THE IMPACT OF ACOUSTICAL ENVIRONMENTAL DESIGN ON CHILDREN WITH AUTISM

A Dissertation

by

SHIREEN MOHAMMAD FAWAZ KANAKRI

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Chair of Committee,	Mardelle M. Shepley
Co-Chair of Committee,	Louis G. Tassinary
Committee Members,	James W. Varni
	Susan Rodiek
	Stephen Caffey
Head of Department,	Ward V. Wells

May 2014

Major Subject: Architecture

ABSTRACT

In recent years, research has shown that the educational environment has a profound effect on learning and performance among students, especially those with autism. Many design solutions that target autistic populations have been introduced for implementation in both mainstream and special education classrooms. Classrooms serve as the major setting for emotional, cognitive, social, and psychological development for all students. Additionally, for most students with autism, education is centered on learning skills for future independence.

If classrooms and learning environments are not designed to accommodate students with developmental disabilities, it can be assumed that they will not learn these important skills and may struggle to live in our society. Acoustics is one of the most important issues in the interior design requirements of these children.

This study consisted of two main stages. The first stage was to evaluate the current situation by distributing a questionnaire to teachers and professionals associated with programs serving children with autism. The second stage involved observing the children‟s behavior in classrooms with varying noise levels and a short interview with teachers every day of the observation.

The findings of this study demonstrate that there is a strong correlation between the level of noise and inappropriate behaviors of children with autism. The findings led the

researcher to recommend a preliminary framework of design guidelines using a quantitative and qualitative analysis to transform the data into tangible knowledge.

DEDICATION

To my Mother and Father for their endless support

To the two greatest joys of my life, my sons, Adam and Ibraheem

To my husband, Naeem, for the encouragements and support during my PhD

To my brothers and sisters

ACKNOWLEDGMENTS

The author gratefully acknowledges the collaborative support of many people who contributed to this amazing doctoral journey at Texas A&M University. First, I would like to express my deepest gratitude and appreciation to Dr. Mardelle Shepley and Dr. Louis Tassinary, Chair and co-chair of my committee, for their expert guidance, nurturing, and incredible inspiration that provided the essential encouragement that made this PhD. Experience so fulfilling. Their professional guidance and integrity has provided inspiration for a lifetime standard of excellence to emulate.

It is with great gratitude that I thank my other committee members. In addition to his extensive experience in healthcare research, Dr. James Varni provided immeasurable wisdom and guidance through the literature and methodology, which will continue to inspire my future research in healthcare and autism design. My deep appreciation and reverence go to Dr. Stephen Caffey for his inspiration in understanding the essence of the creative mind, providing greater insights as a researcher. I would also like to thank Dr.Susan Rodiek for her valuable comments.

Research for this dissertation would not have been possible without the support of school administration in Houston, TX, as well as the administration staff of Texas Children Hospital in Houston, Texas. Special thanks go to Barbara Boyett, CEO, and head of School II, Houston, Texas and Becky Ingalls, principal of School II, for her boundless support and friendship throughout the data collection.

TABLE OF CONTENTS

Page

Page

LIST OF FIGURES

FIGURE Page

FIGURE Page

FIGURE Page

FIGURE Page

FIGURE Page

FIGURE Page

LIST OF TABLES

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

Special needs users require special design considerations. Autism, a developmental disorder has many characteristics such as delayed verbal skills, difficulties on any social interaction, challenges on tolerate with any distracted and environment has long been excluded from the various architectural and interior design guidelines of practice for special needs (Mostafa,2008). This disorder is likely organic in nature and may be indicated in brain cell structure, (see, Figure 1.1).

Figure 1.1 Brain Cell Defects in Child with ASD (Source: National Institute of Mental Health, 2007)

Current estimated rates of ASD range between 3 and 7 for every 1,000 children between the ages of 3 and 10, which suggest that this is a more common disorder than was previously thought (Centers for Disease Control, 2007; National Institute of Mental Health, 2007). These disorders are more common in boys than in girls; the ratio is three to five boys per girl (American Psychiatric Association, 2000), (see Figures 1.2 and 1.3).

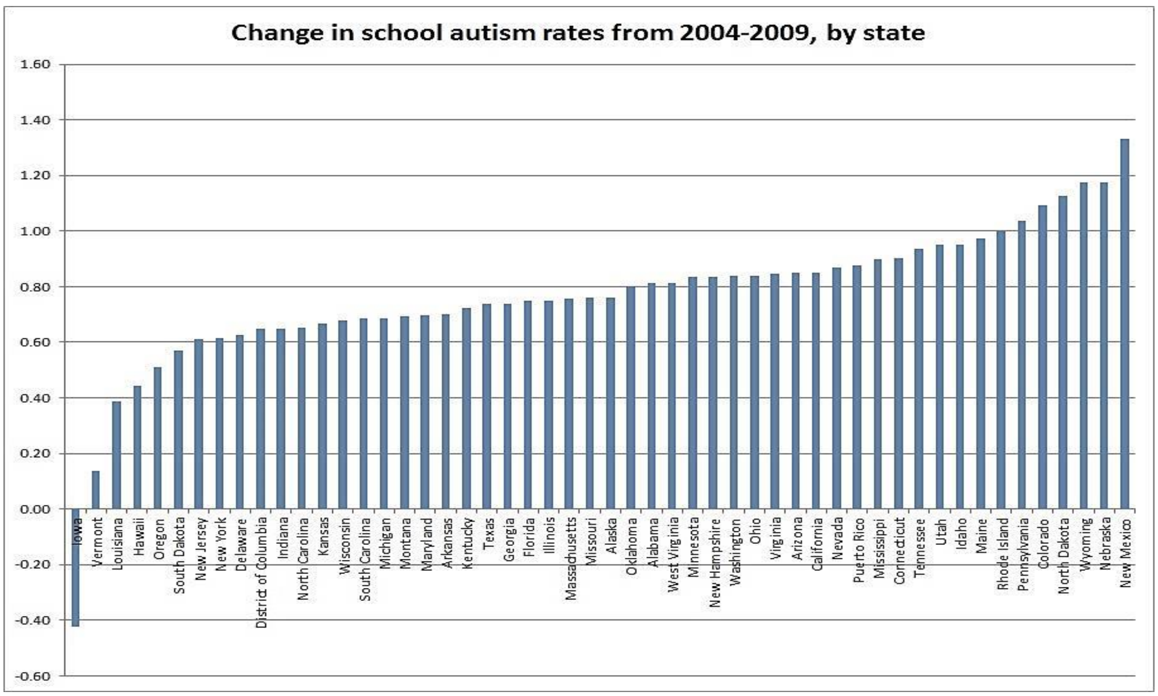

Figure 1.2 Changes in School Autism from 2004-2009 in USA (Source: National Institute of Mental Health, 2007**)**

Acoustics is one of the most important issues in the interior design requirements of these children (Caldwell, 2006). Most people with ASD live with auditory hypersensitivity (hyperacusis) (Baguley, 2013). Observers report seeing people with ASD cover their ears when noise levels rise. The Main purpose of this research is to understand how acoustics impact the behavior of autistic children, and to generate design guidelines that will support the needs of these children.

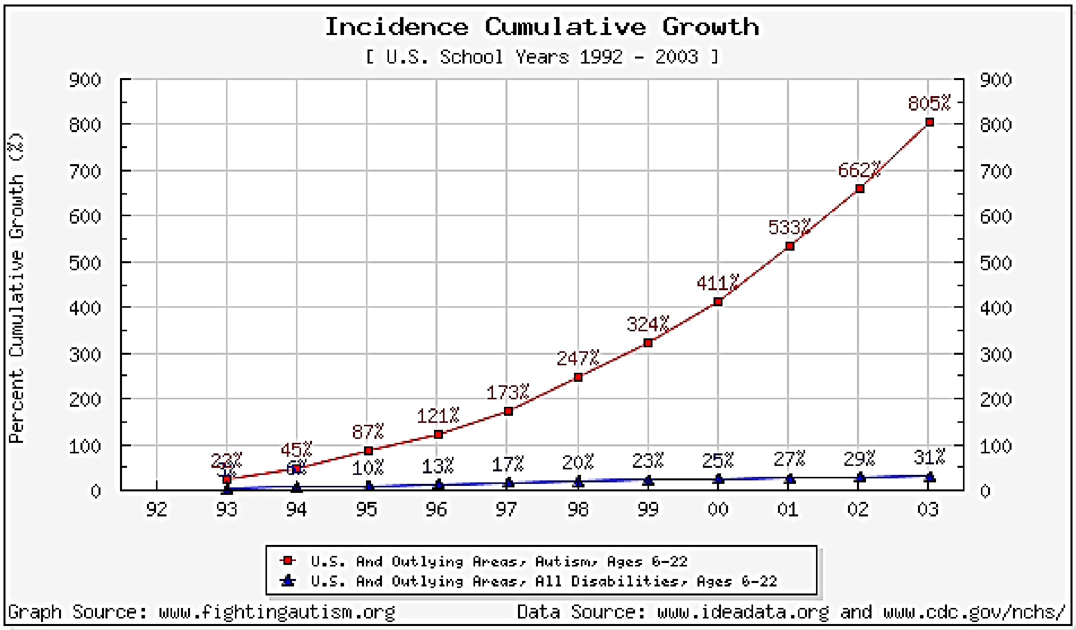

Figure 1.3 Growth of Autism in USA (Baguley, 2013)

1.2 AUTISM AND THE BUILT ENVIRONMENT

Autism is one of the most challenging disorders studied by physicians, psychologists, mental health practitioners, therapists, and educators. This is evident from the relatively large body of research on the topic. Although researchers believe that individuals with autistic characteristics lived well before the twentieth century, the syndrome of Autism was first named and described by a psychiatrist, Leo Kanner (1943).

In his research, Kanner described eleven children whose condition was different from anything reported at that time. The children had certain characteristics in common which set them apart from others (Groden & Baron, 1991; & Scheuermann, 2002). These included the following:

1) An inability to relate to others in an ordinary manner.

2) An extreme autistic aloneness that seemingly isolated the child from the outside world.

3) An apparent resistance to being picked up or held.

4) Deficits in language including autism and echolalia.

5) In some cases, an excellent rote memory.

6) Early specific food preferences.

7) Extreme fear reactions to loud noises.

8) Obsessive desire for repetition and maintenance of sameness.

9) Few spontaneous activities such as typical play behavior.

10) Bizarre and repetitive physical movement such as spinning or perpetual rocking.

11) Normal physical appearance.

Architects can help people with autism by designing appropriate interior and exterior environments that help them use the space appropriately and comfortably. According to this literature review, guidelines generated by research include specific design criteria concepts such as sensory zoning, use of transition spaces between zones, adoption of escape spaces, and the use of visual clues to enhance wayfinding.

1.2.1 Definition of Autism

Autism in children is a disorder in which the child‟s ability to communicate and interact socially is seriously impaired; children with autism have specific language deficiencies, demonstrate a need for sameness in their environment, and often engage in repetitive and stereotyped kinds of behaviors (Parke & Gauvain, 2009).

Also, there are many definitions for autism in children and one of the most common definitions is the sensory definition of autism, which has been put forth by researchers such as (Rimland,1964, p.23;Delacato,1974, p.45) and (Anderson,1998, p.10). In all these theories, behaviors of children with autism have been discussed as a sensory problem when understanding the visual and verbal information from the environment around them (Mostafa, 2008). It is important for the architect, who designs the physical sensory environment for these children, to provide solutions to help those children tolerates and cope with their environment with this critical sensory input.

Children with autism often fail to develop a useful means of interacting with others, whether verbal and nonverbal. According to literature on this area, such children may be highly resistant to change and new behavior patterns. At the same time such children prefer to deal with inanimate objects rather than humans (Parke & Gauvain, 2009). Children with autism often avoid eye contact with others and fail to develop any kind of social interaction with others. Often, they appear to be unaware of other people and even of themselves (Parke & Gauvain, 2009).

Some children with autism seem not to recognize themselves as independent social being (Dawson et al., 2004). Some research indicates that autistic children show deficits in self-recognition. When researchers in one study showed children with autism a mirror, 31% failed to demonstrate recognition of their mirror images (Spiker & Ricks, 1984).

One of the most common behaviors for autistic children is Obsessive Self-Stimulatory Behavior. This behavior is common in children with autism in which they engage in repetitive actions that seemingly have no purpose (Appropriate, 2011). For example, switching lights on and off, or flapping their hands in front of their eyes (Rogers & Pennington, 1991). Recent research has indicated that autism is growing at almost epidemic proportions (Hill & Frith, 2003; Fombonne, 2005).

By understanding the mechanisms of this disorder and consequent needs of the autistic user, this environment may be designed favorably to alter the sensory input, and perhaps modify the autistic behavior, or at least create an environment conducive to skill development and learning (Mostafa, 2008).

1.2.2 Rates of Autism in USA

Estimates of the frequency of autism ranged from 4 to 5 per 10,000 individuals (American Psychiatric Association, 2000, Patterson & Rafferty, 2001) a decade ago. Since then the rates of ASD have increased, owing not only to better detection, but also to the use of broader diagnostic criteria that increase the number of children being labeled as part of the autistic spectrum (Baron-Cohen, 2007). Current estimated rates of ASD range between 3 and 7 for every 1,000 children between ages 3 to 10, which suggest that this is a more common disorder than was previously thought (Centers for Disease Control, 2012; National Institute of Mental Health, 2012). These disorders are more common in boys than in girls; the ratio is three to five boys to one girl (American Psychiatric Association, 2000).

1.2.3 Types of Autism

Children with autism display deficits in both verbal and nonverbal communication. Also they have difficulty understanding facial expressions and emotions and integrating gestures such as those meaning “be quiet” or “come here” or “look” (Baron-Cohen, 2003, 2007). They are less likely to respond when called by name or to respond to an adults‟ point and gaze (Dawson et al., 2004). In addition, 50% of autistic children never develop meaningful speech, and most others had limited means of verbal expression speech. The following are the five types of autism as defined by the Autism Society of America, which can help in the diagnosis of autism:

1. Kanner's syndrome**:** is often referred to as "early infantile autism." Kanner's syndrome is not a diagnosis; it is another term for autistic disorder. Symptoms typically occur before the age of three, and these symptoms are typical of autism. In many cases, a delay in a child's development, including speech and social skills is noticed. The child may appear oblivious to his surroundings, focusing in on one or two particular objects instead. They may seem unable to make eye contact with those around him and may not respond to typical communication efforts (Dawson et al., 2004).
2. Asperger's Syndrome: This disorder was first described in the 1940s by Viennese pediatrician Hans Asperger, who observed autistic-like behaviors and difficulties with social and communication skills in boys who had normal intelligence and

language development (Autism Society, 2013). Uta Frith (2012) a professor at the Institute of Cognitive Neuroscience of University College London and editor of *Autism and Asperger Syndrome*, describes individuals with Asperger's Disorder as "having a dash of Autism". The main characteristics of this disorder are; difficulties in social interaction and communication skills, language delay, couldn‟t tolerate with exposure to loud noise or bright lights. Some professionals consider Asperger‟s Disorder a form of autism and they used the term "High-functioning autism" to describe these individuals (Autism Society, 2013).

3. Autistic Disorder: Autism spectrum disorder (ASD) and autism are both general terms for a group of complex disorders of brain development. These disorders are characterized, in varying degrees, by difficulties in social interaction, verbal and nonverbal communication and repetitive behavior (echolalia)s (Autism Speaks, 2013). With the May 2013 publication of the DSM-5 diagnostic manual, all autism disorders were merged into one umbrella diagnosis of ASD. Previously, they were recognized as distinct subtypes, including autistic disorder, childhood disintegrative disorder, pervasive developmental disorder-not otherwise specified (PDD-NOS) and Asperger syndrome (Autism Speaks,2013)
4. Pervasive Developmental Disorder**:** The pervasive developmental disorders (PDD) are a group of neuropsychiatric disorders that include autistic disorder, Asperger's disorder, childhood disintegrative disorder, Rett's disorder, and PDD not otherwise specified (American Psychiatric Association,1994). These disorders are characterized by atypical development in social, communicative,

and behavior areas. Onset typically occurs within the first years of life. Prevalence rates as high as 63 per 10 000 children have recently been reported (Chakrabarti & Fombonne, 2001). Although commonly associated with mental retardation, the developmental and behavioral features of PDD are distinct and do not simply reflect developmental level (Campbell & Shay, 1995; Volkmar, 1996).

5. Childhood Disintegrative Disorder**:** Childhood disintegrative disorder (CDD), also known as Heller's syndrome and disintegrative psychosis, is a rare condition characterized by late onset (>3 years of age) of developmental delays in language, social function, and motor skills. Thomas Heller, an Austrian educator, first described childhood disintegrative disorder in 1908. It is a complex disorder that affects many different areas of the child's development. It is grouped with the pervasive developmental disorders (PDDs) and is related to the better known and more common disorder of autism (Charan, 2012).
6. Rett Syndrome**:** Rett syndrome (RS) is a unique progressive neurodegenerative illness occurring in girls (Hagberg, 1989; Sekul & Percy, 1992). It has been recognized in all ethnic groups all over the world and the prevalence estimated in Sweden, Scotland and Texas ranged from 1:12,000 to 1:20,000, (Hagberg, 1989;Sekul & Percy, 1992). This disorder characterize with the following; After normal general and psychomotor development up to the age of 7 to 18 months, developmental stagnation occurred, followed by rapid deterioration of higher brain functions. Within one-and-a-half years this deterioration led to severe

dementia, autism, loss of purposeful use of the hands, jerky truncal ataxia, and acquired microcephaly (Hagberg, Aicardi, Dias & Ramos, 1983).

1.2.4 Sensory Abnormalities in the Brain

An autistic child may demonstrate some inappropriate behaviors because certain sounds make him or her uncomfortable. A sudden noise (even a relatively faint one) will often make my heart race (Courchesne, 1989). Cerebellar abnormalities may play a role in increased sound sensitivity. Research on rats indicates that the vermus of the cerebellum modulates sensory input (Crispino & Bullock, 1984). Stimulation of the cerebellum with an electrode will make a cat hypersensitive to sound and touch (Chambers, 1947).

Many autistics have problems with modulating sensory input (Ornitz, 1985). They either overreact or under-react. Ornitz (1985) suggests that some cognitive deficits could be caused by distorted sensory input. Autistics also have profound abnormalities in the neurological mechanisms that control the capacity to shift attention between different stimuli (Courchesne, 1989).

In addition to the abnormalities in the neurological mechanisms paradigm, autism has been diffrenet characterized as a disorder of executive function (Ozonoff et al., 1991), complex information processing (Minshew et al., 1997), theory of mind (Baron-Cohen et al., 1985), and empathy (Baron-Cohen, 2002). Recent attempts at a theoretical synthesis have focused on abnormal neural connectivity, and, superficially, there seems some disagreement as to whether this abnormality involves a surfeit (Rubenstein and Merzenich, 2003; Belmonte et al., 2004) or a deficit (Brock et al., 2002; Just et al., 2004) of connectivity. Belmonte, Allen, Beckel-Mitchener, Boulanger, Carper & Webb (2004) discussed potential effects of network connectivity patterns on brain activation (see Figure 1.4).

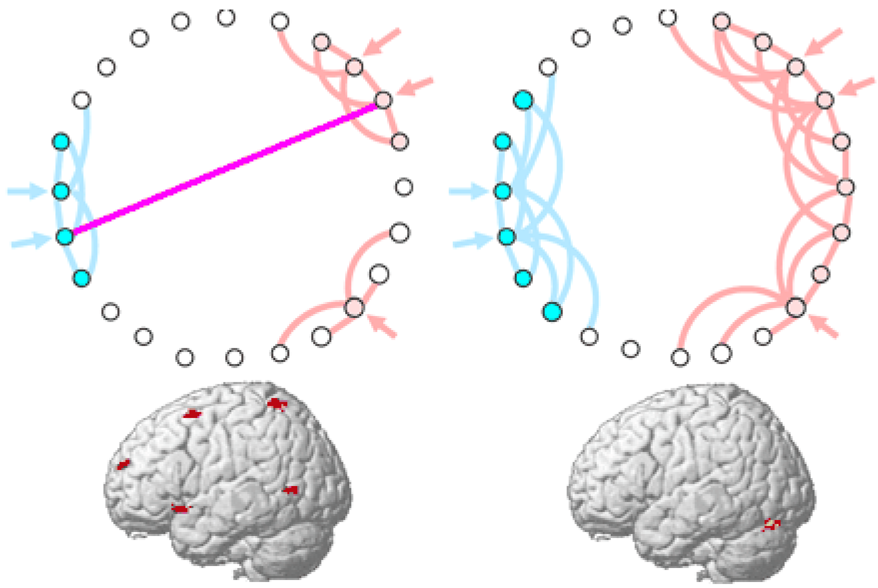

Figure 1.4 Effects of Network Connectivity Patterns on Brain Activation. Normal brain (left) and Autistic Brain (right), source (Matthew K. Belmonte, Greg Allen, Andrea Beckel-Mitchener, Lisa M. Boulanger, Ruth A. Carper, and Sara J. Webb. 2004)

In the network on the left, a combination of strong local connectivity within delimited groups of neural units and selective long-range connectivity between local groups constitutes a computational structure within which information can be efficiently represented and efficiently propagated (Belmonte, Allen, Beckel-Mitchener, Boulanger, Carper & Webb, 2004). Inputs (double arrows) evoke representations that are easily differentiable from noise (single arrow) and can be correlated across regions, finding a high computational connectivity, strongly connected sub-regions are not appropriately delimited and differentiated, and computationally meaningful long-range connections fail to develop (Belmonte, Allen, Beckel-Mitchener, Boulanger, Carper & Webb, 2004). The brain images at bottom, from a visual attention task, display distributed patterns of functional activation in the normal brain (left) and abnormally intense and regionally localized activation in the autistic brain (right (Belmonte, Allen, Beckel-Mitchener, Boulanger, Carper & Webb, 2004).

