination to engage in an On-task assignment. Individual children who were traumatized by learning experiences were severely prone to negative disinclination towards educational tasks. The participants were unanimous about limiting Noise, effective employment of visual stimuli, segmentation of empty workplaces with visual aids, spaces, and physically demarcated barriers aiding classroom areas.

4.5.3 Enabling Environment

This sub-section addresses: **What could be plausible classroom environment transformation to assist modification intervention for ameliorating sensory disruptive behaviours and effective on-task engagement?** This section apprehends the enquiry of establishing the enabling environment conception thematically. This category emerged in relation to the sensory design theory elicited in the literature review chapter section 2 (Mostafa, 2008, Delmolino and Harris, 2012, Kinnealey et al., 2012). It factored upon the sensory modification of the specific classroom environmental variables conducive to the learning and emotional well-being of the ASD child (Mullick, 2008).

Classroom Facilitation

In the enabling environment category, interviewees overwhelmingly responded to the interrogation of classroom facilitation by underlining noise as very significant (7 out of 9 participants). Subsequently, advocating the significance of a conducive noise-free built classroom environment. The unit of analysis clutter-free based classroom organization environment was significantly important (5 out of 9 participants). Also important was the regulation of appropriate lighting design (3 out of 9), recommending the elimination of direct light and substituting it with the installation of indirect lights. One participant also gave importance to children's specific problem unit and temperature regulation. Three participants gave importance to both a clutter-free and noise-free space simultaneously. One participant underlined the continuous background noise effect from fluorescent lights, constancy of talking, crying, screaming and long meltdowns than a sharp transient, momentary sound such as chairs crashing down etc. It was underscored that the time span of loudness was more important than loudness itself. It was further highlighted that in most situations, children’s disruptive behaviours were manifested with immediacy. The participants, extrapolating from the concept of a clutter-free space, further echoed the importance of classroom space segmentation and the reduction of visual stimuli. It was asserted that visual stimuli were the major distractible factor inhibiting attention span besides noise.

Communication and Linguistic Acquisition Skills

The communication and linguistic acquisition skills theme apprehends the examination of the interviewee participant’s views on the classroom sensory confines and physical structure impact on achieving better speech, linguistic acquisition, and hearing. Five of the interviewee's responses underscored that the noise variable was the key determinant factor in the thematic category of communication and linguistic acquisition in the classroom design adjustment. One participant categorically underlined ASD child’s difficulty in filtering foregrounded relevant information threshold confronting the presence of extraneous background noise. Another participant accentuated the broad nature of background noise variables affecting ASD children in the classroom, underlining the necessity of examining aspects of noise such as echoes and sudden, startling noise. Four out of nine participants underscored the unit of analysis visual cues and recommended demarcated areas with visual cues to support language barriers and communication. Two out of nine participants recommended the delimits to expansive space by spatial layout, representing clearly marked zoned areas and visually recognizable markers for specific activities to enhance routinized predictability and communication. One participant underscored children's specific (unit of analysis) levels of importance in enhancing linguistic acquisition and hearing skills. To support children in the most optimum way, a clutter-free, zoned, visually cued, noise-free environment was underscored.

Taxonomy of acoustical variable

The majority of participants underlined the classroom acoustic theme, the background noise (7 out of 9 participants), as the most significant variable; it is corroborated by the literature review. It vitally underscored the significance of ambient noise's impact on auditory hypersensitivity and processing dysfunctionality in children with ASD. These include the reverberation time (3 out of 9 participants) and signal-to-noise ratio SNR (1 out of 9). The participants stressed that reverberant rooms were a source of distraction for children in addition to background noise. One participant referred to background noise as a broad variable stressing the overall soundproof nature of the classroom. It was noted that some participants subsumed both RT60 and SNR under generic ambient/background noise. Two participants stressed startling noise led to a child’s spiked anxiety. Three participants revealed that processing simultaneously dual visual information and auditory noise was significantly difficult as foreground directives or instruction mingled with background noise in which the immediacy lost the ability to focus.

4.6 Discussion

This chapter examines the research variables and systematically sets out the qualitative enquiry of the study represented in the interview questionnaire addressed to professional experts. The embedded responses were transcribed and analysed via directed content analysis. The key findings corroborated how the significant variables of the classroom sensory environment feature, light, noise, spatial layout, and smell, affected the learning and behaviour of children with ASD, which were analytically delineated.

The above results show that the classroom interior environment was the most salient feature in the learning and classroom performativity of children with ASD, which was corroborated in the literature review (Kanakri, 2017a, Kinnealey et al., 2012, Ashburner et al., 2008a). It had a multiplicity of effects most significantly felt upon children’s performativity leading to fluctuations in their participatory and behavioural functionality (Orekhova and Stroganova, 2014, Pfeiffer et al., 2017). The spatial physical classroom extensively affected on-task engagement, concentration, attention span, interests and social activities (Pfeiffer et al., 2005, Tomchek and Dunn, 2007, Kinnealey et al., 2012). A re-occurring coding category child specific underscored heterogeneous responses to environmental stimuli in children with ASD consistent with existing research (Pfeiffer et al., 2017).

Findings ascribed Noise as the predominant architectural factor for on-task learning, which specifically delineated ambient noise as the most critical factor. This was consistent with the literature review where children's stress, anxiety, and sensory reaction to noise were overriding factors affecting on-task as a result of noise (Ashburner et al., 2008b, Dockrell and Shield, 2006). The findings' units of analysis underscored spatial layout and classroom segmentation in association with subdued colours, texture, odours, and olfactory factors (Kanakri, 2017a, 2013a, Howe and Stagg, 2016).

The thematic pedagogical environment findings underlined that an effective classroom model combined architectural environment elements with teaching pedagogies to optimise results, whose effect was significant on on-task attention span and on-task engagement level. Factors such as noise, spatial, lighting, and colour were corroborated in the literature review (Kinnealey et al., 2012, James, 2010, Ashburner et al., 2008b). The literature attested to unique apprehension of pedagogical practices such as small groups with a setting of six children from a distance not exceeding 2 meters to reduce noise signal dispersal that an appropriate environment was necessary for the pedagogical practices. However, pedagogical practices were mostly not considered in research catering to classroom acoustics for special needs and children with ASD, where children are taught in smaller groups of up to 6 kids, and the typical distance from the teacher to children does not exceed 2 meters. Therefore, signal amplification is not required, but noise reduction is the main criterion for designing acoustic for a conducive learning environment (James, 2010).

The thematic investigation of pedagogy findings stressed the effectiveness of the teaching methodology curriculum delivery and implementation, which could enhance when calibrated with architectural variables for on-task activity. However, the complex difficulty levels of the curriculum led to off-task difficulty behaviours dependent upon comprehension level, linguistic difficulty, distractibility of the environment, and disinclination to engage in the on-task situations (Ashburner et al., 2008a, Orekhova and Stroganova, 2014, James, 2010).

Although heterogeneity and environmental factors were assisted by significant curriculum, pedagogies, and classroom arrangement, there existed universals and commonalities which could be employed in educational practices. Creative stratagem and adaptations according to circumstances was a constructive approach in the environment dynamics embodying new learning pathways for children with ASD (Perko and McLaughlin, 2002). An appropriate classroom sensory environmental modification supported increased participation, demonstrated in preschool children's home environment (Piller and Pfeiffer, 2016). The literature corroborated that the reduction of visual classroom inputs related to ASD children's difficulty with filtering school setting inputs in On-task attending as they had unique sensory processing patterns (Piller and Pfeiffer, 2016, Ashburner et al., 2008b).

The theme interrogates the significant classroom architectural elements facilitating sustained engagement in Children with ASD, learning tasks, and activities positively correlated to a sensory design built environment, specifically a sensory noise-free classroom incorporating major elements. The elements of design included lighting, segmentation, and obliterating continuous temporal flow of noise, which impacted with immediacy resulting in stemming behavioural stimuli responses allowing the neurological threshold (Martin, 2009, Mullick, 2008) (Pfeiffer et al., 2017, Kinnealey et al., 2012, Ashburner et al., 2008b, Kanakri, 2017a).

The thematic interrogation findings' in linguistic acquisition correlating speech/ language acquisition in relation to classroom environmental variables showed the significance of the noise variable affected by classroom design-assisted self-stimulation regulation and enhanced learning abilities through a declination. The improvement also entailed language, communication attentiveness and speech intelligibility attainment. In the particular cases of hypersensitive children, it could improve levels of concentration (Tomchek et al., 2014),(Nelson and Soli, 2000, James, 2010), (Howe and Stagg, 2016).

In the interrogation of the specific acoustical variable, the findings depicted that the background noise (BN) and its ambient character was the most significant variable. The critical literature review in Chapter 2 corroborated this as a dominant factor whose improved classroom acoustics through sensory environment modification was correlated to modulated behavioural outcomes (Kanakri, 2017a). The literature also underlined the consistency of the HVAC system source background noise factor, which had differential effects when children were exposed to it (American Speech-Language-Hearing Association, 2016). The emergent aspect of the background noise was the echo, sudden unsettling noise, and continuous ambient noise (Kanakri et al., 2016).

The literature review also evidences the importance of particular classroom setting pedagogy, including adjacent children's seating which was directly correlated to their speech intelligibility, privacy, distractions, and attentiveness (Shield et al., 2010).It was highly recommended that children be provided conducive listening classroom environment with effectively furnished to desist environmental noise effects (American Speech-Language-Hearing Association, 2016).

The domain of children's learning, performativity, and attentiveness reflected a particular gap in the representation of relevant pedagogies addressing environmental acoustics. This gap depicted the absence of an appropriate environment, as discussed above, due to which children manifested heightened sensory responses such as restlessness, anxiety, and aggression (James, 2010).

Limitations and Recommendations

This study was strictly limited to the classroom environments; therefore, these results cannot be generalized for other environmental contexts. The focus of the research was sensory environmental factors, such as lighting, noise, smell, temperature, and spatial layout. Due to the acute heterogeneity nature reflected in the variegated symptoms dependent upon an individual child, these results do not reflect each ASD individual child. The professional experts reflected variances in their quality contributions as their demographic representation was subject to the plurality of perspectives and conversations representing their subjective fields and the nature of the study entailing children with ASD. Furthermore, the qualitative nature of the research relied on verbal explanations and interpretations of the participant's experiences through content analysis.

The scope for further research is enhanced in manifold ways, but primarily in examining the impact of sensory environment in other school settings, including the environmental dynamics in the school lunch room, music room, gym etc. Research could focus on classroom activities in definitive schools for children with ASD to gauge the impact of environmental attributes on the built environment.

4.7 Concluding Remarks

This chapter encompasses the qualitative methodological approach whose data was gathered from nine international professional experts in the field of education of children with ASD, psychology and sensory environment. This entailed semi-structured interviews to gather pertinent reflections to articulate their expertise and thoughts. The qualitative research aspect leads to the collation of data which was analytically and descriptively apprehended to verify that noise/ acoustics was the most critical factor impacting classroom behaviours and learning in children with ASD.

With reference to this chapter, the main research question is: How the sensory related architectural elements within the classroom environment are related to either the inhibition/or facilitation of on-task learning and behaviour in children with ASD?

It was validated that children's sensory behaviours were individual-specific, environmental-specific, and situational-specific, which supposed the importance of mediation through and within varying immediate surroundings. The environmental fragility and specificities with children's engagement had broad implications consistent with seminal research findings interrogating how the individual sensory stimuli were mediated through stress or stress-free. Study findings are concurrent with similar studies investigating the sensory experiences which reflected inconstancy of state, dependent upon interspersing of transient variables (Smith and Sharp, 2013, Howe and Stagg, 2016). These findings highlight the need for a carefully calibrated classroom sensory design of the learning environment to cater to individual responses.

Research sub-questions a) What specific classroom sensory feature elicits sensory disruptive behaviours in children with ASD? b) What specific classroom sensory feature affects pedagogics and learning? It was validated that the classroom interior environment was the most salient feature in learning sensory behaviour outcomes in children with ASD. Spatial physical classroom sensory confines extensively affected on-task engagement and behaviours in a classroom setting. It was established that the ambient background noise level was the predominant critical sensory feature within the classroom setting. It acted as an environmental stress feature for the children and would affect their behaviours, learning and pedagogics. It further echoed the importance of classroom space segmentation and the reduction of visual stimuli. It was asserted that besides noise, visual stimuli were a major distractible factor inhibiting attention span. The validated noise/ acoustics and the RT60 were deduced as the significant independent variable leading to the hypothesis testing of the sensory behavioural responses and learning of children with ASD in the classroom.

Research sub-question c) identified and validated that a noise-free built classroom environment was a plausible classroom environment transformation to assist modification intervention for ameliorating sensory disruptive behaviours and effective on-task engagement. The verification of the significant variable of noise/acoustics assisted the construction of Stage 2 and 3 studies in Chapters 5 and 6, respectively.

5

CHAPTER 5: MODIFYING CLASSROOM ACOUSTICAL ENVIRONMENT TO AFFECT SENSORY BEHAVIOURS

This chapter investigates the critical hypothesis which emerged from the previous chapter: noise/acoustics being the most significant factor that affects the behaviour of children with ASD. It examines the association between the classroom acoustic parameters, such as RT60, LAeq and LA90 levels, upon children's sensory behavioural in a classroom.

5.1 Background

The prevailing studies indicate a positive correlation between ASD diagnosed children and the sensory impact of noise on their resultant behaviours (Kanakri, 2017a). Although these behaviours stemmed from auditory sensory processing dysfunctionality, they exacted a severe toll on children's health and learning which was detrimental to their well-being (Stiegler and Davis, 2010). The study in this chapter addresses the question of the impact of noise on children's sensory behaviours. The navigation of the research apprehends explicitly the interdisciplinary areas of classroom sensory built environment, sensory behaviours in children with ASD, and the sensory modulation through intervention SCED research methodology.

The literature review (Pg. 36, sec 2.3) critically discussed the most significant behaviours of children with ASD resulting from particular sound stimuli and noise. These were generally identified and categorised the repetitive behavioural movement, typified as hand-flapping, rocking, spinning, ear-covering, crying, meltdowns, leaving the immediate area to discover sound-emitting and occurring source, producing loud noise, increased muscle-tone, hyperventilating, eye-pupil dilation, and self-injurious behaviours(Stiegler and Davis, 2010, Kanakri, 2017b).

Several key studies pointed out that appropriate sensory design modification by mitigating classroom noise can ameliorate auditory sensory processing in children with ASD. Very few empirical research dealt with the specificity of classroom physical design for children with ASD and to what degree it correlated to children's noise regulatory, and acoustic comfort in educational settings (Dargue et al., 2021, Kanakri, 2017a). This research task necessitated the complexity of apprehending appropriate methodologies in capturing these types of enquiry. Thus, this chapter addresses the existing knowledge gap and delineates how to particularly address the plausible investigating through sensory design modification of the classroom acoustical environment. This would be achieved through the installation of acoustic sound-absorbent wall panels, which would yield considerable RT60 and its correlates declination. The following Figure 5.1 explains the investigation process in this chapter.

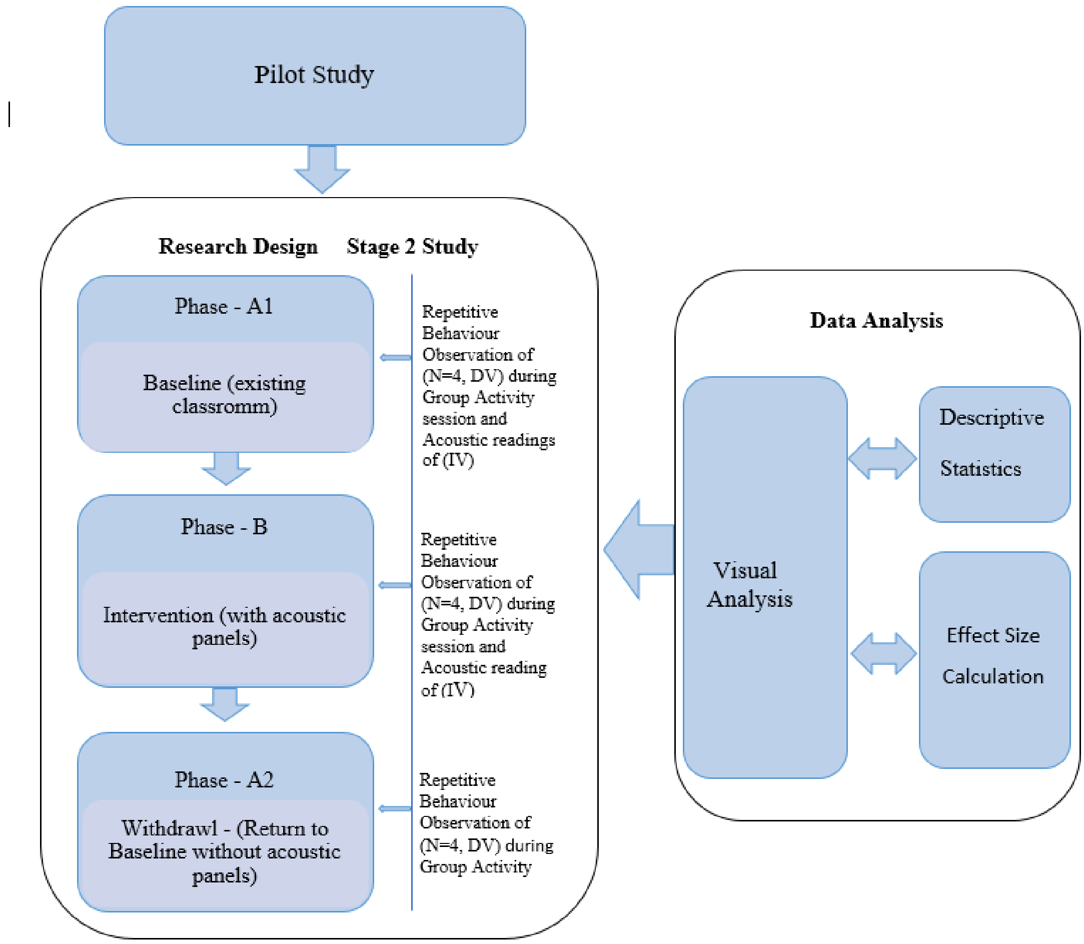


Figure 5.1: Stage 2 Study Inquiry Road Map

5.1.1 Sensory Modulation

In children with ASD, the modulatory processing effect challenges the child's ability to organise information from the environment resulting in stereotypical repetitive behaviours and the ability to engage effectively in educational tasks. This modulation regulatory feature was essentially the neurological process enabling children's imbibe, organise, and act upon the information provided (Anzalone and Lane, 2012). This is pivotal, especially in the classroom setting where children with ASD fail to successfully cohere these processes leading directly to stereotypical and repetitive movements impacting their educational process (Schilling and Schwartz, 2004) (Stiegler and Davis, 2010)). Research had shown that some indicators have the potential to aid and enhance classroom engagement, specific attentiveness in children with ASD; when necessary acoustical conditions are created through design, it will also lead to the amelioration of their behavioural dysfunctionality (Kinnealey et al., 2012).

The sensory modulation problem of children with ASD demonstrated a significantly high percentage (95%) in an empirical study of 200 children compared to their neuro-typical peers (Baranek et al., 1997, Greenspan and Wieder, 1997). Therefore, it is vital to assess the unique educational and pedagogical needs of children on the spectrum through different curriculum and classroom modifications, which take into account their sensory modulation and information integration. However, these specific requisite needs for their learning, assessment and intervention strategies were largely absent (Kanakri, 2017b, Martin, 2014).

Auditory Sensitivity and Input Processing

This part of the research takes into account that auditory processing in children with ASD was the key factor underlying the heightened sensory processing anomalies, as pointed out by Tomchek (Tomchek and Dunn, 2007). Auditory sensory inputs and responses are complex in children with ASD, such as exhibiting obsessive, ritualistic responses, the extreme polarity of deterring, equal fascination and aversion to specific sounds, sights, tastes, textures, or smells (Association, 2013b). Studies indicate that the underlying causes of these sensitivities and processing are linked to noise and emotional-behaviour irregularities (Stiegler and Davis, 2010). This is echoed by the research work done by Alcántara that there exists a complex correlation between children's auditory perception, attention and the effect of ambient background noise (Alcántara et al., 2004). Given the comment from Alcántara, there are no conclusive studies exploring this relationship (Ashburner et al., 2008a, Dargue et al., 2021).

Danesh 's work explored the auditory heterogeneity in children with ASD and found that individual child has a different effect on their idiosyncratic sensory processes, regulatory mode, and specific dysfunctionality. (Danesh and Kaf, 2012). Essentially, it means that ASD individuals would display symptoms and characteristics of the autism spectrum; however, their behaviours and responses would vary in presentation and severity.

According to American Speech-Language-Hearing Association (2011), children with ASD are significantly impacted by hypersensitivity or hyperacusis condition of unusual intolerance to what was generally considered normal environmental sound. Particular hypersensitivity conditioning in children with ASD was evidenced through observational studies of 17,000 children diagnosed with ASD from different countries over three decades between 1964-1994. The results of the data collected by the Autism Research Institute also affirmed that 40% of parents substantiated that children were highly sensitive to the sound factor (Rimland and Edelson, 1995). A high proportion of children with ASD (88%) reflected the problem of hearing from a qualitative study of classroom environmental experiences of children (Howe and Stagg, 2016). Evidence correlates to children's noise-elicited patterns of sensory behaviours conceptualised on different levels of difficulties, autonomic fear response, and behavioural regulation strategy (Stiegler and Davis, 2010); this is pivotal to this chapter.

5.1.2 Sensory Response and Acoustic Environment

The behavioural response in children with ASD to auditory stimuli as a self-treatment stratagem, automatically responding to fear, or emotive regulatory strategy reacting to the environment was discussed in the previous Chapter 2. The most common occurrences of characteristic behaviours observed evidentially were the repetitive stereotypical gestures, e.g. ear-covering, fleeing the area of the source of sound emission, crying/tantrums, humming/vocalisation responses, shivering, increased muscle-tone, hyperventilating, inflicting self-injurious blows (Stiegler and Davis, 2010).This heightened level of demonstrated endemic reactivity to sounds was presumed to be their natural adaptability to sensorial increment or decrease oscillation upon the levels of behavioural hypersensitivity stimulation (Kargas et al., 2015).

The classroom sensory environment led to stimulation reactivity in children with ASD, which created the problem of sustaining attentiveness upon learning and achievement. More significantly, it demonstrated rapidly shifting and getting side-tracked and difficulty re-orientation towards the given instructional on-task learning. These sensorial complexities due to overriding sensory stimuli and arousal level regulation behaviours were evidenced in both ASD and neuro-typical students (Orekhova and Stroganova, 2014, Ashburner et al., 2008a) (Tomchek et al., 2014, Varni et al., 1979).

The current research only marginally considers the noise regulation and effect through the prism of the sensory design significant factor (Kanakri, 2017a). Therefore, this chapter addresses this knowledge gap.

5.1.2.1 Sensory Environment

Through the literature review, it was critically established that the classroom sensory design modification was plausible in deploying positive adaption of sound absorbent materials, which alleviated levels of sensory comfort, disposition, and sustained attentiveness towards the on-task learning in children with ASD. Contrasted with the sensory modulation environment, unregulated acoustics exerted energies and distractibility, restrictive concentration and engagement upon classroom learning tasks. It was underlined above that the children's behavioural disruptions were determined most significantly by the noise leading to failure to engage in on-task learning. A carefully calibrated sensory environment is therefore essential for this study to examine the correlation between the regulation of the sensory environment and averting children's harmful behavioural responses (Kanakri et al., 2016, Kinnealey et al., 2012, Howe and Stagg, 2016).

Classroom Acoustics

The observational investigation established the multifarious impact of long RT60 acoustics, i.e. conclusively drawing negative correlated social relationships with classroom peers and teachers when the RT60 is over 1.0s (Klatte et al., 2010). Therefore, it is essential to examine the impact of long RT60 and short RT60 with reference to acoustic comfort through comparative methodological analysis. This will enable us to conclude how a classroom with a long RT60 prevalence of a highly competitive atmosphere could be turned positively in the investigation.

The measure of Acoustic Intervention for Children with ASD

It was evident that the teaching methodologies and the curriculum are significant aspects of teaching and learning of children with ASD, which have been ignored as most research focused on classroom acoustic modification (James, 2010). It is important to assess the pedagogy of structured learning one-to-one teacher-student ratio, which eliminates the physical distance to fewer than two meters and was considered effective as it considerably reduced the delivery of teachers' acoustical signals (James, 2010). However, this does not eliminate the classroom's internally generated sounds, noise build-up, and reflection, which have been evidenced to be the children's classroom instruction processing and behavioural distractions. This chapter hence installed the sound absorbent wall panels as an acoustic intervention measure.

5.2 Research Questions and Objectives

The aim of this chapter is to investigate the relationship between classroom acoustical environment and delineated sensory disruptive behaviours in children with ASD. It addresses the following research question of What is the correlation between the classroom acoustic parameters, such as long and short RT60 and the LAeq and LA90, with delineated sensory disruptive behaviours in children with ASD? This research question can be subdivided into three questions:

a) Does there exist a relationship between the acoustic variable (RT60) and the repetitive behaviour of children with ASD in the classroom environment?
b) Does there exist a relationship between the acoustic variable (RT60) and the ear-covering behaviour of children with ASD in the classroom environment?
c) Does there exist a relationship between the acoustic variable (RT60) and the loud vocalising behaviour of children with ASD in the classroom environment?

Objectives

The objectives of this chapter are:

a) To examine the correlation between the prevailing unconditioned classroom RT60 (Tmf 1.11s) and correlates LAeq and LA90 pressure levels upon individually targeted sensory disruptive behaviours in children with ASD through SCED methodology.
b) To examine the ramification of the classroom sensory condition upon the (N=4) individual sensory disruptive behaviours through SCED methodology.
c) To test the aforementioned hypothesis through the impact of the return to baseline phase A, prevailing unconditioned classroom RT60 (Tmf 1.11s) upon the (N=4) disruptive behaviours.

Hypothesis

The hypothesis to the above research questions does there exists a significant correlation between the reduction of reverberation time (from Tmf 1.11s to 0.39s) and the frequency of sensory behaviours in children with ASD. It was predicted to have a positive change in the children's behavioural outcomes through a declination of the delineated sensory behaviours.