1.3 NOISE AND THE BUILT ENVIRONMENT

Noise tends to play a significant role in the effecting our health during using the physical environment. Noise is generally defined as the unpleasant sounds which distract the human being physically and physiologically and cause environmental pollution by destroying environmental properties (Melnick, 1979). Negative effects of noise on human beings are generally of a physiological and psychological nature (Atmaca, Peker & Altin, 2005).

Noise has many psychological and physiological effects, the psychological effects of noise are more common compared to the physiological ones and they can be seen in different forms such as; annoyance, stress, anger and concentration disorder as well as difficulties in resting and perception (Cheung, 2004; Ohrstrom, 1989; Finegold, Harris & Gierke Von, 1994). One of the most dangerous effects of exposure to continuous and extensive noise is hearing loss (Atmaca, Peker & Altin, 2005). Rise in blood pressure, heart beat acceleration, appearance of muscle reflexes, and sleeping disorders may be considered among the other psychological effects. Exposure to continuous and extensive noise at a level greater than 85dBA may lead to hearing loss. Continuous hearing loss differs from person to person with the level, frequency and duration of the noise exposed (United States Environmental Protection Agency, 1974).

Other inappropriate effects of noise on human beings have been presented in many studies. The effects of noise on task performance are quite complex, and not as predictable as other noise effects (Suter, 1989).

"People are often affected by non-acoustical factors, such as biological and psychological state, as well as external factors such as task complexity and the presence of other stressors" (Suter, 1989, p.120). Suter describes effects from high noise levels on thresholds of sensitivity, critical flicker fusion, and visual field shifts. Small but reliable effects have been demonstrated on vestibular function, especially with asymmetric exposures.

> Motor performance usually adapts with repeated or prolonged exposure, but high noise levels can show persisted decrements. Some startle responses, notably the eye- blink response, do not habituate. With respect to task variables, noise has little effect on simple tasks, and can even improve performance on monotonous tasks. Tasks requiring continuous performance may be disrupted, especially by noise levels over 100dB and if the job requires a high level of sustained performance. Intellectual function is not usually affected, but vigilance tasks are susceptible to noise, particularly under certain conditions. Noise can sometimes produce significant after effects, one of the most common being a reduced tolerance for frustration. It also appears that noise can increase anxiety levels and

the risk of hostile behavior, while decreasing the incidence of helpful behavior. (Suter, 1989, p.103).

From Suter (1989) we can see that there is a relation between the high level of noise and the inappropriate behaviors, which will effect the performance on solving any task or problem. Sound levels typically exceed 60-80dB(A) before a typical person will experience inappropriate behaviors even for exposures that last as long as 12-24 hours (Evans, Steffan & Bullinger, 1995). Other important and equal thing, the greater the intensity over 60-80 dB (A), their greater amount of inappropriate behaviors (Evans, Steffan & Bullinger, 1995).

In conclusion the inappropriate effects of noise could occur under conditions consisting of long-term of hearing loud noises and repeated exposures.

1.3.1 Definition and Types of Noise

Noise is the unwanted sound. Noise can be produced by many sources - man's vocal cords, a running engine, a vibrating loudspeaker diaphragm, an operating machine tool, and many other sources (Environmental Protection Department, 2013).

The response of the human ear to sound is dependent on the frequency of the sound. The human ear has peak response around 2,500 to 3,000 Hz and has a relatively low response at low frequencies (Errede, 2013).

Frequency: The count of pressure differences per second is called the frequency of sound, and is measured in Hertz (Hz) which is defined as cycles per second. The higher the frequency, the more high-pitched a sound is perceived. (Environmental Protection Department, 2013).

Physicians define the frequency of the wave as the number of complete back-and-forth vibrations of a particle of the medium per unit of time (Kumar, 2006).

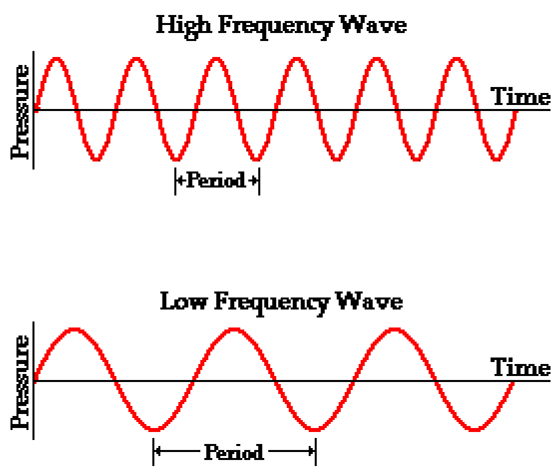

Figure 1.5 High Frequency Wave vs. Low Frequency Wave (Source Gupta, 2008)

Loudness: A loud noise usually has a larger pressure variation and a weak one has a smaller pressure variation. Pressure and pressure variations are expressed in Pascal (Pa) (Gupta, 2008). To express sound or noise in terms of Pa is quite inconvenient because we have to deal with numbers from as small as 20 to as big as 2,000,000,000. A simpler way is to use a logarithmic scale. As such, the loudness of sound is commonly expressed in decibel (dB) (Gupta, 2008). (See Figure 1.6).

Pitch is a subjective response to frequency. The presence of a discernible pitch in a complex noise is indicative of one or more pure tone components (Bies & Hansen, 2004). Qualitatively, high frequencies correspond to high pitch. However, at low sound pressure levels, pitch is not linearly related to frequency (Bies & Hansen, 2004).

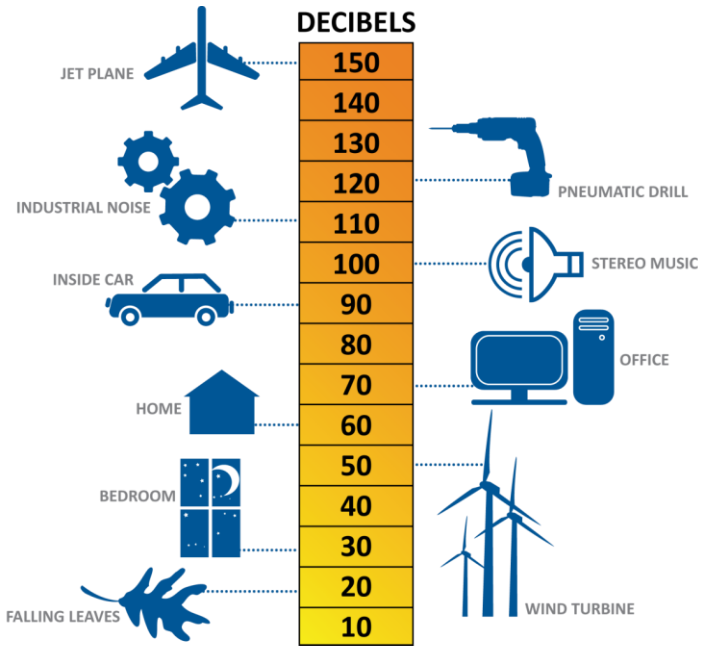

Figure 1.6 Typical Noise Levels in Decibel Meter Scale (Source: Bies & Hansen, 2004)

1.3.2 Effect of Noise on Children with Autism

One of the most commonly known characteristics of persons with autism is hypersensitivity to environmental stimulation. As the topic covers a wide range of environmental factors, physiological responses have been observed or discussed by many investigators of the effects of low and high frequency noise on human behavior. These responses have included cardiac rhythm and respiration rate (measured by EKG recordings, pulse counts and impedance anemography), change of systolic rhythm, blood and endocrine changes, and disturbances to the central nervous systems, as well as subjective responses (Kanakri, 2012). It is now well known that low and high frequency noise can produce unpleasant subjective effects in some people, including such effects as nausea and feelings of panic or euphoria (Wigram, 1987). Persons with autism are particularly susceptible to negative effects. The more accurately autistic children understand auditory information, the better they will be able to comprehend their environment, both socially and academically (Autism Research Institute, 2013). The better we understand the autistic child, the better we can develop ways to intervene in an effective manner (Autism Research Institute, 2013).

Hypersensitivity or hyperacusis is broadly defined as an unusual intolerance of the normal sounds in the environment (American Speech Language-Hearing Association, 2008; Anderson, Lindvall, Hursti, & Carlbring, 2002). Hypersensitivity to sound has been mentioned to be discussed for decades as a very important problem issues within the autism spectrum disorder (ASD) community. Between (1964) and (1994), the Autism Research Institute gathered the medical histories on more than 17,000 children with autism in different countries, and more than 40% included parent notations of sound sensitivity (Rimland & Edelson, 1995). Schwartz (2005) defines the hyperacusis as the loudness discomfort levels less than 70 to 75dB, in the presence of normal hearing.

Stlegler and Davis (2010) mentioned that in numerous compelling daily observations, parents" reports, and clinical experience narratives, authors have described behaviors shown by individuals with ASD in response to noise (e.g. Grandin, 1995; Grinker, 2007; Hughes, 2003; Jackson & King, 1982; Park, 2001). Additionally, Stlegler and Davis (2010) added that depending on the researchers view, the behaviors may be presented as very having difficulties in many behaviors, self-treatment strategies, autonomic fear responses, or emotional regulatory strategies. Such behaviors include covering ears, crying, and/or tantrums in response to certain sounds, feeling the area where the sound is occurring, humming/vocalizing in the presence of sound, trembling, increased muscle tone, hyperventilation, and pupil dilation and even self-injury in the form of blows to the ears. Temple Grandin, a high functioning autistic person, wrote about her own hyperacusis in Thinking in Pictures (1995):

> When I was little, loud noises were also a problem, often feeling like a dentist‟s drill hitting a nerve. They actually caused pain. I was scared to death of balloons popping, because the sound was like an explosion in my ear. Minor noises that most people can turn out drove me to distraction. When I was in college, my roommate‟s hair dryer sounded like a jet plane taking off. (p.67)

A gifted, autistic man from Portugal wrote, "I jumped out of my skin when animals made noises" (White & White, 1987, p. 45). An autistic child will cover his ears because certain sounds hurt. It is like an excessive startle reaction. A sudden noise (even a relatively faint one) will often make my heart race (White & White, 1987). He wrote that carrying on a conversation was very difficult. The other person's voice faded in and out like a distant radio station (White & White, 1987). Temple Grandin (2011) in her book "The Way I See it" wrote*:*

> I still dislike places with confusing noise, such as shopping malls. High-pitched continuous noises such as bathroom vent fans or hair dryers are annoying. I can shut down my hearing and withdraw from most noise, but certain frequencies cannot be shut out. It is impossible for an autistic child to concentrate in a

> classroom if he is bombarded with noises that blast through his brain like a jet engine. High, shrill noises were the worst. A low rumble has no effect, but an exploding firecracker hurts my ears. As a child, my governess used to punish me by popping a paper bag. The sudden, loud noise was torture. Even now, I still have problems with tuning out. I will be listening to a favorite song on the radio, and then realize I missed half of it. My hearing just shuts off. In college, I had to constantly keep taking notes to prevent tuning out. (p.34)

Lang (1987) contends that autistic behavior can be influenced favorably by altering the sensory environment, i.e. the stimulatory input, resulting from the physical architectural surroundings (color, noise, texture, ventilation, sense of closure, orientation, acoustics etc.) before, rather than after the sensory malfunction occurs. By altering this sensory input in a manner designed to provide and cover specific autistic needs, behavior may be improved, or at least a more conducive environment created, for more efficient skill development.

1.3.3 School Design Criteria

According to Myler, Fantacone and Merritt (2003), there is limited literature on designing specialized schools for autistic children. Architectural design is secondary when it comes to educating and treating autistic youngsters; it cannot offset the need for well-trained, experienced teachers. Schools for autistic children must incorporate diagnostic, medical/ therapeutic and social support services that are much more extensive than those in traditional public school. Also autistic children respond best to education that is continuous and consistent. The teachers need to support develop these needs and the architect should design the environment to support this educational process.

Myler, Fantacone and Merritt (2003) use guidelines from their practical experience to help architects who are interested in design for autistic children as follows:

1. Color is one of the most identified aspects in design process. Holmes says no hard data exists on color-related distractibility, but both educators and designers concur that a muted. Subdued palette- pastels, neutral and browns plain, unpattern finishes are sensible choices for children with autism.
2. Controlling sensory stimulation goes hand in hand with providing a comfortable and non-threatening environment. For example, using low ceiling heights, small spatial volumes, and using transitional zone between the outside and inside the classroom.
3. Children with autism have chronic upper- respiratory problems, and poor air indoor quality can interfere with their education. As a designer we should improve the design features to help improve the air quality inside the classrooms.
4. Controlling the acoustical environment inside the classrooms is important. Learning spaces must be configured in ways that control sound transmission. Adjacencies between classrooms and noisy spaces have to be planned carefully.

5. Increasing the overall softness of the environment through materials other than carpets will be helpful. Rubberized flooring might be appropriate in some areas. Using drywalls might be preferable to masonry walls.

Lang (1987) also discusses various mechanisms through which meaning is obtained from the architectural environment. Architects utilize this concept in designing space, by giving certain meanings through form, to influence user behavior. Deasy and Laswell (1990) discuss the architect‟s use of common patterns of cognition to guide and manipulate user behavior in a space. If we look at meaning, or the cognitive value given to an experience, we can understand how a user typically interprets his architectural environment (Deasey & Laswell, 1990).

CHAPTER II

METHODOLOGY

2.1 RATIONALE FOR THIS STUDY

This study aims to describe and compare the effect of different noise levels inside classrooms on the behavior of children with high functional autism levels. The knowledge gained from this study is expected to serve as a new framework for environments for children with autism. The new perspectives and insights on preferred environments will enhance the previous studies, predictions, and generalizations on this topic.

This chapter discusses the overall methodological design for the two phases study, which encompasses both quantitative and qualitative methods. Chapter III provides more detail about the design and specific issues and hypotheses as they relate to the individual methods.

2.2 GOALS & SIGNIFICANCE OF THIS STUDY

This study is significant for children with autism for five different reasons:

1. Autism has not been addressed by the design community or building codes and guidelines, even those standards developed specifically for special needs individuals (Mostafa, 2008). In reference to this exclusion, Baron, of the International Code Council stated, "I know of no building or accessibility code that incorporates requirements specifically to address children with autism.

However, accessibility in general is addressed in the codes developed by the International Code Council" (Baron, 2003, p.4).

Therefore, one of the primary aims of this research is to correct this exclusion by developing a preliminary framework of design guidelines for autism. A framework is provided in part by placing the theory in the context of other conceptual understandings. Deasy and Laswell (1990) discuss the architect"s use of common patterns of cognition to guide and manipulate user behavior in a space. If one looks at the meaning, or the cognitive value given to an experience, it becomes clear the way in which a user typically interprets his interior environment.

2. Acoustics is one of the most important issues in interior design. No specific references or standards are made in the United Nations mandate on the Global Program on Disability regarding individuals with developmental disorders or autism, but the term "consideration" is used in reference to "other communication disorders" (UN Global Program on Disability, 1993). Individuals with developmental and psycho-social disorders, of which autism is one, have been overlooked (UN Global Program on Disability, 1993).
3. In a study by Mostafa (2008), most parents and teachers ranked acoustics as the most significant architectural feature influencing the behavior of autistic children (79.3% and 67%, respectively) and spatial sequencing as the second most significant (13.19% and 20%, respectively). Lighting, colors and patterns, texture, and smell were ranked lower (Mostafa, 2008).

4. If autistic children are able to understand auditory information, they will be more likely to comprehend their environment, both socially and academically (Turkington & Anan, 2007). The better we understand the autistic child, the better we can develop ways to intervene in an effective manner (Rimland & Edelson, 1995).
5. Research indicates that environment is important to the treatment of autism because it influences behavior. The autistic child‟s environment can be shaped to discourage destructive behaviors and encourage positive behaviors (Rimland & Edelson, 1995).

This research gives compelling reasons for the architects and designers to modify the environment for children with autism. These modifications will help these children develop their skills, cope with the auditory problems and improve their behaviors.

2.3 PURPOSE OF THE STUDY

The main purposes of this research are:

- To understand how acoustics impact the behavior of autistic children, and
- To generate design guidelines that will support the needs of these children.

2.4 HYPOTHESIS

Hypothesis 1: There is a relationship between noise and the behavior of autistic children. It is predicted that acoustics have been ranked as the most architectural feature influencing the behavior of autistic children.

Research indicates that environment is important to the treatment of autism because it influences behavior. The autistic child"s environment can be shaped to discourage destructive behaviors and encourage positive behaviors (Rimland & Edelson, 1995).

Hypothesis 2: There is a correlation between destructive or withdrawn behaviors and noise levels. In Edelson"s (1999) study, if autistic children are able to understand auditory information, they will be more likely to comprehend their environment, both socially and academically. The better we understand the autistic child, the better we can develop ways to intervene in an effective manner (Rimland & Edelson, 1995).

2.5 MULTI-METHODOLOGY

To reach this goal of developing a framework for architectural guidelines for autism, a two phase study was carried out using methods appropriate for each inquiry: a teacher questionnaire and a behavioral observation study in the field. The questionnaire contributed to the formulation of the field study. Noise needs to be studied in real-life settings since the response to sound is the result of complex patterns intersecting with human perception and behavior. This research has both quantitative and qualitative components as it uses several research methods to collect data.

A multi-method approach is important for understanding and applying this research. The aim is to understand the meaning of behaviors from different viewpoints. It involves an investigation of how the noise affects the behavior of children with autism from their teachers" perspectives. This approach also involves a comparison of how those children will behave in noisy and quieter environments. The use of multiple data-collection methods enables the researcher to complement the weaknesses and strengths of research problems, to obtain convergent findings, and to promote a better understanding.

2.6 METHODOLOGY FOR PHASE 1: TEACHERS SURVEY

2.6.1 Purpose

The first phase of this research was a survey for the teachers of children with autism. The objective of this first phase was to rank the impact of acoustical features such as noise and insulation material on the children‟s behavior. The results from this ranking indicated the most influential acoustical factors on autistic behavior, which would become the guide for the second phase of this study.

2.6.2 Participants

2.6.2.1 Demographic Information of Participants

Ninety-five teachers from three schools for children with moderate to high functioning autism level in Houston, Texas, were approached to participate in this study. The schools used as research sites for Phase 1 were: Westview School, School I, and School II. The Westview School had 30 teachers of which 26 responded. In the School I 25 teachers responded from a total of 40 teachers. In the third school, School II House, 24 of 25 teachers responded.

Most of the teachers in these schools had experience in teaching children with autism for more than five years and some of them had experience for more than 18 years. The average number of years of experience for all teachers was about 8 years and 4 months (refer to Figure 2.1). Most of the teachers instructed a typical range of classroom subjects, while a smaller number taught specialized classes such as music, art and language. Classes ranged from preschool to middle school (refer to Figure 2.2).

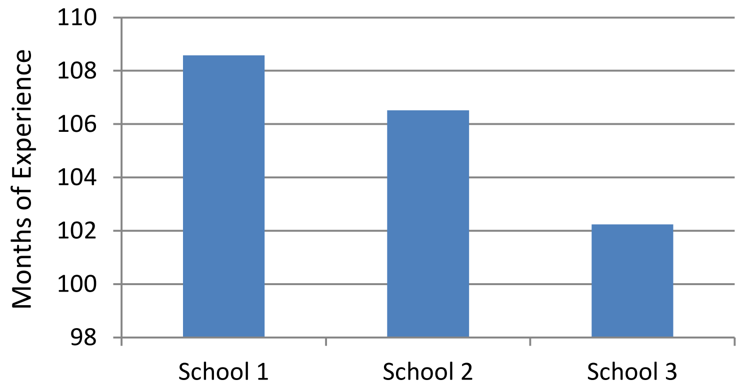

Figure 2.1 Shows the Experience of the Teachers in Teaching Children with Autism

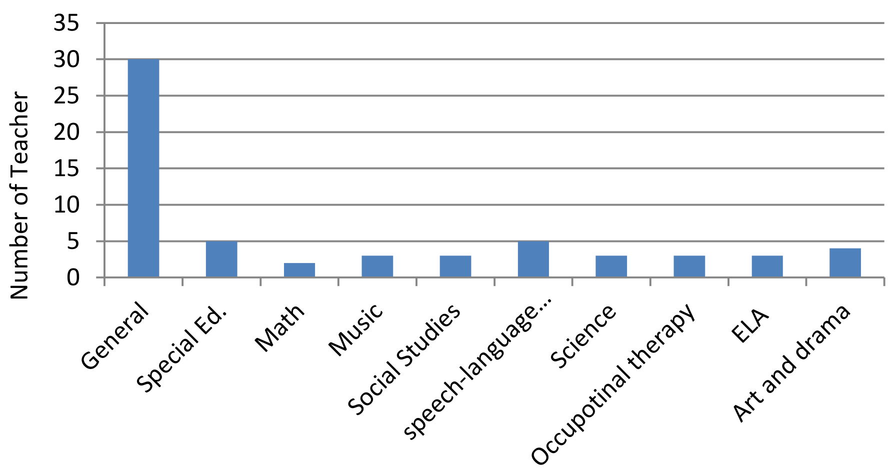

Figure 2.2 Shows Area of specialist for Teachers who"s Teaching Children with Autism

2.6.2.2 Recruitment of Participants

Permission forms were sent to the schools to be signed and returned prior to participation. Data collection of the teacher‟s survey was mainly conducted from May 2011 to September, 2011. This study was approved by the Texas A&M University Institutional Review Board – Human Subjects in Research for the schools that participated in this study.

2.6.3 Site Selection and Study Settings

In order to find a suitable study setting and participants for this study, the researcher contacted an administrator at the Autism Center of the Texas Children‟s Hospital in Houston, Texas, in May 2010. The Autism Center at Texas Children's Hospital sees patients with autistic spectrum disorders or those suspected of having autism. The center provides diagnosis of autism and related conditions. Visiting this center and meeting twice with the administrators guided the researcher to determine which schools treated children with high functioning autism.