Significance

This chapter examines the viability of an appropriate design classroom environment to address the sensory modulatory processes, disruptive behaviours, and classroom engagement of children with ASD. The significance of this chapter is to enable the improvement of the children's sensory behavioural responses and to enhance their temporal and spatial transformed wellbeing through classroom environment modification.

5.3 Methodology

Chapter 3 sets out the methodological rationale, criteria, and justification for the research design for this chapter, which explicates the relevance and salience of the Single Case Experimental Design A-B-A, Baseline-Intervention-Withdrawal experimental design. The salient SCED methodology enables interrogation and examination of the critical hypothesis, the children's (N=4) sensory behaviours processing response to the classroom environment stimuli and its modulation. The independent variable in this chapter is the classroom RT60 and correlated LAeq and LA90, and the dependent variable (DV) is sensory behaviour stimuli responses in children with ASD. The research design methodology entailed a phased examination of the behavioural responses prior to and post-installation of the intervention acoustical sensory design modulation utilising sound-absorbent panels.

5.3.1 Data Collection

Participant Sample and Setting

Four male pupils with ASD aged between 9-11 years were selected for this Stage 2 study in this chapter. Social group activity took place in a group arrangement, which consisted of a single large 'C' shaped PVC table, providing sitting for the children and the moderating teacher (see fig: 3.3) using photographic activity schedule with visual cues in a ring binder form to initiate activities for the group interaction. It required the students to engage in an activity that corresponded with the picture in the binder. The activities focused on listening skills, imitating, attending, turn-taking and sharing material and waiting for their turn.

5.3.1.1 Independent Variable, Reverberation Time and Correlated LAeq and LA90

This chapter investigates the independent variable classroom's RT60 and its correlated LAeq (equivalent continuous noise level) and statistical level LA90 representing average noise levels. These were measured and attested during the group activity lesson. The group activity noise levels measurements were taken each day during the research Phase (A) and Phase (B), whose numerical readings were averaged to derive the approximation. The key constructing factors of noise and acoustics in the classroom sensory environment are discussed in depth in Chapter 3, Methodology Section 3.4.6.

5.3.1.2 Dependent Variable for chapter 5

In this chapter, Stage 2 Study, the marked sensory behaviours in the children with ASD were used as the dependent variable to test the hypothesis.

Behaviour Observation and Dimension

The frequency of the targeted behaviour of each child with ASD (N=4) was delineated and categorised. These recorded behaviours were apprehended by counting the occurrence of each incidence within a time frame. Video recordings were conducted for the behaviour observations to monitor and analyse the participant's stimuli response in classroom activity sessions. Each session lasted approximately 5 to 10 minutes, although it is essential to understand that each session could not strictly adhere to the time frame. This is due to participant heterogeneity which was a strong factor leading to their spilling into responses time overflow. Therefore, the Frequency Rate of Behaviour (FRB) of the four participants was calculated by each participant's Behaviour Occurrences (BO) observed empirically and divided by the Length of Observed Time (LOT) for rate per minute: [FRB = BO / LOT]. The session variability factor was achieved by deducting the participant's session unexpected non-attendance divided by the (LOT). The repeated behaviour within the first 3 seconds of observation recording was omitted.

The rules for identifying any specific behaviours have been established. One important rule was not to count a behaviour which re-occurred during the preliminary three seconds of its first being noticed. The observations were carried out over the period of 4 weekdays, stretching two weeks' duration per phase, excluding Fridays (half-days), Saturdays and Sundays. The observational behaviour study was conducted in a three-phased study, the baseline Phase A, intervention Phase B and withdrawal Phase A (A1-B-A2).

Targeted Observed Behaviours and Operationalizing Constructs

1. Repetitive Restrictive Motor Movements: Characterised by rhythmic, ritualistic patterned movement of body parts including legs, hands, head and or upper body (American Psychiatric et al., 2000). More specifically, significant repetitive movements consist of three major patterns:

Observable Definition

Jumping: Two or more continuous instances of jumping up and down from the ground surface.

Rocking: Two or more continuous instances of swinging back and forth and or side-to-side upper body movement.

Repetitive hand movement: Two or more continuous instances of flapping hands and or finger flickering in an up and down vertical and/ or side to side motion horizontal movements.

2. The action of Covering Ears: Although functionally considered protection, the prolonged action was an intrusive behaviour linked to anxiety. It also included anticipatory apprehension of fear from potentially unpleasant noises pre-empted by the act of covering (Kennedy, 2006).

Observable Definition

Protecting and or touching one or both ears simultaneously.

3. Repetitive Vocalization: Continuous or non-continuous loud unprompted vocalisations unrelated to the present situation, activity or task (Bogdashina, 2003).

Observable Definition

Unprompted vocal sounds such as grunting and or high-pitched sounds.

The above-delineated sensory behaviours extracted from the literature review were observed in each ASD child during the pilot study, and observable operational definitions tailored to each individual child were completed for outcome measures. The following Table 5.1 shows the participant-specific behavioural Topography of the three delineated behaviours.

Table 5.1: Stage II Study - Dependent Variable Participant Specific

Participants	Behavioural Variable	Behavioural Topography
ABD	Ear Covering	Touching or covering one or both ears.
	RB	Two or more instances of jumping, rocking or finger flickering.
IBT	Ear Covering	Touching or covering one or both ears.
	Loud Noise	Two or more instances of making spontaneous loud meaningless sounds.
	RB	Two or more instances of rocking back and forth or side to side.
MOH	Ear Covering	Covering one or both ears with hands or elbow.
	RB	Repetitive arms or hand movements, back and forth movement, jumping or flickering fingers.
SHA	Ear Covering	Touching or Covering one or both ears.
	Loud Noise	Loud, spontaneous meaningless sounds
	RB	Jumping on the spot, rocking back and forth, repetitive hand or arm movement

Behaviour Coding Scheme

The behaviours observed were codified to allow the empirical data representation and analyses using the Interact Mangold Software, which permits close representation and paralleling of behaviours. The schematic codification of the behavioural codes and symbols is presented in the following Table. Event recording in Table 5.2 refers to the number of times (frequency of occurrence) a specific target behaviour (event) occurs during a particular activity within a time frame.

Table 5.2: Behaviour Coding Scheme for Mangold Interact software

Disruptive Behaviours	Symbol	Measurement Procedure/ Dimension
Repetitive Restrictive Movements	RB	Event recording /Frequency Rate
Loud Vocalizing	VC	Event recording/ Frequency Rate
Covering Ears	CE	Event recording/ Frequency Rate

5.4 Procedure

The Study in this chapter was approved by the Sheffield University Ethics Review Board. The Oasis School's Principal despatched the Letters of Consent to the parents of ASD pupils selected for participation in the research study. Informed consent was obtained from all participants of the Study. Participants were assigned an acronym to respect their confidentiality and identity, as per the ethical procedures. This study was conducted over three phases over a period of six weeks, delineated as (a) Base Line Data Collection; (b) Intervention Phase, which included the installation of sound absorption wall panels; and (c) Return to Baseline Phase. Each phase lasted for a duration of two weeks. The Classroom normalcy and its weekly routines were maintained and remained unchanged. All four ASD (N=4) participants' delineated stimuli responses through disruptive behaviours were recorded. The collated data were analysed and interpreted for this chapter's three-phased (A1-B-A2) investigation.

Baseline Data (Phase A1)

Observations for the social group activity were steered in sessions ranging from approximately 5 to 10 minutes in duration. The Data was collected for four days each week, excluding Fridays and weekend days. The two weeks' investigation of the Four participants' behaviour for this phase was conducted for two weeks in the existing normal classroom. The data were collated for analytical interpretation, and the descriptive statistics were transformed for comparative purposes through visual analysis.

Intervention (Phase B)

Subsequent to Phase A, an adjacent separate classroom was specifically modulated through appropriate sensory design through the sound-absorbent panels. This phase was in compliance with the controlled acoustical design in order to maintain the relatively smooth spatial transference of the four ASD participants to the new adjacent environment. A two-day spatial sensitisation was provided to the participants to acclimatise with the routines and classroom activities, and norms with consistency prior to the actual investigation. The recording of all the children's behaviours was initiated for the next two weeks, excluding Fridays and weekend days.

Return to Baseline (Withdrawal, Phase A2)

The final phase involved the removal of the acoustic sound-absorbent panel's intervention. This phase included the procedural behavioural data collation without any alteration of classroom routines and activities in order to maintain the levels of normalcy. The observation strictly adhered to restricting effects which would encroach upon this study's investigation. The examination of behaviours was conducted over two weeks. The collated data were analytically interpreted, and the descriptive statistics were transformed for comparative purposes through visual analysis.

5.4.1 Data Analysis

Once the cumulative A1-B-A2 Phased data were collated, the systematic analyses in Phase and comparisons and contrasts across Phases were undertaken and finally subjected to visual inspection graphing for the ASD participant's empirical findings correlating the RT60, long and short reverberation time upon their delineated sensory behaviours. The representative Data was analysed in the following manner:

- Firstly, the gathered RT 60 and correlates LAeq and LA90 Levels representational data were gathered prior to and post-installation modification of classroom environment acoustic conditions compared and analysed, previously discussed in chapter 3 (sec section (3.4.4).
- Secondly, Each Individual subject (N=1) data were collated, and their representation was analytically and comparatively drawn, demonstrating the significance of intervention relative to each ASD child within the phase and across phases. The analytical evaluation is reflected through data represented in graphs for visual inspection in Levels of change, trend, immediacy and consistency.
- Supplementary effect size metrics based upon the Tau-U method and NAP of all pair's percentage points is reported for individual ASD participant behaviour to ensure the credibility of the results.
- Supportive Descriptive statistics mean range and standard deviation representational for each singular subject sensory behaviour are depicted in tables to enable the overall relevance of evaluation.

Procedural Fidelity

The following table presents the procedural fidelity for individual participants during this study across phases. For two of the participant, ABD and MOH, there was inadequate outcome measure for loud vocalising behaviour. These were, therefore, validly omitted from the study part.

Table 5.3: Stage II Study - Treatment Fidelity

Participant	Fidelity %	Explanation
ABD	93%	Absent one session, attended 23 out of 24 sessions
IBT	79%	Absent 5 sessions, attended 19 out of 24 sessions
MOH	79%	Absent 4 sessions and non-attending 1 session, attended 19 out of 24 sessions
SHA	100%	No absentees attended all 24 sessions

Reliability and Social Validity

This Study's inter-observational reliability and social validity measures were rigorously implemented, discussed in detail in Chapter 3 Methodology in the Experimental Control Section (3.4.7). Towards the termination of the final research Teacher's Survey Questionnaire was requested to be filled (Appendix – D.) The Survey response reflected strong concordance and acceptance of the acoustical Sensory Design modification classroom treatment elements in the spatial environment. The intervention was retained in the classroom and was rated significantly positive, acknowledging the overall impact of the sensory design acoustic intervention.

5.5 Results

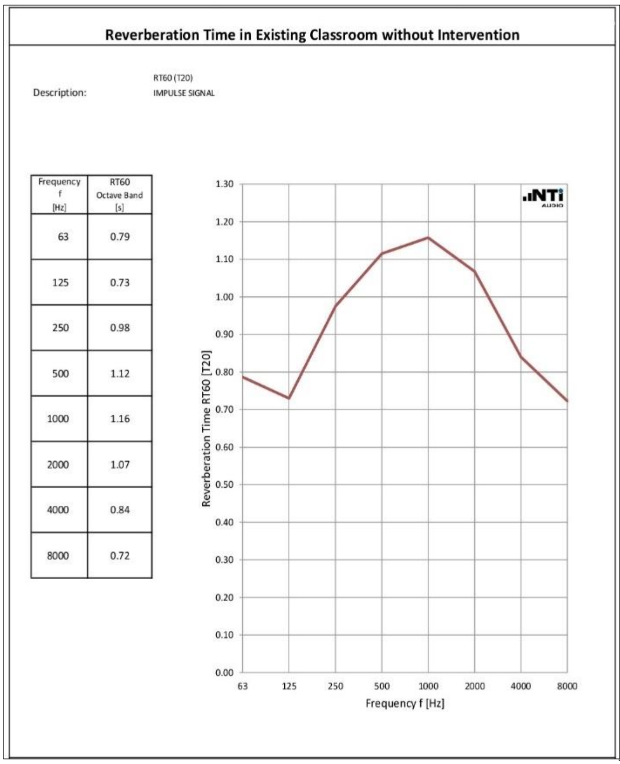
This section presents the results of acoustic refurbishment on classroom conditions and delineated sensory behaviours in children with ASD.

5.5.1 Effect of Refurbishment on Classroom's Acoustic Environment

For this study, precise classroom acoustic parameter measurements were vital. This involves undertaking the pilot measurements before the actual beginning of the study to test the environmental scope for the study's consecutive full-scale research. The acoustic measurements were taken prior to the classroom refurbishment during the vacant period. The specific Mid-Frequency (Tmf) RT60 was 1.11s, yielding a significantly high distribution, which necessitated the classroom acoustic treatment. The measurements were taken before and after the modification, and the results are tabulated in Table 5.4. The Building Bulletin (BB93) (British Acoustic Standards for schools) standard method conversion of the RT60 high-frequency variance was used for validating the averages of the Mid-Frequency (Tmf) RT60 reflecting the frequencies taken at 500Hz., 1000 Hz., and 2000 Hz.; which yielded the adequate acoustic conditioning. The result of the measurement after the modification has a Tmf of 0.39s, which complies with the recommendation from BB93, which suggests Tmf be equal to or less than 0.4s.

Table 5.4: Classroom Reverberation Times and Mid Frequency (Tmf) Pre and Post-Acoustic Modification

Frequency (Hz)	500		1000		2000		Tmf (500-2000 Hz) Seconds	
	Before	After	Before	After	Before	After	Before	After
RT60	1.12	.41	1.16	.40	1.07	.35	1.11	0.39



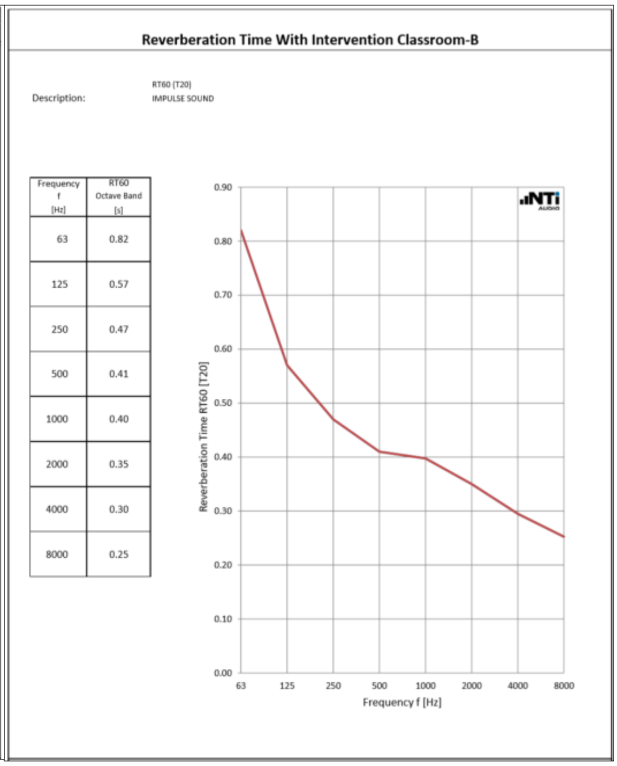


Figure 5.2: RT 60 Before Intervention

Figure 5.3: RT 60 After Intervention

Effect of Acoustical Treatment on Average Noise Levels

The nature of sounds, whether embodied or external, does not reflect steadiness or stability as the sound pressure levels constantly fluctuate in duration. In mathematical representation, it is only meaningful in its minimum, maximum, or average time (Canning and James, 2012). The measurement of classroom sound levels LAeq and LA90 correlates of the acoustic parameters are essential for this chapter. This study was designed around an A-B-A Single Case Experimental Design approach to determine the relationship between the acoustics variable (RT60) and sensory behaviours in children with ASD. Table 5.5 shows the derivative effect of classroom sound levels, Averaged LA90 and LAeq, during Phase A and B, before and after the acoustic refurbishment, respectively.

Table 5.5: Classroom Average Noise Level before and after Acoustic Refurbishment

Noise Condition	Average LAeq dB		Average LA90 dB		Average LAF max dB		Average LAF min dB	
	Before	After	Before	After	Before	After	Before	After
Leq dB(A) 30min Unoccupied with HVAC	38.9	35.6						
Group Activity Lesson Time (10 min) Occupied with HVAC	75.8 (3.48*)	64.08 (3.55)	65.07 (3.03)	52.15 (6.94)	96.92 (3.78)	85.33 (6.15)	47.2 (2.87)	41.26 (1.54)
Full day (5Hr) Classroom Noise Measurement Occupied with HVAC	70.85 (2.60*)	61.88 (1.97)	51.9 (5.39)	44.5 (6.62)	99.62 (4.41)	94.26 (1.94)	41.53 (1.26)	37.84 (1.05)
* The number in the bracket represents the standard deviation.								

Classroom Noise Levels Without Activities

Unoccupied Levels: The mean LAeq (30 min) unoccupied before the acoustic intervention was 38.9 (Table 5.5), and after the acoustic intervention was 35.6 (Table 5.5) with HVAC on. The acoustic modification achieved a 3 dB range declination, a significant subtle decrease in the unoccupied LAeq (30 min) dB Levels, whereas RT60 reduced from Tmf 1.11s to Tmf .39s with a difference of 0.7s as can be seen in Table 5.4. This is a significant declination compared to unoccupied LAeq levels.

Occupied Levels: The ambient noise level measurement (NLM) before the acoustic treatment with the HVAC in operation was 71.85 dBA; this accounted for the classroom activities build-up. The verifiable factors discerned included the children's movement, play, crying, fidgeting, stimming, meltdown, and loud noise combination of assorted behaviours, compounded by the HVAC and noises percolating from the adjoining music classroom and the corridors (Shield et al., 2015). The occupied NLM was monitored for the duration of the entire school day to consider the temporal noise level (TNL) fluctuations during the classroom routines and structured lesson activities. This also assisted in distinguishing the transience LAF min and LAF max noise levels between the quietest and noisiest periods of the day. The social group activities were deemed to be the noisiest, attested by the teacher feedback before beginning this study.

The classroom measurements further established that occupied classroom mean LAeq level over the entire typical 5-hour school day was 70.85 dBA with a standard deviation of 2.60 dBA before acoustic treatment and 61.88 dBA with a standard deviation of 1.97 dBA as shown in Table 5.5 after the treatment. These daily fluctuations necessitated averaging the occupied classroom LAeq Level measurements. Therefore, the two weeks of Phase (A) and Phase (B) measurement readings' average was sought before and after the acoustic treatment, whose LAeq levels difference was demonstrated to be within the 10 dBA range. It was vital to attain this level of declination compared to earlier LAeq (30 min) dB under unoccupied before and after acoustic treatment conditions. The underlying rationale for measuring the unoccupied ambient noise level (LAeq) enabling to relate to the actual occupied lesson sessions, linking the LAeq and mid-frequency RT60.

For the exercise in this chapter, it was important to control both the LAeq and the RT60 to a minimum during the classroom lesson sessions. It was deduced from the average obtained the difference between the occupied lesson noise LAeq 64 dB and unoccupied LAeq 35 dB post-treatment approximated 30 dBA. This was particularly salient for this study because the research outcomes emphasise the positive acoustical treatment impact of the classroom design interior sensory environment for optimising the children's learning (Shield et al., 2015).

The LA90 measurements also demonstrated the efficiency of the acoustic intervention; the average background noise levels decreased from 51.9 dB to 44.5 dB. The standard deviation of 6.62 dB post-treatment was slightly higher in responding to impulse noise events. LAFmax, which represents the maximum sound level during the entire 5-hour day, decreased from 99.62 dBA to 94.26 dBA, whereas the minimum noise level (LAFmin) decreased from 41.53 dBA to 37.84 dBA.

Classroom Group Activity Noise Levels

The Stage 2 Study in this chapter tests the hypothesis that the classroom group activity noise levels and its impact on the participants' three behavioural responses during the Baseline, Intervention, and Withdrawal A1-B-A2 Phases. The activity duration ranged between 5 – 15 minutes. The measurement of noise levels included identifying the emission-noise source and the levels of noise and recording the number of children and adults present. This examination directed the investigation of significant differences in group lesson activity noise levels measured in relation to the RT60 (Shield et al., 2015). The noise levels were measured each day for the duration of the two weeks in Phase A and Phase B sessions and numerically averaged.

The ambient noise levels mean LAeq during Phase (A1) was 75.8 dBA, and the mid-frequency RT60 was 1.11s, exceeding the value recommended by the BB93 standards. The teacher's views, based on their observations and experiences, revealed that during the social group activity time, the levels of noise were significantly higher and similarly reflected an increase in disruptive, non-attending behaviour and instances of leaving the classroom to avoid the activity. This was further evidenced during Phase (A2) of the study.

During Phase (B), the acoustic treatment condition resulted in the mean LAeq levels of 64.0 dBA and the RT60 of 0.39s. The acoustic treatment condition reflected a significant transformation range of 11dBA. The LA90 also reflected a significant average during group activity lessons in which the background noise levels decreased from 65.0 dB LA90 to 52.1 dB LA90. Post-intervention phase (B) reflected a significant reduction in the social group activity LA90 and LAeq levels. This finding conformed to the research indicators depicting the acoustic treatment effect on classroom activity LAeq and LA90 levels (Kristiansen et al., 2016). It demonstrated that the higher the LAeq unoccupied levels and RT60, the higher the LAeq and LA90 during the actively occupied classroom lesson due to carry over effect of the consistent ambient and background noise levels during the unoccupied condition (Shield et al., 2015).

5.5.2 The Relationship Between Acoustic Parameters and Repetitive Behaviour in children with ASD (in different classroom environments)

Participant ABD

Figure 5.4 demonstrates the Participant ABD's visual analysis for the rate of repetitive behaviour during Phases A1-B-A2 Baseline, Intervention and Return to Baseline (Withdrawal) Phase.

Baseline Phase A

During the Baseline Phase A, ABD demonstrated the average occurrence of repetitive behaviour at the rate of 2.0/min during the observation session (Range 1.9, SD=0.3), a High Level of 2.05 and a Zero-accelerating trend. The data path depicted stability without any outliers and a free pre-intervention trend.

Intervention Phase B

During intervention Phase B, ABD demonstrated an average rate of 0.5/min during the session and repetitive behaviour observation (Range 1.3, SD = 0.3) with a significantly low level of 0.55 and a decelerating trend (- 0.02). This demonstrates a significant initial decrease in repetitive behaviour at the onset of Phase B, fairly maintained with low variability in-between data points. A significant decreased level change (-1.50) difference was revealed between Phase A1 and the Phase B treatment condition. The comparative descriptive mean value between Phases A1 and B revealed a substantive 75 % defined decrease in repetitive behaviour (as shown in Table 5.6). The 100% NAP comparison data pairs between Phase B and A1 first pairing demonstrated higher than 93%, suggesting a substantial difference between data pairs.

Return to Baseline A (Withdrawal)

During Phase A2, ABD demonstrated repetitive behaviour at an average rate of 1.4/min during the observation session (range 1.7, SD = 0.5) with a level of 1.30 and an accelerating trend of 0.07. There was a significant Level Change between Phases B and A2 (+0.75), with an initial increase at the onset of the intervention withdrawal, consistently maintained. Across Phases A1 and A2, the trend and level remained consistent. The Means Value revealed a 64% percent increase compared to Phase B Intervention and A2 condition second baseline comparison (table 5.6), the repetitive behaviour indicating a substantial upsurge. The 92% NAP comparison data pairs between Phase B and A2 second pairing demonstrated higher than 93%, suggesting a substantial difference between data pairs.

ABD Repetitive Behaviour Concluding Remarks

For the participant, ABD, the analysis of Phase B acoustic intervention condition reflected a positive hypothesis validated by the decrement means value in repetitive behaviours. This positive correlation between acoustical intervention and ABD's behavioural response in Phase B depicted the immediacy and relevance of acoustic conditioning. The supplementary descriptive mean values resulting from the rate of repetitive behaviours across the Phases proved the significance of the acoustic intervention. Whereas both the Baseline A1 and Withdrawal A2 demonstrated an increment in the behaviour response when the testing was done in an acoustically unconditioned environment. ABD's consistent NAP data pairs percentage (100% - 92%) reflected the high importance of the acoustic intervention through the sound-absorbent wall panels.