The researcher made several phone calls to the schools that the Autism Center recommended. Four of the ten schools responded. Those schools were: Westview School, School I, School II, and Including Kids School. The researcher chooses the first three for this study. The Including Kids School was eliminated from the study because the researcher found that the interior design of the school was based on unstructured open plan with partitions separating the classes. From the researcher‟s point view the school interior environment seemed, less structured and more temporary. The program director, Mrs.Elizabeth Gregory indicated that the site was indeed temporary and that the school administration was looking for a new building that was more appropriate.

The **Westview School**, Houston, Texas, is "a private, non-profit school for children with Autism Spectrum Disorders. The school was founded in 1981 "to provide a structured, nurturing, and stimulating learning environment for children with learning differences which prevent them from being successful in regular programs" (Westview School, 2011, p. 3). The school served students from the ages two years old through middle school that have been diagnosed with different levels of autism including Asperger‟s Syndrome, Autism, and Pervasive Developmental Disorders (PDD) or related Autism Spectrum Disorders (ASD). Westview School (2011) outlined their mission as in the following statement

> The program is unique in its ability to meet the needs of high-functioning children with ASD, not only offering a full academic program but also addressing the social and language challenges which make mainstreaming into regular classes so difficult (see Figure 2.3). Enhancing self-confidence and building appropriate behaviors are an integral part of the program. (p. 4)

Figure 2.3 Westview School, Houston, TX

The **School I** (2011) titled their mission and how they offer their services for the children with autism as following

> The only school in Houston, public or private, which offers a multi-age, language-based, developmental curriculum for children 18 months through fifth grade. Children served have communication and learning differences, but average to above average learning potential. These differences may include problems with speech/language, learning to read, focusing attention, visual motor areas, social skills, and auditory processing. (p.1)

The School I has a classroom designed specifically for the therapy program implemented by certified teachers and speech/language pathologists. Classroom ratios were well designed to provide an excellent treatment and individualized education plans designed to maximize the success of each child. Haidamous (2011) mentioned

> The state-of-the-art facilities include parent/therapist viewing areas, built in assisted listening devices, play and picnic areas, gardens and large, bright classrooms (see Figure 2.4). The creative and visual arts play a large role in the academic program receptive and pragmatic language skills while giving children a creative outlet in which to express themselves. Individual therapies and testing including speech, occupational therapy, social skills groups and family therapy are available through our on-site clinic. (p.3)

Figure 2.4 School I, Houston, TX

The **School II** (2011) titled their mission and how they offer their services for the children with autism as following

> Is not for profit agency that provides education services, a day habilitation program and residential services for individuals diagnosed on the autismspectrum. Founded in 1976 by parents of children with autism, the program was originally located on School II Street. Today, the organization is housed in a state-of-the-art, spacious 33,000 square foot facility specifically designed to address the unique sensory, educational, and developmental needs of those we serve. (p.5)

The school provides different levels of autism-specific services to individuals pre-K and older, regardless of where they fall on the autism spectrum. The school offers five core programs one of which is to support services for families of individuals with autism, more explanation in the following statement

School II House (2011) believes that each individual with autism has unique strengths and unique needs and utilizes various training strategies to support their different learning styles.

Figure 2.5 School II, Houston, TX

By focusing on this approach and by remaining open and receptive to the new and the old, the school will have the ability to be effective and promoting positive changes on those children who attending School II. (p.4)In all three schools the teachers were able fill in the questionnaire at their own desk in the school or at any time and place inside the school environment (see Figure 2.5).

2.6.4 Tools

A questionnaire, which addressed the impact of architectural design elements on autistic behavior, was developed for the caregivers (teachers) of autistic children (see Appendix A). The purpose of this survey was to determine the most influential elements in the environment. The questions for the survey were generated as the result talking with parents who had a child with autism, talking with teachers who had experience teaching children with autism, and from different books describing specific daily lives of children with autism. The following is an example of some of these questions:

- "Do you think that noise levels significantly impact the behavior of your child? If so, in what way?"

- "In addition to air conditioner sounds, echoes, sounds from children in the classroom, sounds from other classrooms and traffic noise, are there other acoustical environmental conditions that you feel negatively affect children with autism? Please describe and include examples."

The questions chosen for the final version of the questionnaire were selected from several sources. The most important source was the literature review and particularly the literature which focused on the stories and daily activities of people with autism such as *Finding You Finding Me* by Phoecbe Caldwell and *Born on a Blue Day* by Daniel Tammet. At the same time, I conducted several unstructured interviews with teachers and parents of children with autism. These unstructured interviews helped me to identify the most important features that relate to the effect of the acoustical environment on the behavior of children with autism (see Table 2.1).

Table 2.1 Keywords teachers, parents and books most frequently mentioned related to acoustics and the behavior of children with autism

	Noises	**Behaviors**
Teachers	Echos, air conditioner sounds, sounds from children in the classroom, sounds from other classrooms, traffic noise	Covering their ears, hitting, repetitive speech or repetitive behavior (echolalia)
Parents	Air conditioner, traffic sounds	Covering their ears, hitting, repetitive speech or repetitive behavior (echolalia), blink eye.
Finding You Finding Me (Book)	Loud sounds, some people voices,	Complain, Painful
Born on a Blue Day (Book)	Traffic, loud sounds	Cover ears
My Experiences with Visual Thinking Sensory Problems and Communication Difficulties (Temple Grandin)	My hearing is like having a sound amplifier set on maximum loudness. My ears are like a microphone that picks up and amplifies sound. School bells, fire alarms, score board buzzers	I have two choices: 1) turn my ears on and get deluged with sound or 2) shut my ears off Some autistic children will attempt to break the telephone because they are afraid it will ring.
Voluntary acceptance of restraint by sleep, Applied Animal Behavior Science. (Grandin, T.	Sudden loud noises hurt my ears--like a dentist's drill hitting a nerve (Grandin 1992a). High-pitched continuous noise, such as bathroom vent fans or hair dryers	Cover his or her ears Withdraw from most noise

2.6.5 Procedure

Hard copies of the questionnaires were introduced and distributed by administrators in each of the schools and teachers were initially given two weeks to respond.

In the Westview School, the behavioral specialist presented the survey and explained the aim of the study to teachers at a faculty meeting in order to increase the teachers" understanding regarding the importance of the study. Seventeen teachers responded at the first request. In order to increase the response rate, the behavioral specialist sent subsequent reminder emails three times during June, July and August, 2011. There were 26 total responses from the Westview School.

In the School I the head of the school distributed the questionnaire to teachers via their mail boxes in the beginning of August, 2011. Twenty-four responses were received from 40 teachers. The administrator sent reminders at the end of August and the beginning of September, 2011, but no additional responses were received.

In School II, the survey was distributed by Principal / Education Specialist of the school via their mail boxes in September, 2011. Twenty-four of twenty-five teachers submitted responses by September 23, 2011, (see Figure 2.6).

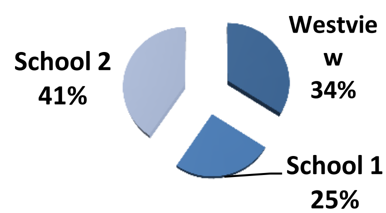

Figure 2.6 Percentages of Teachers Responses on Phase 1

2.7 METHODOLOGY FOR PHASE 2: BEHAVIORAL OBSERVATION WITH NOISE AND VIDEO RECORDING OF CHILDREN

2.7.1 Purpose

The purpose of this study is to understand how interior space features and spatial environment characteristics can be used to support the learning and developmental needs of autistic children and, to compare the behavior of the children in noisy classrooms to those in quiet classrooms in order to understand and define the effect of acoustical features on the children with autistic behavior.

2.7.2 Participants

2.7.2.1 Selection of Participants Population

The sample size of the second phase of this study was made up of children with high levels of autism in the second and third grades at the School I and School II. Two classrooms of children participated in the study from each school; each classroom had approximately 12 children.

2.7.2.1.1 Participants from School I

About 22 high functioning children with autism (21 males) and (1female) were included in this study from two classrooms in School II. They were diagnosed according to DSM-IV criteria (American Psychiatric Association, 1994) by an expert clinician. The school' criteria for admission was using different psychological criteria‟s. The verbal and non-verbal intellectual abilities were assessed using different scales related to each school criteria. Fifteen had no mental retardation (IQ=117), Five had mild mental retardation (IQ between 50 and 70), and one had severe mental retardation (IQ from 41 to 48). All subjects ranged in age from 6-9 years, had normal hearing.

2.7.2.1.2 Participants from School II

About 20 high functioning autistic children (16 males) and (4 females) were included in this study from two classrooms in School I. Sixteen had no mental retardation (IQ=117), three had mild mental retardation (IQ between 50 and 70) and one had severe mental retardation (IQ from 41 to 48). The verbal and non-verbal intellectual abilities were assessed using different scales related to each school criteria. All subjects ranged in age from 6-9 years and had normal hearing.

2.7.2.2 Recruitment of Participants

A Consent Form was sent by the School I and School II to obtain permission from parents to allow the researcher to observe, record sound levels, and videotape the children in the four classrooms. Data collection took place from March 2012 to July 2012. This study had the approval from the Texas A&M University Institutional Review Board – Human Subjects in Research, and received approval prior to the distribution of the Consent forms and prior to the collection of data.

2.7.3 Site Selection and Study Settings

2.7.3.1 Selection of the Classrooms

The behavioral observation took place in four classrooms -two classrooms from each school. In the School I the environment of the interior of both classrooms was similar. The most important difference between the two classrooms was in the sources of external noise. One of the classrooms had good sound control, but the other classroom was adjacent to an air handling unit and the noise from the playground area that was located beside that classroom. In School II the environment of the interior of both classrooms was similar. They differed in the sources of the external noise. One of the classrooms had good sound control, but the other classroom was adjacent to an air handling unit and noise from the long corridor that was located beside that classroom.

2.7.3.2 Characteristics of the Classroom Environment

Classrooms of School I: The School I in Houston, Texas, occupies rectangular buildings gathered on different court yard zones as shown in (refer to Figure 2.7). Each building consists of four classrooms. Those classrooms function as both educational and social environments. They are also used as classrooms for other activities like music; dancing, art, and lunch. On the average, students spent 30 hours a week for learning purposes in these classrooms, but for other activities, they used the other rooms in the school.

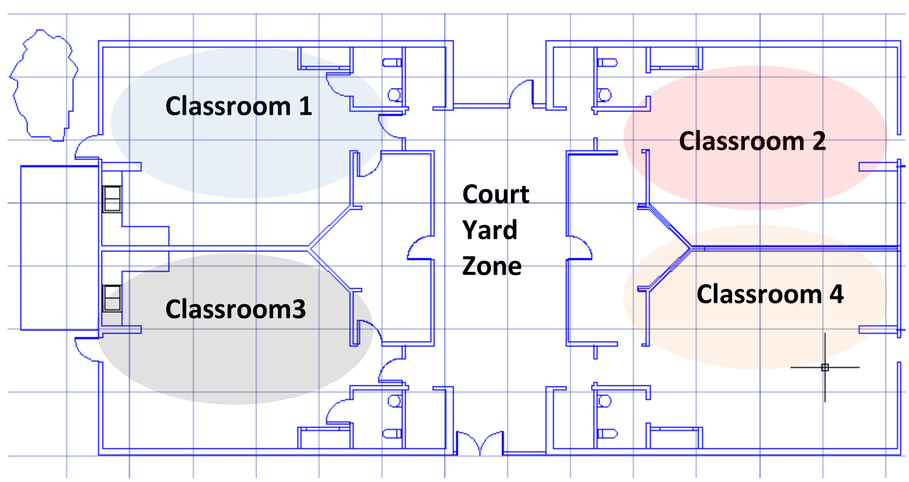

Figure 2.7 The Two Classrooms that have been Used to Observe the Children in School I

Classrooms of School II: The School II in Houston, Texas occupies one building with a huge glass facade as shown in (Figure 2.8). All the classrooms are located in the same building and corridors have been used to separate the classrooms groups from each other. Students used their classrooms for all academic or artistic activities. Students warmed their lunches using the classroom microwave and ate their lunches in a multipurpose room with all the children from the school. On the average, students spent 25 hours a week for learning purposes in these classrooms, but for other activities, they used the multipurpose room in the school. Each day the students spent one hour playing on the playground of the school. Usually this play time comes after the lunch time.

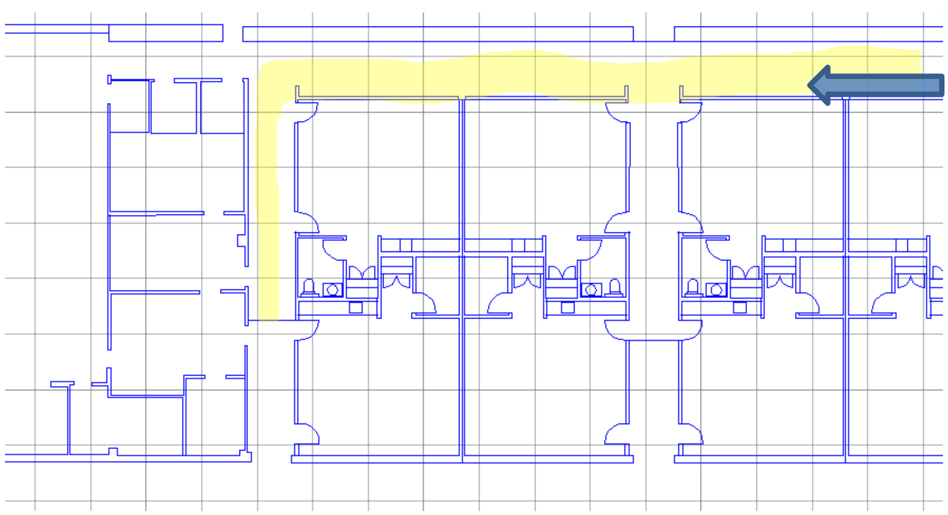

Figure 2.8 The Two Classrooms that have been used to Observe the Children in School II

2.7.3.2.1 Noise and Sound Characteristics

The noise levels were recorded at different days and times inside the classrooms. The mean noise levels recorded across the schools were between 43.3 dB and 69.7 dB inside the classrooms. These ranges of values were beyond the WHO recommended 35dbA noise level for community learning (school) environments. The noise sources varied between the schools.

Classrooms of School I: In the School I one of the classrooms was located within two meters of the main playground area of the school. In addition, the classroom had been connected to the HVAC system room which turned on and off every ten minutes. The highest dB level of noise was 94.7 dB and the lowest was 46.2dB. The other classroom in the School I I was located 10 meters from the main playground area of the school. This classroom hadn‟t been connected to the HVAC system. The highest dB level of the noise was 68.3dB and the lowest was 40.3dB. (See Figure 2.9).

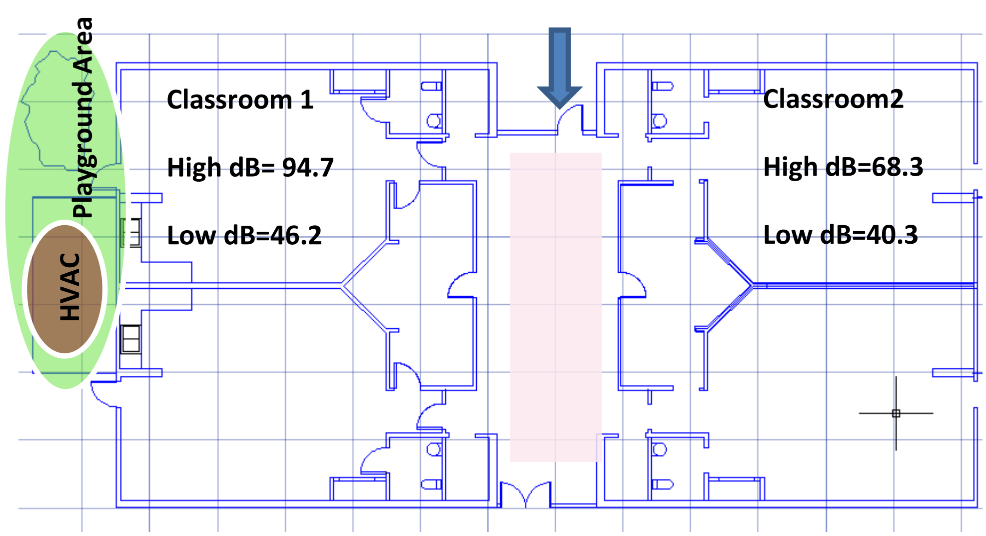

Figure 2.9 The Sources of Noises in School I Classrooms

Classrooms of School II: In the School II one of the classrooms was located within four meters of the main playground area of the school. In addition, the classroom had been connected to the HVAC system room which turned on and off every ten minutes.

The highest dB level of noise was 96.7dB and the lowest was 50.5dB. The other classroom in School II was located seven meters from the main playground area of the school. In addition, the classroom hadn‟t been connected to the HVAC system room. The highest dB level of the noise was 69.7dB and the lowest was 41.1dB (see Figure 2.10).

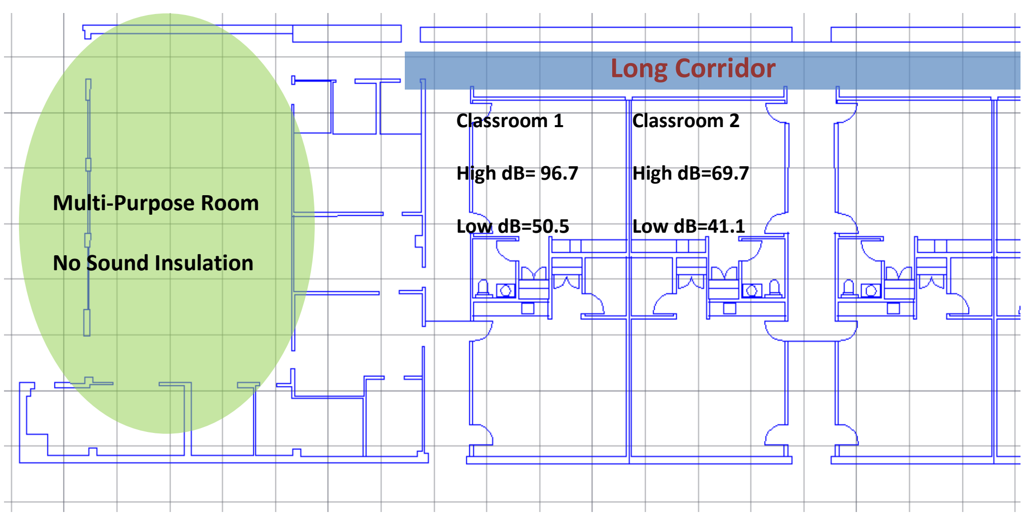

Figure 2.10 The Sources of Noises in School II Classrooms

2.7.3.2.2 Layout and Furniture

Classrooms of School I: The two classrooms in School I were identical. The typical design layout of the classroom was well-defined and relatively big (200m2), with two exits, and a low false ceiling nine feet high. Windows were located on one of the two long sides while the other three walls were covered with boards, teaching sheets and much art work. A huge amount of natural, lighting entered the classroom. The color of the ceiling and the floor finish was light grey and off-white. Each classroom in this school has bathroom, a small kitchenette and a small teacher room connected to the classroom. Figures 2.11 and 2.12 illustrate most of such spatial qualities of the environment.

The classroom was divided into six zones. The largest zone was the teaching area. It contained a metal table and chair for each student. Each classroom contained from 10 to 12 tables. The other zone was the carpet area which was used to read a story or to discuss a project or have a science session. The third zone was the individual teaching area. It contained one table with two chairs and a small library with some books and children‟s stories. The teacher used this area to teach the students individually and to let the students pick some books and read using that area. The fourth area was is the kitchen. It contained a microwave, a sink and preparation table. The other two areas were the teacher room and the bathroom inside the classroom. The classrooms were furnished with curtains, two carpets, many shelves and a small storage unit.

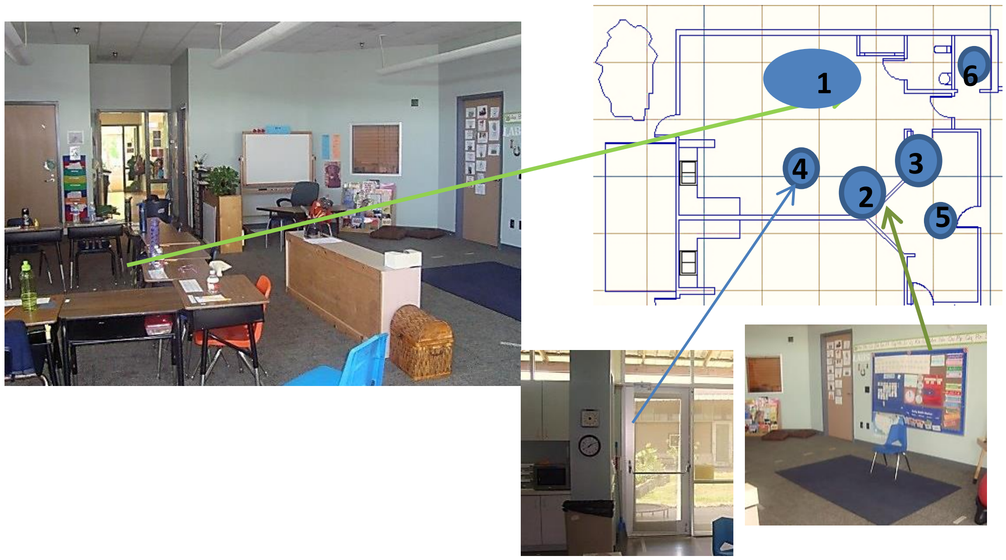

Figure 2.11 The Layout and the Furniture of Classroom 1 in School I

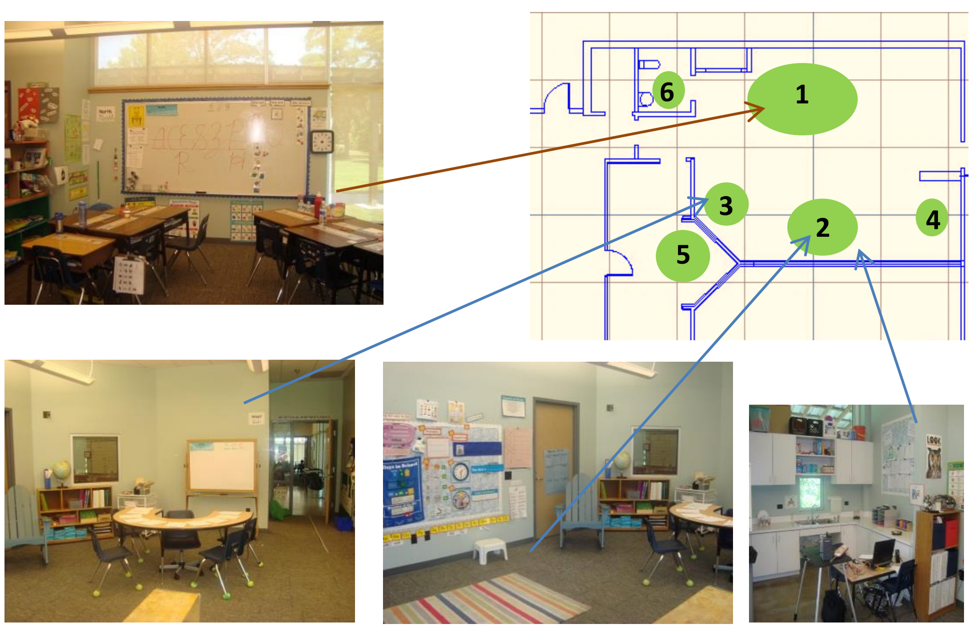

Figure 2.12 The Layout and the Furniture of Classroom II in School I

Classrooms of School II**:** The two classrooms in School II were identical. The typical design layout of the classroom in School II was a well-defined area (100m2), with two exits, and a low false ceiling of a 3m height. There were no windows, while all the walls were covered with boards, teaching sheets and art work. The only source of natural lighting was small windows fixed on the upper level of the walls. The color of the ceiling and the floor finish was light grey and off-white. Each classroom in this school has a bathroom, a small kitchenette and a small teacher room connected to the classroom. Figures 2.13 and 2.14 illustrate most of such spatial qualities of the environment.