Table 5.6: Descriptive Statistics for ABD Repetitive Behaviour Across Phases

Phase	Mean	SD	Range
Baseline A1	2.0	0.3	0.9
Intervention B	0.5	0.3	1.3
Return to Baseline A2	1.4	0.5	1.7

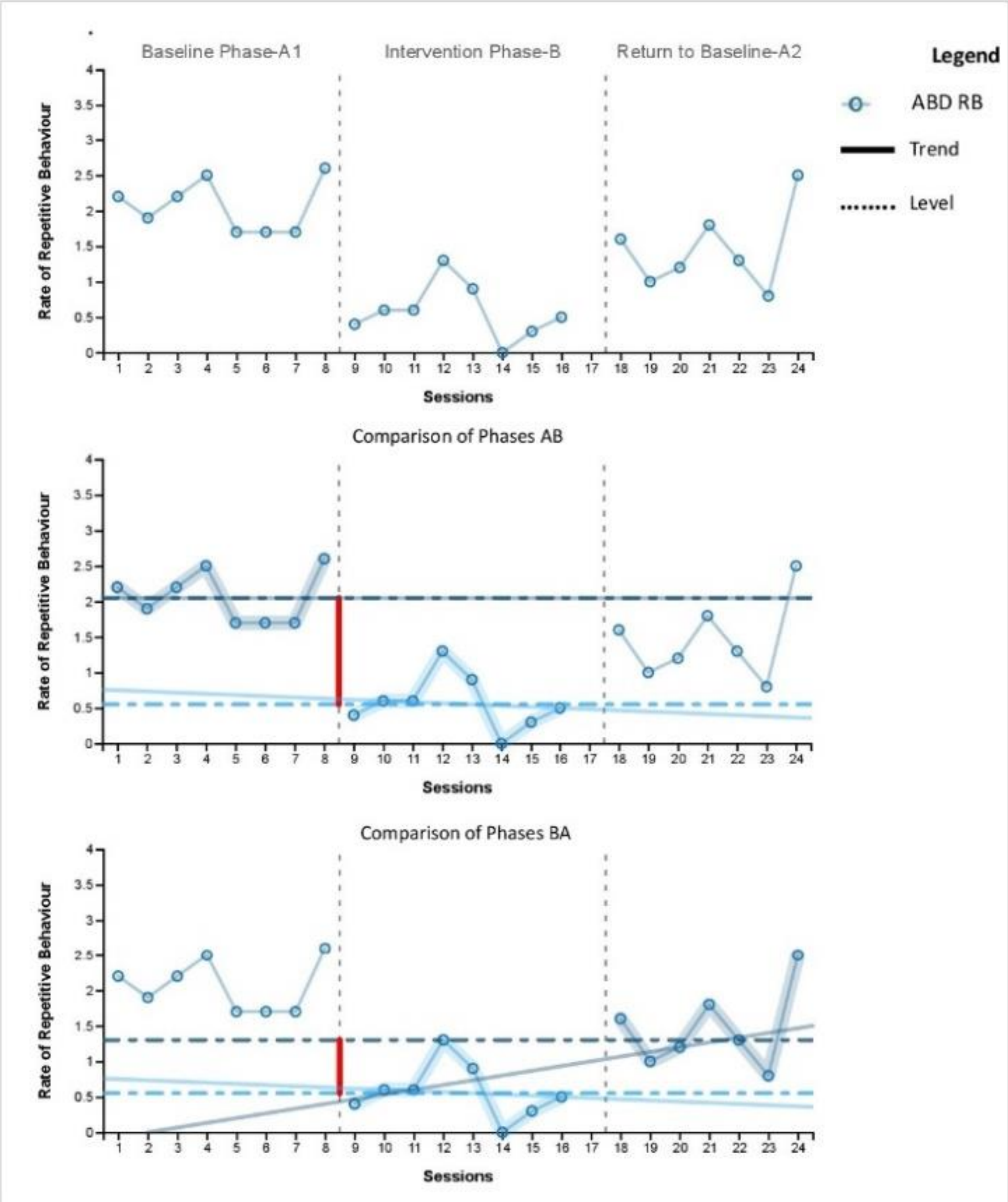


Figure 5.4: ABD- Rate of Repetitive Behaviour Across Phases

Participant IBT

Figure 5.5 is the visual representation of the participant IBT's results demonstrating the rate of the repetitive behaviour during Phases A1-B-A2.

Baseline Phase A1

IBT reflected the average rate of 1.6/min repetitive behaviour during observation session Phase A (Range 1.3, SD=0.4) at a high level of 1.60 and 0.18 accelerating trend. The conditioning depicted a stable data path without any outliers.

Intervention Phase B

During Phase B, IBT demonstrated an average rate of 0.9/min repetitive behaviour during the observation session (Range 1.7, SD = 0.2) and a low level of 0.80, shallow accelerating trend of 0.06. At the onset of Phase B, IBT maintained an initial decreased repetitive behaviour consistently with low variability between data points. The hypothesis test for IBT revealed a positive correlation in Phase B with a level change, a difference of -0.80, depicting a significant decrease from Phase A1. The mean value comparison between Phases A1 and B revealed a 44 % decrease in repetitive behaviour (Table 5.7). IBT demonstrated a 96% NAP comparison between Phases B and A1 first pairing data, marking a significant difference between data paths.

Return to Baseline A2

During Phase A2, IBT demonstrated the average rate of 1.4/min repetitive behaviour during an observation session (range 0.4, SD = 0.2) with a 1.50 Level and 0.07 accelerating trend. The +0.70 level change between Phases B and A2, with a delayed initial increase at the onset of the intervention withdrawal, was maintained consistently. The trend and level across A1 and A2 phases were consistent. The Phases B and A2 Withdrawal comparison mean values revealed a 55 % increase (Table 5.7) in repetitive behaviour, indicating a significant upsurge. The 97% NAP comparison data pairs between Phase B and A2 second pairing demonstrated higher than 93%, suggesting a substantial difference between data pairs.

IBT Repetitive Behaviour Concluding Remarks

For the participant IBT, Phase B reflects a positive hypothesis test correlation depicting the decrement mean value in repetitive behaviour, demonstrating the immediacy and relevance of the acoustic conditioning. The supplementary descriptive mean values findings of the rate of Repetitive Behaviours across Phase B proved the significance of the acoustic intervention in comparison with the Baseline A1 and Withdrawal A2 Phases acoustically unconditioned environment. IBT's NAP non-overlapping data pairs Percentage (96% - 97%) reflected the significant importance of the Intervention acoustic modification through sound-absorbent wall panels.

Table 5.7: Descriptive Statistics for IBT Repetitive Behaviour Across Phases

Phase	Mean	SD	Range
Baseline A1	1.6	0.4	1.3
Intervention B	0.9	0.2	0.7
Return to Baseline A2	1.4	0.2	0.4

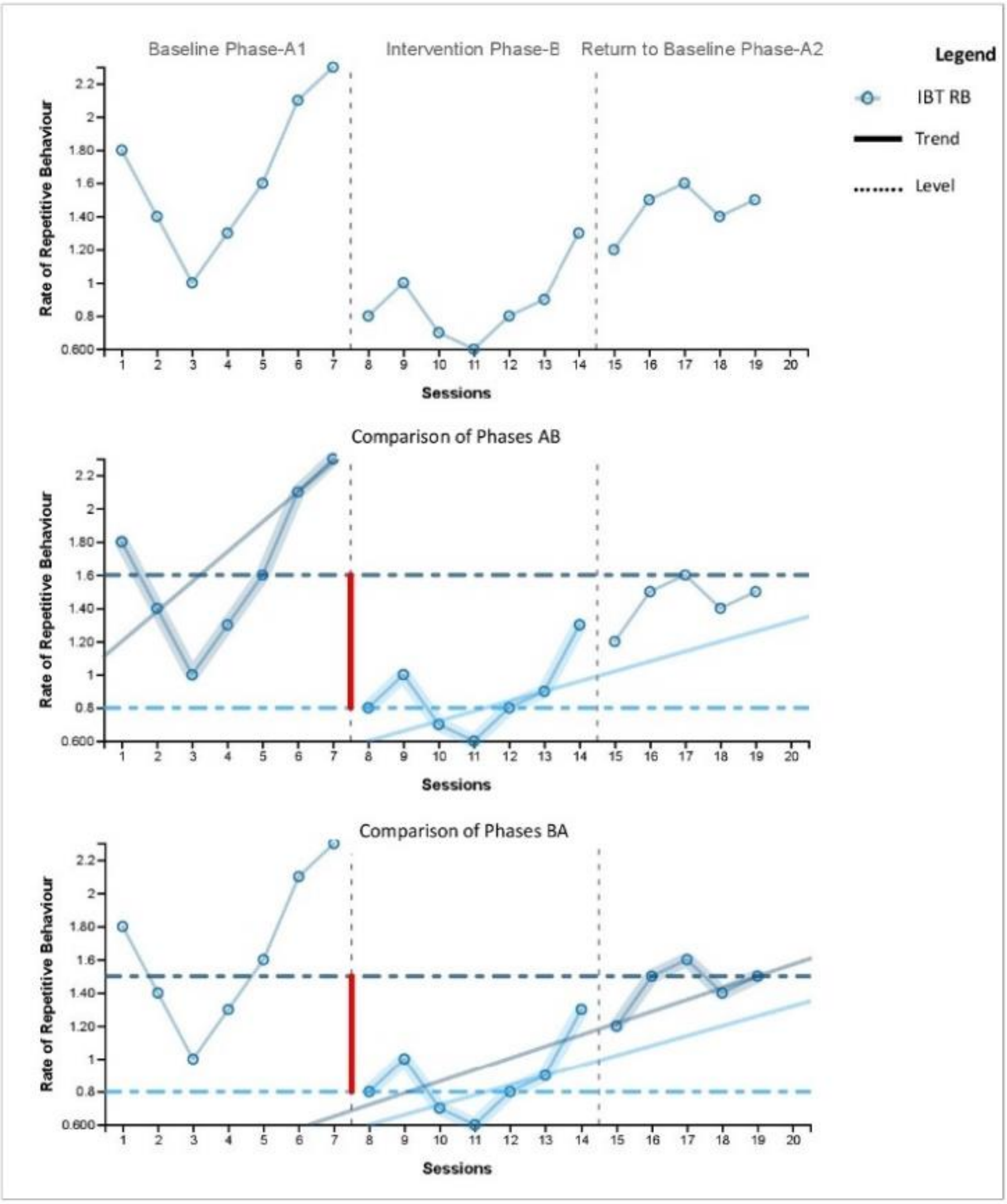


Figure 5.5: IBT- Rate of Repetitive Behaviour Across Phases

Participant MOH

Figure 5.6 represents the participant MOH's repetitive behaviour visual analysis of the hypothesis testing during Phases A1-B-A2 Baseline.

Baseline Phase A1

MOH reflected the average rate of 1.0/min repetitive behaviour during observer session Baseline Phase A1 (Range 1.1, SD=0.4) with a high level of 1.10 and 0.05 shallow accelerating trend. The conditioning depicted a stable data path without any outliers.

Intervention Phase B

During Phase B, MOH demonstrated an average rate of 0.4/min repetitive behaviour during the observation session (Rage 0.9, SD = 0.3) and a significantly low level of 0.50, decelerating trend (-0.17). At the onset of Phase B, overall MOH maintained a low variability between data points. The hypothesis test for MOH revealed a positive correlation in Phase B with the Level Change difference (-0.60), a significant decrease from Phase A1. The Trend Slope Angle reflected a decline of -13° (Baseline Phase A1 3° to -10° in Phase B).

The Tau-U (Baseline Trend Corrected) indicated 57% non-overlapping between Phases A1 and B. The Tau-U (Treatment Trend Corrected) 67% points non-overlapping between Phases. The Fully Corrected Tau-U adjustment indicated 53% Non-Overlapping points between Phases. The data suggests systemic change between Phases.

Return to Baseline A2

The hypothesis testing for MOH's return to Withdrawal Phase A2 reflected the average repetitive behaviour rate of 1.1/min during the observation Session (Range 0.2, SD=0.8) with 0.75 Level and a shallow decelerating trend of -0.07, an under-par direction with high variability which indicated a negative correlation. MOH did not maintain the initial increase between level change between Phases B and A2 (+0.25) reflected at the onset of the withdrawal and depicted high variability, yet maintained consistency across Baseline A1 and A2 Phase. The mean value comparisons between Phases B and A2 revealed a substantial increase (Table 5.8).

The data outcome for MOH, The Tau-U (Baseline Trend Corrected), indicated a 40%-point non-overlapping between Phases B and A2. The Tau-U (Treatment Trend Corrected) 28% points between Phases. The Tau-U (Fully Corrected)-indicated 27% non-Overlapping points between Phases. Deducing from the fully corrected Tau-U, the data outcome for MOH reflected no systemic change between Phases.

MOH Repetitive Behaviour Concluding Remarks

The data below for the participant MOH depicted unusual, idiosyncratic heterogeneous Trend. At the initial Intervention of Phase B acoustic treatment, a gradual stable positive correlation was evident. However, at Baseline A1 and Withdrawal A2 considerable increase in Levels of repetitive behaviours was evident. There remained parallel variability in Phase A2 through the Trend Slope angle, and the Levels across the A1 and A2 stayed consistent incrementally. The Supplementary Descriptive Mean Values Rate for repetitive behaviours also supported the conditioning effect.

Table 5.8: Descriptive Statistics for MOH repetitive behaviours Across Phases

Phase	Mean	SD	Range
Baseline A1	1.0	0.4	1.1
Intervention B	0.4	0.3	0.9
Return to Baseline A2	1.1	0.8	2.0

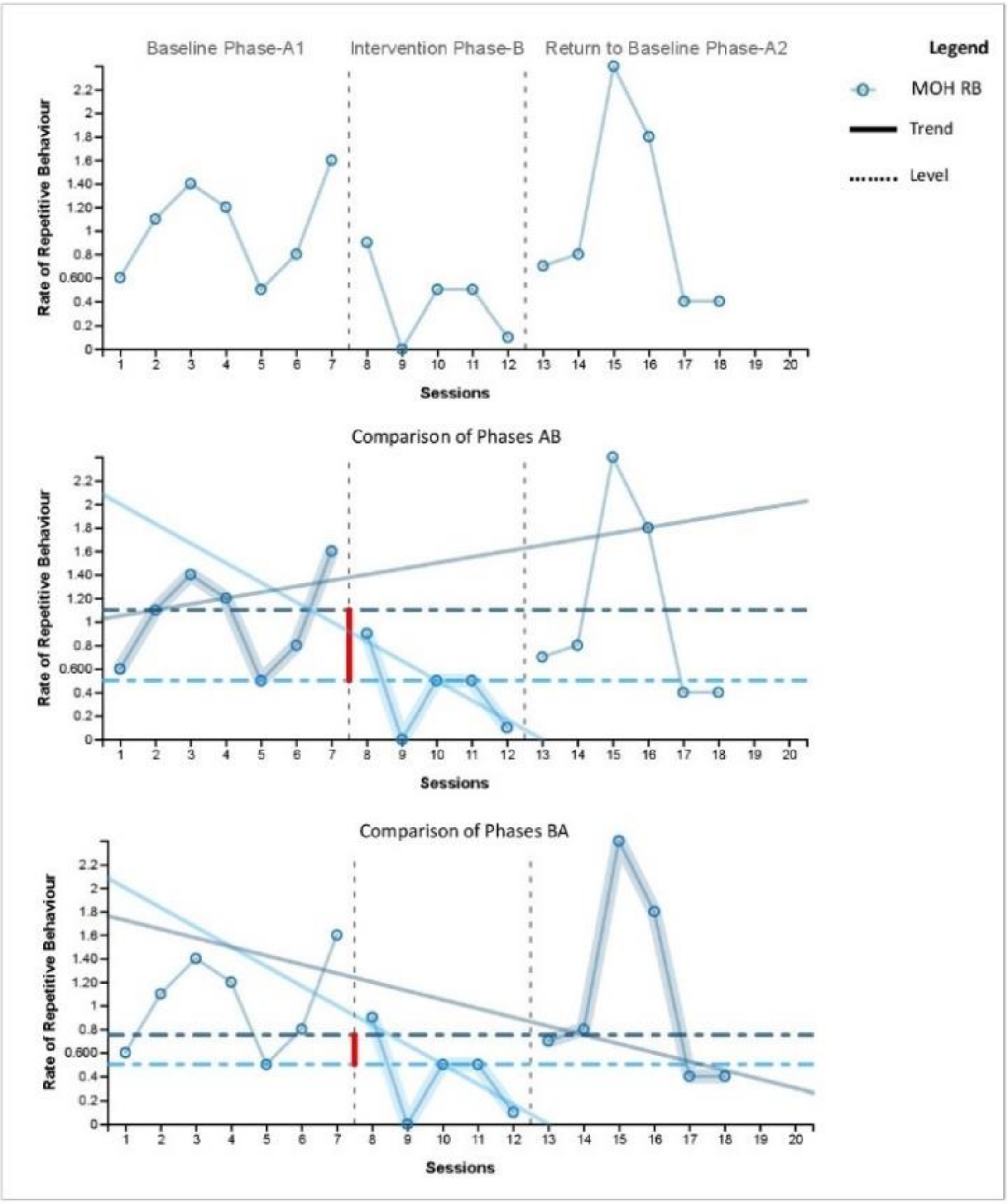


Figure 5.6: MOH- Rate of repetitive behaviour across Phases

Participant SHA

Figure 5.7 Demonstrates the participant SHA's hypothesis test outcome of the repetitive behaviour rate represented analytical visual representation during the Phases A1-B-A2.

Baseline Phase A1

SHA's repetitive behaviour during the Phase A test reflected a 0.9 average rate per/min during the observation session (Range 1.1, SD=0.4), a high level of 0.85 and a -0.04 shallow decelerating trend. The data path remained stable without any outliers during the condition.

Intervention Phase B

SHA demonstrated a repetitive behaviour of 0.2/min average rate during the observation session (Range 0.5, SD =0.1), a significantly low level of 0.15 and a shallow accelerating trend (-0.03) during Phase B with modulating sound-absorbent wall panels. The repetitive behaviour depicted a shallow initial decrease at the onset of the intervention, maintained consistently through the rest of the data points. The level change difference indicated a significant decrease (-0.70) between Phases A1 and B. The trend slope between Phase A1 to treatment in B reflected static. The descriptive mean value revealed a 77% decrease in repetitive behaviour from Phase A1 to B, indicating a significant decline (Figure 5.9).

The Tau-U (Baseline Trend Corrected) indicated 57% points non-overlapping between Phases B and A1, 72% non-overlapping (Treatment Trend Corrected), and 52% non-overlapping (Fully Corrected). The data suggests systemic change between Phases.

Return to Baseline A2

In Phase A2, SHA demonstrated the average rate of 0.9/min repetitive behaviour during the observation session (Range 1.9, SD=0.6) with 0.85 Level and -0.13 decelerating trend. A significant increase of +0.70 was observed at the outset of the change level from Phases B to A2. The observation reflected the maintaining of the trend through the first four data points and was followed by a downward trend suggesting high variability across the Phases A1 and A2 condition. The comparison of the mean values between Phases B and A2 condition transition revealed a significant increase in SHA's repetitive behaviour, indicating an upsurge (Table 5.9).

The trend slope angle Phases B to A2 reflected an increase of +5° (From -7° to -2°), depicting the Intervention data path as having a greater magnitude trend than the Baseline A2 path. The Tau-U (Baseline Trend Corrected) indicated 67% points non-overlapping between Phases B and A2, 42% non-overlapping (Treatment Trend Corrected), and 43% non-overlapping (Fully Corrected) points suggest a systemic change between Phases.

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SHA repetitive behaviour. Concluding Remarks

The participant SHA hypothesis test for the repetitive behaviour results depicted a positive correlation of the Phase B Intervention acoustic modulation with the sound-absorbent panel leading to a significant decrease compared with the Baseline A1 and A2. A considerable level of consistency was depicted in the Baseline Phases, and immediacy during phases B and A2 further increased confidence in the acoustic intervention effect. The results were attested by the Descriptive Mean Values supplementary across the A1-B-A2 Phases, demonstrating a positive effect of the Research Question.

Table 5.9: Descriptive Statistics for SHA Rate of repetitive behaviour Across Phases

Phase	Mean	SD	Range
Baseline A1	0.9	0.4	1.1
Intervention B	0.2	0.1	0.5
Return to Baseline A2	0.9	0.6	1.9

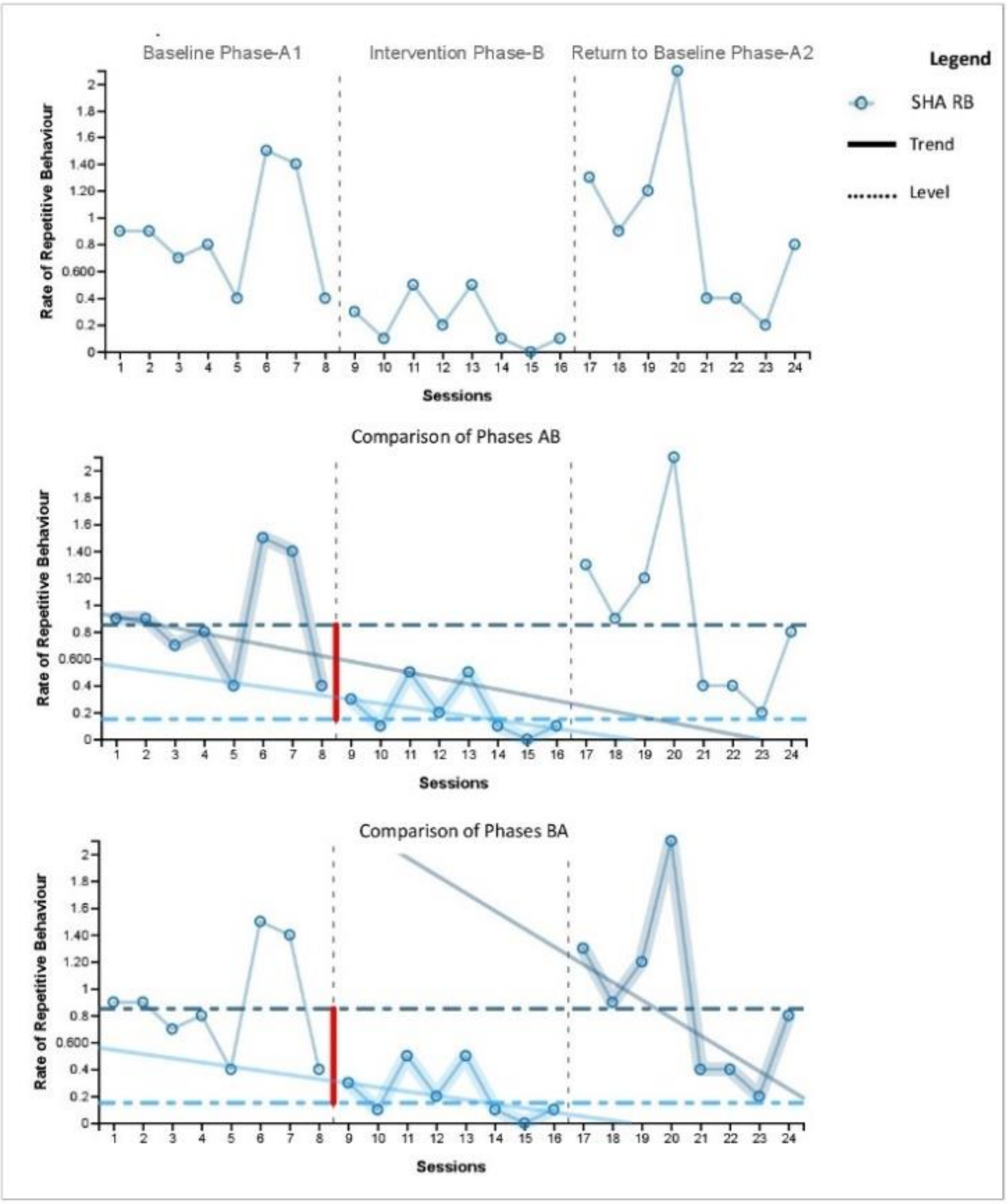

Figure 5.7: SHA- Rate of Rate of repetitive behaviour Across Phases

5.5.3 The Relationship Between Acoustic Parameters and Ear Covering Behaviour in children with ASD (in different classroom environments)

Participant ABD

Figure 5.8 demonstrates the rate of ear covering behaviour during Phases A1-B-A2 for Participant ABD.

Baseline Phase A1

During Baseline Phase A1, ear covering behaviour was demonstrated at an average rate of 0.2 /min during the observation session (Range 0.3, SD=0.1) with a level of 0.30 and a zero trend.

Intervention Phase B

During Phase B, ABD demonstrated ear-covering behaviour at an average rate of 0.1/min observation session (Range 0.2, SD = 0.1) with a visibly low level of 0.05 and a zero trend. The difference in level change between A1 and B indicates a significant decrease in the rate of ear-covering behaviour during the intervention condition. A significant initial decrease in ear covering behaviour was apparent at the onset of the intervention Phase B, which was fairly maintained even though low variability existed between data points; overall, a zero trend was observed. Comparison between Phases A1 and B shows a 50 % decrease in the mean value of ear covering behaviour (Table 5.10). Percent Non-Overlap of All Pairs (NAP) comparison between Phases B and A1 demonstrated 95% non-overlapping of all data pairs. The percentage of all non-overlapping data pairs of 95% or greater suggests a distinct difference between the two data paths.

Return to Baseline A2

During Phase A2, ABD demonstrated ear-covering behaviour at an average rate of 0.2/min during the observation session (range 0.6, SD = 0.2) with a level of 0.20 and a zero trend. Change in levels between Phases B and A2 (+0.15) with a low initial increase at the onset of the intervention withdrawal; this change was fairly consistent. Trend and level were consistent across Phases A1 and A2. Comparison between Phases B and A2 revealed a 50 % increase (Table 5.10) in mean value in-ear covering behaviour, a noticeable increase. NAP comparison between Phases B and A2 demonstrated 86% of non-overlapping of all data, which suggests a noticeable difference exists.

ABD Ear Covering Behaviour Concluding Remarks

Table 5.1 summarise the statistics for the rate of ear covering the behaviour of participant ABD; it shows acoustic intervention exhibits a significant improvement in reducing the rate of ear covering.

Table 5.10: Descriptive Statistics for ABD Rate of Ear Covering across phases

Phase	Mean	SD	Range
Baseline A1	0.2	0.1	0.3
Intervention B	0.1	0.1	0.2
Return to Baseline A2	0.2	0.2	0.6

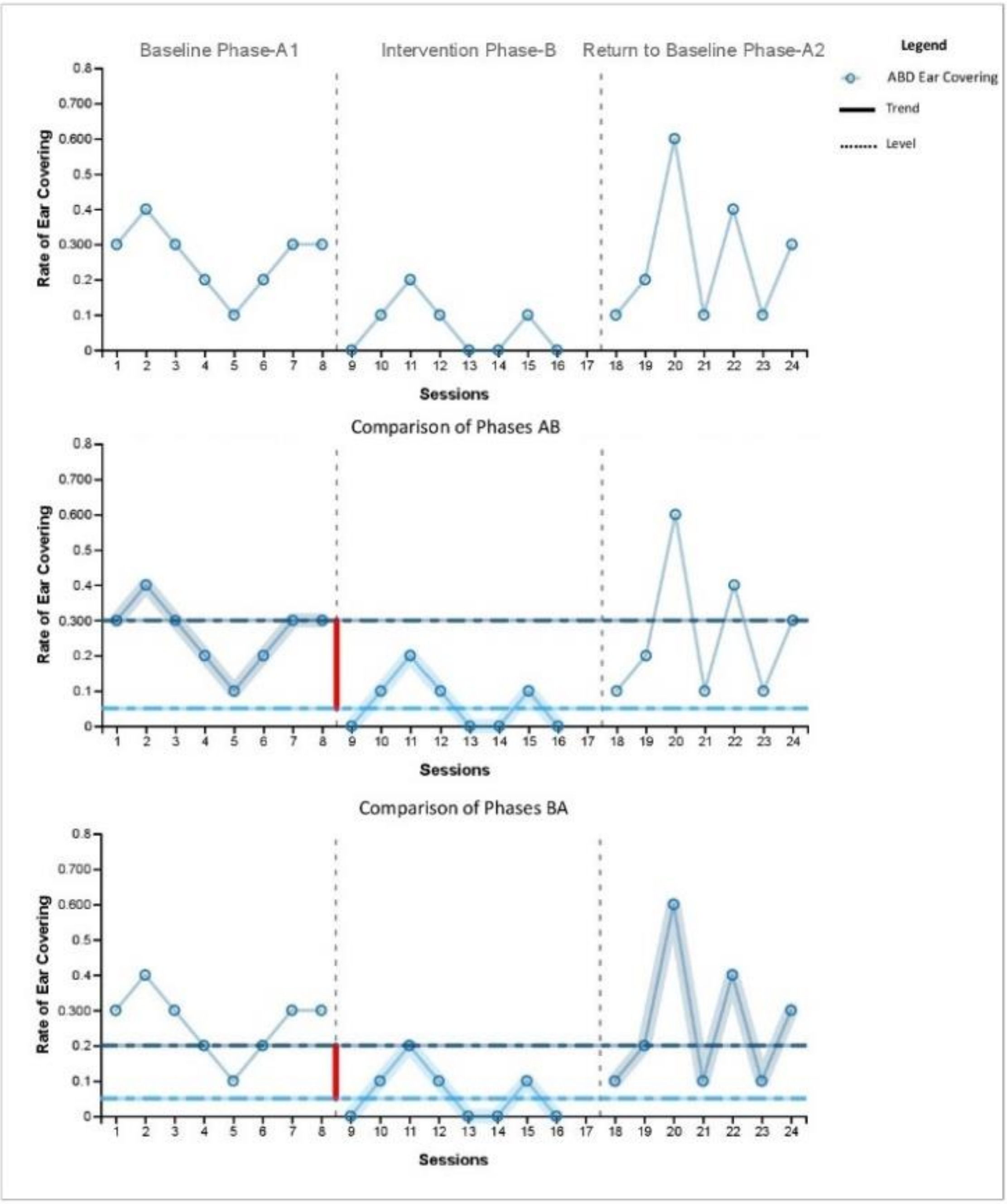

Figure 5.8: ABD- Rate of Ear Covering across phases

Participant IBT

Figure 5.9 represents the outcome of the participant IBT's rate of ear covering behaviour visually analysed impact of the acoustic modulation during the Phases A1-B-A2 Baseline, Intervention and Return to Baseline (withdrawal).

Baseline Phase A1

The participant IBT demonstrated an average rate of 0.3/min during the observation session Baseline Phase A1, with range (Range 0.5, SD = 0.2) and 0.20 Level and a 0.03 accelerating trend.

Intervention Phase B

During the intervention Phase B, IBT demonstrated ear covering behaviour of 0.17/min average rate during the observation session (Range 0.4, SD = 0.2) with a shallow 0.10 Level and (-0.05) decelerating trend. There was a demonstrated (0.10) level change difference between Phases A1and B, indicating a significant rate decrease in Phase B. At the Phase B onset, IBT showed a slight initial decrease during the first two data points, which, however, became more significant during the rest of the data points, with a visible decelerating trend maintained throughout. A 10% descriptive mean value was revealed in the Phases A1 and B comparison indicating a significant decrease in ear covering behaviour (Table 5.11). A 71% of NAP comparison was demonstrated between Phases B and A1, which shows a distinctive difference between the two data paths.

Return to Baseline A2

During the A2 Phase, IBT demonstrated an average rate of 0.2/min during the observation session of ear covering, which ranged (range 0.3, SD = 0.1) with 0.20 Level and 0.01 shallow accelerating trend. There was a +0.10 level change between Phases B and A2, with a low initial increase at Phase B, which was not consistent throughout the rest of the data points. The correlative variability factor was IBT's high absenteeism days and non-attending behaviours, attested by his 5-session presence during the A2 Phase. The data characteristics were consistent across the A1 and A2 Phases with a shallow accelerating trend (0.03-0.01), respectively, and a constant of 0.20 level for Baseline (A1) and withdrawal (A2) conditions. There was a 63% of NAP between Phases B and A2, which suggests a weak or no two-path difference.

IBT Ear Covering Behaviour Concluding Remarks

Table 5.11 summarises the tests on participant IBT; it shows a shallow impact of the Phase B acoustic intervention. Consistent results from Phases A1 and A2 increase the confidence in the minor impact of the acoustic. Further details will be discussed in the analyses section (section 5.6).

Table 5.11: Descriptive Statistics for IBT Rate of ear covering across phases

Phase	Mean	SD	Range
Baseline A1	0.3	0.2	0.5
Intervention B	0.17	0.2	0.4
Return to Baseline A2	0.2	0.1	0.3

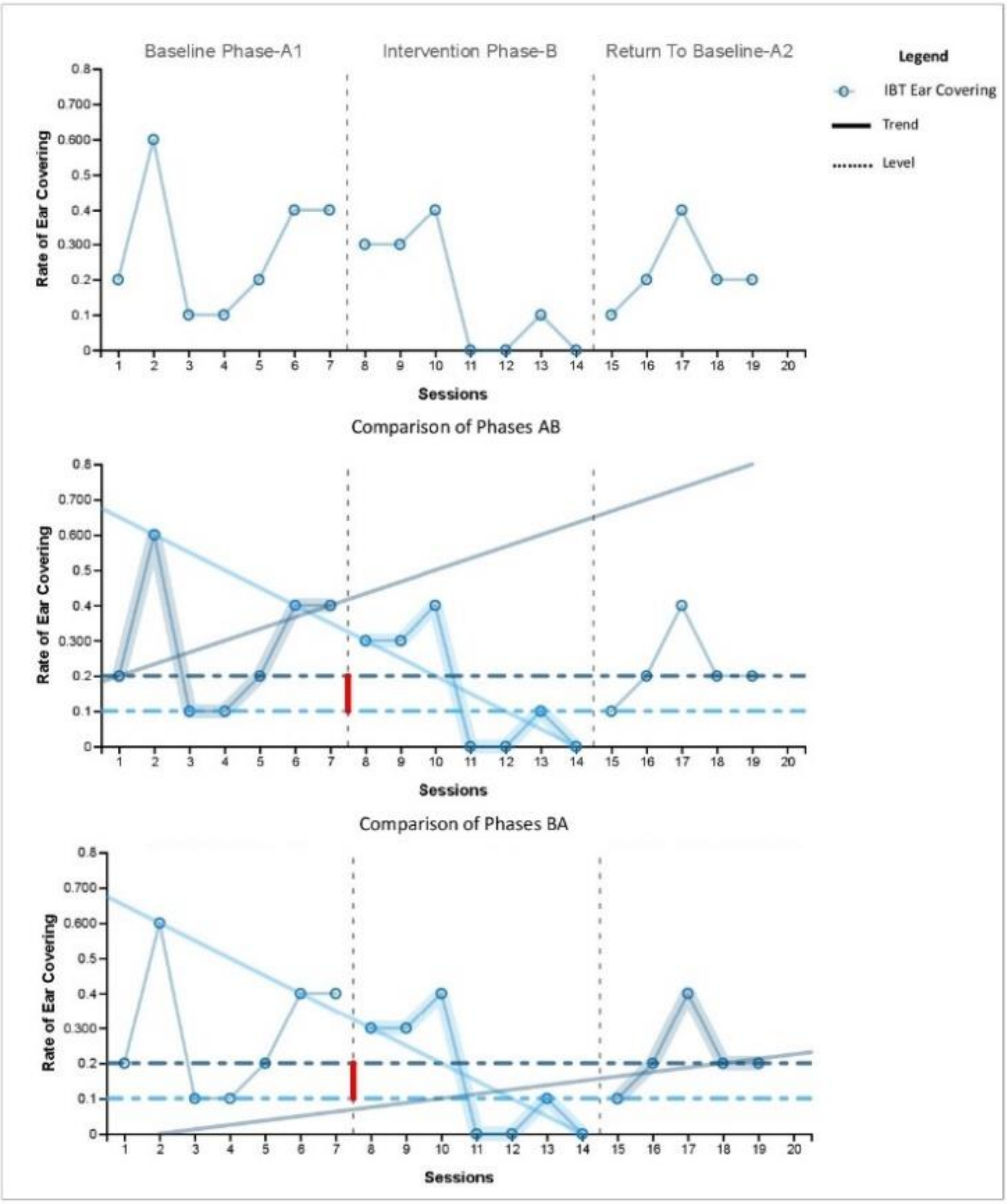

Figure 5.9: IBT- Rate of ear covering across phases

Participant MOH

Figure 5.10 shows the rate of ear covering behaviour during Phases A1-B-A2 for participant MOH.

Baseline Phase A1

MOH demonstrated ear covering behaviour at an average rate of 0.4/min during observation session Phase A1, with a range of 0.6 and standard deviation of 0.2), Level 0.30 and a zero trend.

Intervention Phase B

During Phase B, MOH demonstrated an average rate of 0.3/min of ear covering during the observation session with a range of 0.8 and a standard deviation of 0.3, the Level is 0.3 with an attested (-0.13) decelerating trend. No level change difference was evidenced between A1 and B; the effect is marginal. There was no ear-covering immediacy demonstrated at the onset of the Intervention Phase. However, a decreasing trend was consistent through the second and the following data points, indicating ear-covering behaviour decreased response. This variability was attributed to MOH's absenteeism days, and non-attending behaviour represented only during 5 sessions during Phase B. The descriptive mean values comparison between Phase A1 and B revealed a 10 % decrease, which indicates a minor decrease (Table 5.12). MOH demonstrated a 63% NAP between Phases A1 and B, which implies weak or no difference between the data paths.

Return to Baseline A2

MOH demonstrated an average rate of 0.5/min during the observation session in ear covering behaviour, ranging from 0.7 with a standard deviation of 0.2 and 0.45 Level and an accelerating trend (0.6). The level change (+0.15) between Phases B and A2 depicted an apparent increase at the onset of the withdrawal phase, consistently maintained through the rest of the data points. The data characteristics trends were 0.00 to 0.06 and Levels 0.30 to 0.45 from Phase A1 to A2. The 68% NAP between Phases B and A2 fell between the range of 66%-92%, suggesting a reasonable difference between the paths.

MOH Ear Covering Behaviour Concluding Remarks

Data on the participant MOH represents a less direct impact of the acoustic intervention due to 63 % NAP during the first pairing A1 and B, which implies a weak difference. A considerable consistency with regard to level across baseline Phases A1 ad A2 condition was observed. The results are tabulated in Table 5.12. Supplementary results of descriptive mean values for the rate of ear covering behaviour during Phases A1 and A2 without acoustic wall panels (0.4 and 0.5), respectively reflect an increase compared to phase B. This phenomenon will be discussed in detail later. Collective measures discussed above nevertheless suggest a shallow impact of the intervention on ear-covering behaviour for participant MOH.

Table 5.12: Descriptive Statistics for MOH Rate of ear covering across phase

Phase	Mean	SD	Range
Baseline A1	0.4	0.2	0.6
Intervention B	0.3	0.3	0.8
Return to Baseline A2	0.5	0.2	0.7

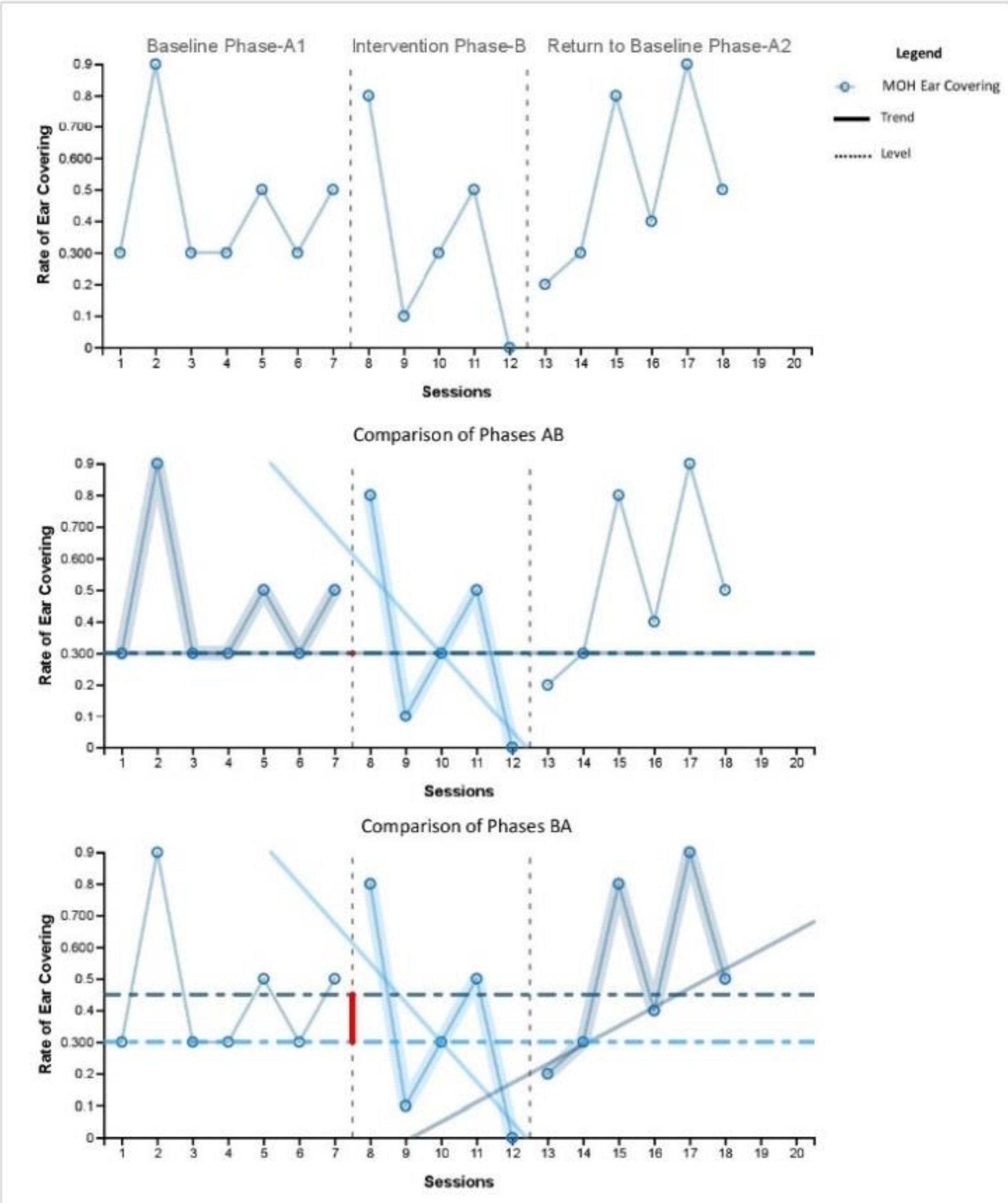

Figure 5.10: MOH- Rate of ear covering across phases

Participant SHA

Figure 5.11 demonstrates the rate of ear covering behaviour during Phases A1-B-A2 for Participant SHA.

Baseline Phase A1

SHA demonstrated an average rate of 0.3 of ear covering behaviour per observation session during Phase A1, Ranging from 0.1 with a standard deviation of 0.3, with 0.20 Level and low decelerating trend (-0.03).

Intervention Phase B

During the Intervention Phase, SHA demonstrated the ear covering behaviour average rate of 0.1/min during the observation sessions Ranging from 0.1 with a standard deviation of 0.4, a Level of 0.10 and decelerating trend (-0.01). The -0.01 level change between Phases A1 and B indicated a significant effect. At the onset of Phase B, SHA reflected a slight increase and a decreasing trend line slope through the rest of the data points with low variability, indicating a shallow decrease in ear-covering behaviour. The Descriptive Mean Value of 66% decrease in Phase A1 Baseline and Phase B Intervention indicated a shallow decrease (Table 5.13). The Tau-U (Baseline Trend Corrected) indicated 33% points non-overlapping between Phases A1and B, 48% non-overlapping (Treatment Trend Corrected) and 29% non-overlapping Tau-U (fully corrected) between Phases indicated there was no systemic change.

Return to Baseline A2

SHA demonstrated ear covering behaviour at an average rate of 0.2/min during the observation session in the Baseline A2 (Withdrawal) Phase, with a range of 0.4 and standard deviation of 0.1, the Level is 0.15 with a 0.04 accelerating trend. The change level of +0.05 between Phases B and A2 explains no initial increase at the outset of the Withdrawal condition and an apparent delayed increase consistent with low variability through the rest of the data points. The 50% descriptive mean values between Phases A1 and B indicated a shallow decrease in ear-covering behaviours (Table 5.13). The Tau-U (Baseline Trend Corrected) indicated 9 % points non-overlapping between Phases B and A2, 11 % non-overlapping (Treatment Trend Corrected) and 3% non-overlapping Tau-U (fully corrected) between Phases indicated there was no systemic change.

SHA Ear Covering Behaviour Concluding Remarks

SHA's test of the intervention upon ear covering behaviour reflected no overall systematic impact of the acoustic modulation. Although the supplementary descriptive mean values for the ear covering behaviour rate during Baseline A1 and A2 were respectively (0.3 and 0.2) reflected an increase over Phase B (0.1) (Table 5.12), evidencing a positive response. SHA's Tau-U fully corrected for A1 and B first pairing and A2 and B second pairing depicted no systemic changes in between Phases. This suggests no significant impact of the Intervention.

Table 5.13: Descriptive Statistics for SHA Rate of ear covering across phases

Phase	Mean	SD	Range
Baseline A1	0.3	0.2	0.5
Intervention B	0.1	0.3	0.1
Return to Baseline A2	0.2	0.1	0.4

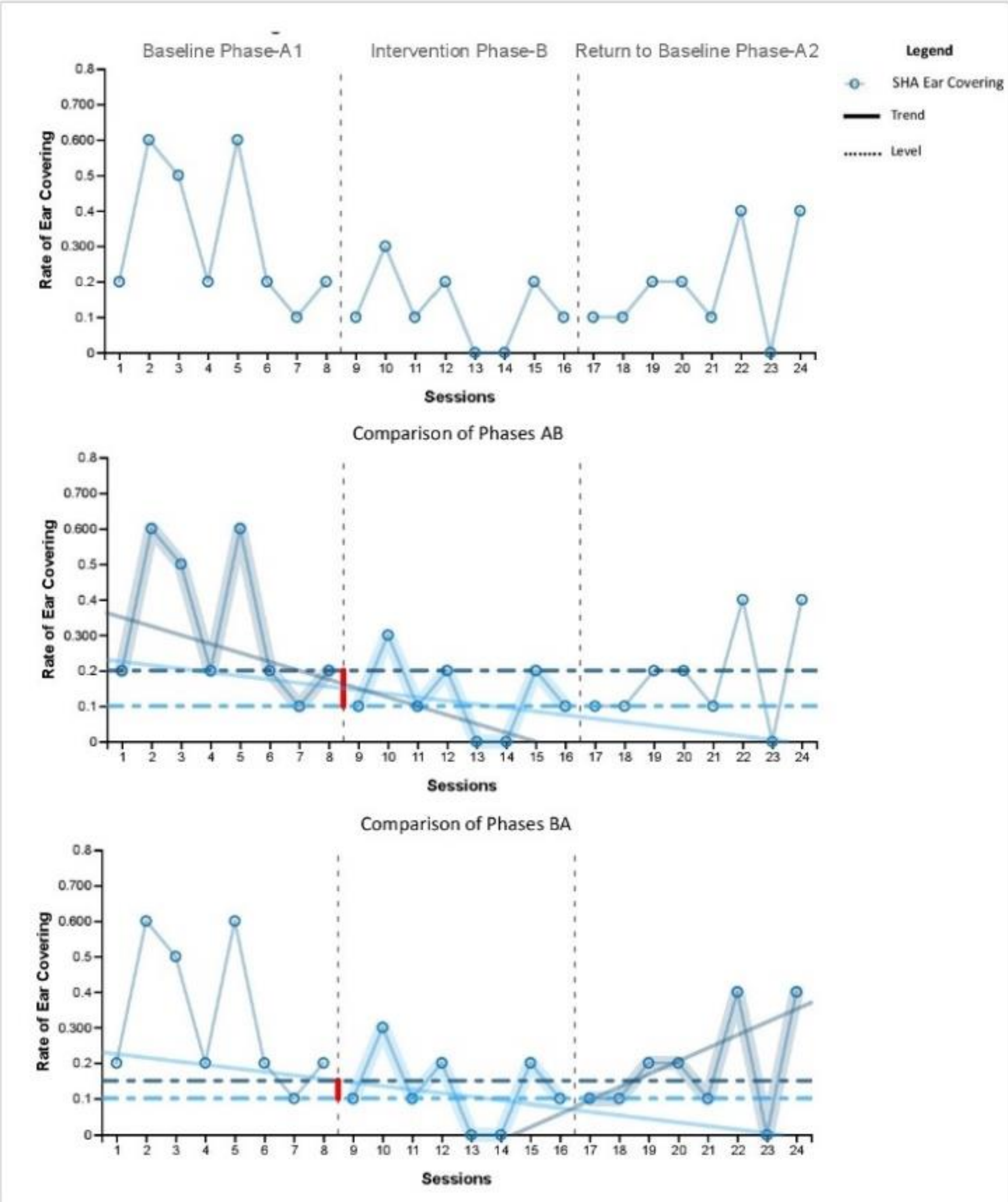

Figure 5.11: SHA- Rate of ear covering across phases

5.5.4 The relationship Between Acoustic Parameters and Loud Vocalising in children with ASD (in different classroom environments)

Participant IBT

Figure 5.12 demonstrates the analysis for the rate of loud vocalising behaviour during Phases A1-B-A2 for Participant IBT.

Baseline Phase A1

IBT reflected loud vocalising at an average rate of 1.3/min during the observation session Baseline phase A, ranging to 0.8 with a standard deviation of 0.3 and 1.10 high level and 0.08 accelerating trend. The data path was stable within Phase A condition.

Intervention Phase B/min

IBT reduced the loud vocalising behaviour to an average of 0.5/min during the observation session in the Intervention Phase. There was an apparent significant initial decrease in loud vocalising behaviour at the onset of Phase B, which was consistent. IBT showed a significant level change (-0.60) during the A1 to B conditions; the comparative descriptive mean values indicate a significant 61% decrease. The Tau-U (Baseline Trend Corrected) indicated 86% non-overlapping between phases. The Tau-U (Treatment Trend Corrected) indicated 67% non-overlapping between Phases. The Tau-U (Fully Corrected) indicated 64% non-overlapping between Phases. The data, therefore, suggested a positive correlation through systematic change between Phases.

Return to Baseline A2

IBT showed an average rate of 1.7 /min of loud vocalising during the observation session the Phase A2 (range of 1.2, SD = 0.5) with a 1.90 level and -0.28 decelerating trend. The Level change in Phase B to A2 condition shows an increase in the Withdrawal Phase (+1.40); however, it also indicates a shallow variability. The descriptive mean values revealed a significant increase in loud vocalising behaviour in Phase A2 compared to Phase B, indicating an upsurge (Table 5.14). The Tau-U (Baseline Trend Corrected) indicated 91% points non-overlapping between Phases B and A2, 66% non-overlapping (Treatment Trend Corrected), and 65% non-overlapping (Fully Corrected). This demonstrated IBT's loud vocalisation behaviour has positively changed between Phases.

IBT loud vocalising Concluding Remarks

The participant, IBT's loud vocalisation behaviour, demonstrated a positive correlation effect through the acoustic intervention (Phase B); this further shows the negative effect of the non-treatment condition at Phases A1 and A2. The supplementary descriptive means value also supported the significant loud vocalising behaviour improvement, and the non-overlapping data pairs of A1-B and B-A2 suggested an overall positive correlation for IBT's loud vocalisation behaviour (100% - 100%).

Table 5.14: Descriptive statistics for IBT Vocalising across Phases

Phase	Mean	SD	Range
Baseline A1	1.3	0.3	0.8
Intervention B	0.5	0.3	0.8
Return to Baseline A2	1.7	0.5	1.2

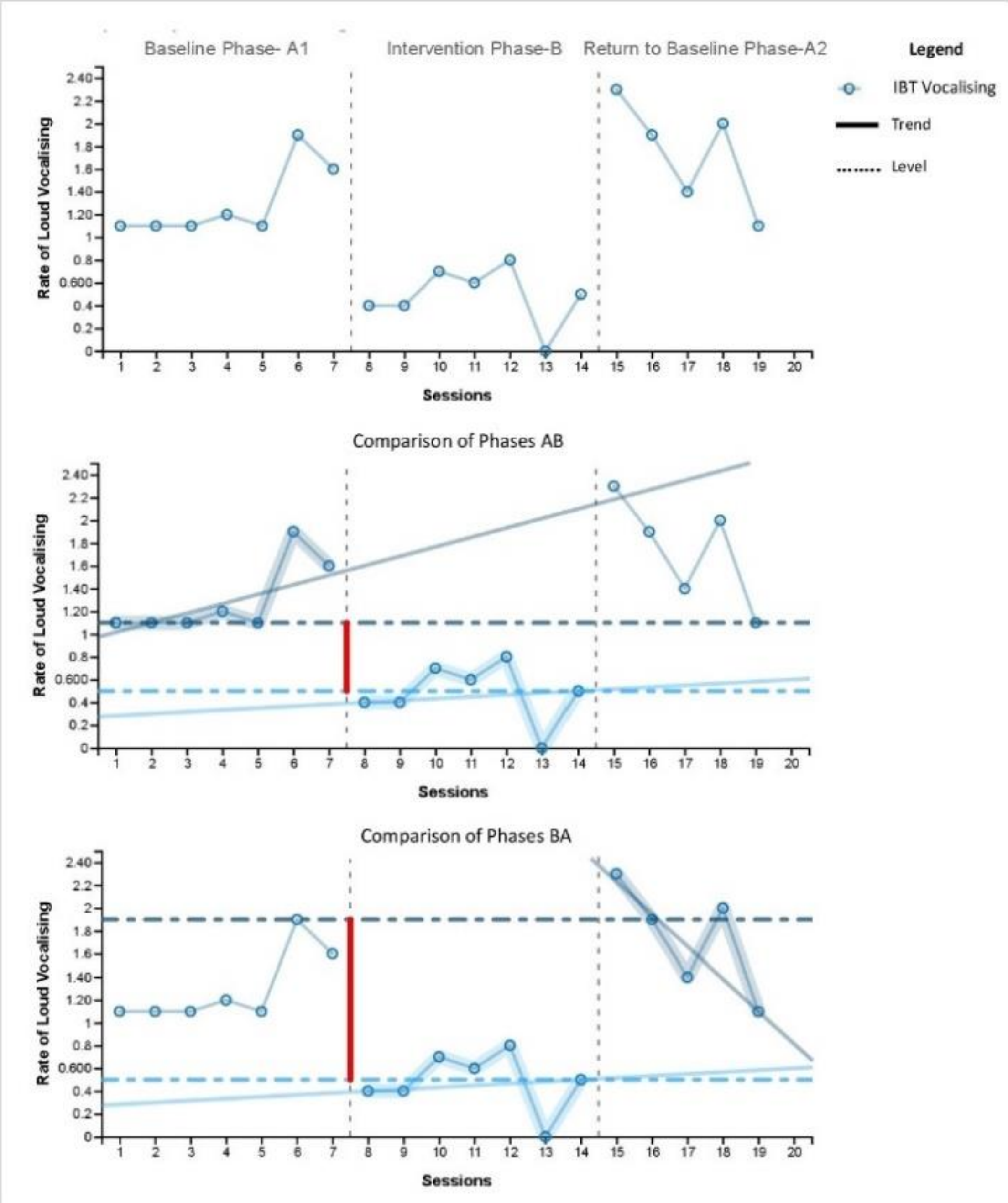

Figure 5.12: IBT- Rate of Vocalising across three phases

Participant SHA

Figure 5.13 shows the analysis for the rate of loud vocalising behaviour of participant SHA.