The classroom was divided into five zones. The largest zone is the teaching area; it contained a table and chair for each student. Each classroom contains from 10 to 12 tables. The second zone was the computer area; it contains two tables with two chairs and two computers. The teacher used this area to let the students watch a movie or play a game. The third area was the kitchen, containing a microwave, a sink and preparation table.

The other two areas were the teacher area and the bathroom inside the classroom. The classrooms have metal tables and chairs, many shelves, and a small storage unit. The only difference between these two classrooms was the arrangement of the teaching tables and chairs. One of the classroom tables was arranged as rows, but the other classroom tables were arranged in a circle.

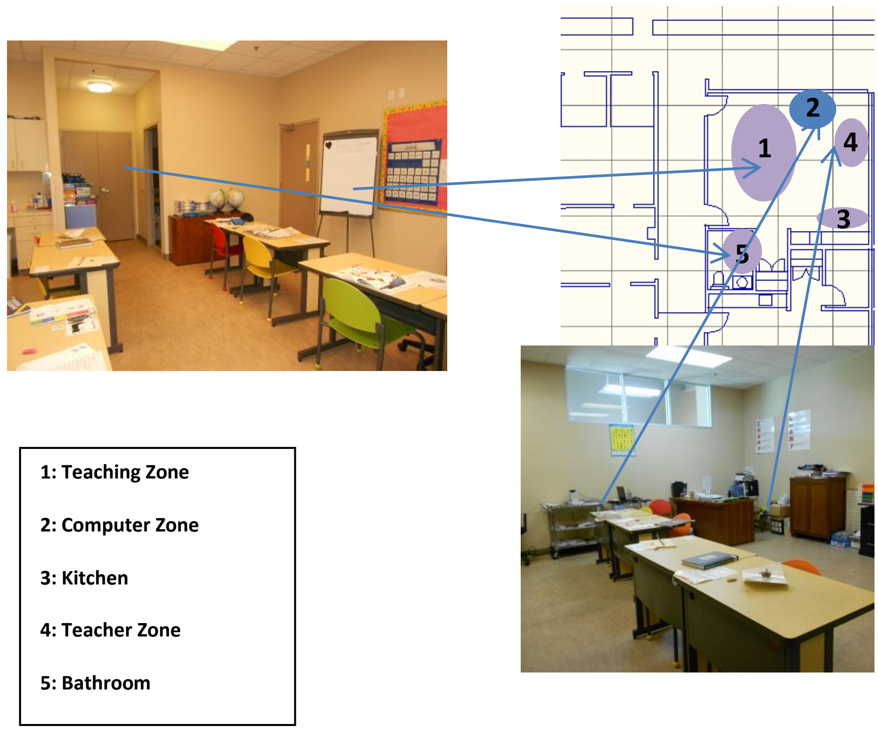

Figure 2.13 The Layout and the Furniture of Classroom I in School II

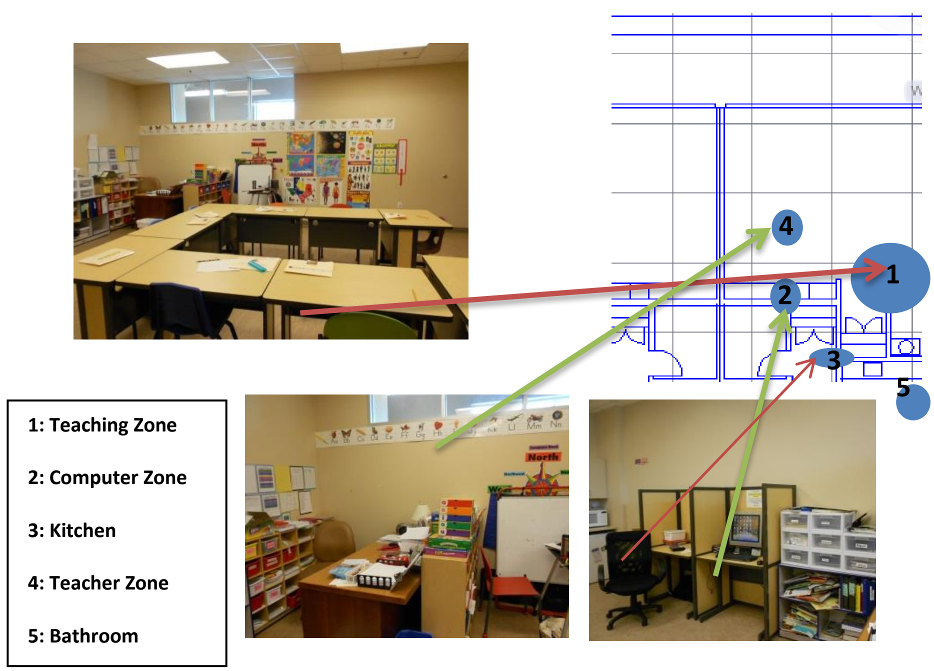

Figure 2.14 The Layout and the Furniture of Classroom II in School II

2.7.3.2.3 Classroom Daily Activities

School I: During the day the students spent most of their time inside their classroom working on their assignments. They had math, science, writing skills, speech therapy, and music inside the classroom and left the classroom for art. The students started their day around 8:15 am.They had half hour morning rotations and teaching sessions started at 9:30 am until 11:30am. After that they went to the playground for half an hour.

They rested for 15 minutes before preparing for story time, and then they had lunch inside the classroom. After that students prepared to have math and science classes for an hour and then at 1:00pm the children went outside to the playground area for half an hour. After the playground, they come back and go to the library or to the art classroom.

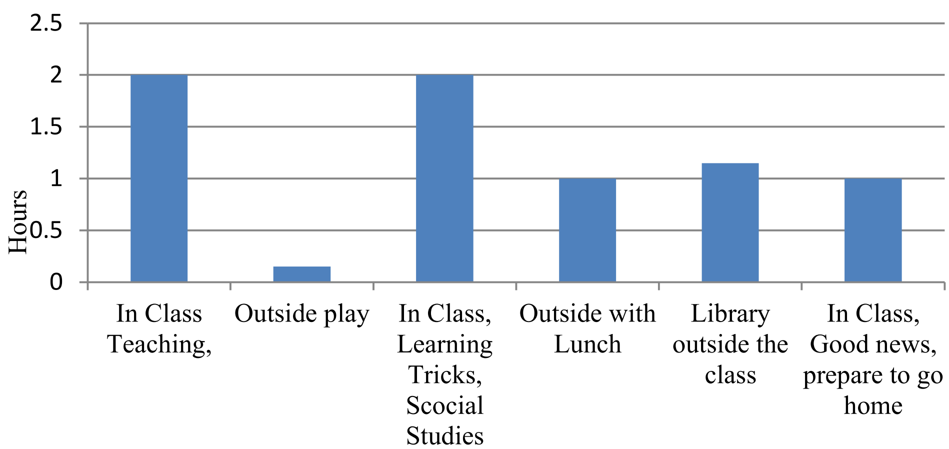

Figure 2.15 The Daily Activities of Children in School I Classrooms

School II**:** During the assigned hours, students spend most of their time inside their classroom working on their assignments and being instructed. They studied math, science, speech therapy, writing skills, music and art class. The students start their day around 8:30 am. They had a morning rotation for half hour then they began teaching sessions for two hours. After that they went to the library outside the classroom for half an hour. They then took a rest for 15 minutes before preparing for story time. Lunch was next outside the classroom in the multi-purpose room. After lunch, the students went outside to the playground area for one hour. Most of the students in the school join the playground area at the same time. When the students came back to the classroom they complete their assignments or they go to art. Figure 2.16 explains more about the student activities during the school day.

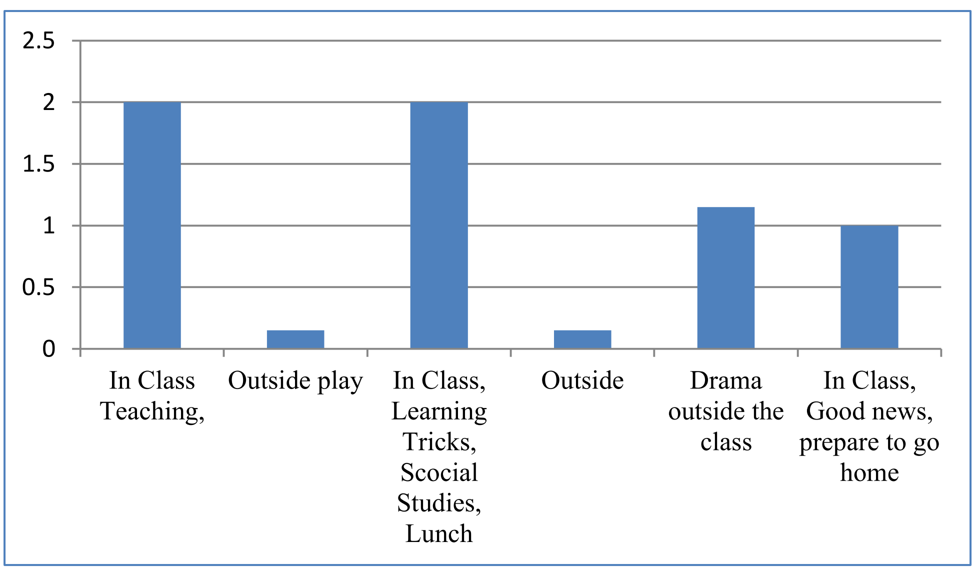

Figure 2.16 The Daily Activities of Children in School II Classrooms

2.7.4 Measurement Techniques

Based upon the results of the questionnaire in the first phase, direct behavioral observation of the children took place in four classrooms. Three techniques were used in the second phase.

2.7.4.1 Direct Observation Tools

2.7.4.1.1 Coding the Children

The researcher provided a code for each child by using the first two letters of his name. For example, one of the children was named Peter and his code was “Pe.”. Mostafa (2008) used a similar tool to record what she observed in the classroom but the coding system in her study used numbers rather than letters. Once we assigned each child in the classroom a specific code, the researcher entered these codes on the template sheet in the software. Then the researcher coded the seven behaviors that were observed.

2.7.4.1.1.1 Choosing and Coding the Behaviors

Seven behaviors were observed during the study. The behaviors were selected from a literature review, teachers and parent‟s interviews, and accounts regarding individuals with autism. The researcher analyzed these materials to generate the list of behaviors (see Table 2.1).

The researcher provided a code for each behavior by using the first two letters of each word in the behavior name. For example one of the behaviors was Repetitive behavior (echolalia). The code was “Re Be.” Mostafa (2008) used a similar tool to record what she observed in the classroom but the coding system in her study used numbers rather than letters. Once we defined each behavior in the classroom with a specific code, the researcher entered these codes on the template sheet in the software.

2.7.4.1.1.2 Definition of the Behaviors

Based on these resources, seven behaviors were used in this study. The behaviors were:

1. Repetitive behavior (echolalia): This is related to any type of repetitive movement done many times by using the hands, legs or any part of the body, as when, for example, the child flaps his hands many times continuously, (National Institute of Mental Health, 2013). Other examples of a repetitive movement would include rocking, twirling, and spinning. Lewis and Bodfish (1998) defied repetitive behavior (echolalia) as an umbrella term used to refer to behaviors linked by repetition, rigidity, invariance and inappropriateness.
2. Repetitive speech: This behavior is related to any type of repetitive and continuous speech. The child started using the same word over and over. Repetitive speech patterns are another characteristic of children in the autism spectrum. Speech can be delayed and can develop in various ways. Words may be repeated over and over (echolalia) or words or phrases that were previously heard are repeated after a time delay of a few minutes, hours, days, weeks, or even months, this is called delayed echolalia (National Institute of Mental Health, 2013).
3. Covering the ears: This behavior can often become a learned behavior and may be linked to anxiety as a child becomes fearful of potential unpleasant noises.

Some children cover both ears and others cover one ear (Tang, Kennedy, Koppekin & Caruso, 2002).

4. Hit in response: This response is related to any type of hitting. Some children hit themselves or other children or throw objects which can injure themselves or others. Michelle Turner (1999) defined the hit in response as any behavior that can cause tissue damage (bruises, redness, and open wounds). Common forms include head banging, hand-biting, and excessive scratching or rubbing.
5. Produce loud sounds: This response is producing continuous loud noises during any kind of activity. These noises could be clear words but the child says them many times using a loud voice, or uses unclear words to produce loud sounds.
6. Blinking eyes: an involuntary process that helps keep the eyes hydrated and protected (Jones & Landa, 2011). During that split second that your eyes are closed, you are temporarily blinded. And throughout a typical day, adults spend about 44 minutes with their eyes closed (Jones & Landa, 2011). This response provides a way to measure social engagement and more the child blinks; the more he is engaged in the event (Shultz, 2011).
7. Complaining: Complaining occurs when the children don‟t want to do what the teacher is asking them to do. This also occurs if the child doesn‟t want to follow directions or if something in the classroom environment bothers him.

2.7.4.1.2 Video and Sound Recording Tool

A video recorder linked to a decimal meter was located in the classroom during the behavioral observation time. The researcher set up the camera and changed the camera‟s memory when it was full.

The researcher defined the range of the noise level which would be observed from the pilot study results. The video camera recorder was a Logitech - C920 Pro Webcam – Black. This type of cameras had different systems and still image resolution up to 5.0 megapixels for intense clarity. Video capture up to 720p for lifelike detail and motion (see Figure 2.17).

The video camera recording system had a two-rotary heads, helical scanning system. The audio recording system had rotary heads and a PCM system. The recording time was up to 6 hours daily (DVM60ME). The lens dimensions were 10x (optical), f=$^{1}/_{4}$ to $2^{5}/_{16}$ inches, $1\ ^{5}/_{8}$ to $16^{9}/_{16}$ inches when converted into a 35-mm still camera. It also had input and output connectors, including S video output, Audio output.

Figure 2.17 The Camera which Used in the Video Recording, source (QUET Manual, 1999)

The decimal meter model is an "1800 Precision Integrating Sound Level Meter" and it contains an octave band filter model OB-100 and 1/1 – 1/3 octave band filter model OB-300. This meter functions as a precision sound level meter, impulse or integrating sound level meter. In all modes, the model 1800 delivers type 1 accuracy include laboratory, industrial, community and audiometric measurement and analysis (QUET Manual, 1999).

The model 1800 is a user-friendly handheld meter with an LCD display that provides a numerical and bar graph readout. The LCD display contains both numeric and a bar indicator along with BAT (battery), RUN, HLD (Hold), and OL (overload) annunciators. The rate at which the numeric display is updated depends upon the settings of a switch located in the battery compartment. Either a one-second or a one-quarter second display rate can be selected (QUET Manual, 1999).

We could choose the range of the sound pressure levels that the bar indicators will present. For example, if the selected range on the range switch was 100 to 140, the bar indicator represented 100-140 db (see Figure 2.18).The sound levels are shown to the nearest 0.1 db (QUET Manual, 1999).

Behavioral recording and sound recording would be analyzed offline using Noldus Observer XT. The Noldus Observer XT is a professional and complete system event recorded for the collection, management, analysis and presentation of observational data. It is an important tool for studying the behavioral process when the researcher needs to record behaviors. The Observer XT is version 11.5@2012.

Figure 2.18 The 1800 Precision Integrating Sound Level Meter, Source (QUET Manual, 1999)

2.7.4.1.3 Teacher Survey Tool

This survey had five questions for the teachers in the observed classrooms. Each question was specific to one of the seven behaviors that the researcher observed: A Likert scale was used to expedite responses (see Appendix B).

2.7.5 Procedure

A 12-hour pilot study to test the tools was done. After integrating the information gathered from the pilot study, observations were started at 8:30am until 2:30 pm for 48 days. Each week, approximately 20 hours of observations were be made. In order to obtain 64 hours of data from each classroom, 6 weeks of observations took place, with a two day break between each observation period. In total, in addition to the half-day pilot study, the observation period was seven weeks.

The observation utilized the three techniques mentioned above. In the beginning the researcher used the observer XT software to record how many times the children exhibited the following behaviors: (1) covering ears, (2) producing sounds, (3) hitting in response to a sound, (4) blinking eyes in response to a sound, (5) complaining (6) repetitive behavior (echolalia) (7) repetitive speech. A measurement was done every 30 seconds. Every time the children exhibited one of the behaviors it was recorded by the researcher as a colored mark indicating the behavior and the child"s gender.

Every ten seconds a video recorder that was linked to a decimal meter recorded all the activities and the sound levels inside each classroom during the observation period. At the end of each day of observation a short questionnaire was submitted to the teachers of both classes of the study in which they were asked to give their opinion and ideas about the classroom environment.

The researcher also recorded the source, volume and duration of the noise every 10 seconds in order to associate the noise types with the times of behavior. A measurement was taken every other 10 seconds. In this way the researcher would have a chance to record and write any notes about the behaviors and the noise properties of that 10 second interval. Every time a child responded with one of the behaviors it was recorded by the researcher as a child code letter to indicate the behavior times. The researcher would use the behavioral observation sheets from observer XT to collect the data.

Every 10 seconds a video recorder that was linked to one decimal meter recorded all activities and sound levels inside each classroom during the observation time. Every 5 minutes the researcher checked the video camera and decimal meter, and then the researcher made notes to match them with the equipment readings.

The researcher used software that linked the behaviors with the decimal meter readings, so in this way the behavioral record was tied to decimal reading for the noise. Behavioral recording and sound recordings were analyzed offline using Noldus XT. At the end of each day of observation a short questionnaire was given to the teachers of both classes of the study allowing them to express their opinion and ideas about the classroom environment.

CHAPTER III

ANALYSIS AND RESULTS

This study aimed to describe and compare the effect of different noise levels inside classrooms on the behavior of children with high functional autism levels. The knowledge gained from this study is expected to serve as a new framework for creating environments for children with autism. The new perspectives and insights on preferred environments will enhance the previous studies, predictions, and generalizations on this topic.

To reach this goal of developing a framework for architectural guidelines for autism, a multi-method approach was utilized in order to understand the ways in which noise affects children with autism. By using a multi-method approach, data can be secured from different perspectives (Zeisel, 1981). The use of the multi-method approach enabled the researcher to evaluate the weaknesses and strengths of research problems, to obtain convergent findings, and to promote a better understanding of the results (Cronholm, 2011). The multi-method approach can be used to collect data, reduce errors, and provide high reliability and validity (Golashani, 2003). This research has both quantitative and qualitative components as it uses several research methods to collect data.

This chapter begins with a description of the statistical analysis technique for each data phase. The second section explains the teachers‟ responses, the ecology of the sound and the seven behaviors that were addressed in this research. The last section presents the findings for each hypothesis.

3.1 STATISTICAL ANALYSIS TECHNIQUES

This section describes the method of analysis for each data phase: 1) the teacher survey and 2) the behavioral observation with sound and video recording. In order to analyze a variety of data obtained through multiple methods, several statistical techniques were used. The data collected from the teachers survey (phase I) and the behavioral observation (phase II) were subject to different statistical analysis.

3.1.1 Statistical Analysis of the Teacher Survey (Phase 1)

The researcher used descriptive statistics as supported by the statistical software program SPSS (BIM) to analyze the results of the teacher survey and to evaluate the behaviors in response to sound. The researcher evaluated the results through applicable statistical methods, including the t-test, chi-square, and descriptive statistics.

3.1.1.1 Descriptive Statistics

As defined by Candappa (2000), descriptive statistics are techniques that deal with the raw data and organize or summarize them in a form that is more applicable to be used. Most of the time raw data are organized in a table or a graph so that it is possible to see the entire set of scores. Another common technique is to summarize a set of data by computing an average. Note that even if the data set has hundreds of point data, the average provides a single descriptive value for all the data (Candappa, 2000).With descriptive statistics the researcher is simply describing what the data shows.