Baseline Phase A1

SHA exhibited loud vocalising behaviour at an average rate of 0.5/min during the observation session Baseline Phase (Range 1.1, SD=0.3) with a 0.45 high level and 0.07 accelerating trend. The data path was stable within this phase.

Intervention Phase B

SHA demonstrated loud vocalising behaviour at an average rate of 0.07 during Phase B (Range 0.08, SD = 0.2) and a 0.05 low level with a Zero-accelerating trend. At the onset of Phase B, a significant initial decrease in loud vocalising behaviour was observed. The level change difference (-0.40) was demonstrated between A1 and B, indicating a significant decrease during the intervention phase. A 86% decrease in descriptive mean values was revealed when comparing Phases A1 and B; this indicates a substantial decrease (Table 5.16). There was a 78% Tau-U (Baseline Trend Corrected) points non-overlapping between Phases A1 and B. The Tau-U (Treatment Trend Corrected) indicated 59% non-overlapping points between Phases. At the same time, the Tau-U (Fully Corrected) indicated 55% non-overlapping points between phases, which suggested a systemic change between Phases.

Return to Baseline A2

SHA demonstrated an average rate of 0.6/min per observation Phase A2 (Range 0.9, SD = 0.3) and a 0.55 level with a minimal -0.07 decelerating trend in the therapeutic direction. However, the (+0.50) immediate increase of level change between Phases B and A2 was not maintained. Across the A1 and A2 conditions, variability was visible in the trend slope, whose level remained consistent. The descriptive mean value demonstrated a significant increase in loud vocalisation behaviour when comparing Phases B and A2 (Table 5.16), which indicates an upsurge. The Tau-U (Baseline Trend Corrected) indicated a 78% points non-overlapping between Phases B and A2. The Tau-U (Treatment Trend Corrected) 76% non-overlapping points between Phases. The Tau-U (Fully Corrected) 65% non-overlapping points between Phases suggest a systemic change between Phases.

SHA loud vocalising Concluding Remarks

SHA's tests have shown that acoustic intervention has a positive impact on loud vocalisation behaviour. The consistency in the level across baseline phases A1 and A2 and immediacy during phases B and A2 have increased confidence in the acoustic intervention effect.

Table 5.15: Descriptive statistics for SHA Vocalising across Phases

Phase	Mean	SD	Range
Baseline A1	0.5	0.3	1.1
Intervention B	0.07	0.08	0.2
Return to Baseline A2	0.6	0.3	0.9

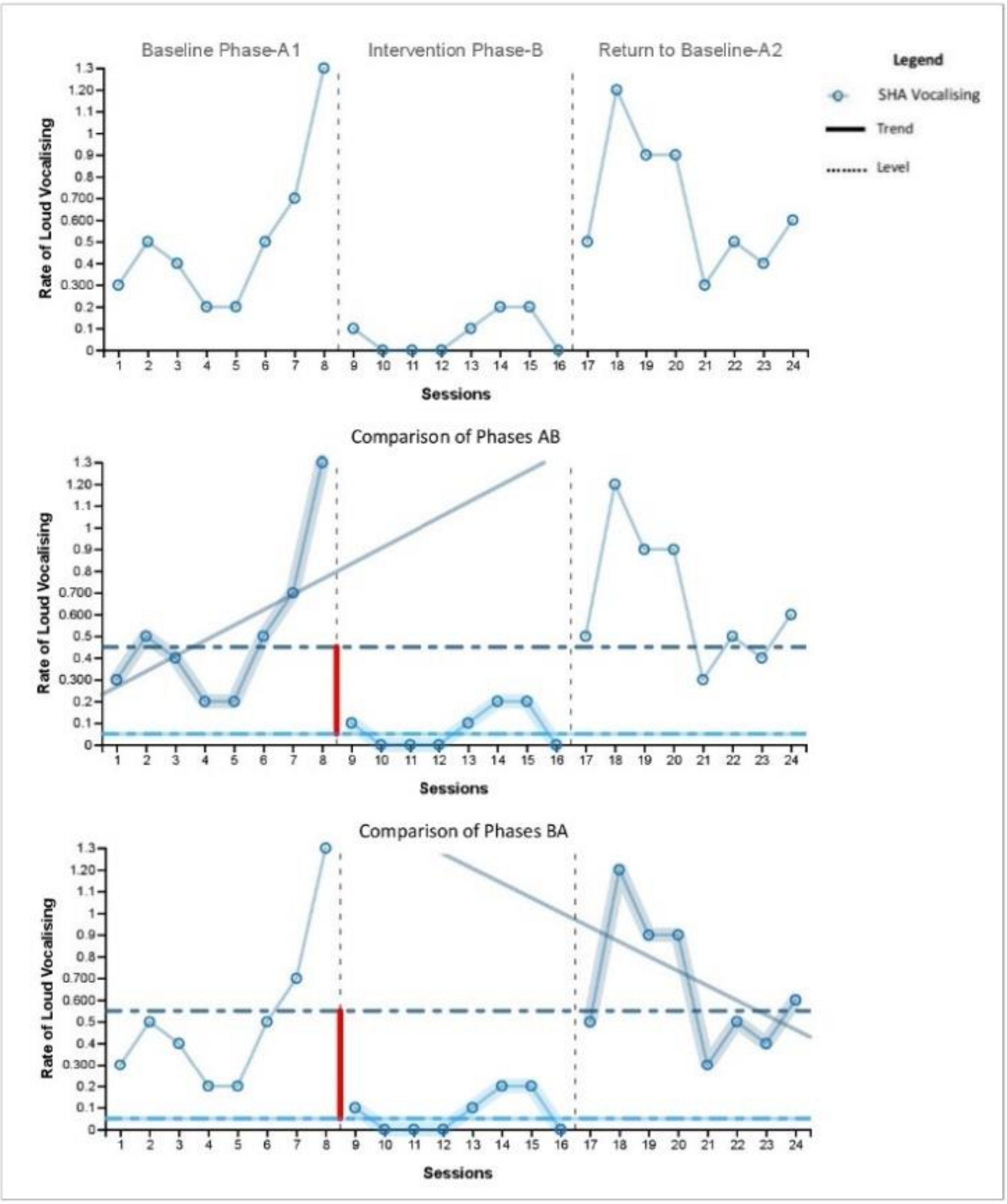

Figure 5.13: SHA-Rate of Vocalising across three phases

5.5.5 Inter-Subject Differential Results

Table 5.16: Inter-Subject Differential Statistics for Repetitive Behaviour

Participant	Descriptive Parameters						Statistical Parameters	
	Baseline A1		Intervention B		Return to Baseline A2		All Phases	
	Behaviour Frequency Mean	Level	Behaviour Frequency Mean	Level	Behaviour Frequency Mean	Level	NAP %	**TAU**
ABD	2.0	2.05	0.5	0.55	1.4	1.30	93	---
IBT	1.6	1.60	0.9	0.80	1.4	1.50	96	---
MOH	1.0	1.10	0.4	0.50	1.1	0.75	63	
SHA	0.9	0.85	0.2	0.15	0.9	0.85		The Tau-U (Fully Corrected) shows no systematic change

Table 5.17: Inter-Subject Differential Statistics for Ear Covering

Participant	Descriptive Parameters						Statistical Parameters	
	Baseline A1		Intervention B		Return to Baseline A2		All Phases	
	Behaviour Frequency Mean	Level	Behaviour Frequency Mean	Level	Behaviour Frequency Mean	Level	NAP %	**TAU**
ABD	0.2	0.30	0.1	0.05	0.2	0.20	95	---
IBT	0.3	0.20	0.17	0.10	0.2	0.20	71	---
MOH	0.4	0.30	0.3	0.30	0.5	0.45	---	Weak or no difference
SHA	0.3	0.20	0.1	0.10	0.2	0.15	---	The Tau-U (Fully Corrected) shows no systematic change

Table 5.18: Inter-Subject Differential Statistics for Loud Vocalising

Participant	Descriptive Parameters						Statistical Parameters	
	Baseline A1		Intervention B		Return to Baseline A2		All Phases	
	Behaviour Frequency Mean	Level	Behaviour Frequency Mean	Level	Behaviour Frequency Mean	Level	NAP %	TAU
IBT	1.3	1.10	0.5	0.50	1.7	1.90	---	The Tau-U (Fully Corrected) shows a Positive correlation through systematic change
SHA	0.5	0.45	0.07	0.05	0.6	0.55	---	The Tau-U (Fully Corrected) shows Systematic change

5.6 Discussion

Classroom noise/acoustics was the most significant factor for analysis in this chapter as it was demonstrated in the literature and further validated in Chapter 4 that acoustic environment led to stimuli processes input and sensitivities in children with ASD (Kanakri, 2017b, Howe and Stagg, 2016, Ashburner et al., 2008a, Kinnealey et al., 2012). The main focus of this Stage 2 Study was to examine the impact of long (1.11 sec) and short (.39sec) RT60 upon delineated sensory disruptive behaviours, ear covering, and repetitive and loud vocalising behaviours in children with ASD. The purpose of the research was not to align the acoustic standards and benchmarks but to examine the impact of the different acoustic conditions on sensory behaviour. The frequency rate of occurrence was calculated through the examination sessions using the Mangold Interac video system, which analyses the behaviour of children with ASD. Overall, the results of the study in this chapter are suggestive of a correlation between children's delineated sensory behaviours and the acoustic classroom environment with a positive response to the second research question. These preliminary findings are in congruence with seminal research that established noise/acoustics as a predominant sensory environmental factor which triggered sensory modulatory behaviour in children with ASD (Kanakri, 2017b, Howe and Stagg, 2016, Ashburner et al., 2008a, Van Kamp and Davies, 2013). The outcomes of the interrogation of the three sub-questions of the 2nd research question: What is the correlation between the classroom acoustical parameters, such as long and short RT60 and the LAeq and LA90, with delineated sensory disruptive behaviours in children with ASD?

Repetitive Behaviour

The first sub-question: investigating the correlation between the acoustic variable (RT60) and the four children's repetitive behaviour during the classroom condition in Phases A1-B-A2. Of the Four participants, Participant ABD's sensory outcome demonstrated consistent stability across all three markers. The visual analysis, NAP percentage, and the descriptive mean values interpretation indicated a significant positive impact of the Phase B acoustic intervention. Participant IBT and MOH data outcomes reflected an overall positive correlation but included considerable variability across all three markers. The Fourth participant, SHA, demonstrated consistent variability in the Baseline A1 and A2 Phases.

The acoustic conditioning in Phase B intervention, RT60 (.39s) and LAeq (64.08) and LA90 (52.15), indicated a positive correlation on the overall decrease of repetitive behaviour for all four participants during the tests. There was some variability observed, but in general, the non-overlapping percentage, levels and trends data and the descriptive means value demonstrated stability and consistency of decreased behaviours. In comparison to Phases A1 and A2, which maintained RT60 (1.11s) and LAeq (75.08) and LA90 (65.07), there were significant effects of increased repetitive behaviours for all four participants. This study, therefore, drew the deduction of the importance of classroom sensory conditioning through modulation as an important aspect for the reduction of repetitive behaviours. This was in concordance with other studies which had extensive studies testing the correlation between self-stimulatory behaviours such as rocking, flapping, jumping, moving back and forth, and ear-covering, which were triggered by the environmental stimuli (Kanakri et al., 2016, Kanakri, 2017b, Stiegler and Davis, 2010). In this study, repetitive behaviour reflected the most confident positive correlation response across all four participants. Moreover, it had the highest frequency of occurrence among the other two delineated behaviours.

Ear Covering Behaviour

The second sub-question (b) investigated if there existed a relationship between the acoustic variable (RT60) and the participating children's ear-covering behaviour in the classroom environment. Results for one participant ABD were indicative of a strong direct impact of acoustic intervention across all three markers visual analysis, NAP percentage and descriptive mean results; this reflects an overall decrease in ear covering behaviour. However, for the second and third participants, IBT and MOH results were partially positive. The results for the second participant IBT were indicative of a positive response only during the first comparison baseline phase and intervention phase; during the second comparison intervention phase and withdrawal phase, the data suggested that weak or no impact was observed with NAP 63% of all data pairs. For the participant, MOH, the results were indicative of a positive response only during the second comparison baseline phase (A2) and intervention phase. During the first comparison of intervention phase B and withdrawal phase A1, data were suggestive of weak or no impact with 63% NAP of all data pairs. Results for the fourth participant SHA show weak or no direct impact of the intervention on ear-covering behaviour. Although the visual analysis doesn't show much effect but based on supplementary descriptive mean values, the author feels that there might be some impact reliably present, which is demonstrated through a decrease in ear-covering behaviour during the intervention phase. All Four participants (N=4) data depicted variability of the ear-covering behaviour continuum during the overlap, trends, and levels. The descriptive mean values were stable and demonstrated a consistent decrease during the baseline conditions in comparison to the intervention condition for all four.

Overall, the results were promising among three (ABD, MOH and IBT) out of four participants, which is indicative of a significant positive correlation to the research sub-question (b): Does there exist a relationship between the acoustic Variable (RT60) and the ear covering behaviour in the participating children with ASD in the classroom environment? This deduction is consistent with the seminal experimental, observational research examining the effect of noise /acoustics on the frequency of ear-covering behaviour in children with ASD in noisy and quiet classrooms (Kanakri, 2014, Kanakri et al., 2016). These results are also consistent with important findings in the research, including evading and hiding from the source of noise emission and covering ears. The positive correlation results of ear covering behaviour through intervention conditions of RT60 (.39s) LAeq 64.08 and LA90 52.15 contrasted with the baseline Phases A1 and A2 RT60 (1.11s) with LAeq (75.08) and LA90 (65.07) substantively showed congruence(Stiegler and Davis, 2010, Kanakri, 2014).

Loud Vocalising Behaviour

This part deals with the research sub-question (C): Does there exist a relationship between the acoustic Variable (RT60) and the loud vocalising behaviour in children with ASD in the classroom environment? Find out the relationship between the acoustic parameter (RT60) and the Four children's loud vocalising behaviour during Phases A1- B -A2 in a classroom. The participant's IBT and SHA results showed that acoustic intervention has a strong impact across the three markers; visual analysis, NAP, and descriptive mean value all suggested an overall decrease in loud vocalising behaviour during Phase B. The participant's MOH and ABD outcomes were indeterminate due to their idiosyncratic trend findings. However, the positive impact of the acoustic intervention on loud vocalising behaviour evidenced in only two participants is still 50%. Therefore, it is still very useful than having none. One of the reasons for this outcome could be attributed to children's idiocentric heterogeneous behavioural responses, as no two children with ASD are similar (Association, 2013a, Gabriels and Hill, 2002). Findings are consistent with the effect of noise/ acoustics on children's frequency occurrence of repetitive vocalising behaviours (Kanakri et al., 2016).

Impact of Reverberation Time on Classroom Group Activity Average Noise Levels

The acoustic intervention resulted in the reduction of noise levels generated by children with ASD during group activity time; this was testified by decreased LAeq and LA90. The LAFmax and LAFmin levels significantly dropped (-11 dBA) and (-6 dBA), respectively. This implies that achieving lower classroom noise levels through sensory intervention had a calming effect on the children with ASD; this was evidenced by children's reduced self-noise generation. The maximum sound level LAFmax was significantly reduced by 11 dBA range (96.92 dBA to 85.33 dBA) with a standard deviation of 6 dBA during the group activity period. Similarly, a significant decrease in the minimum noise level LAFmin (47 dBA to 41 dBA) was reflected during the group activity (Table 5.5). The LAFmax decrease a correlational reduction in children's short instances of making a loud noise and behaviours, including possible meltdowns. This finding also conformed to the research indicators depicting the acoustic treatment effect on classroom activity LAeq and LA90 levels (Kristiansen et al., 2016).

5.7 Chapter Concluding Remarks

Chapter 5 represents the Stage 2 Study of this project which interrogates and examines noise/acoustics parameters identified in previous chapter 4 (Stage 1 Study) as one of the most critical stressors. The Single Case Experimental Design methodology was used to investigate the effects of the acoustic variable both empirically and observationally. This specifically entailed the collation of classroom environment acoustics data, in particular, the RT60 and its correlates LAeq and LA90 average noise levels. This requisite methodology entailed the three Phases approach, Baseline, Intervention, and Return to baseline, based on the Single Case Experimental Design A-B-A. The target behaviours of each participant (N=4) are: (1) repetitive stereotypic movements; (2) ear covering; and (3) loud vocalising under both existing conditions and the modulated intervention classroom environment.

The overall findings in this chapter show that the children with ASD (N=4) demonstrated trends affirming the significance of the acoustic intervention impact on delineated sensory behaviours, which were congruent with the other research that manipulated the classroom physical, auditory environment to affect behaviours (Kinnealey et al., 2012, Kanakri, 2017a). They significantly indicated a positive hypothesis correlation between the participants and their sensory responses to the classroom conditions. However, a delayed immediacy response evidenced in some participants' marked behaviours was an expected outcome which is common with the special population (Hammond and Gast, 2010). The variability factor in the sensory behavioural response to environmental conditions can be attributed to the heterogeneous nature of children with ASD (Association, 2013a, Gabriels and Hill, 2002). The study in this chapter further validated the significance of sensory design modification for the sensory behaviours amelioration in children with ASD through acoustic modulation conditions in the classroom. This outcome was largely positive and demonstrated the relevance of acoustic intervention for the sensory behaviour responses to the three identified and delineated behaviours. These findings are important for the bridging of the research intersecting at the next chapter, which examines the on-task behaviour for ASD participants under differential acoustic conditions.

6

CHAPTER 6: ON-TASK LEARNING AND CLASSROOM ACOUSTIC MODIFICATION

The findings from the previous chapter assert that the classroom noise/ acoustics directly correlated with some of the stereotypic behaviours and their modulation in children with ASD. This chapter tests the ramification of long and short RT60 and its related LAeq and LA90 upon the participants' (N=4) sustained attention on-task behaviour. This chapter focused on how the improved classroom acoustics affect 1:1 educational performativity in children with ASD through a closer teacher pedagogical conveyed instruction. This chapter employs the methodology of Single Case Experimental Design (SCED), of which the details have been discussed in Chapter 3 (Section 3.2.1).

6.1 Background

Chapter 2 has discussed the evidence that children with ASD experienced significant stresses in their educational setting, which affected their academic performativity. These stresses were attributed to children's auditory sensory processing dysfunctionality, which affected behavioural stimulus responses adversely to noise/acoustic levels in the classroom environment. However, only negligible empirical research was availed substantiating the interlinkages between classroom acoustical environment, children with ASD behaviour outcomes, and their academic on-task performance (Kanakri et al., 2016, Dargue et al., 2021). As such, this chapter is to testify to the research hypothesis: Does there exist a causal nexus between the acoustic Independent Variable (RT60) on the Dependent Variable (DV), the participating children with ASD On-task behaviour response in the Classroom Environment? In this chapter, three phases approach was taken, which has been explained in detail previously in chapter 3 (section 3.4.3).

6.1.1 Children with ASD, Sensory Responsiveness and Learning

Sensory response in children with ASD demonstrates that a significantly high proportion of the population (95%) diagnosed with ASD were confronted with sensory processing and modulation problems. Sensory processing affects an individual's entire array of cognitive-mental reception, modulation, integration, interpretation, and response to sensory information. Additionally, it affected their visual, auditory, proprioceptive, vestibular, tactile, and olfactory stimuli (Baker et al., 2008). The effect occurs in a range of severity, simultaneity, and hypertensive frequency through the auditory systems due to the sensory modulatory conditions and results in over-responsiveness to varying pitches or volume of sounds, specific sounds, or multiplicity of sounds as in public places or streets (Minshew and Hobson, 2008). A particular effect was significantly witnessed on the attention and learning aspects of children with ASD; their deemed avoidant behaviour is principally associated with hypersensitivity and linked to auditory stimuli (Ashburner et al., 2008a).

Children with ASD reflected idiosyncratic sensory processing which was related to over-reactivity, anxiety, and behavioural, emotive, and educational outcomes (Baker et al., 2008, Pfeiffer et al., 2005). The self-regulatory aspect was a fundamental consideration as it caused emotive and behavioural limitations, which severely curtailed and impeded cognitive ordering and engagement in children with ASD in the classroom(Eaves and Ho, 1997).

The above backdrop makes it important to consider the sensory responsiveness of children with ASD for the design of a conducive classroom learning environment. Although there is a lot of information about educational interventions for children with ASD in the classroom, there is little information about how to build supportive learning settings for them to work in (Martin, 2014). The majority of available research addressing the wellbeing and education of children with ASD in the classroom environment are either exploratory, qualitative or anecdotal accounts from caregivers and teachers. There is a severe lack of evidence-based studies on the interaction between children's atypical sensory responsiveness and their cognitive, behavioural, and educational outcomes in the classroom (Dargue et al., 2021, Ashburner et al., 2008a, Martin, 2014). This chapter is attentive towards this knowledge gap enquiring how the auditory sensitivities would be aided in assisting their attentiveness to their learning engagement On-task sustained span.

6.1.2 The Enabling Environment

The concept of the enabling environment stressed earlier in chapters 2 and 4 leads to the plausibility of creating a conducive classroom environment for children with ASD, which would assist their attentiveness, on-task engagement span in relation to their sensory dysfunctionality and disruptive behaviours (Rimland and Edelson, 1995). Research points out that it is essential to minimise distractions within the classroom to assist educators/trainers in increasing the focus and learnability of children with ASD. The environment that enables children with ASD to improve their on-task performance includes pedagogical considerations and physical environments (classroom setting), and sensory environments (James, 2010). It is apparent that children with learning difficulties need creative methodologies to cater towards their educational acquisition, such as TEACCH (Treatment and Education of Autistic and Related Communication Handicapped Children) and PECS (picture exchange communication system) (Mesibov, 2018). The Stage 3 Study (Chapter 6), point of departure, investigated the plausibility of an enabling pedagogical environment.

Pedagogical Environment

The consideration of unique pedagogical styles and methodologies employed to teach children with ASD is an important factor for classroom design modification to enable learning opportunities. TEACCH is a highly structured instruction methodology developed by Dr Eric Schopler, it draws upon the disciplines of psychology and neuropsychology to create learning activities and environments to support individuals with ASD. It is widely used in the United Kingdom, Japan, Sweden, and many more countries(Sasaki, 2000, Mesibov, 2018, Durnik et al., 2000). Its worldwide acceptability makes it an important intervention for children with ASD.

TEACCH autism program focuses on the individual person, their abilities, interests, and requirements recognising the "culture of autism" and spotting distinctions based on customised assessments. It focuses on visual structure, organisation and teaching. It allows structured instruction with closer proximity and enables minimal distraction in visual and auditory to create a conducive physical space for learning. It necessitates the organisation of the child's environment and activities such that learning can be maximised and frustrations can be avoided. Three factors are said to be significant in this regard: a conducive physical environment that caters to the particular needs of each kid. (e.g., reducing possible disturbances such as noise, visual, etc.), predictable activity arrangement (e.g., using visual schedules for classroom routines), and task and material organisation to facilitate independence (https://www.autismspeaks.org/).

Classroom pedagogy for children with ASD is seminal for this research as it empirically examines the factors of noise/ acoustics in the classroom environment to ameliorate learning behaviours. This vital aspect is largely unreferenced and under-investigated; thus, a lacuna exists in the study area, which underscores the importance of ASD diagnoses, classroom pedagogies, and classroom design for acoustics, including children with special needs and hearing impairment (James, 2010). This chapter is attentive to this important gap examining the co-relation of the pedagogical method 1:1 structured teaching approach and the declination of the RT60 and its correlates to test the hypothesis effect upon each child's engagement span upon On-task learning heterogeneously.