The second general category of statistical techniques is called inferential statistics. Inferential statistics are methods that use sample data to make general statements about a population (Candappa, 2000). Inferential statistics consist of techniques that allow us to study samples of the data and then make general conclusions about the participants from which they were selected (Candappa, 2000). Sometimes it is impossible to make measurements for every one of the participants in the populations. Because populations are typically very large, a sample is selected to represent the population. By analyzing the results from the sample, we hope to make general conclusions about the population (Candappa, 2000). With inferential statistics, the researcher is can reach the conclusions that extend beside the data results (Cohen, 1988; Field, 2005). For instance, we use inferential statistics to conclude from the data what the participants might think (Rosenthal & Rubin, 1982).

Many techniques can be used to show the distribution of the data, for example the percentages could be one of the ways. Other technique could be the central tendency. The central tendency of a distribution is an estimate of the "center" of a distribution of score of the data. There are four major types of estimates of central tendency: Mean, Median, Mode, and Standard Deviation (Std) (Cohen, 1988; Field, 2005).

3.1.2 Statistical Analysis of the Behavioral Observation and Sound Recording (Phase II)

The researcher analyzed the behavioral observation and sound recording data through two sub-phases of analysis: 1) the descriptive analysis (exploratory analysis) and 2) the confirmatory inferential analysis. The researcher used the statistical software program SPSS (BIM), KGraph and the observer XT 11.5 to analyze the results of the direct observations and the ecology of the sound in order to evaluate the behaviors in response to sound.

3.1.2.1 Exploratory Analysis

Exploratory data analysis (or descriptive analysis) includes the basic, but often not focusing on the data collection processes. Exploratory analysis focuses on summarizing and presenting results, and looking through the data to obtain the maximum amount of the information that will guide the researchers to create generalization results (Martin & Bateson, 1993). In this study the data has been presented in a way that provides the researcher with an understanding of the preliminary results of the data and informs the following analysis.

3.1.2.2 Confirmatory Analysis

Confirmatory analysis including “hypothesis-testing, or inferential statistics, covers the conventional “testing” of the empirical data; that is, calculating the probability that observed result is consistent with a null hypothesis” (Martin & Bateson, 1993, p.127). Confirmatory data analysis is very important to studies of many different variations as well as experiments, since it includes tests of hypotheses about correlation, (Martin & Bateson, 1993). Averaging analysis was used by incorporating correlational statistics, histograms analysis and other descriptive analyses.

3.1.2.2.1 Averaging Analysis

Averaging analysis was used by gathering the mean values of the sound by using the observer XT and SPSS software. The frequency of the seven behaviors was calculated also. A histogram analysis has been done to the dB readings for all the days of observation. Most the histograms reflect a normal distribution for the sound recording. After that a correlational test was done to see the relationship between the dB values and the frequency of the behaviors.

3.1.2.2.1.1 Histogram Analysis

A histogram “representation of a sample set of a population with respect to a measurement represents the frequency of quantized values of that measurement among the samples” (Cha & Srihari, 2002, p132). Other researchers (e.g., Gilbert, Kotidis, Guha, Muthukrishnan, Indyk & Strauss, 2002) define histograms as space-efficient approximations of distributions of numerical values, one often visualizes histograms as a sequence of vertical bars whose widths are equal but whose heights vary from bar to bar. Using a histogram analysis helps the researcher to figure out the shape, central location (the middle), and the distribution of the other values around the middle location. “More generally histograms are of varying width as well: that is, they are general piecewise-constant approximations of data distributions” (Gilbert, Kotidis, Guha, Muthukrishnan, Indyk & Strauss, 2002, p.23).

3.1.2.2.1.2 Correlational Statistics

Correlations are" a method by which we describe the relationship between pairs of variables resulting from a survey of a single group" (Black, 2002, p.5).This does "*not* mean establishing cause and effect relations, since correlations only indicate the strength of relations between variables in a single sample of subjects and regression equations tell how one variable changes with respect to another" (Black, 2002, p.6).

In Phase 1 of this study, the researcher created different categories in order to find correlations between the variables: noise sources, noise masking and the behaviors of children with autism. The focuses were to determine if specific types of noise affect the behaviors of children with autism, and to determine if specific sound insulation affects the behaviors of these children. Comparisons of sound characteristics on the children‟s behaviors in Phase 2 (direct observation) were conducted using frequency and mean values. The degree of correlation strongest classified as following; under 33% weak relationship, between 33% and 66% medium relationship and above 66% strong relationship.

3.2 RESULTS

3.2.1 General Results (Exploratory Results)

This section begins with an explanation of the sources of noise in the school environments and shows the relationship between noise and the inappropriate behaviors from the teachers‟ point of view. The raw data of Phase I of this study presents the teachers‟ responses to the questioner and shows the relationship between the noise levels and the behaviors of the children with autism. This section is followed by the actual data of Phase II. The raw data of 128 hours of observation is presented in a way that allows the reader to see the three major measurements: the seven behaviors, the decibel reading of noise (dB), and the actual time of the observation during each second in the same screen. The actual observational data is important for many reasons: first, because it provides the raw material for answering the hypotheses and the research questions and, second, it provides the quantitate recording of the behaviors and other environmental factors.

3.2.1.1 Descriptive Results of Phase I

A total of 74 teachers finished the survey from three schools (70 females, 4 males). A correlational analysis was used to determine if there were a correlation between the teachers‟ observations of the children‟s behavior and the noise level in and around the classroom (see Figure 3:1).

A strong relationship was found between high dB noise and the inappropriate behavior of the autistic children. Ninety-five percent (95%) of the teachers strongly agreed with the negative impact of the high dB on the children‟s behavior (refer to Figure 3.2).

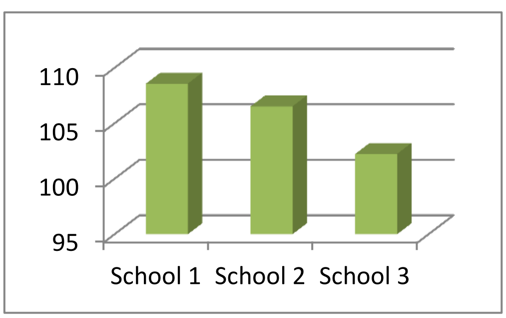

Figure 3.1 Shows the Response Number of the Teachers in Phase 1

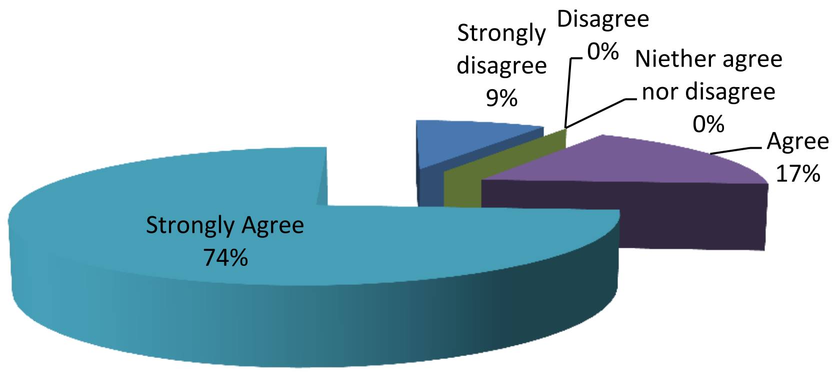

Figure 3.2 Teachers Assessment of the Relationship between Loud Sounds and Behavior of Children with Autism in the Three Schools

Eight-five percent [85% (*df=2, p=0.071)]* agreed that covering the ears was one of the most common behaviors of autistic children when they heard loud sounds. Ninety-seven percent [97% (*df=4, p=0.073]* agreed with using carpets as a strategy to help reduce the dB level inside the classrooms. Sixty-eight percent (68%) agreed with using wall insulation to reduce the dB level inside the classrooms (refer to Figure 3.3).

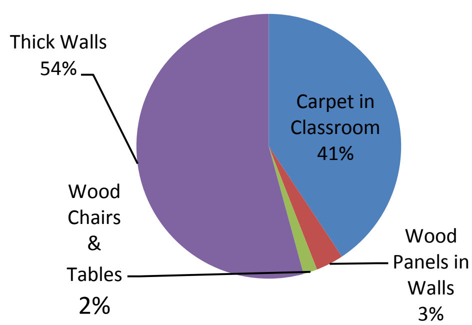

Figure 3.3 Teachers Assessment of the Importance of Acoustical materials in the Classroom

3.2.1.2. Descriptive Results (Exploratory Results) of Phase II

A total of 46 subjects were observed from two schools (5 females, 41 males). The 128 hours of observation included recording the behaviors using the observer XT software sheets, sound recording and video recording. A descriptive analysis using histograms was conducted in order to illustrate the 128 hours of observation, the dB distribution, the daily activities percentages, and the daily frequencies of the behaviors. The researcher used these techniques to understand the type of noises which are shown in the dB graphs. Eighty percent (80%) of the sound distribution using the histogram graph shows normal distribution for the sound on all four classrooms. The maximum value of the dB was 96.6dB and the lower value was 40.0dB (see Figures 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11 and 3.12) show the histograms of the sound/class/school). The behaviors are distributed as follows: the most common behavior was repetitive behavior (echolalia) at 40%, sound production behavior was 28%, repetitive speech behavior 20%, covering the ears 7%, verbal complaints 2%, hitting1.8%, and blinking the eyes 1.2%.

3.2.1.2.1 Sound and Behaviors Results: Classroom I (Noisy Classroom) in School I

This section describes the daily ecology of the noise that was recorded in the noisy classroom (Classroom I) in the School I, and the description of the frequency of the seven behaviors that were observed while recording the sound levels in that classroom.

The observations in this classroom took place from April 27, 2012 until May 09, 2012. The sound ecology in this classroom was recorded by measuring the dB readings for the duration of the observation. Most sources of noise in this classroom came from the children themselves (they are highly talkative students), the teacher"s voice, the air conditioning unit, and the sounds from the playground area, which was close to this classroom.

By looking at the distribution of the sound during all the observation days, high dB readings were shown most of the time. The maximum value was 93dB and the minimum value was 40dB. The baseline of phase II was measured by recording the dB level during the day with the students inside the classroom without the children presenting any of the seven behaviors.

A comparison was designed to numerically compare the increase or decrease in the sound level and the increase or decrease in the frequency of the seven behaviors. On the observation days, using a rating scale of 0% to 100%, all the behaviors increase once the dB reading increased but in different percentages (see Figures 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11 and 3.12). On the observation days, using the rating scale from 0% to 100%, all of the behaviors correlate with the increase in dB readings.

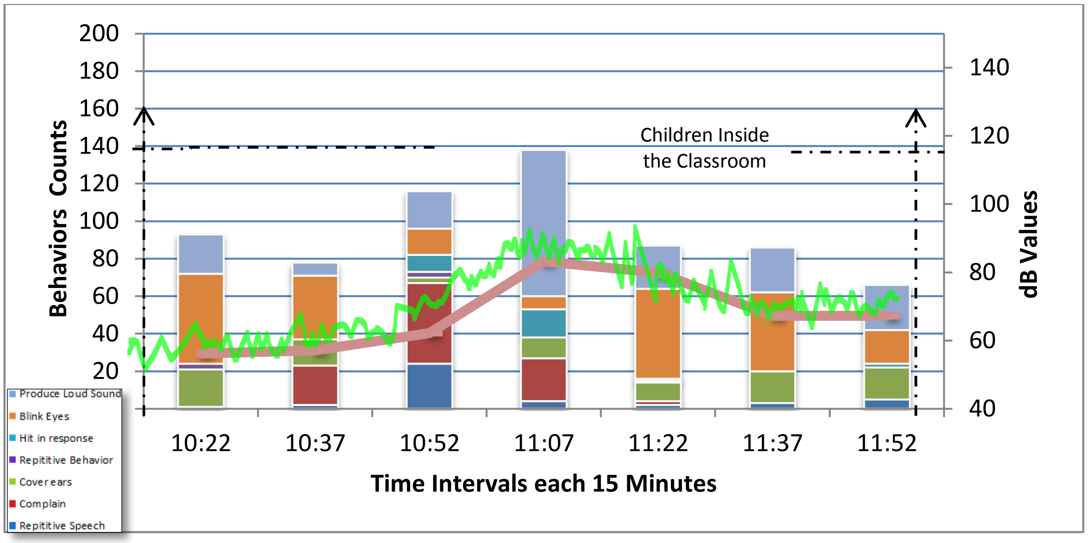

Figure 3.4 dB(A) Values for the Seven Behaviors Observed in Classroom I (Noisy) in the School I on 4/27/12

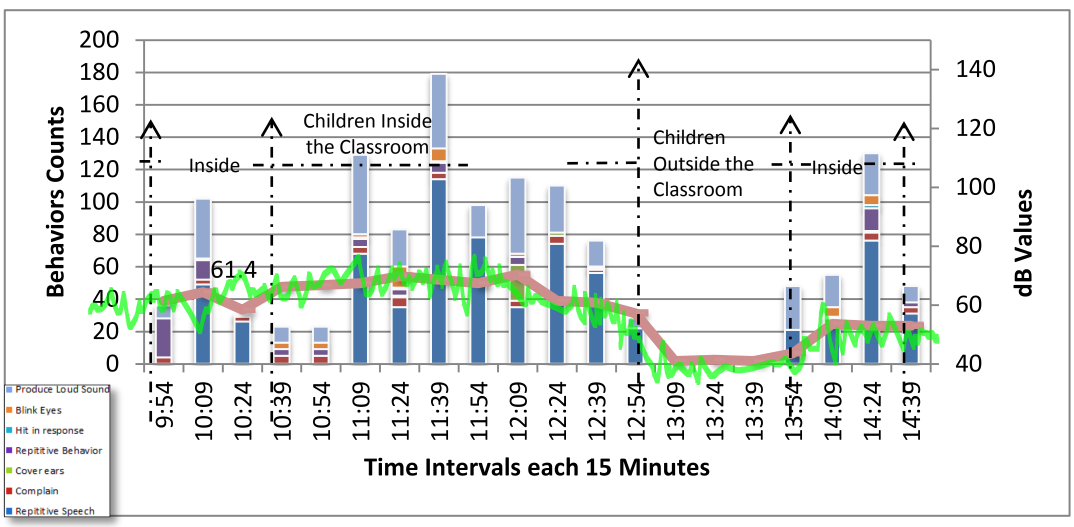

Figure 3.5 dB(A) Values of the Seven Behaviors Observed in Classroom I (Noisy) in the School I on 4/30/12

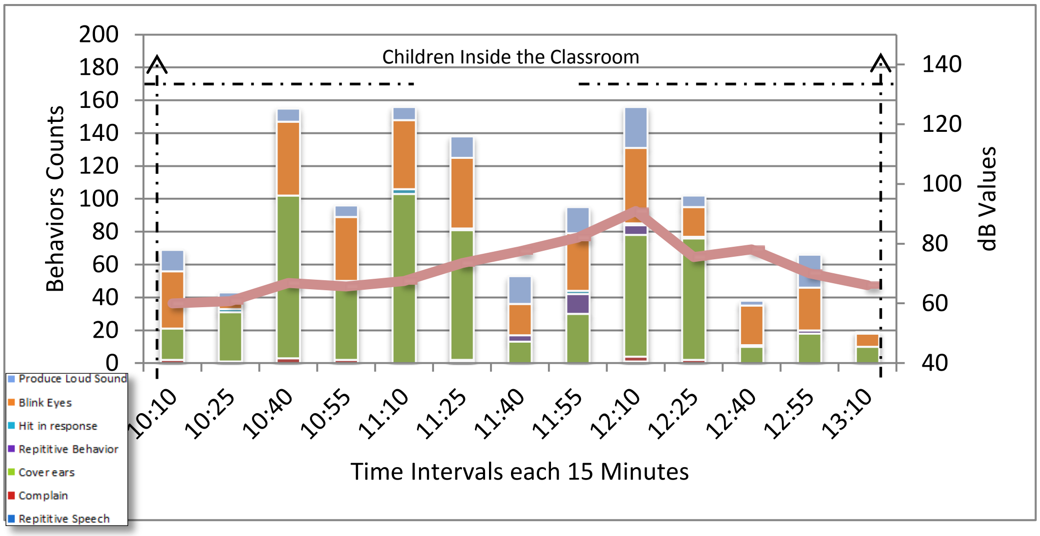

Figure 3.6 dB(A) Values of the Seven Behaviors Observed in Classroom I (Noisy) in the School I on 5/01/12

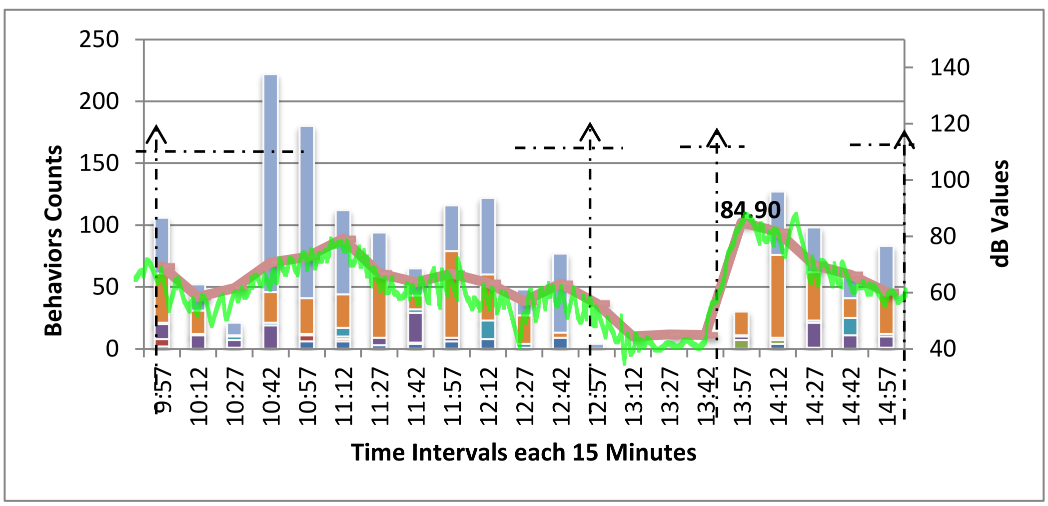

Figure 3.7 dB(A) Values of the Seven Behaviors Observed in Classroom I (Noisy) in the School I on 5/02/12

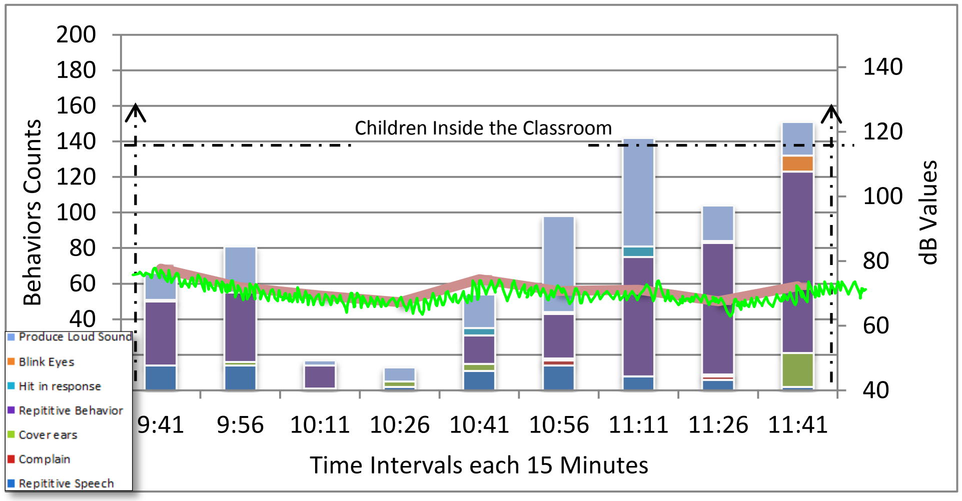

Figure 3.8 dB(A) Values of the Seven Behaviors Observed in Classroom I (Noisy) in the School I on 5/04/12

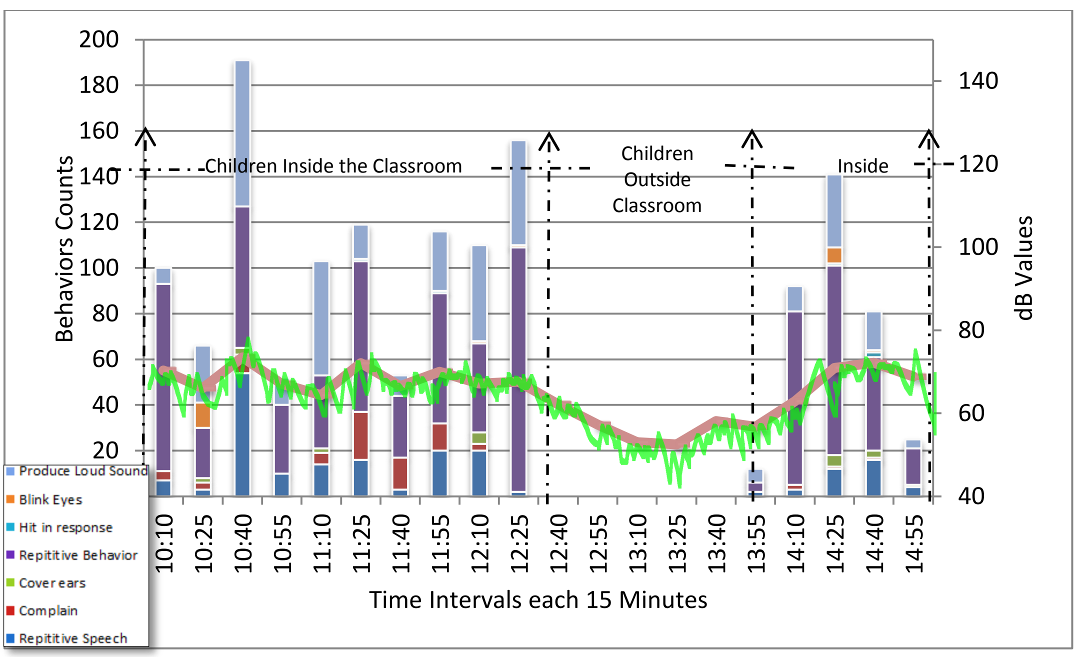

Figure 3.9 dB(A) Values of the Seven Behaviors Observed in Classroom I (Noisy) in the School I on 5/07/12