Classroom Acoustics and Refurbishments

For the testing of the hypothesis, the designated classroom environment was of immediate significance for investigating the correlated ramification of sound acoustic modulation intervention upon the ASD participants' (N=4) and plausible aiding of their performativity upon the on-task attention span. In this research, two intervention approaches were considered. The first involves improving the signal's delivery of the Signal to Noise Ratio (SNR), whereas the second entails intervention targeting the reduction of noise. The FMS (frequency modulation system) and SFA (Sound field amplification system) technology, as discussed in Chapter 2 (section 2.3.3), could be used to improve poor classroom acoustics by amplifying sounds to improve the SNR. However, this research selected the second approach, i.e. noise reduction intervention which ought to correspond with the structured teaching pedagogy employed in the classroom(James, 2010). This research, therefore, undertook the appropriate classroom acoustics modification earmarking the echo and noise levels reduction, which was aided by the strategic placement of sound-absorbent wall panels (Dockrell and Shield, 2006, 2015). These sound absorbent wall panels were designed with the help of a sound engineer, using locally sourced materials customized and improvised through modification, which enhanced the classroom acoustical environment through the transformative and efficacious mode of treatment. The testing of the transformation achieved through sound absorbent wall panelling installation reflected a significant impact on the classroom (RT60) and average noise levels LAeq and LA90 levels discussed in detail in the results section in the previous chapter (section 5.5.1).

6.2 Research Questions and Objectives

The aim of this chapter is to investigate the correlation between classroom acoustical environment and on-task behaviour performativity of children with ASD. It is to answer the research question: ***Does there exist a causal nexus between the acoustic parameters (RT60) on the on-task behaviour response of children with ASD in the classroom environment?*** In particular, what is the correlation between the classroom long and short RT60 and the related LAeq and LA90 upon the participating children's on-task behaviour marked by percentage time of on-task engagement?

Objectives

a) To examine the correlation between the prevailing unconditioned classroom RT60 (Tmf 1.11s) and correlates (LAeq) and LA90 average noise levels upon each individual participating ASD Child's targeted on-task behaviour through A1-B-A2 Phases approach.
b) To examine the ramification of the classroom sensory condition, an acoustically modified enabling environment, upon each individual participating ASD child's (N=4) targeted on-task-behaviour.

Hypothesis

The central hypothesis of this chapter is that the on-task behaviour performance of children with ASD would be improved in a modified classroom environment with shorter RT60 and reduced LAeq and LA90 levels.

Significance

This chapter identifies, examines, and concludes the research gap that a viably sensory-designed classroom is essential for positive ramifications on participating children (N=4) with ASD to sustain on-task engagement. Through identifying the knowledge gap, the research enables systematic and discursive enquiry, which plausibly aided through classroom intervention procedures the attenuation of children's sensory behaviours, wellbeing, and educational performativity.

6.3 Methodology

The methodology of this chapter is built upon Chapter 4, of which the qualitative methods validate the primary hypothesis that the classroom sensory environment noise/acoustics was of major significance. This chapter also lent upon the previous chapter, which investigates and tests the critical hypothesis. The difference between this chapter 6 (Stage 3 Study) and chapter 5 (Stage 2 Study) is the data collection procedure, dependent variable and observable activity setting of the research. Overall the research method is the same in both the Stage 2 and Stage 3 studies grounded upon the (SCED) methodology, whose crux was the investigation of the single subject as a unit of analysis aided by the intervention of three-phased A-B-A research, discussed in Chapter 3 Methodology (Section 3.4.1).

The procedural methodology involved for the acoustics is discussed in Methodology Chapter 3 (Section 3.9.2) and represented below in Fig 6.1.

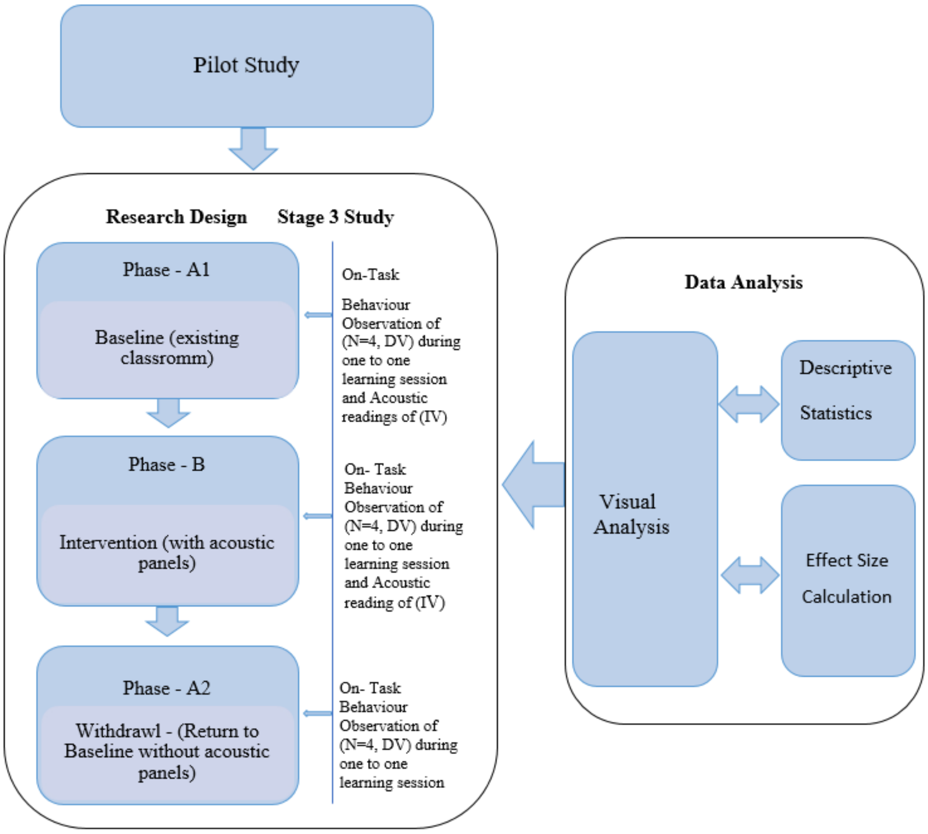

Figure 6.1: Stage 3 Study Inquiry Road Map

6.4 Data Collection

Behaviour data was collected for each ASD student (N=4) for two weeks per phase. The On-Task behavioural data was monitored and recorded within the duration of time the ASD student remained engaged on-task. The observations of the specific On-task behaviour were coded during the 10-minute sessions over the period of 4 weekdays, excluding Friday, Saturday and Sunday. The Stage 3 Study of this chapter involved approximately 5 to 8 sessions per student, depending on any absentees, over two weeks per phase across A1-B-A2 Phases. On-task and off-task behaviours were demarcated mutually exclusively through the coding schematics within the Interact Mangold software. Only the on-task behaviour engagement data was reported.

1:1 on-task activity time was focused on structured activities based on following directions, sorting, matching, sequencing, puzzles, object labelling, and letter and number tasks. They were based on an individual treatment plan, educational goals, deficits and needs, strengths and interests of the child with ASD. Activities were compartmentalized and stacked vertically in a pull-out tray table with a colour-coded visual cue corresponding to the visual schedule available to the child with ASD. The visual activity schedule available to the child provided clarity, independence, predictability and visual order of task events to be followed.

The child first enters the designated blue or green cubicle and settles in the chair, and follows the teacher's directives. He then picks the first colour-coded shape from the visual schedule and matches it to the corresponding pull-out tray in the table (see Fig:3.3). In the second step, he pulls out the tray after matching and places it on the study table to start the activity which is visually presented. Once the activity is finished, he places the activity back in the tray and hands it over to the teacher. In this sequence, the student completes five activities presented to him.

Independent Variable (IV) for Stage 3 Study

Reverberation Time (RT60) and its derivatives, the Equal Sound Pressure Levels (LAeq) and LA90, were designated as the key Independent Variable (IV) for Study 3, which is discussed in depth in Chapter 3 Methodology (Section 3.4.6.). For Study 3, the Dependent Variable (DV) was the On-task behaviour of children with ASD. Each participant, as a single unit of analysis, was observed in the topography, which measured the targeted performance.

Dependent Variable (DV) for Stage 3 Study

The correlation between the Variable (DV) and the children's targeted On-task behaviour was tested with the Acoustics Independent Variable (IV) Reverberation Time. The Topography of each participating children's (N=4) On-Task behaviour; engaged with the task material as directed, looking at the teacher and following directives. Simultaneously, Off-task behaviour was reflected by lack of engagement with the provided on-task material, fidgeting, stimming behaviours, hitting, making noise, not following instructions, task-disengagement and leaving or shifting away from the designated work area or seat, distractions or staring in space. Committee on Educational Interventions for Children with Autism (2001) National Research Council (2001) This defined their vital engagement in their ability to sustain attentiveness upon an activity, recognised as a key component in learning of children with ASD. For the participants, the on-task and off-task distinction were maintained as per the individual's engagement with the attentive span moments, whose ultimate purpose was to calculate the percentage of on-task attention span time demonstratively.

Behaviour Observation and Measurement Procedure

Observations were carried out during one-to-one on-task sessions, of which the first 10 min of the session coding-maintained time-consistent for IBT, MOH and SHA. For the fourth child, ABD's observation sessions were kept at a 5 min duration due to his inability to attend the session for a longer time duration and make the session conducive for him. Each observation session was divided into 15-sec intervals for time sampling. These mutually exclusive on-task and off-task behaviours were coded at the end of each 15-sec interval for IBT, MOH and SHA. ABD's shorter observation sessions were divided into 10-sec intervals. The percentage number was achieved by dividing the total of on-task intervals by the complete total number of intervals and multiplying by 100%. For example, a child's 15 intervals out of 30 in 5-minute sessions were calculated by dividing the intervals [15/ 30 X 100%], resulting in 50% of the time.

Table 6.1: Stage 3 Study - Dependent Variable Operational Construct

Participants	Behavioural Variable	Behavioural Topography
ABD	On-Task	Engaged with the task material as directed, looking at the teacher and following directives.
IBT	On-Task	
MOH	On-Task	
SHA	On-Task	

The delineated behaviour explicated above was codified schematically in order to allow the empirical data symbolic representation and for analytical purposes using the Interact Mangold Software, which allowed very close representation and paralleling of behaviours.

Table 6.2: Behaviour Coding Scheme and Measurement Procedure

Behaviour	Symbol	Measurement procedure / Behaviour dimension
On-Task Behaviour	OT	Time Sampling /Percentage over time duration

6.4.1 Procedure

The University of Sheffield, U.K., granted the Procedural Ethical Approval for the Stage 3 Study Intervention Research to the Ethics Review Board prior to this study. The Oasis School principal administrator assisted the researcher in obtaining the informed and signatory parental consent of the participants. This three-phased study took place over a period of six weeks, of which each phase will be explained below:

Baseline Data Collection Phase A1

During the baseline data collection phase, Phase A, the classroom activities and routines were maintained to the daily levels of normality to reduce the emergence and impact of any confounding factors. The Study's observational aspects were carried out every day at a specific designated time within the 1:1 ratio structured learning session, which minimised the Teacher's verbal and classroom instructions. All on-task and off-task engagements of individual children were observed and collated as the participants worked on the curriculum. The Data recording assisted in establishing a suitable stable baseline condition within the time frame.

Intervention Phase B

In Phase B, the acoustical intervention was induced through the installation of sound-absorbent wall panels to create the acoustical-conditioned classroom. This Intervention was the key aspect which necessitated the reduction of the RT60 from 1.11 sec to 0.39 sec, the LAeq and the LA90 noise levels in the classroom environment. After the installation, children's behaviours were recorded and observed for two weeks, excluding Friday, Saturday and Sunday cumulatively for 8 school days. The daily classroom routines were undisturbed to implement and facilitate the intervention phase.

Return to Baseline (withdrawal) Phase A2

The Baseline Return (A2) Phase involved the acoustical intervention absorbent panels' removal, induced in Phase (B). During this Withdrawal Phase, all daily classroom routines were kept to levels of normality throughout the Phase. Children's on-task behaviours were recorded and observed for two consecutive weeks.

6.5 Data Analysis

The data for this exercise was systematically analysed through visual analysis, discussed in detail in the previous chapter (Sec 5.4.3). For each respective phase, descriptive statistics were generated as supplementary information allowing the differentiation of the data and its comparability across the phases. The significant effect size measure based upon the NAP of all pair's percentage points enabled the comparisons to depict the relevance and projection of visual data, which was explicated in detail in Methodology Chapter 3 Section (3.4.5).

6.5.1 Procedural Fidelity

The Study underscored the acute heterogeneity of the participant children with ASD and its unforeseen consequence on the research. One evident impact was manifested by the participant's absenteeism and non-attending behaviour, which therefore limited the consistency of the number of sessions, sequence and session duration for some students affecting projected results and findings of the study. The following table 6.3 shows the procedural fidelity in implanting the current research.

Table 6.3: Stage III Study - Procedural Fidelity

Participant	Fidelity %	Explanation
ABD	100%	No absentees; all 24 sessions attended
IBT	75%	Absent 8 sessions, attended 18 out of 24 sessions
MOH	91%	Absent 2 sessions, attended 22 out of 24 sessions
SHA	95%	Absent 1 session, attended 23 out of 24 sessions

6.5.2 Reliability and Social Validity

The Study's inter-observational reliability and social validity measures were rigorously implemented, discussed in detail in Chapter 3 Methodology in the Experimental Control Section (3.4.7).

6.6 Results

This chapter investigated the relationship between acoustic classroom environment and sustained on-task engagement behaviour of children with ASD through a three-phased (A1-B-A2) approach. The hypothesis tested is that the appropriately conditioned and designed classroom with the RT60 declination from Tmf 1.11s to 0.39s would lead to a positive impact on the individual participant's on-task engagement behaviour.

6.6.1 Effects of Acoustic Refurbishment on Classroom Sensory Condition

The existing literature evidenced that most classroom architecture models were heuristically and anecdotally designed despite studies establishing that appropriately sensory-designed interior décor was highly important for the wellbeing and education of children with ASD (Martin, 2014). The study in this chapter, based upon these indicators, apprehended the empirical investigation of the noise/acoustics based on the RT60 and its related LAeq and LA90, validating their positive impact on the on-task behaviours of children with ASD.

The RT60 of the classroom before acoustic intervention was significantly higher than the BB93 standard (Tmf=1.11s versus less or equal to 0.4s); the classroom was later refurbished to reduce the level of Tmf=0.39s, a significant improvement. Table 5.4 in chapter 5 represents the RT60 distribution frequency (Hz) measurements under differential conditions before and after the modification. The recorded (Tmf) for classroom RT60 prior to the acoustical sensory design refurbishments was 1.11s, which was then dropped to 0.39s after the refurbishment. The intervention subsequently affirmed the reduction of classroom acoustical parameters LAeq and LA90 levels consistent with existing research (Shield et al., 2015). This finding emphasised the positive acoustical treatment impact on the classroom sensory environment for optimising the learning engagement of children with ASD (Kinnealey et al., 2012).

6.6.2 Acoustical Parameters and Refurbishment Effect On On-Task Behaviour

Participant ABD

Figure 6.1 demonstrates the percent time on-task for participant ABD during A1-B-A2 Phases.

Baseline Phase A1

During baseline Phase A, ABD showed an average of 33.7% of the time engaged (range of 50 with a standard deviation of 15.3), with a level of 36.6 and a shallow decelerating trend (-1.17). The data point zero for the first session could be considered an outlier with no on-task intervals, which could be attributed to avoidance and non-attending behaviour.

Intervention Phase B

During the intervention phase, the on-task engagement time of ABD has increased to an average of 62.9% (range of 57.0 with a standard deviation of 17.8), with a level of 59.9 and a zero trend. The difference in level change between A1 and B conditions demonstrated (+ 27.0) a significant increase in on-task behaviour. At the onset of intervention phase B, a shallow increase in on-task behaviour was apparent, which was maintained even though variability existed between data points overall with a zero trend. Comparing the Phase A1 and Phase B mean values revealed a 29.2 % increase in the on-task behaviour. A 92% of NAP comparison was demonstrated between Phases B and A1, which shows a distinctive difference between the two data paths.

Return to Baseline Phase A2

During the Phase A2, ABD demonstrated an on-task engagement with an average of 39.4 % of the time (range 36.6%, SD:12.5) with a level of 38.30 and a decelerating trend (-1.26) with a visible initial decrease with the onset of the intervention withdrawal. This change was fairly maintained. ABD depicted a consistent trend and level across baseline A1 and A2 phase conditions. The comparison between intervention phase B and phase A2 (second baseline) demonstrated a level change of – 21.6, and the difference between mean percent time on-task values revealed a 23.5 % decrease over intervention phase B, indicating a noticeable decrease in the on-task behaviour. The 83% NAP comparison data pairs between Phase B and A2 second pairing demonstrated a substantial difference between data pairs.

ABD On-Task Behaviour Concluding Remarks

The above data signifies a direct impact of the acoustic intervention on participant children's on-task engagement behaviour. A considerable consistency in level and trend, and immediacy increased the confidence in this conclusion. Supplementary results of the on-task engagement intervals during baseline conditions A1 and A2 without acoustic wall panels are 33.75 % and 39.4 % on average, respectively. They are significantly less than Phase B (62.97%). The collective measures discussed above suggest a considerable increase in the on-task behaviour during acoustic intervention phase B, a positive response to the research question in this chapter.

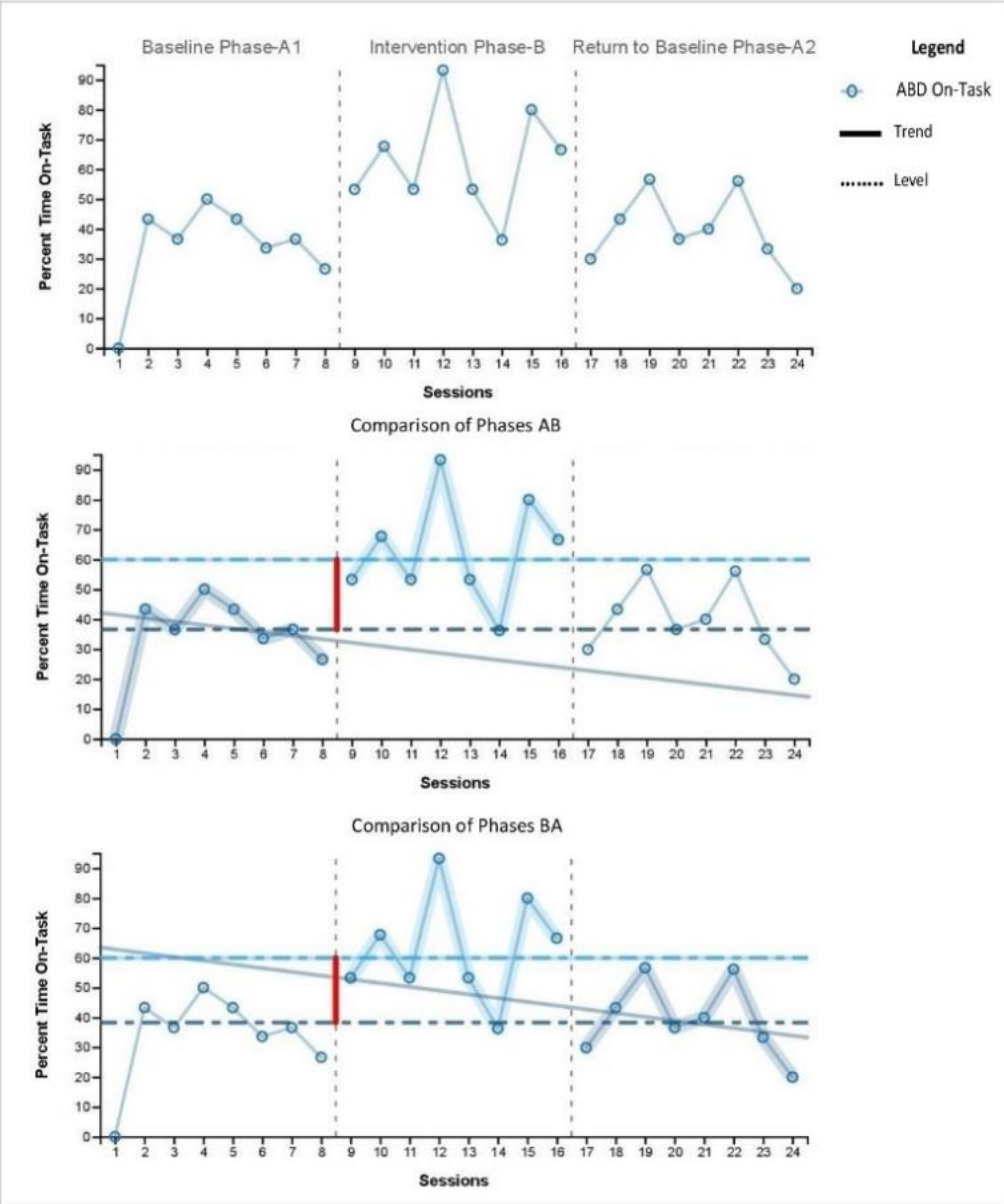

Figure 6.2: ABD On-Task Behaviour across Phases

Participant IBT

Figure 6.2 illustrates the proportion of the time of participant IBT's on-task engagement during the three phases.

Baseline Phase A1

During Phase A, IBT had an average of 37.5 % of the time engaged (range of 25.0 with a standard deviation of 11.1) with a level of 42.50 and a decelerating trend of -1.25.

Intervention Phase B

During Phase B, IBT's on-task engagement increased to 66.9% (range of 27.5 with SD = 9.0), attaining a high level of 70.0 with a slight decelerating trend of (-2.50). The difference in level change between the A1and B conditions demonstrated a positive impact (+ 27.5). Comparing Phases A1 and B, the mean values revealed a 29.4% increase indicating a significant increase in the on-task behaviour. At the onset of intervention phase B, a significant initial increase was observed in the on-task behaviour, which was maintained at a consistent level during the first three data points out of 5, but later the observation depicted a slight decrease. IBT demonstrated a 100% NAP comparison between Phases B and A1 first pairing data, marking a significant difference between data paths.

Return to Baseline Phase A2

During Phase A2 (withdrawal of intervention), IBT demonstrated on-task engagement at an average of 38.4 % of the time (range 25.0, SD = 8.9) with a level of 35.0 and a decelerating trend of -5.00. A significant initial decrease in the on-task behaviour was observed at the onset of the withdrawal of the intervention condition. This change was maintained throughout the remaining data points showing a decelerating trend. A comparison between intervention Phases B and A2 revealed a noticeable level change of -35.00, and the difference between mean percent time on-task values showed a 28.4 % decrease from intervention phase B, indicating this reflected decrease in the on-task behaviour. The data path pattern across baseline phases A1 and A2 presented a fairly steady pattern, with slightly more variability in the Phase A1 condition. The 100% NAP comparison data pairs between Phase B and A2 second pairing demonstrated higher than 93%, suggesting a substantial difference between data pairs.

IBT On-Task Behaviour Concluding Remarks

The data represents a positive impact of the acoustic intervention. It is in consistency in level, trend, and salient immediacy during Phase B; this increases confidence in the acoustic intervention effect. The results of the on-task engagement intervals during baseline conditions A1 and A2 are 37.5 % and 38.4 %, respectively. This is significantly less than Phase B (66.9%) also indicated a positive response. The collective measures discussed above reflect a considerable increase in the on-task engagement of IBT during the acoustic intervention phase.

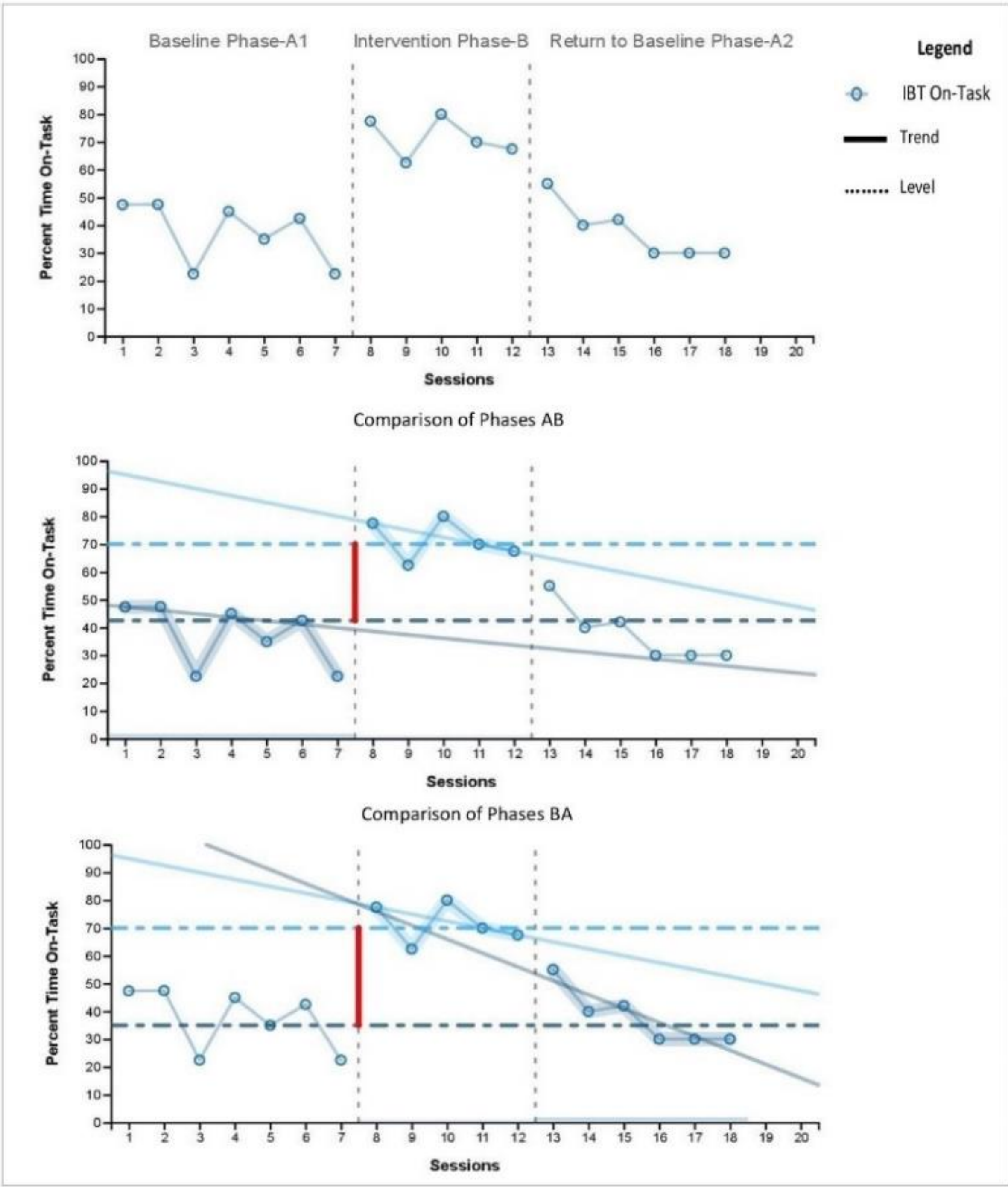

Figure 6.3: IBT On-Task Behaviour across Phases

Participant MOH

Figure 6.3 illustrates the on-task engagement behaviour of the participant MOH during Phases A1-B-A2.