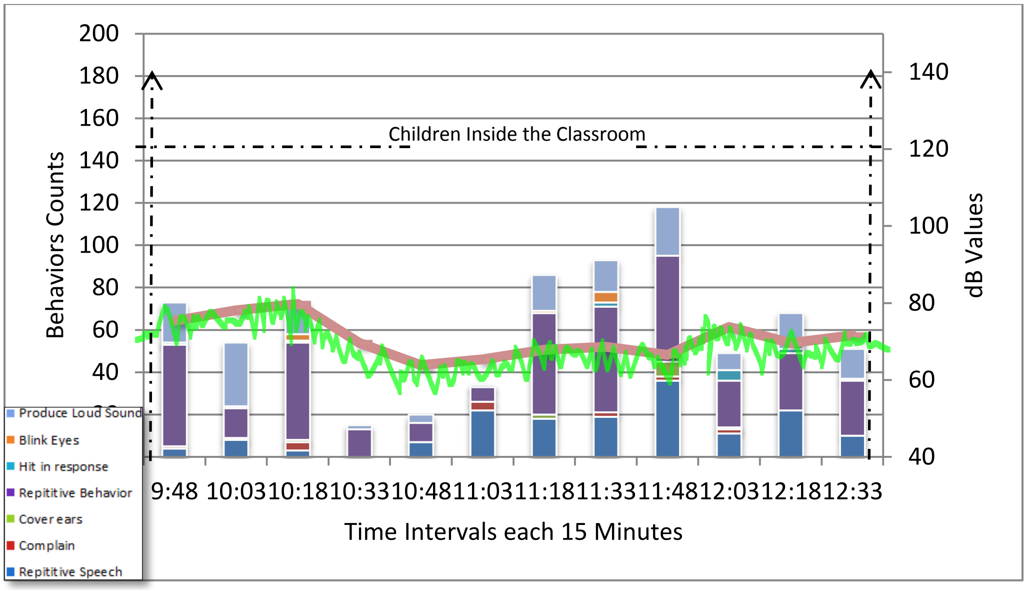

Figure 3.10 dB(A) Values of all the Seven Behaviors Observed in Classroom I (Noisy) in the School I on 5/08/12

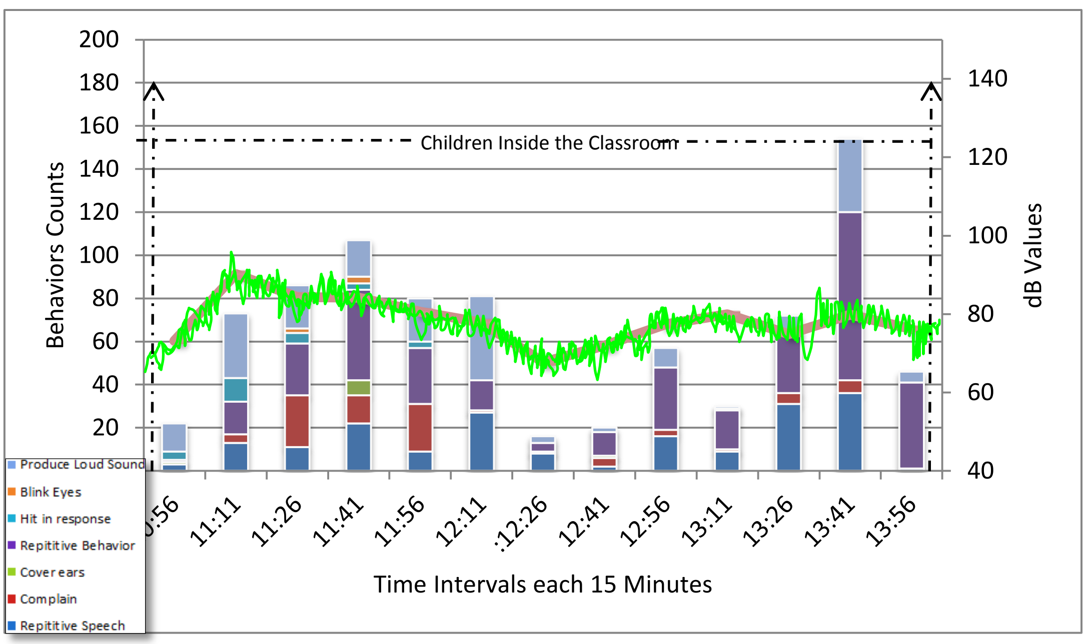

Figure 3.11 dB(A) Values of all Seven Behaviors Observed in Classroom I (Noisy) in the School I on 5/09/12

Table 3.1 Percentage of Correlation between Sound and Behaviors in Classroom I (Noisy) in the School I

Behavior	**Percentage Average**
Repetitive behavior (echolalia)	79%
Repetitive Speech	12%
Produce Loud Sound	66%
Cover Ears	10%
Hit in Response	100%
Complain	16%
Blink Eyes	29%

Figure 3.12 shows the percentage of the behaviors for each day of observation. Repetitive behavior (echolalia) was one of the most dominant behaviors recorded. However, this does not necessarily indicate that this behavior correlates strongly with the increase in the dB values. However, hitting behavior was recorded as having the lowest percentage of occurrence (see Figure 3.12), but Table 3.1 indicates that hitting behavior correlates very strongly with the increase in the dB.

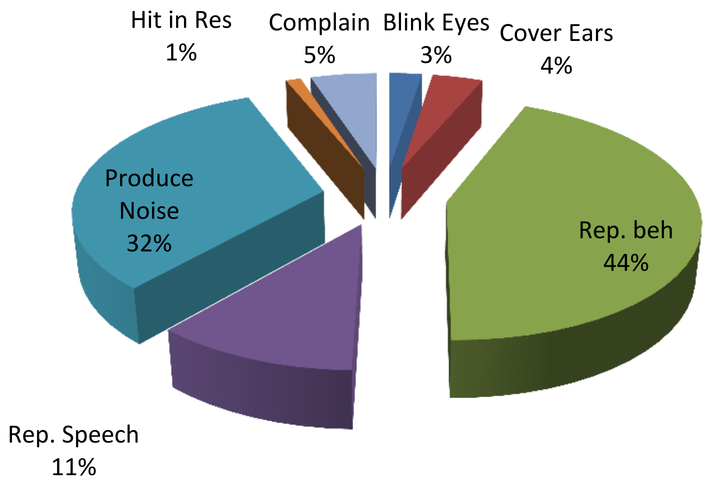

Figure 3.12 Percentage of each Behavior in the School I Classroom 1 (Noisy Classroom)

3.2.1.2.2 Sound and Behaviors Results: Classroom II (Quiet) in School I

This section describes the daily ecology of the noise that was recorded in the quieter classroom (classroom II) in the School I, and a description of the frequency of the seven behaviors which were observed while recording the sound levels in, that classroom.

The observations in this classroom took place from May 10, 2012 until May 23, 2012. The sound ecology in this classroom was recorded by measuring the dB readings for the entire time of the observation. The ecology of noise in this classroom was different from classroom 1. It was more calm and quiet. The children in this classroom were less talkative and less hyper- active, the teacher spoke less frequently, there was no air conditioning unit noise, and no sounds came from the playground area which was far away from the classroom.

By looking at the distribution of the sound during all the observation days, normal dB readings were shown most of the time. The maximum value was 68.01dB and the minimum value was 43.56dB. The baseline measured by recording the dB level during the day with no student behavior was 41dB. Most of the readings of the dB fell under 40 to 60 dB. There were few readings above and below this range in the classroom.

A comparison was designed to numerically compare the increase or the decrease in the sound level and the increase or the decrease in the frequency of the seven behaviors. On the observation days, using a rating scale of 0% to 100%, all the behaviors recorded an increase once the dB readings increased but in different percentages (see Figures 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, and 3.20). On the observation days, using the rating scale from 0% to 100%, all the behaviors correlated with the increase in dB readings.

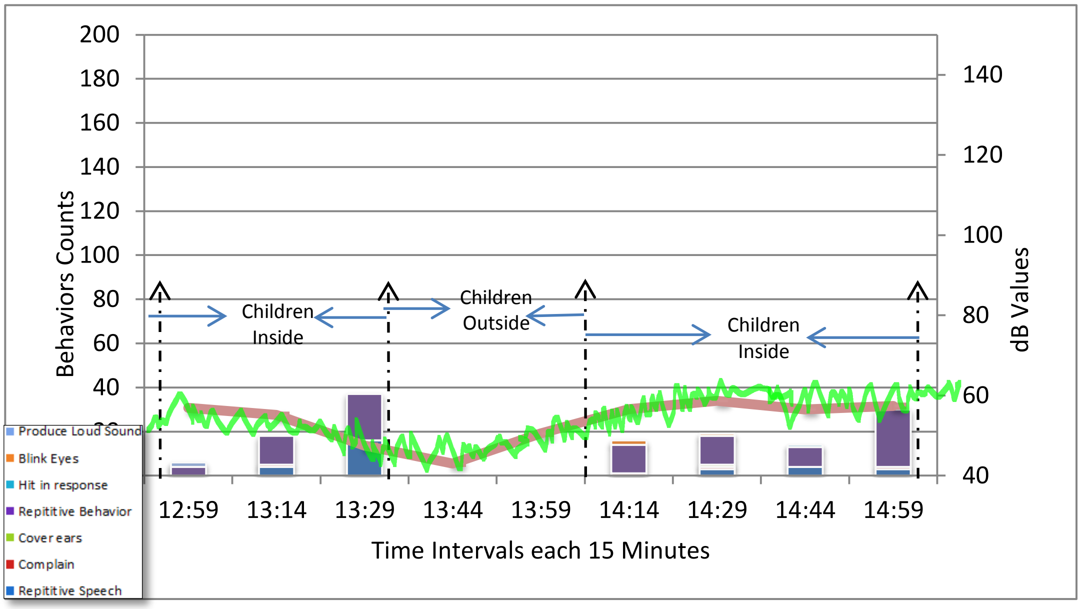

Figure 3.13 dB (A) Values with all the Seven Behaviors were Observed in Classroom II(Quiet) in the School I on 5/10/12

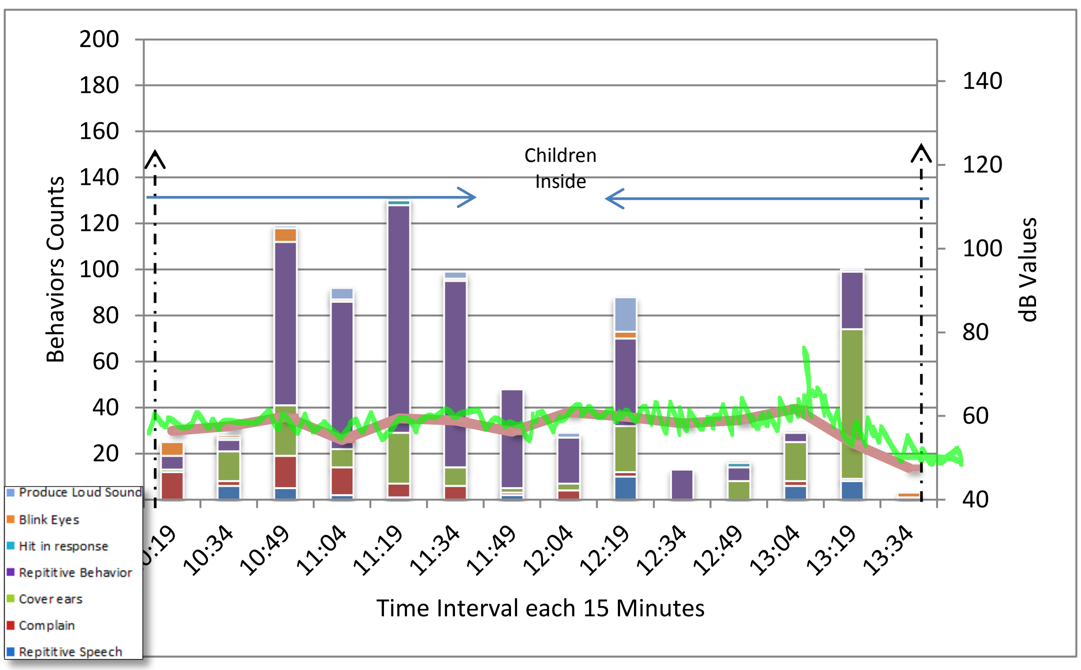

Figure 3.14 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in the School I on 5/13/12

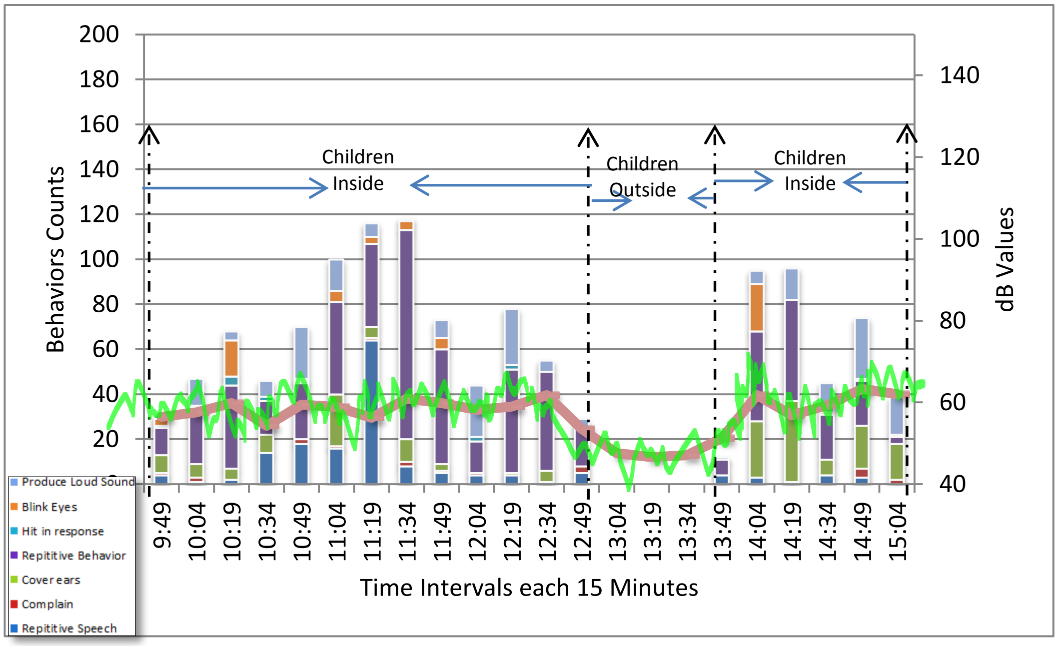

Figure 3.15 dB(A) Values with all the Seven Behaviors were Observed in Classroom II(Quiet) in School I in 5/16/12

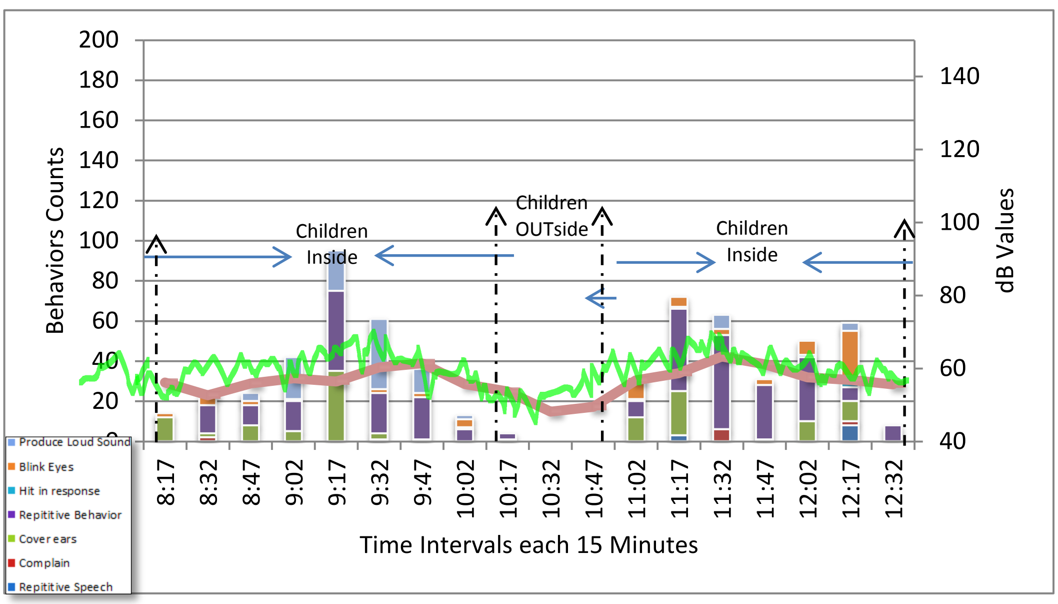

Figure 3.16 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in School I in 5/17/1

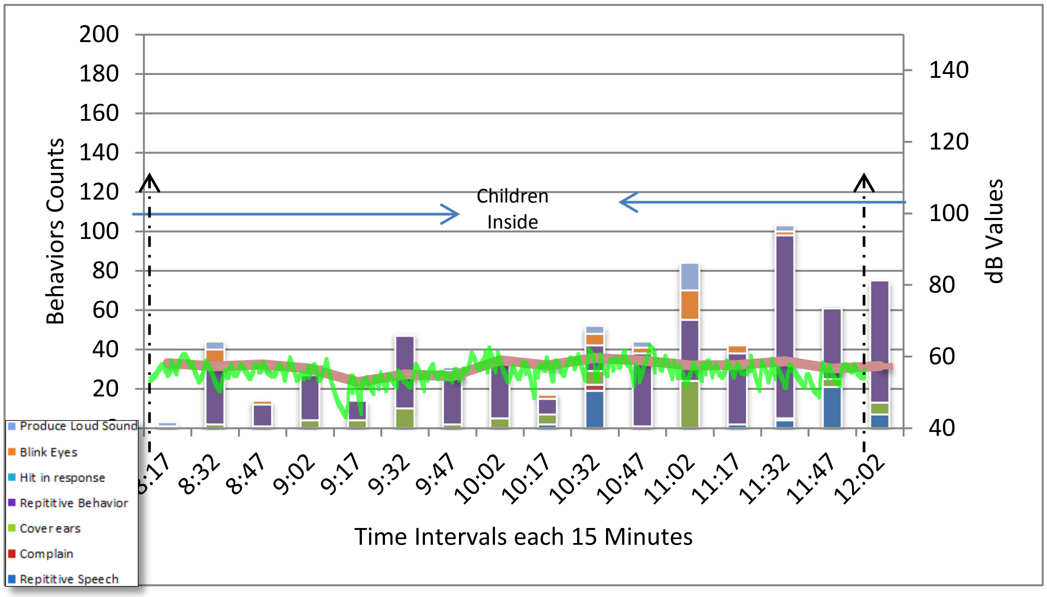

Figure 3.17 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in the School I on 5/21/12

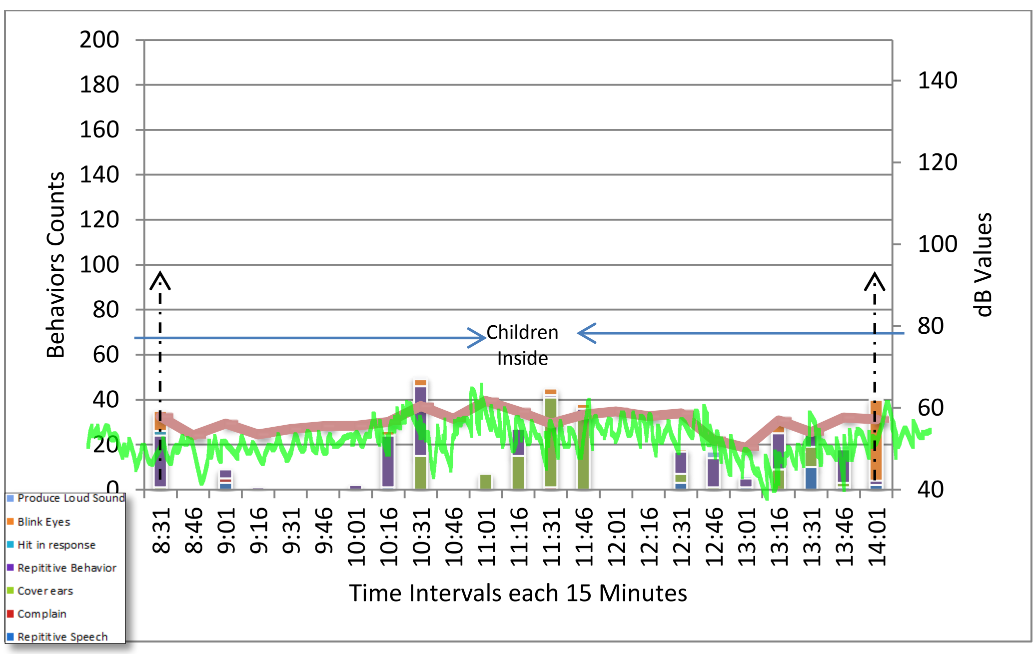

Figure 3.18 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in School I on 5/22/12

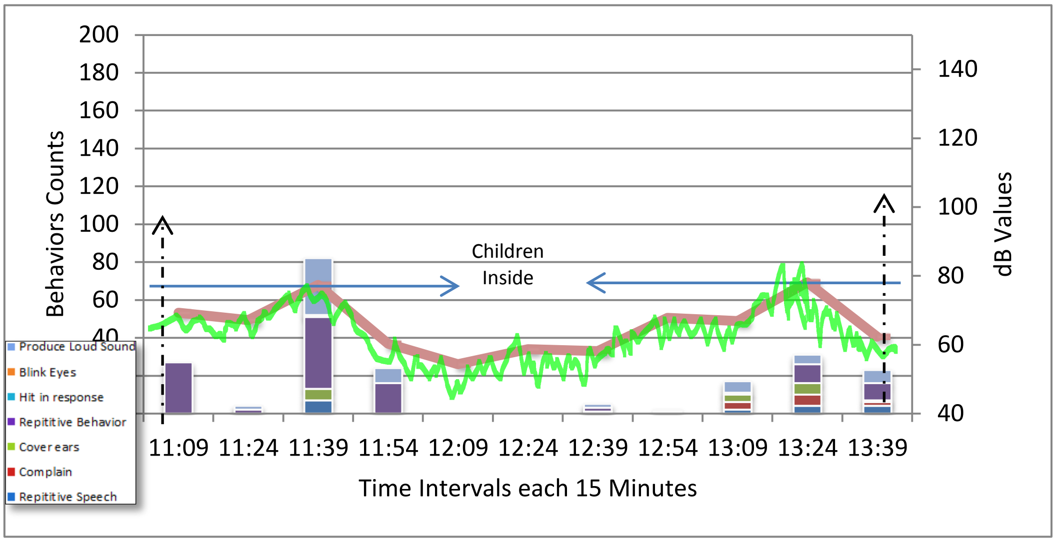

Figure 3.19 dB(A) Values with all the Seven Behaviors were Observed in Classroom II(Quiet) in School I in 5/23/12

In Figures 3.15, 3.16, and 3.17 few hit behavior responses were observed, but once the dB reading was above 70dB hitting behavior took place, correlating 100% with the increased in sound level. All other behaviors demonstrated lower correlations. (See Figure 3:18) Repetitive behavior (echolalia) correlates 79% with the increase of the sound, and producing loud sound behavior correlates 66% with the increase of the sound. The correlations for other behaviors were even lower. Blinking eyes correlated at 33%, complaining behaviors correlated at16%, repetitive speech correlated at 12%, and covering ears behavior was found to correlate at 10%. See Figure 3.21 for the conclusion of the results.

Table 3.2 Percentage of Correlation between Sound and Behaviors in Classroom II (Quiet) in the School I

Behavior	**Percentage Average**
Repetitive behavior (echolalia)	79%
Repetitive Speech	12%
Produce Loud Sound	66%
Cover Ears	10%
Hit in Response	100%
Complain	16%
Blink Eyes	29%

Table 3.2 and Figure 3.21 demonstrate that many behaviors occur frequently but do not correlate strongly with the increase in dB value. For example, covering ears was common, but had a poor correlation with the increase of dB values (10%).

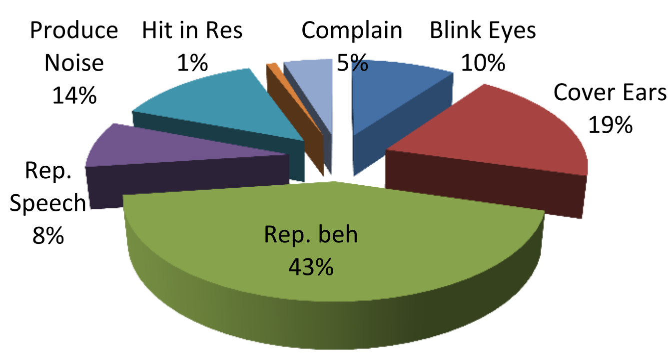

Figure 3.20 Summary of Percentage of Behaviors Observed in the School I Classroom II (Quiet Classroom)

3.2.1.2.3 Sound and Behaviors Results: Classroom I (Noisy Classroom) in School II

This section describes the daily ecology of the noise that was recorded in the noisy classroom (classroom I) in the School II, and a description of the frequency of the behaviors that were observed while recording sound levels.

The observations in this classroom took place on seven different days during May, June, and July of 2012. The sound ecology in this classroom was recorded by measuring the dB readings for the entire length of the observation. The ecology of sound in this classroom had different sources of noise. It was a very noisy environment. The children in this classroom were highly talkative and hyperactive, the teacher spoke frequently, the air conditioning unit was connected to the classroom, and there were sounds made by other children which came from the nearby main corridor.

By looking to the distribution of sound during all the observation days, high dB readings were recorded most of the time. The maximum value was 88.01dB and the minimum value was 42.56dB. The baseline was measured by recording the dB during the day with the students inside the classroom during the period in which they were not exhibiting any of the seven behaviors of interest. This measurement was 41dB.

A comparison was designed to numerically compare the increase or the decrease in the sound level and the increase or the decrease in the behavior frequency. On the observation days, using a rating scale of 0% to 100%, all the behaviors demonstrated some kind of increase once the dB reading increased but in different percentages (see Figures 3.21, 3.22, 3.23, 3.24, 3.25, 3.26 and 3.27). On the observation days using the rating scale from 0% to 100% all the behaviors correlate with the increase in dB readings.

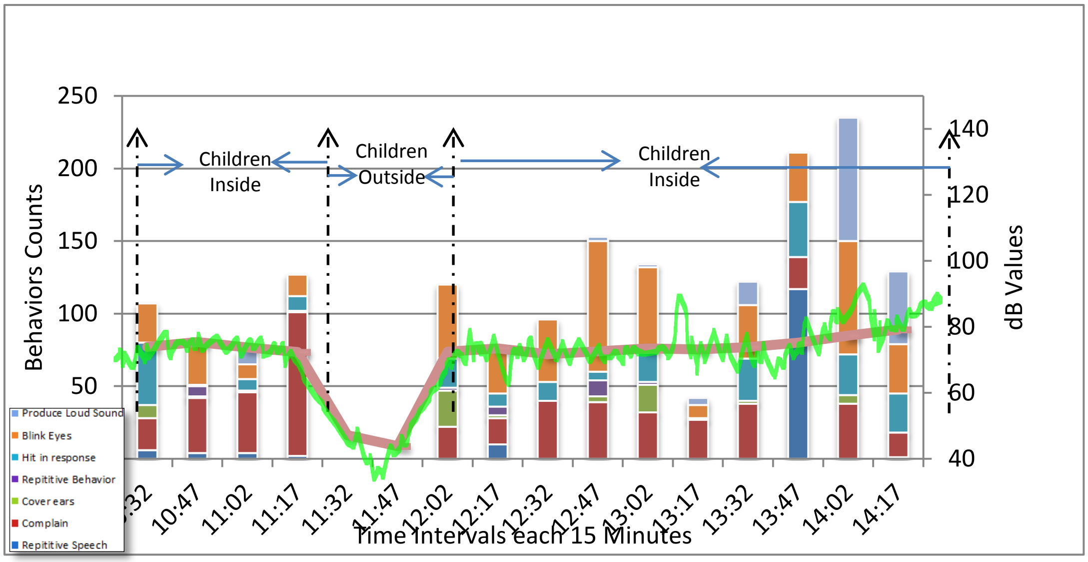

Figure 3.21 dB(A) Values with all the Seven Behaviors were Observed in Classroom I (Noisy) in School II in 5/03/12

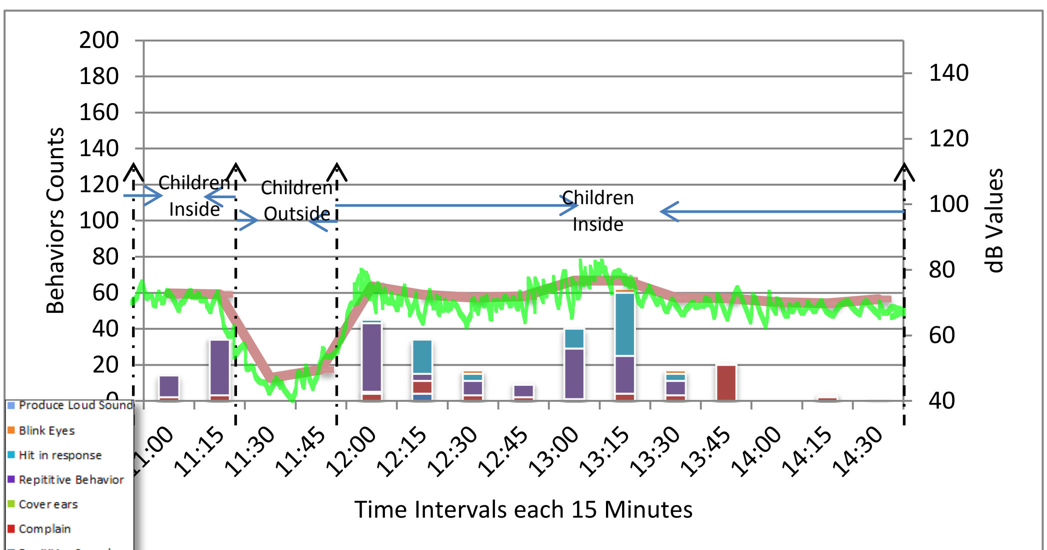

Figure 3.22 dB(A) Values with all the Seven Behaviors were Observed in Classroom I (Noisy) in School II in 6/05/12

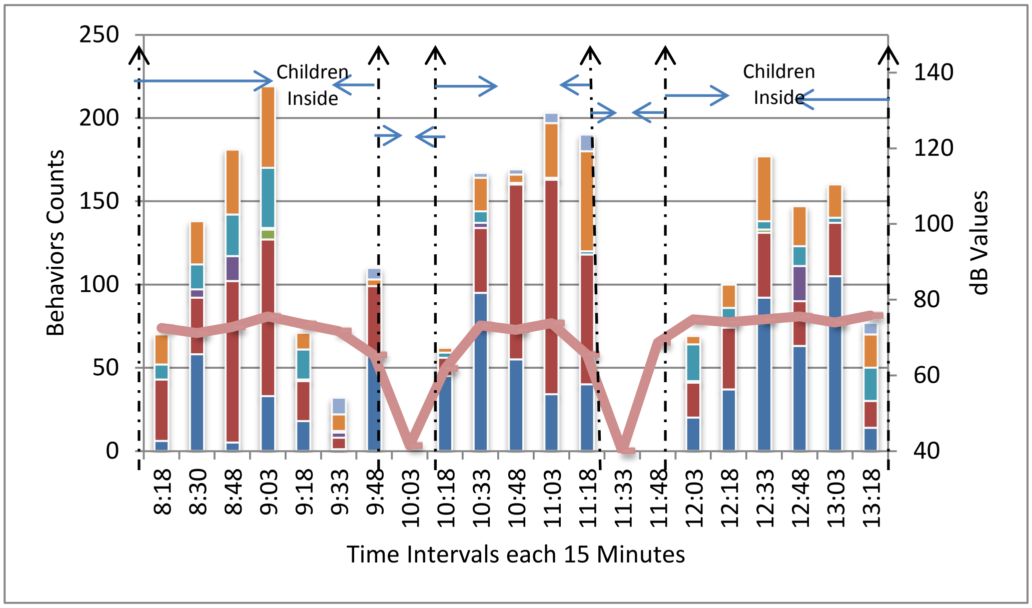

Figure 3.23 dB(A) Values with all the Seven Behaviors were Observed in Classroom I (Noisy) in the School II on 6/29/12

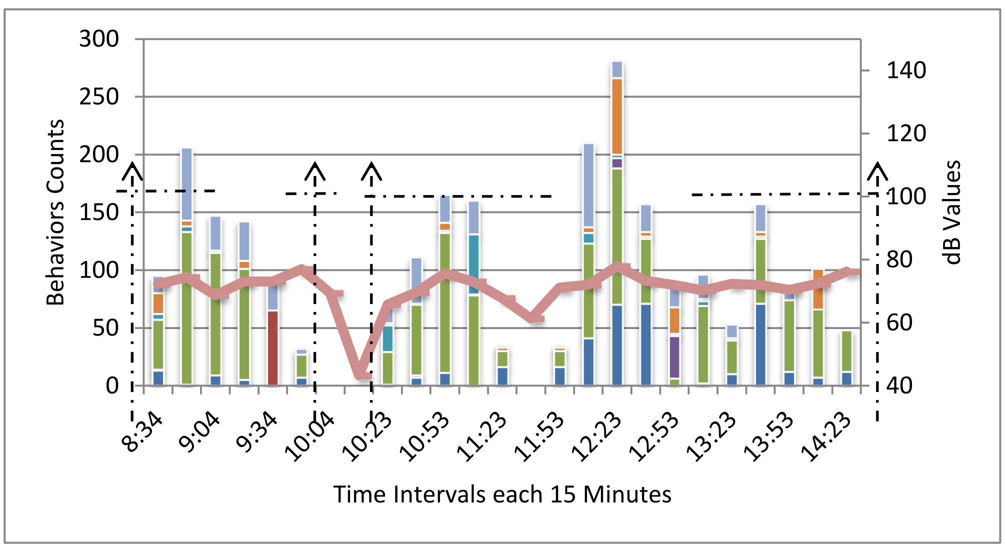

Figure 3.24 dB(A) Values with all the Seven Behaviors were Observed in Classroom I (Noisy) in the School II on 7/02/12

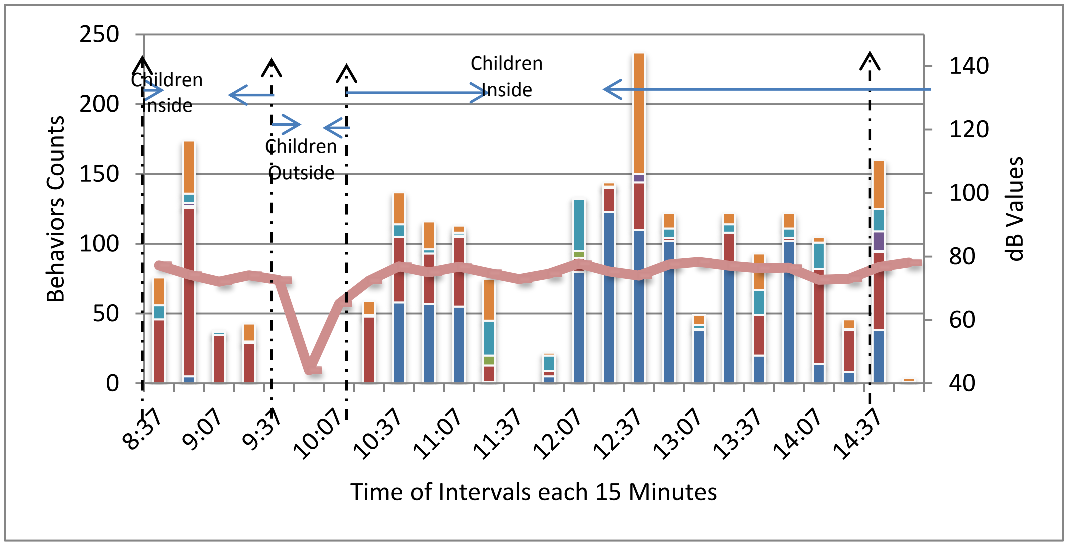

Figure 3.25 dB(A) Values with all the Seven Behaviors were Observed in Classroom I (Noisy) in the School II on 7/03/12

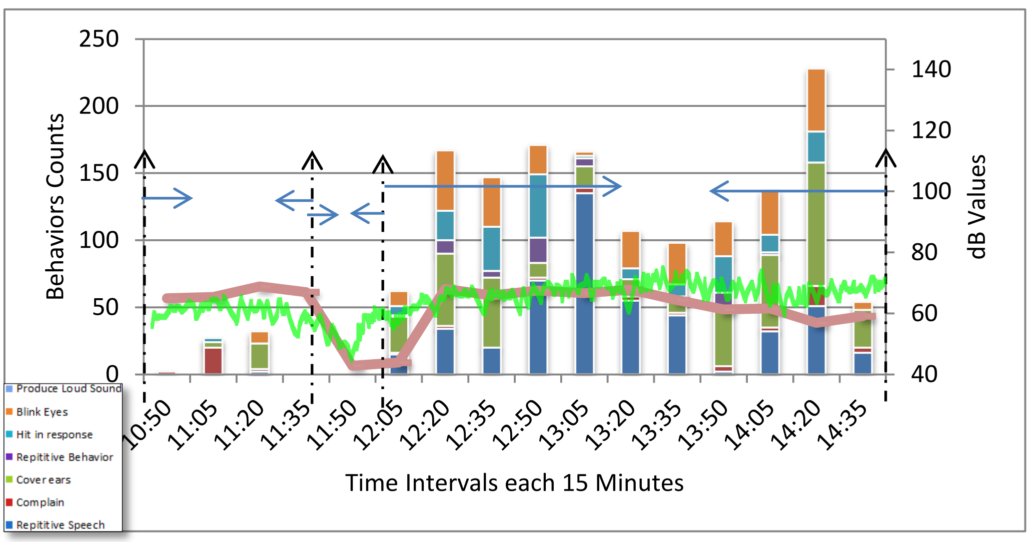

Figure 3.26 dB(A) Values with all the Seven Behaviors were Observed in Classroom I (Noisy) in the School II on 7/11/12

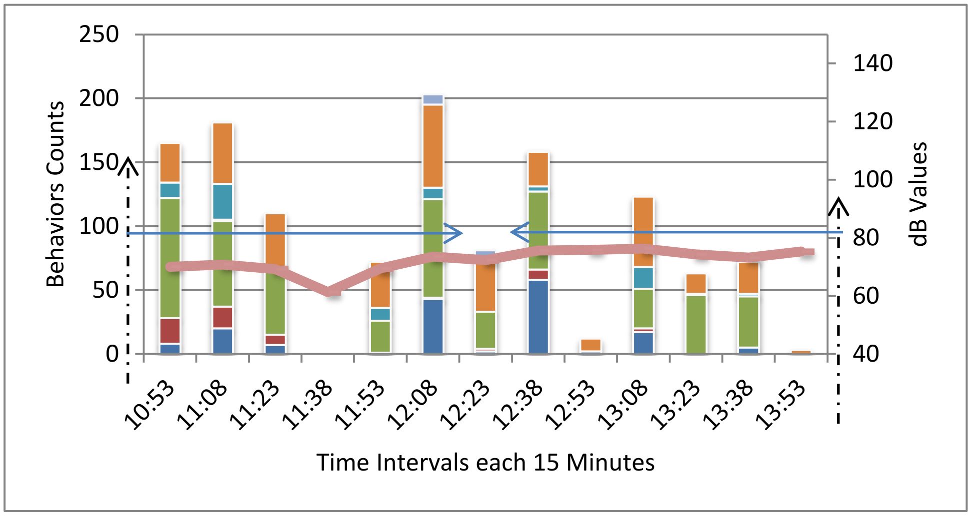

Figure 3.27 dB(A) Values with all Seven Behaviors were Observed in Classroom I (Noisy) in the School II on 7/10/12

Table 3.3 Percentage of Correlation between Sound and Behaviors in Classroom I (Noisy) in the School II

Behavior	Percentage Average
Repetitive behavior (echolalia)	70%
Repetitive Speech	98%
Produce Loud Sound	88%
Cover Ears	96%
Hit in Response	100%
Complain	66%
Blink Eyes	9%

As demonstrated in Figures 3.22, 3.23, and 3.24, few hit behaviors in response to noise levels were observed, but once the dB reading rose above 72.4dB most of the hitting behavior occurred. This behavior correlated 100% with the increase in sound level. Repetitive behavior (echolalia) correlated 70% with the increase of the sound, producing loud sound behavior correlated 88%, repetitive speech correlated at 98%, and covering ears behavior was correlated at 96%. Complaining behavior was less correlated (66%), and blinking eyes was least correlated when the dB value increased (9%) (see Figure 3.28).

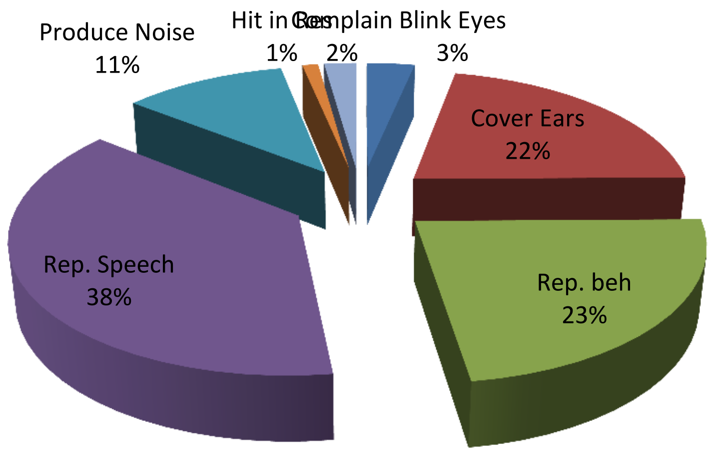

Figure 3.28 Percentage of Behaviors were Observed in Classroom I (Noisy) in the School II

3.2.1.2.4 Sound and Observed Behaviors Results: Classroom II (Quiet Classroom) School II

This section describes the daily ecology of the noise recorded in the noisy classroom (classroom II) in the School II II, in relation to the frequency of the seven behaviors observed during that period. The observations in this classroom took place on seven different days during May, June, and July of 2012. The sound ecology in this classroom was recorded by measuring the dB readings during the entire time of the observation. The ecology of noise in this classroom included different sources of noise. It was a quiet environment; the children in this classroom were quiet, the teacher spoke infrequently, and the air conditioning unit was not connected directly to the classroom.

By looking at the distribution of the sound during all the observation days, high dB readings were recorded most of the time. The maximum value was 62.05dB and the minimum value was 41.5dB. The baseline measured by recording the dB during the day, when the students were not exhibiting any of the behaviors of interest, was 41dB.