Baseline Phase A1

During Phase A1, MOH showed an average of 27.8 % of the time engaged (range of 25.0 with a standard deviation of 8.9) with a level of 26.0 and a zero trend.

Intervention Phase B

During Phase B, MOH demonstrated on-task behaviour with an average of 60.0 % of the time (range = 20, SD = 8.3) and a high level of 57 with a zero trend. The difference in level change between the A1and B conditions demonstrated a positive impact (+ 31). In comparison between Phases A and B, the mean values revealed a 32.2 % increase over the baseline phase, indicating a visible increase in the on-task behaviour. At the outset of intervention phase B, a significant initial increase in on-task behaviour was demonstrated and maintained even though slight variability existed between data points overall with a zero trend. MOH demonstrated a 100% NAP comparison between Phases B and A1 first pairing data, marking a significant difference between data paths.

Return to Baseline Phase A2

During Phase A2 (withdrawal of intervention), MOH demonstrated on-task behaviour on an average of 31.4 % of the time (range 37.5, SD = 14.1) with a level 31.0 and an accelerating trend of (+5.00) in the undesired direction, reflecting variability. A significant initial decrease in the on-task behaviour was observed at the onset of the withdrawal of the intervention condition. However, this change was not maintained at the same intensity throughout the remaining data points, and the variability existed with regard to trend slope, but the level change was fairly consistent across Phases A1 and A2. The comparison between Phase B and A2 demonstrated a level change of -25, and the difference between on-task engaged time values revealed a 28.6 % decrease over the intervention phase, indicating a noticeable decrease in the on-task behaviour for participant MOH during withdrawal phase A2. The 100% NAP comparison data pairs between Phase B and A2 second pairing demonstrated higher than 93%, suggesting a substantial difference between data pairs.

MOH On-Task Behaviour Concluding Remarks

The data of MOH represents a visible impact of the acoustic intervention. Supplementary results of the on-task intervals during baseline conditions A1 and A2 showed the averaged engagement time of MOH was 27.8 % and 31.4 %, respectively, which is significantly less than Phase B (60.0 %). This shows the acoustic intervention has a positive impact on MOH's on-task engagement.

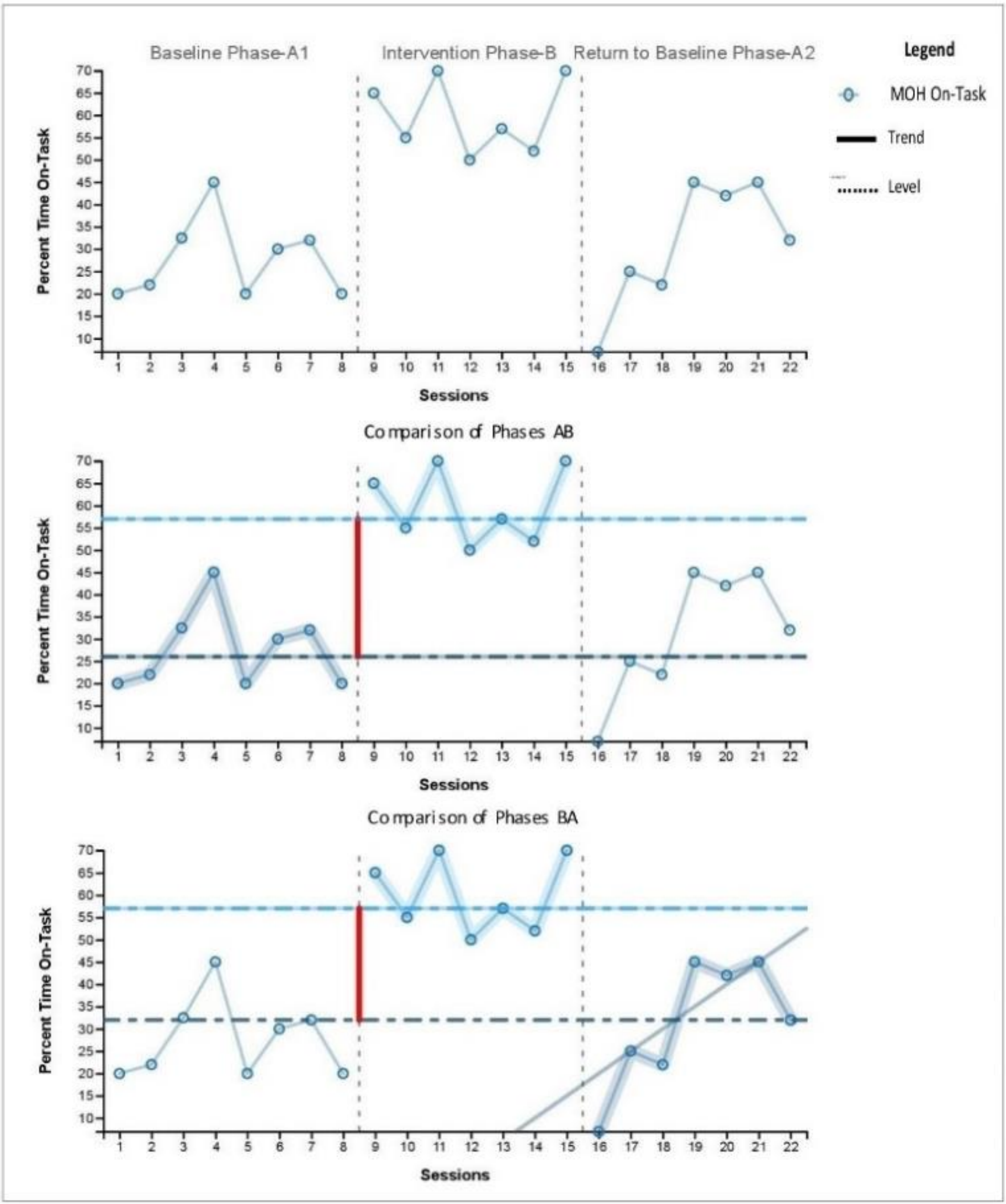

Figure 6.4: MOH On-Task Behaviour across Phases

Participant SHA

Figure 6.4 demonstrates the on-task engagement time for Participant SHA during Phases A1-B-A2.

Baseline Phase A1

During the baseline phase, SHA shows an average of 31.5 % of the time on-task engagement (range 45.0, SD =16.9) with a level of 30.51, depicting a high variability and a shallow decelerating trend of -2.63.

Intervention Phase B

During Phase B, SHA demonstrated on-task engagement in an average of 57.2 % of the time (range 42.5, SD = 14.6) and a high level of 53.75 with slightly lower variability and a shallow trend +0.57. The difference in level change between Phases A1 and B demonstrated a positive change (+ 23.24). The comparison between Phases A and B reveals a 25.7 % increase in the on-task engagement time, a noticeable increase for SHA. At the onset of the intervention phase, an initial shallow increase in on-task behaviour was demonstrated, and variability existed overall between data points. The Intervention Phase B data path displayed a greater magnitude trend when compared to the baseline Phase A1 data path. NAP 89% comparison was demonstrated between Phases B and A1, which shows a distinctive difference between the two data paths.

Return to Baseline Phase A2

During the return to the baseline phase (A2), SHA demonstrated an on-task engagement on an average of 16.6 % of the time (range 45.0, SD = 13.9) with a level 41.0 and a low decelerating trend (-0.31). A significant initial decrease in the on-task behaviour was observed at the onset of the withdrawal of the intervention condition. This change was maintained visibly throughout the remaining data points, and the variability existed with regard to trend and level change across Phases A1 and A2. A comparison between Phases B and A2 demonstrated a -41.25 level change marking a significant decrease. The 97% NAP comparison data pairs between Phase B and A2 second pairing demonstrated higher than 93%, suggesting a substantial difference between data pairs.

SHA On-Task Behaviour Concluding Remarks

Consistency in the level and the trend, and immediacy reflected high variability but supported the expected positive outcome for participant SHA. The results showed SHA on-task engagement intervals during baseline conditions of 31.5 % and 16.6 % during Phases A1 and A2, respectively. They were significantly less than in the intervention phase (57.2 %), indicating a positive response to the acoustic intervention. A reasonably consistent percentage of all non-overlapping data pairs (89%-97%) respectively across the A1-B and B-A2 phase conditions suggest an overall positive response. The collective measures discussed above reflect a considerable increase in the on-task behaviour of SHA during the acoustic intervention phase B.

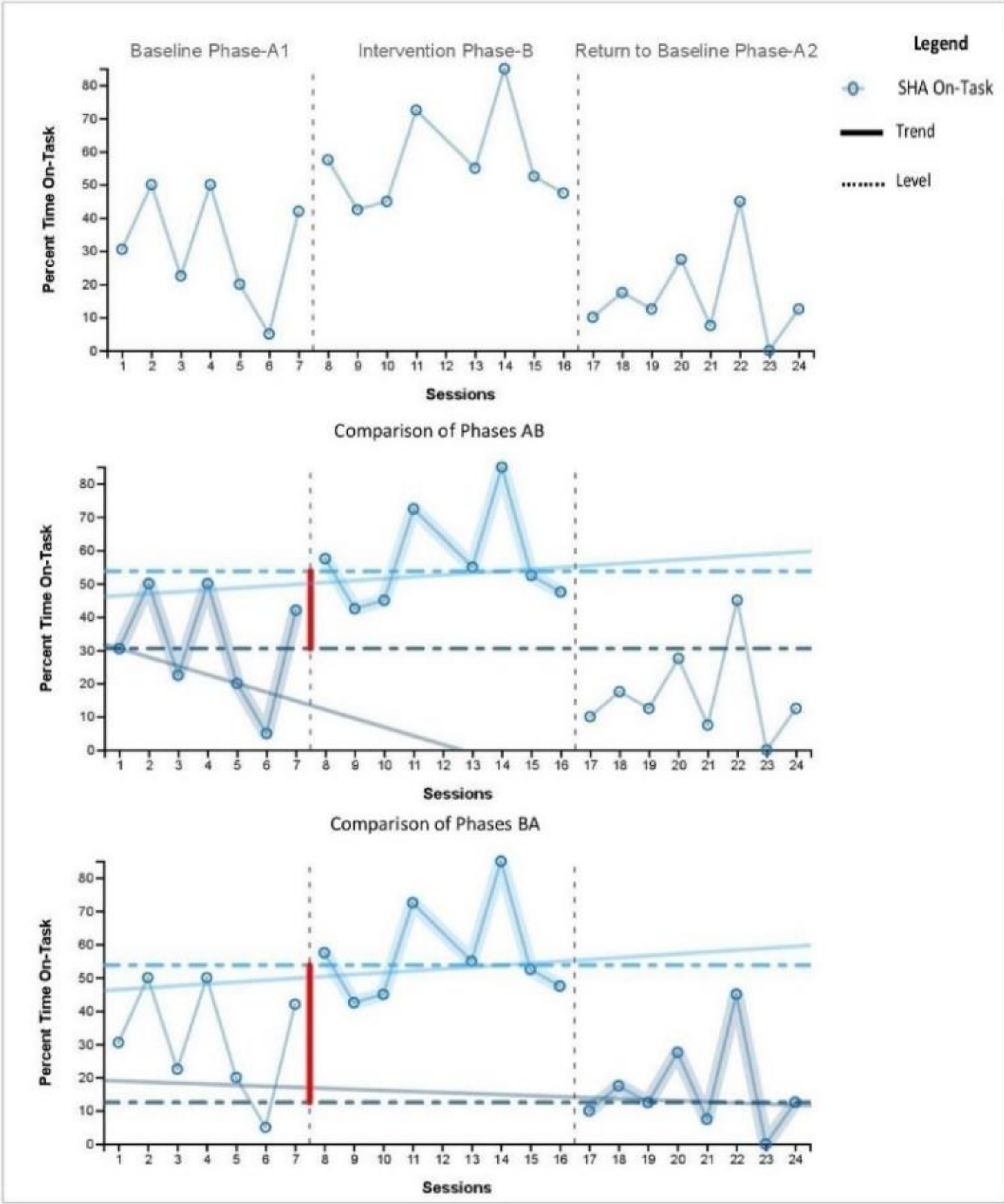

Figure 6.5: SHA On-Task Behaviour across Phases

Participant Differential Statistics

The summary of the four ASD participant is presented in Table 6.4. The observation of the collated (N=4) data yielded a consistent pattern during the execution of Phases A1-B-A2. Individual Participant's percent time On-task mean reflected a significantly higher engagement [in the percentage of time] during the intervention phase, whereas without and upon its removal, it reflected much lower engagement. This draws supportive results complementing visual analysis of the graphed data indicating a positive co-relationship of the hypothesis.

Table 6.4: Inter-Subject Differential Statistics for On-Task Behaviour

Participant	Descriptive Parameters						Statistical Parameters
	Baseline A1		Intervention B		Return to Baseline A2		All Phases
	Percent On-Task Behaviour Mean	Level	Percent On-Task Behaviour Mean	Level	Percent On-Task Behaviour Mean	Level	NAP %
ABD	33.75	36.6	62.97	59.9	39.4	38.30	92
IBT	37.5	42.50	66.9	70.0	38.4	35.0	100
MOH	27.8	26.0	60.0	57.0	31.4	31.0	89
SHA	31.5	30.51	57.2	53.75	16.6	41.0	93

6.7 Discussion

This chapter (Stage 3 Study) investigates the ramification of classroom acoustics on the on-task behaviour of children with ASD during 1:1 teaching sessions. The study findings analysed above in detail reflected what effect would ensue with the classroom acoustic intervention with the significantly lower RT60 (Tmf 0.39s) from its earlier higher value (Tmf 1.0s +).

Effects of Acoustic Refurbishment on On-task Behaviour of Children with ASD

The selection of the SCED experimental design methodology employed in the study allowed a detailed analysis and interpretation of the data of individual ASD participants revealing their heterogeneous nature to sensory stimuli, response, and educational On-task engagement. The study underscored that the participant children's acute heterogeneity had unforeseen consequences on the research. The prevalence of the heterogeneity factor was reflected by the behavioural impact spill-over, such as tantrums and meltdowns upon other children and had an impact on the smoothness of the observational research. This was starkly evident when the classroom teacher was absent, and the substitute teacher controlled the session, affecting the participant's behaviours and class-peer rapport with increased off-task and attentiveness, particularly in the case of MOH. It also impacted participants' absenteeism, and non-attending behaviour specifically observed on MOH and IBT, therefore limiting the consistency of the number of sessions, sequence and session duration affecting projected results and findings of the study.

One notable observation made during Phase B involves an unanticipated consequence of the acoustical intervention. As the participating children (N=4) were being moved to the adjacent classroom, two participants showed an initial heightened behavioural response, whereas a third participant abjectly refused to attend the sessions. This could be conjecturally attributed to the change in the classroom with noticeable visual presence of the classroom acoustical wall panels. The highest number of disruptions occurred for (N=3) participants during Day 1. Therefore, the initial 2 days were used primarily to desensitize as well as acclimatize the participants to the level of comfort. The actual behavioural observation for Phase B was therefore initiated after the novelty phase.

Overall a positive relationship was depicted with the decrease in RT60 in the classroom environment, and a significantly higher increase in percentage on-task intervals during the 1:1 learning sessions. The classroom teacher's subjective observations of the children were suggestive of an overall calm, contained, and relaxed learning atmosphere during the intervention phase. The results across four participants affirmed a positive response to the acoustic intervention. On the general level, variability continued for all children in which some participants demonstrated a more positive sensory and educational attentiveness response on-task than others. However, overall, the results were promising across the sample. This finding conformed to the research indicators that sensory modulation intervention plausibly aided participant children's enhanced classroom engagement, specifically attentiveness when necessary acoustical minimised conditions were created through design, also leading to their ameliorated behavioural dysfunctionality (Kinnealey et al., 2012, Kanakri, 2017b).

6.8 Concluding Remarks

This chapter tries to answer the research question: Does there exist a causal nexus between the acoustic parameters RT60 and the on-task behaviour response of children with ASD in the classroom environment? Overall, the results of this chapter are suggestive of a correlation between participant children's on-task engagement behaviour and the acoustic classroom environment. Individual participants' mean percent time on-task reflected a significantly higher engagement during the intervention phase, whereas without and upon its removal, it reflected much lower on-task engagement. Thus, data indicates a positive co-relationship of the hypothesis. These preliminary findings are in congruence with seminal research that established noise/acoustics as a predominant sensory environmental factor which affected sustained attention, and on-task engagement of children with ASD in a classroom environment (Kinnealey et al., 2012, Dockrell and Shield, 2006, Kanakri, 2017b, Howe and Stagg, 2016, Van Kamp and Davies, 2013)

7

CHAPTER 7:

7.1 Introduction

This research encapsulated primarily three distinctive staged studies apprehended through interdisciplinary and integrative approaches, involving the study of low-incidence, heterogeneous, four male children with ASD aged 9-11 years participants at Oasis School for Children with Autism. It specifically focused on the RT60 and correlated LAeq and LA90 levels upon their sensory, and auditory sensitivity impacting their behaviour and on-task learning. The critical hypotheses were subsequently tested against the dynamics of the classroom sensory transformation through acoustical modification.

7.2 Major Findings of the Three-Stage Studies

This thesis contains three stages, which were presented in Chapters 4, 5, and 6. The major findings derived are presented as follows:

Research Question 1: How the sensory-related architectural elements within the classroom environment are related to either the inhibition/or facilitation of on-task learning and behaviour of children with ASD in a classroom?

The research question of Stage 1 Study (Chapter 4) interrogated the investigation of the correlation between the physical classroom sensory environment and the participant children's inhibition/or facilitation of on-task learning and behaviours. The results have shown that the critical variable noise/acoustics emerged as a significant variable in affecting children's sensory behaviour, learning and engagement with the pedagogies in their mediation through the learning environment. The descriptive content analysis subsequently drew up important variables corroborated with the literature review in Chapter 2. The investigation specifically demarcated BNL and RT60 as key noise variable in the classroom environments impacting children's auditory hypersensitivity and processing dysfunctionality. These results are congruent with other research in the field, simultaneously correlating decreased classroom involvement and performativity of children with ASD with heightened environmental sensory stimuli aspects which demonstrated children's adverse behaviour traits and sensory processing (Piller and Pfeiffer, 2016, Howe and Stagg, 2016, Kanakri et al., 2016, Kanakri, 2017b, Ashburner et al., 2008a). This Study's findings have added supplementary significance to the classroom sensory environment research, specifically the ramification of noise/ acoustics for children with ASD.

Research Question 2: What is the correlation between the classroom acoustical parameters, long and short RT60 and the LAeq and LA90, with delineated sensory disruptive behaviours of children with ASD?

The research question in the Stage 2 Study (Chapter 5) investigates the impact of RT60 and correlates LAeq and LA90 upon the participant children's three earmarked sensory behavioural responses; ear covering, repetitive restricted movements and loud vocalising. In a three-phased A1-B-A2 Intervention Study, the investigation validated the correlation between the children's delineated sensory behaviours and the long and short RT60 in the classroom environment. Importantly, it indicated that RT60 to remain below 0.4 secs, reflecting consistency with the other research and the BB93 acoustic standards (Crandell, 1992, ASHA, 1995). Repetitive behaviour reflected the most confident positive correlation response under improved acoustic conditions across all four participants, moreover, it had the highest frequency of occurrence among the other two delineated behaviours under long RT60. Ear Covering behaviour outcome was largely positive; results were promising among three out of four participants, which were indicative of a positive correlation under short RT60 (.39s). For loud vocalising behaviour, the findings for two participants, IBT and SHA, were indicative of a clear impact of acoustic intervention across the three markers, visual examination, non-overlapping percentage and descriptive mean values indicating an overall decrease in loud vocalising behaviour during the Phase B intervention. However, for participants' MOH and ABD loud vocalising behaviour, results were not collated due to inadequate behavioural outcomes. The collated data analysis for the Stage 2 Study was suggestive through its validation that the participating children's sensory behaviour modulation was considerably influenced by classroom environment acoustical modification through intervention and an important factor in their learning and behaviour.

Research Question 3: Does there exist a causal nexus between the acoustic parameters RT60 on the participant children's on-task behaviour response in the classroom environment?

The Stage 3 Study (Chapter 6) investigated the relationship between the classroom acoustic (RT60) and the children's on-task behaviour. The overall result drew a positive correlation when the RT60 of the classroom sensory decreased to 0.39s, during which the participant children showed a significantly higher percentage increase in on-task intervals during the 1:1 learning sessions. Moreover, the classroom teacher's subjective observations of the children suggested an overall calm, contained, and stress-free learning atmosphere during the intervention phase, further validating the findings. The overall four participant's results depicted a positive response to the classroom acoustical intervention treatment effect. Across the sample, the children's variability was consistent for all participants through a positive sensory environment effect and response to on-task engagement.

Concluding Remarks

In light of the three-stage studies in this thesis, this research substantively demonstrated the profound impact of the inter-linkages between the classroom acoustic sensory environment and the targeted sensory behavioural and educational responses of children with ASD.

In sum, it could be stated that this research and it's three staged studies contributed with plausible repercussions in modestly contributing towards the gaps identified and the areas studied. Importantly, it has vital implications for children with ASD worldwide. Its significant contribution lay in its apprehending through interdisciplinary prisms, children's dysfunctionality, sensory behaviours and educational pedagogy intervention modes and Neuro-Architecture informed classroom sensory design. The problem regarding the lack of interventionist-based methodologies, its implicative impact on children with ASD and the practices of normative-heuristic approaches to buildings was critically underlined. This allows to set out upon the fields of research bridging neuroscientific advances, architecture and the built environment and the pedagogies and instruction of children with ASD in the learnt environment. This research adds to the body of knowledge through this intersectionality and, in particular, adds to the existing corpus of knowledge that children with ASD are inadvertently confronted by the spatial confinement of sensory environment through acoustics in anecdotally designed buildings.

7.3 Limitations

As this research thesis demonstrated through its analytical frame, children with ASD as a social group are vastly heterogeneous, possessing individual idiosyncratic sensory dysfunctionality (Baker et al., 2008), greatly impacted by sensory acoustics. Therefore, the normalcy of rigorous academic research for this group is circumscribed in its scope, which bore upon its sampling and variability, delimiting its range of study of variables and broad empirical, methodological approaches. Pursuing the participants' research in the best possible way was necessary due to their circumstances. The research dealt modestly and with empathy towards the school and the children participants in particular. This had an insightful effect upon seeking methodologies constrained by the acute heterogeneity in children with ASD. Some primary deliberations upon the research analysis limitations have been identified as follows.

Research Setting and Sample size

This research was conducted in a single educational context of a classroom setting at a purpose-built school for children with ASD with a capacity of 6 students in the research classroom.

At the start of the study, all six students were recruited. However, two out of six students could not continue with the study; one student got very sick at the start of phase B and was not present for the intervention phase and only attended one week of phase A2(return to baseline). The second student had to travel due to an urgent situation and did not attend phase B and Phase A2. Hence data was collected and reported for only 4 participants with ASD. Those children who could not participate left the classroom, and they then re-join the exercise later when they felt better.

The generalizability of the results was delimited by a small sample size and a specific ASD population group. Some one-to-one learning sessions were conducted outside the designated blue and green cubicle sections but within the classroom bounds due to the ASD student participant's temporary resistance to a specific setting, which may have affected the results with some variance.

Intervention Flexibility

It highlighted the fact that the complete intervention refurbishment involved only the fixed single mode of the acoustic modification aspect, which impacted experiment flexibility. Secondly, as the research was experimental and subject to the school calendar time duration, the study was not able to gauge the graduated modification instalment and the flexibility of phase shifting effect correlated to individual participant progress. The data was, therefore, strictly collected over a period of two weeks per phase for a reasonable time frame to establish participant progress stability and result verification.

Absenteeism and Non-Attending Behaviour

The Study underscored the unforeseen consequentiality of the acute heterogeneity of the children participants in the research. One evident impact was manifested by the participant's absenteeism and non-attending behaviour, which therefore limited the consistency of the number of sessions, sequenced-session and duration for some students. The implications drew upon the affected projected results and findings of the Study, which is the norm in the Social Sciences and research involving applied settings.

Sensory Disruptive Behaviours Relative to Each ASD Participant

The other limitation of this research was that data were only collated regarding student-specific sensory disruptive and on-task behaviours. This pointer was accentuated in the analysis of the literature. The important prevalent heterogeneity factor depicted the spill-over impact of tantrums and meltdowns on other children present in the classroom, shifting the normalcy of observations. Similarly, the heterogeneity factor was starkly demonstrated due to staff sickness or short leave absenteeism, which impacted the participant's behaviour and class-peer rapport with the substitute teacher.

7.4 Implications and Recommendations

The predominant traditionally rooted educational model of teachings and pedagogies for classroom instruction and management have been demonstratively proven to be irrelevant and ineffective for children with ASD (Martin, 2014). It is vital to address the delivery of educational methods and curriculum taking into account the specificities of their sensory modulation, integration, and dysfunctionality identified in the diagnoses of each individual child through ASD. However, these learning and teaching techniques are largely absent due to prevailing ill information and lack of requisite knowledge, assessment, and specific environmental and interventional strategies considering the vital children's sensor modulation techniques. (Kanakri, 2017a).

The findings of this Three Stage of Study research draw important implications, in particular for architects and designers, which was the core of the built environment aspect of this study. These findings evidentially assert that sensory acoustically designed classroom environments are very significant in light of the prevailing models of architecture based on anecdotal and heuristic evidence. The application of this model can be highly cost-effective, considering that built design is a creative enterprise which necessitates imagination and empathy with the paradigmatic shift. Considering that Pakistan's educational architectural model system lacks formal standards and criteria-based building, including the acoustics for special needs schools and classrooms. Children with ASD confront daily the rigours of classroom spatial design confined to the anecdotal design buildings and sensory environment. It underscores the architect /designer's potential, ability and responsibility in affecting health, well-being and learning outcomes for children with ASD. Hence an understanding of the interrelated nature of psychological, physiological and neurological aspects of the ASD child can inform the salutogenic learning environment. The dire need for the paradigm shift is essential in terms of offering built environment designs grounded in principles of harmony, and peace, providing dignity for all children and specifically for populations of autism.

For future research prospects, this Study recommends the investigation of children's meltdown and withdrawal as a specific behaviour correlating to the specificities of classroom sensory noise and acoustical environment. Replication of this study with additional phases to add to the current findings and increase the generalizability. Future research is needed to determine whether the causal relationship between the acoustical variable (IV) and the on-task learning behaviour and disruptive behaviour (DV) variables is also found in different educational contexts and classroom settings for children with ASD. Lastly, researchers investigate and examine the correlation between children's physiological and neurological markers relating to classroom sensory acoustic in addition to behaviours and pedagogies.

APPENDICES

Appendix A:

a) General Design Recommendation for Sensory Supportive Classrooms

b) Acoustic Modification Recommendations for Existing Classrooms

a) General Design Recommendation for Sensory Supportive Classrooms

When designing classroom settings for a heterogeneous group of children with ASD, the focus needs to be on creating an enabling environment that caters to sensory differences, maximizes independence, predictability and skill acquisition, and builds on their existing strengths. Moreover, it focuses on the factors that have the potential to affect the health, well-being, and learning of children with ASD. Classroom design can cater to sensory differences in children with ASD by minimizing sensory stimulation, controlling noise and acoustics and any auditory stimulus, and avoiding strong smells, direct lighting, glare, and unregulated temperatures(Gaines et al., 2016). Some specific recommendations are provided below.

- Classroom design should provide clear visual boundaries to establish a definite context associated with the given space for each task, such as one-on-one learning activities clearly defined by workstations using colour coding and visuals (Mesibov, 2018).
- Design a spacious classroom that accommodates flexibility and furniture arrangement that supports multiple activities and arrangements with a clear structure and marked visual boundaries (Mesibov, 2018).
- Design Low arousal interior colour scheme to provide a calm atmosphere that enhances focus on task activity.
- Design clear routes and zoning without crowding the classroom
- Create an uncluttered visual interior by organizing teaching resources and any extra materials out of sight of children in the classroom.
- Provide a quiet, calming, and low-stimuli-safe withdrawal space in the classroom for emotional regulation to support children with ASD, who often feel overwhelmed in socially demanding environments and can have meltdowns(Freed and Parsons, 1998).

b) Acoustic Modification Recommendations for Classrooms

First, a detailed acoustic survey of the existing classroom needs to be conducted to know how much noise level is to be controlled. Examples of some methods of classroom acoustic treatment, underscored by the American Speech-Language-Hearing Association (ASHA), are provided below. They can be used parallel or individually to modify classroom acoustics.

- Use of Acoustic Wall panels to reduce reverberation time
- Acoustic Ceiling panel installation with a higher NRC rating
- Insulation of floor and ceiling assemblies to control noise penetration
- Add soft furnishings such as area rugs with rubber backing, commercial carpets with cushion backing, and heavy cloth curtains to dampen the noise
- Movable screen with upholster partitions to mitigate noise and beak noise reflections
- Upholster cleanable seating to reduce noise levels
- Avoid the use of hard surfaces on the walls and floors to limit sound reflections
- Rubber stoppers or tennis balls (neoprene tips) for movable furniture.
- Install Indoor lighting such as LEDs instead of fluorescent lights that produce a continuous humming sound.
- Use Classroom Communication boards made from acoustic panels, felt or corkboard for wall mounting installations.
- Double glazing of windows to prevent noise penetration
- Use acoustical caulking to fill seams and gaps in windows and door installations.
- Inspection of noisy equipment in the classroom, switching them off when not in use.
- Inspection of the HVAC systems or units for noise levels and insulation of the ducts to dampen noise levels.
- Strategic zoning and compartmentalisation of classroom space to reduce noise build-up in the interior space.

Appendix B: Participant Information and Consent Form for Interview Experts (stage 1 Study)

Consent Form for Experts

Title of Research Project: A neuro-architectural approach to creating sensory attuned salutogenic-learning environments for children with autism

Name of Researcher: Ayesha Ghazanfar

Participant Identification Number for this project: Please initial in the boxes

1. I confirm that I have read and understand the information sheet dated, 2015-012-08 explaining the above research project and I have had the opportunity to ask questions about the project.
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.

   Lead researcher contact: 966566400922 Email: aghazanafar1@sheffield.ac.uk
3. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research
4. I am aware that the interview in which I participate will be audiotape

   recorded and transcribed.
5. I agree for the data collected from me to be used in future research.
6. I agree to take part in the above research project.

Name of Participant (or legal representative)	Date	Signature

Name of person taking consent (if different from lead researcher)	Date	Signature

To be signed and dated in presence of the participant

Ayesha Ghazanfar Lead Researcher	Date	Signature

To be signed and dated in presence of the participant

Copies:

Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be placed in the project's main record (e.g. a site file), which must be kept in a secure location.

Participant Information Sheet for Multi-Disciplinary International Experts

1. Research Project Title: A neuro-architectural approach to creating sensory attuned salutogenic-learning environments for children diagnosed with Autism.

Explanation: The study seeks to identify environmental factors in a classroom environment, which represent the different types of environmental stressors that inhibit learning or affect cognitive functioning in children diagnosed with Autism. The data collection method for the research project comprises of 4 studies:

1. Interviews (via Skype meetings) with international experts to identify key environmental variables that impact on outcomes for children diagnosed with autism.
2. Interviews (one-to-one) with the staff and school children at the school 'before' and 'after' modifications to the learning environment.
3. Observation of children at the school 'before' and 'after' modifications to the learning environment.
4. Carrying out scientific measurements (e.g. noise level) at the school 'before' and 'after' modifications to the learning environment.

2. Invitation

You are being invited to take part in this research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

3. What is the project's purpose?

This study aims to investigate the learning challenges faced by children diagnosed with Autism in a classroom environment, specifically to establish the key physical environmental factors that contribute to positive outcomes for the school children. Findings from the study will also be used to develop guidelines for designing and creating better learning environments for children diagnosed with Autism.

4. Why have I been chosen?

You have been selected because of your expertise in this area of study as indicated by your published papers, talks at international conferences and references by researchers.

5. Do I have to take part?

Participation is entirely voluntary. It is up to you to decide whether or not to take part. If you do agree to take part, you will be asked to sign a consent form. If you agree to take part, you may still withdraw at any time, without giving a reason. If that happens, any information or data you have given will not be used in the study.

6. What will happen to me if I take part?

There are no possible disadvantages and risks for you taking part.

7. What do I have to do?

As a participant you will be contacted by email and invited to answer questions in a Skype meeting, which will be arranged at a mutually convenient time.

8. What are the possible disadvantages and risks of taking part?

There are no possible disadvantages and risks of taking part in the study. In case of any unexpected discomforts that may arise due to participation in the research, it should be brought immediately to researcher's attention to avoid any further discomfort.

9. What are the possible benefits of taking part?

Whilst there are no immediate benefits for those people participating in the project, it is hoped that this research will help increase our knowledge and understanding of what makes for a quality learning environments for children diagnosed with Autism.

10. What happens if the research study stops earlier than expected?

The research is expected to complete in its due time, expected completion date is Fall 2016.

11. What if something goes wrong?

Should there be any discomfort due to your treatment by the researcher or due to any other unexpected reason, this should be brought immediately to researcher's attention and also by contacting the investigator's supervisor. To further escalate the complaint if not handled to your satisfaction, you can contact the Head of Department, who will then escalate the complaint through the appropriate channels.

12. Will my taking part in this project be kept confidential?

All the information that will be collected during the course of the research will be kept strictly confidential. You will not be identified in any reports or publications.

13. What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives?

The information requested from you will be used to gain insights on the environmental factors that affect the quality of learning of children diagnosed with Autism in a typical learning environment.

14. What will happen to the results of the research project?

At the end of the research a report will be written and the results will be published in peer reviewed journals and conference presentations. No research participant will be identifiable from any publications. Data collected during the course of the project might be used for additional or subsequent research. This study has been reviewed and approved by the University of Sheffield ethics review board. Participant can obtain a copy of the published results if they wish to by contacting the researcher.

15. Who is organising and funding the research?

No organisation or funding body is funding this research.

16. Who has ethically reviewed the project?

This project has been ethically reviewed and approved by the University of Sheffield's Ethics Review Committee.

17.Will I be recorded, and how will the recorded media be used?

The interview will be recorded on audiotape only and transcribed to facilitate coding and analysis via a computer. The audiotapes will be kept in accordance with The University of Sheffield guidelines and destroyed at the end of the study. The audio recordings during this research will be used only for analysis and for illustration in conference presentations and lectures. No other use will be made of them without your written permission, and no one outside the project will be allowed access to the original recordings. Your response will be treated with full confidentiality and only code numbers or false names will identify anyone who takes part in the research.

18. Contact for further information

The University of Sheffield, Department of Architecture

Contact 1 Name: Ayesha Ghazanfar (PhD Candidate)

Email Address: aghazanfar1@shefiield.ac.uk

Telephone number: 966566400922

Contact 2 Name: Dr Michael Phiri (PhD Supervisor)

Email Address: m.phiri@sheffield.ac.uk

You will be given a copy of this information sheet and a signed consent form or email confirmation agreeing to take part in the study to keep for record purposes.

Thank you for your valuable time and taking part in the research project.

Appendix C: Participant Information and Consent form for ASD Child Primary Caregiver

Recruitment script for Parents/Guardians of pupil diagnosed with Autism

Study Title: A neuro-architectural approach to creating sensory attuned salutogenic-learning environments for children diagnosed with Autism.

Researcher Name: Ayesha Ghazanfar (PhD Candidate)

Supervised by: Dr Michael Phiri

E-mail Subject line: Sheffield University – PhD research study

I am a PhD candidate at The University of Sheffield, conducting a study to identify factors in a classroom, which inhibit learning or affect cognitive functioning in children diagnosed with Autism.

I wish to invite you as a parent/guardian of a child diagnosed with Autism attending the Oasis School for Autism and enrolled in the early intervention program to take part in the study. You are being asked to:

- Answer a few questions about your child's behaviour and any associated sensory problems in an interview, which will take about 30 minutes. You will be contacted to confirm when and where the interview will take place.
- Give written informed consent for your child to be observed in a classroom for the purposes of the study.

Please find attached

1. Participant Information Sheet explaining what the study is about.
2. Consent Form for you sign to consent to take part in the study.

Please note that your participation in the study is voluntary and that this study has been reviewed and approved by the University of Sheffield Ethics Committee Reference No. 3556. If you any have concerns or questions about your rights as a participant or about the way the study is being conducted you can contact the investigator's supervisor Dr Jian Kang (PhD Supervisor)Email Address: J.kang@sheffield.ac.uk

I would like to thank you in advance for your time and consideration.

Ayesha Ghazanfar

PhD Candidate

The University of Sheffield, School of Architecture, Arts Tower, Sheffield, S10 2TN United Kingdom

Email contact: aghazanfar1@sheffield.ac.uk

Consent Form for Parent and Guardians

Title of Research Project: A neuro-architectural approach to creating sensory attuned salutogenic-learning environments for autistic children

Name of Researcher: Ayesha Ghazanfar

Participant Identification Number for this project:

Please initial in the boxes

I confirm that I have read and understand the information sheet dated, 2017-02-01 explaining the above research project and I have had the opportunity to ask questions about the project. ☐

1. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. ☐

   Lead researcher contact: 03110436464

   Email: aghazanafar1@sheffield.ac.uk

2. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research ☐

3. I give consent for my child to participate in the study. ☐

4. I am aware that the interview in which I participate will be audiotape recorded and transcribed. ☐

5. I agree for the data collected from me to be used in future research. ☐

6. I agree to take part in the above research project. ☐

______________________	______________	____________________
Name of Participant	Date	Signature
(*or legal representative*)		

Name of person taking consent	Date	Signature

(if different from lead researcher)

To be signed and dated in presence of the participant

Ayesha Ghazanfar	________________	______________________
Lead Researcher	Date	Signature

To be signed and dated in presence of the participant

Copies:

Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be placed in the project's main record (e.g. a site file), which must be kept in a secure location.

The University Of Sheffield.

Participant Information Sheet for Parents and Guardians

2. Research Project Title: A neuro-architectural approach to creating sensory attuned salutogenic-learning environments for children diagnosed with Autism.

Explanation: The study seeks to identify factors in a classroom, which represent the different types of environmental stressors that inhibit learning or affect functioning of children diagnosed with Autism. The data collection method for the research project comprises of 4 studies:

5. Interviews (via Skype meetings) with international experts to identify key environmental variables that impact on outcomes for children diagnosed with autism.
6. Interviews (one-to-one) with the staff at the school 'before' and 'after' modifications of the learning environment.
7. Observation of school children 'before' and 'after' modifications of the learning environment.
8. Carrying out scientific measurements (e.g. noise level) at the school 'before' and 'after' modifications of the learning environment.

2. Invitation

You are being invited to take part in this research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

3. What is the project's purpose?

This study aims to investigate the learning challenges faced by children diagnosed with Autism in a classroom, specifically to establish the key factors that contribute to positive outcomes for them. Findings from the study will also be used to develop guidelines for creating better learning environments for children diagnosed with Autism.

4. Why have I been chosen?

You have been selected because you are the parent or legal guardian of the selected child diagnosed with Autism.

9. Do I have to take part?

Participation is entirely voluntary. It is up to you to decide whether or not to take part. If you do agree to take part, you will be asked to sign a consent form. If you agree to take part, you may still withdraw at any time, without giving a reason. If that happens, any information or data you have given will not be used in the study.

6. What will happen to me if I take part?

There are no possible disadvantages and risks for you taking part.

7. What do I have to do?

As a participant you will be invited to answer questions related to your child's behaviour. You will be provided with an informed consent form to sign for giving permission for your child to be observed during several short sessions in the classroom environment to gain insight on a specific task learning behaviour.

8. What are the possible disadvantages and risks of taking part?

There are no possible disadvantages and risks of taking part in the study. In case of any unexpected discomforts that may arise due to participation in the research, it should be brought immediately to researchers attention to avoid any further discomfort.

9. What are the possible benefits of taking part?

Whilst there are no immediate benefits for those people participating in the project, it is hoped that this research will help increase our knowledge and understanding of what makes for a quality learning environments for children diagnosed with Autism.

10. What happens if the research study stops earlier than expected?

The research is expected to complete in its due time, expected completion date is Fall 2017.

11. What if something goes wrong?

Should there be any discomfort due to your treatment by the researcher or due to any other unexpected reason, this should be brought immediately to researcher's attention and also by contacting the investigator's supervisor. To further escalate the complaint if not handled to your satisfaction, you can contact the Head of Department, School of Architecture, who will then escalate the complaint through the appropriate channels.

12. Will my taking part in this project be kept confidential?

All the information that will be collected during the course of the research will be kept strictly confidential. You will not be identified in any reports or publications.

13. What type of information will be sought from me and why is the collection of this information relevant for achieving the research project's objectives?

The information requested from you will be used to gain insights on the factors in a typical learning environment that affect children diagnosed with Autism.

Information sought from you: You will be requested to provide information on your child's behaviour and any associated sensory problems that you observe at school or at home. This information is on the challenges confronting the child while performing daily activities. For each incidence you will indicate where it takes place (which room or area), any factors such as lighting, noise, taste, smell, vibrations and sensations that affect the challenges. Please also indicate any coping strategies or any physical modifications of the home you adopt or make.

Information sought from your child: Your child will be observed during timed sessions in the classroom to establish the challenges faced by the child due to factors such as lighting, noise, taste, smell, vibrations and sensations.

14. What will happen to the results of the research project?

At the end of the research a report will be written and the results will be published in peer reviewed journals and conference presentations. No research participant will be identifiable from any publications. Data collected during the course of the project might be used for additional or subsequent research. This study has been reviewed and approved by the University of Sheffield ethics review board. Participant can obtain a copy of the published results if they wish to by contacting the researcher.

15. Who is organising and funding the research?

No organisation or funding body is funding this research.

16. Who has ethically reviewed the project?

This study has been ethically reviewed and approved by the University of Sheffield's Ethics Review Committee (Reference No. 003556).

17.Will I be recorded, and how will the recorded media be used?

The interview will be recorded on audiotape only and transcribed to facilitate coding and analysis via a secure computer. The audiotapes will be kept in accordance with The University of Sheffield guidelines and destroyed at the end of the study. The audio recordings during this research will be used only for analysis and for illustration in conference presentations and lectures. No other use will be made of them without your written permission, and no one outside the project will be allowed access to the original recordings. Your response will be treated with full confidentiality and only code numbers or false names will identify anyone who takes part in the research.

18. Contact for further information

The University of Sheffield, School of Architecture, Arts Tower, Sheffield, S10 2TN United Kingdom

Contact 1 Name: Ayesha Ghazanfar (PhD Candidate)

Email Address: aghazanfar1@shefiield.ac.uk

Telephone number: +3110436464

Contact 2 Name: Name: Dr Prof Jian Kang (PhD Supervisor)

Email Address: j.kang@sheffield.ac.uk

You will be given a copy of this information sheet and a signed consent form or email confirmation agreeing to take part in the study to keep for record purposes.

Should you wish to know of the results of the study please leave your contact details with the researcher.

Thank you for your valuable time and taking part in the research project.

والدین اور سرپرستوں کیلئے منظوری فارم

تحقیقی منصوبے کا عنوان: ایک نیورو-آٹسٹک بچوں کیلئے سیکھنے کے ماحول میں حسی آہنگ پیدا کرنے کیلئے آرکیٹیکچرل تناظر۔

اس منصوبے کیلئے شریک کے شناختی نمبر: ڈبوں میں ابتدائی براہ مہربانی۔

1. میں نے پڑھا ہے کہ اس کی تصدیق اور معلوماتی پرچہ سمجھتے۔ تاریخ 2015-5-2 مندرجہ بالا تحقیق کے منصوبے کی وضاحت کی ہے اور میں نے اس کے بارے مجھے سوال پوچھنا کا موقع ملا ہے۔

2۔ میں نے اپنی شرکت رضاکارانہ ہے اور میں کسی بھی منفی نتائج دینے کے بغیر کسی بھی وقت واپس لینے کے لئے آزاد ہوں جو کہ سمجھ لیا۔ اس کے علاوہ میں نے کوئی لیڈ محقق جواب دینے کی خواہش نہیں کرنی چاہیے۔ رابطہ

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3۔ میں نے اپنے جوابات کو انتہائی خفیہ رکھا سمجھا جائیں گے کہ میں نے تحقیق کی ٹیم کے ارکان نے میری گمنام کے جوابات تک رسائی حاصل کرنے کیلئے اجازت دے۔ میں نے اپنا نام تحقیقی مواد کے ساتھ منسلک نہیں کیا جائے گا۔ کہ اس کو سمجھے اور میں نے نشاندہی کی یا تحقیق کے نتیجے میں رپورٹ یا رپورٹوں میں قابل شناخت نہیں رکھا جائے گا۔

4۔ میں نے مطالعہ میں حصہ لینے کیلئے اپنے بچے کیلئے رضامندی دینے۔

4۔ میں نے شرکت کی جس میں انٹرویو ریکارڈ کیا اور تحریر آڈیو ٹیپ کی جائے گی کہ آگاہ ہوں۔

5۔ میری طرف سے جمع اعداد و شمار پر مبنی تحقیق میں استعمال کرنے کیلئے میں اتفاق کرتا ہوں۔

6۔ میں نے مندرجہ بالا تحقیق کے منصوبے میں حصہ لینے کیلئے اتفاق کرتا ہوں۔

شرکا کے نام یا قانونی نمائندے	تاریخ	دستخط
شخص لینے سے رضامندی کا نام تو لیڈ محقق سے مختلف	تاریخ	دستخط

دستخط کئے اور شریک کی موجودگی میں مورخہ کیا جائے گا۔

عائشہ غضنفر................. لیڈ محقق	تاریخ	دستخط

دستخط کئے اور شریک کی موجودگی میں مورخہ کیا جائے گا۔

نقول:

اس تمام جماعتوں نے دستخط ہو جانے کے بعد شریک سے دستخط اور تاریخ شریک رضامندی کی ایک نقل حاصل کرنا چاہیے خط / پہلے سے لکھے سکرپٹ / معلوماتی پرچہ اور شرکا کو فراہم کی کسی بھی دوسری تحریری معلومات۔ ایک محفوظ جگہ میں رکھا جانا چاہیے جس میں (مثال کے طور پر ایک ویب سائٹ کے فائل) منصوبے کے اہم ریکارڈ میں رکھا جانا چاہیے کی طرف سے دستخط کیے اور رضامندی کی ایک نقل۔

والدین کیلئے بھرتی سکرپٹ رطالب علم کے رکھوالوں آٹزم کے ساتھ تشخیص

مطالعہ عنوان: ریسرچ پروجیکٹ عنوان: اٹزم کے ساتھ تشخیص بچوں کیلئے حسی آہنگ ایک نیوروار کیٹیکچرل نقطہ نظر۔

محقق کا نام: عائشہ غضنفر (پی ایش ڈی کی امیدوار)

کی طرف سے زیر نگرانی: ڈاکٹر مائیکل فری

ای میل کے موضوع کی لائن: شیفیلڈ یونیورسٹی سے پی ایش ڈی کی تحقیق کا مطالعہ

میں شیفیلڈ یونیورسٹی میں پی ایش ڈی کے امیدوار ہوں، ایک کلاس روم میں عوامل کی نشاندہی کرنے کی ایک تحقیق کے انعقاد، سیکھنے یا آٹزم کے ساتھ تشخیص بچوں میں کام کاج پر اثر انداز کو روکنا۔

میں آٹزم کیلئے نخلستان اسکول میں شرکت اور مطالعہ میں حصہ لینے کی ابتدائی مداخلتی پروگرام میں داخلہ کے ساتھ تشخیص ایک بچے کے والدین رسر پرست کے طور پر آپ کو مدعو کرنا چاہتے ہیں۔ آپ کر رہے ہیں کہا جا رہا ہے:

* ایک انٹرویو میں اپنے بچے کے رویے کے بارے میں چند سوالات اور کسی بھی منسلک حسی مسائل کا جواب دیں، جس کے بارے میں ۳۰ منٹ لگیں گے۔ تم نے کب اور کہاں انٹرویو جگہ لے جائے گا اس بات کی تصدیق کرنے کیلئے رابطہ کیا جائے گا۔

* آپ کے بچے کو مطالعہ کے مقاصد کیلئے ایک کلاس روم میں مشاہدہ کیا جانے کیلئے لکھا یا خبر رضامندی دے دو۔

منسلک کو تلاش کریں

1۔ شرکا معلوماتی پرچہ مطالعہ کے بارے میں وضاحت کی۔

2۔ آپ مطالعہ میں حصہ لینے پر رضامند کرنے کیلئے دستخط کیلئے منظوری فارم

براہ کرم مطالعہ میں آپ کی شرکت رضاکارانہ ہے کہ نوٹ اور یہ کہ اس تحقیق کا جائزہ لیا اور شیفیلڈ یونیورسٹی اخلاقیات کمیٹی کی طرف سے منظور کیا گیا حوالہ نمبر 3556۔ آپ کو کسی بھی ایک شریک کے طور پر یا مطالعہ تفتیش سے رابطہ کر سکتے ہیں یا کیا جا رہا ہے جس طرح کے بارے میں اپنے حقوق میں خدشات یا سوالات ہیں تو سپروائزر ڈاکٹر مائیکل فری ای میل

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میں آپ کا وقت اور غور کیلئے ایڈوانس میں آپ کا شکریہ ادا کرنا چاہوں گا۔

عائشہ غضنفر

پی ایش ڈی امیدوار

شیفیلڈ فن تعمیر کے سکول کی یونیورسٹی، آرٹس ٹاور، شیفیلڈ S10 2TN برطانیہ۔

رابطہ ای میل: aghazanfar1@sheffield.ac.uk

Appendix D: Social Validity Questionnaire (Study 2 and 3)

Social Validity Questionnaire

Questions:		1 Strongly disagree	2 Disagree	3 Agree	4 Strongly Agree
1	This intervention was effective.				
2	I found the intervention suitable for the classroom environment.				
3	The use of intervention increased sustained attention and participation in classroom.				
4	The use of intervention decreased disruptive behaviors in class.				
5	I think if the intervention continues desired behavioral outcomes can be sustained.				
6	Overall classroom environment felt calm with the intervention.				
7	I would recommend this intervention for other schools and classrooms for ASD children.				
8	I would like to maintain this intervention as it suits the needs of classrooms and ASD students alike.				

Appendix E: Interview Questions for Study 1

Question 1: In your opinion, do features or elements of the classroom environment stimulate any specific behaviours that may affect On-task learning? Explain.

Coding category: Participation, Performance, Functioning

Question 2: Which environment features noticeably triggered sensory behaviour in a classroom environment? Such as ear-covering, easily getting distracted, rocking, spinning etc.

Coding category: Noise sensitivity, Light sensitivity, Temperature, Environment specific, Child specific

Question 3: Which architectural variable in a classroom environment has the strongest effect on the On-task learning behaviour of children with ASD?

Coding category: Noise, Light, Smell, Texture, Spatial Layout

Question 4: Are the teaching methods such as ABA and TEACCH affected by any significant architectural variable/s?

Coding category: Spatial Layout, Visual Space, Noise, Colours

Question 5: Does the difficulty level of academic material appear to produce any off-task behaviours in a classroom environment?

Question 6. Which is the most important type of classroom accommodation that could be recommended to achieve sustained periods of attention on a learning task or activity?

Coding category: Noise reduction, Clutter free, Lighting, Child Specific, Temperature

Question 7. In your opinion, which classroom variables can play an important role in achieving better speech, language acquisition and listening?

Coding category: Visual cues, Noise reduction, Child specific, Spatial layout

Question 8. Which Acoustical Variable has the most significant impact in an ASD specific Classroom-learning Environment?

a. **Signal to Noise Ratio SNR**

b. **Reverberation Time (Echo)**

c. **Background Noise BN**

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