A comparison was designed to numerically compare the increase or the decrease in the sound level and the increase or the decrease in the frequency of the seven behaviors. On the observation days, using a rating scale of 0% to 100%, all the behaviors recorded an increase once the dB reading increased but to different degrees (see Figures 3.30, 3.31, 3.32, 3.33, 3.34, 3.35, 3.36 and 3.37). On the observation days, using the rating scale from 0% to 100%, all the behaviors correlated with the increase in dB readings. (See Table 3.4)

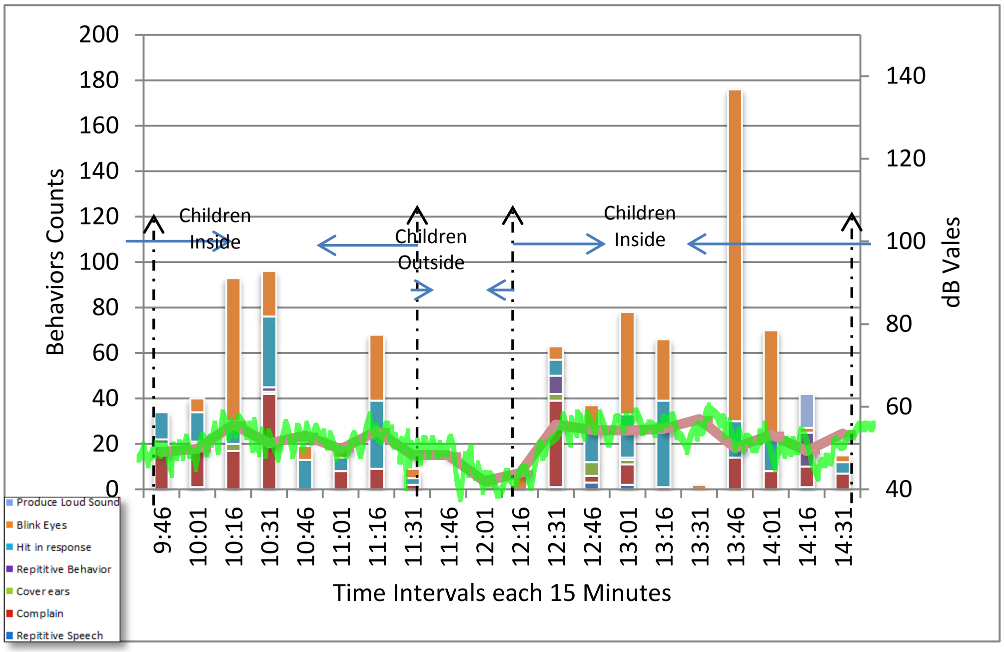

Figure 3.29 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in the School II on 6/06/12

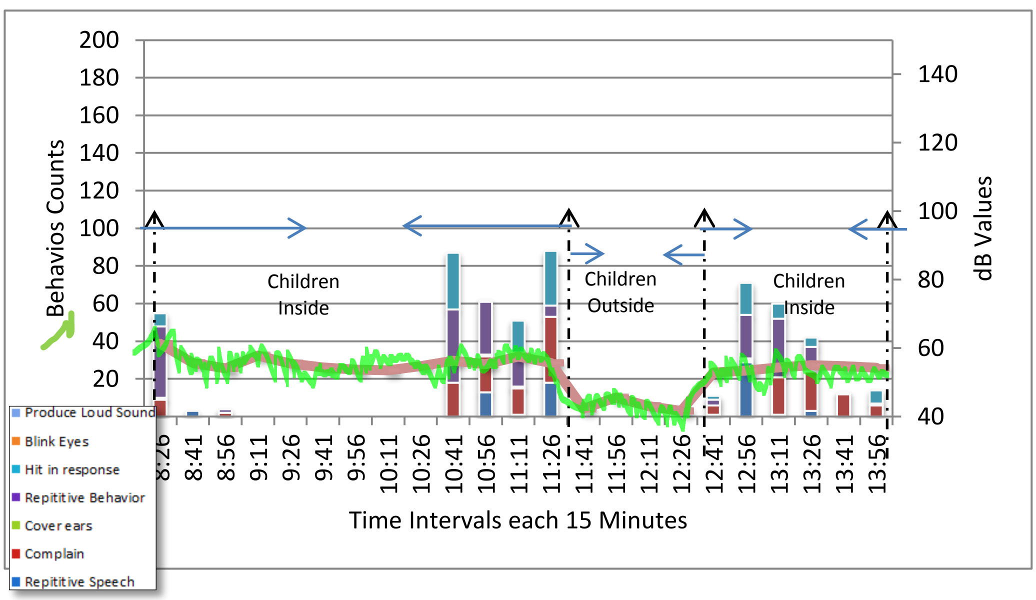

Figure 3.30 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in the School II on 6/07/12

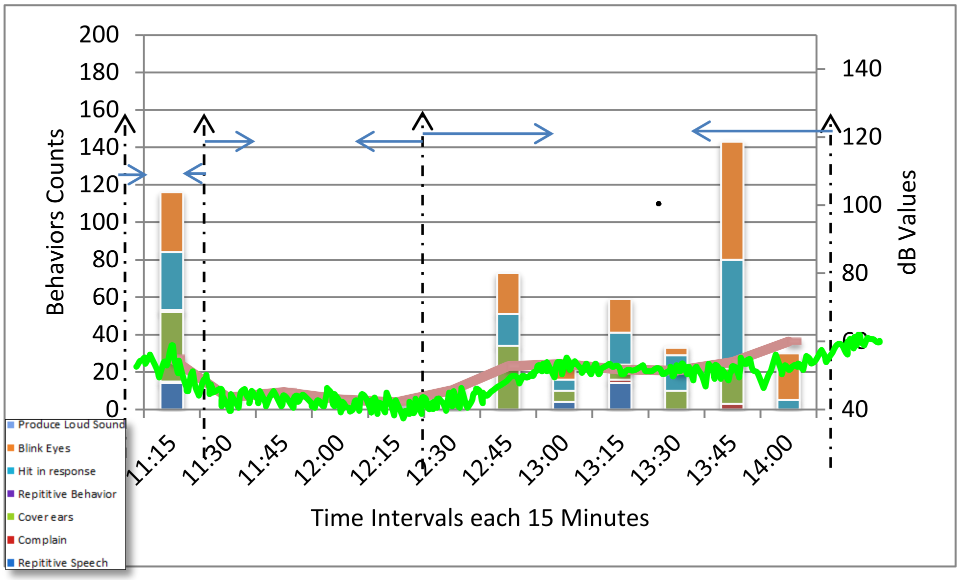

Figure 3.31 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in School II in 6/14/12

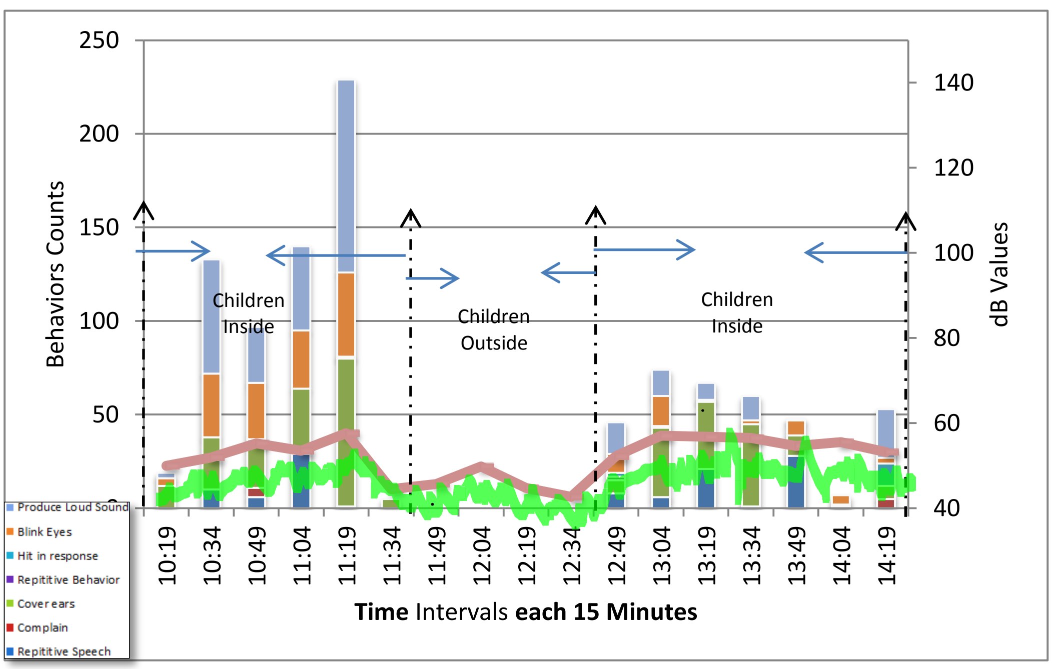

Figure 3.32 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in School II in 6/21/12

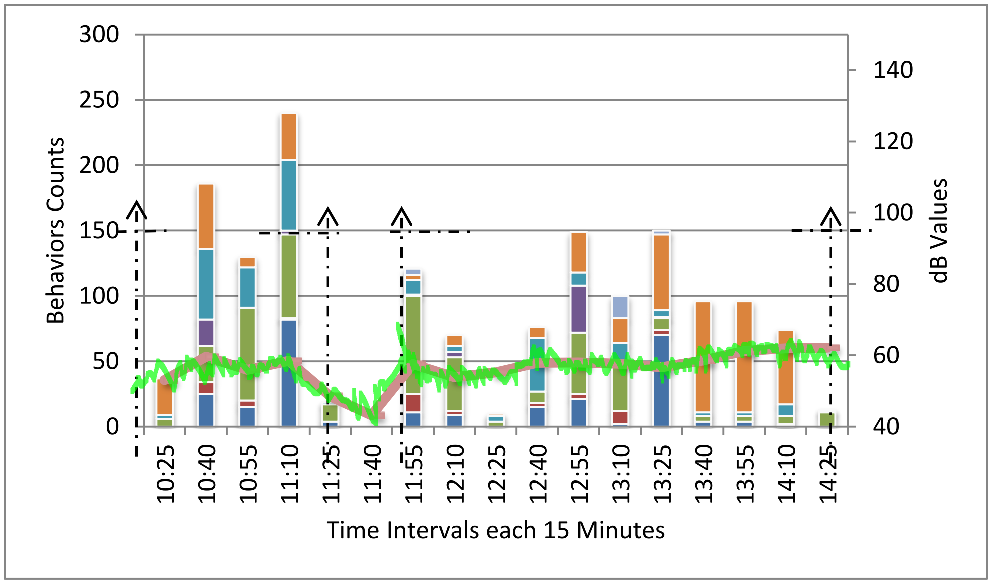

Figure 3.33 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in School II in 6/26/12

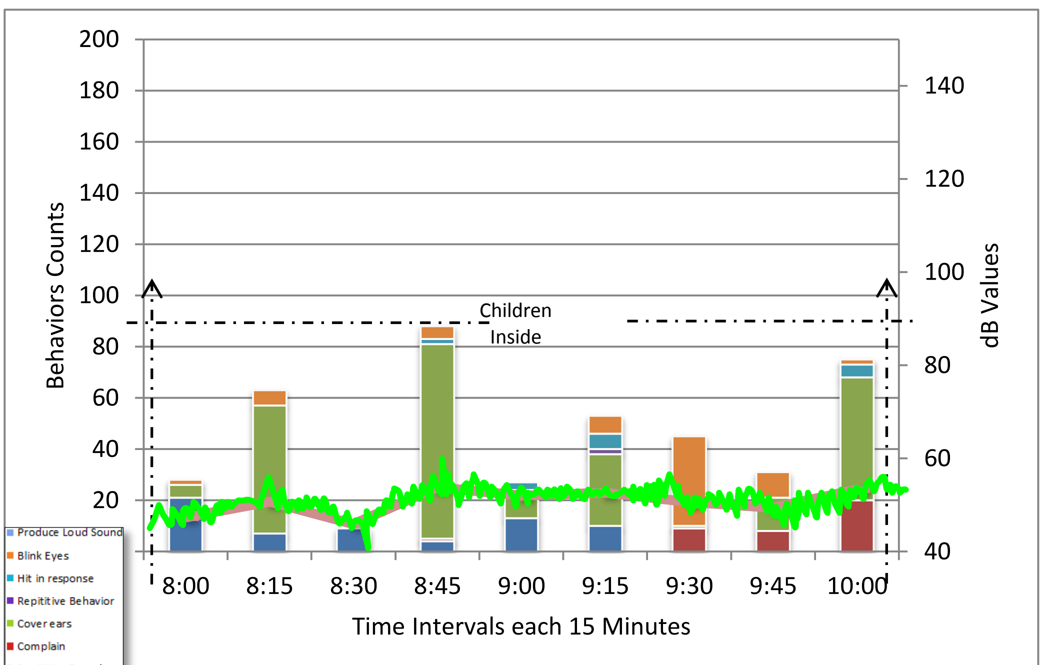

Figure 3.34 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in School II in 6/28/12

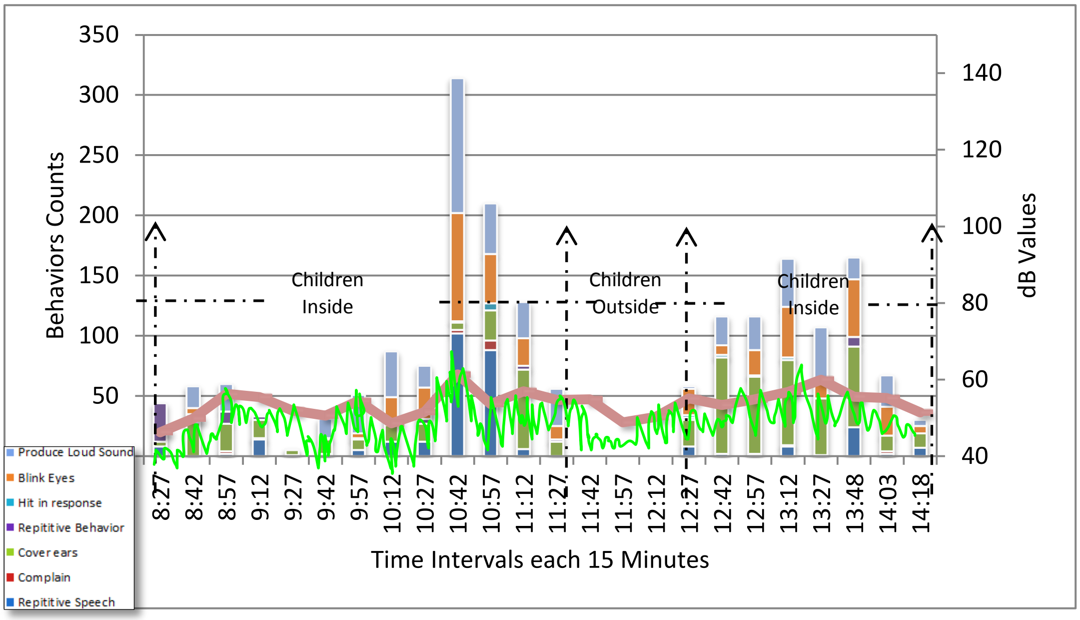

Figure 3.35 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in School II in 7/05/12

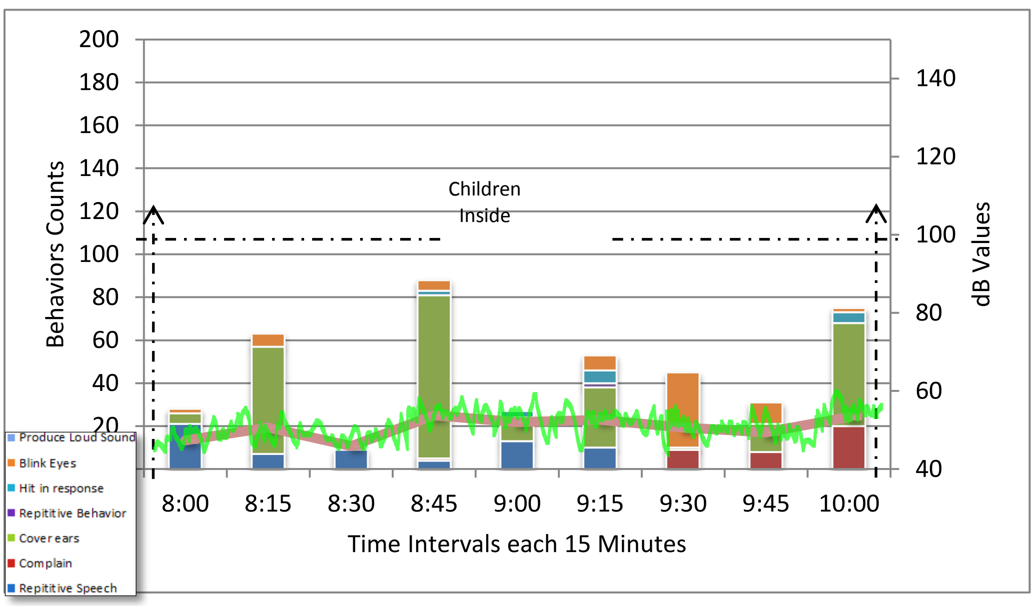

Figure 3.36 dB(A) Values with all the Seven Behaviors were Observed in Classroom II (Quiet) in School II in 7/12/12

Table 3.4 Percentage of Correlation between Sound and Behaviors in Classroom II (Quiet) in the School II

Behavior	Percentage Average
Repetitive behavior (echolalia)	79%
Repetitive Speech	83%
Produce Loud Sound	66%
Cover Ears	78%
Hit in Response	100%
Complain	6%
Blink Eyes	34%

Table 3.4 demonstrates that hitting behaviors in response to noise had a greater frequency when there was a high decibel reading, but hitting in response behavior represented 3% of the total of all the behaviors. Producing loud sounds comprised 35%of the total and correlated with the increase in sound at 66%. Complaining behavior occurred as often as hitting behavior 3% but it did not correlate with increase or decrease in the sound.

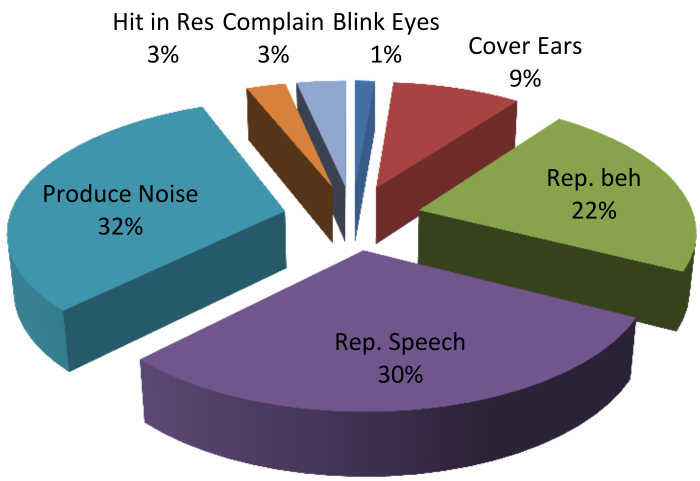

Figure 3.37 Summary of Percentage of Behaviors in School II Classroom II (Quiet Classroom)

Figure 3.38 shows that produce loud noises and repetitive speech behaviors occurred a high percentage of the time in this classroom, followed by repetitive behavior (echolalia). Covering ears behaviors occurred a few times and the rest of the behaviors happen very infrequently. These results guided the researcher for the next step of the analysis, the confirmatory analysis, which was developed to address the hypotheses set forward in this study.

3.2.2 Confirmatory Results

3.2.2.1 Descriptive Results (Exploratory Results) of Phase II

This section discusses the hypothesis-testing of this study by using an event based averaging technique. This technique was used for testing the data from Phase II of the study.

For Phase II, a total of 46 subjects was observed from two schools (*n=5 female & n=41 males).* The 128 hours of observation included recording behaviors, sound recording and video recording. Observer XT 11.5 was used to nest and filter the dB readings five seconds before any behavior was recorded. The five seconds period was chosen by the researcher referring to Acoustical Society of America (ASA) (2002) standards. The maximum permissible background-sound level for "typical" classrooms is 35 dBA, with a maximum reverberation time of 0.6 to 0.7 second, (depending on room volume and building material of the room). For this study some calculations have been done to find the best period time, 5 seconds was the most appropriate period to capture the frequency of all observed behaviors.

The mean values of the dBs were taken for each behavior on each day in each of the four classrooms. The total number of mean values was: 7 behaviors x 10 days of observation for each classroom x 4 classrooms equaling 280 mean values (see Table 3.4). After this, the mean value was calculated for the mean values of each behavior in each classroom. The total of that was: four classrooms x mean value of the dB level five seconds before each of the seven behaviors were recorded, which equaled 28 mean values.

3.2.2.2.1 Event-Based Averaging for School 1 Class 1

This section discusses the mean values of the dB 5 seconds before any behavior happened in the School I in Classroom1. An event based average was done for all the observations in this classroom. The figures below present the mean dB value 5 seconds before any behavior was recorded. Hitting in response to noise occurred each time the high dB value of 73dB was recorded. Repetitive speech and covering ears came next, followed by the other behaviors. (See Figure 3.39 for more information).

These dB numbers show a direct relationship between the sound and the behavior. When one compares each behavior with the mean dB value and considers the baseline of the dB (41dB), a correlation between the increase the sound level of loudness and the increase of the behaviors is apparent. The recommended range of the dB inside the educational environment as recommended by the WHO is 35dB. This information provides an indication of the degree of noisiness inside the classrooms and we expect to see different inappropriate behaviors, (see Figure 3.40).

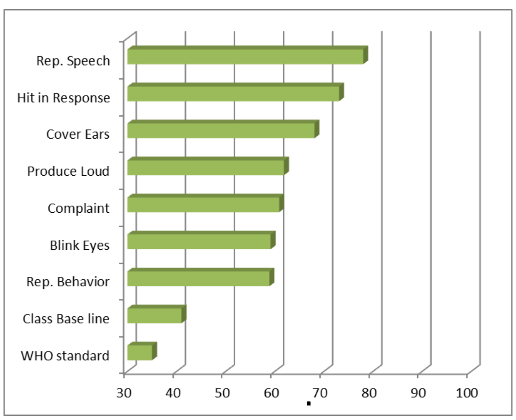

Figure 3.38 A Summary of Mean dB Values Five Seconds before Behavior was Recorded in the School I Classroom I (Noisy Classroom)

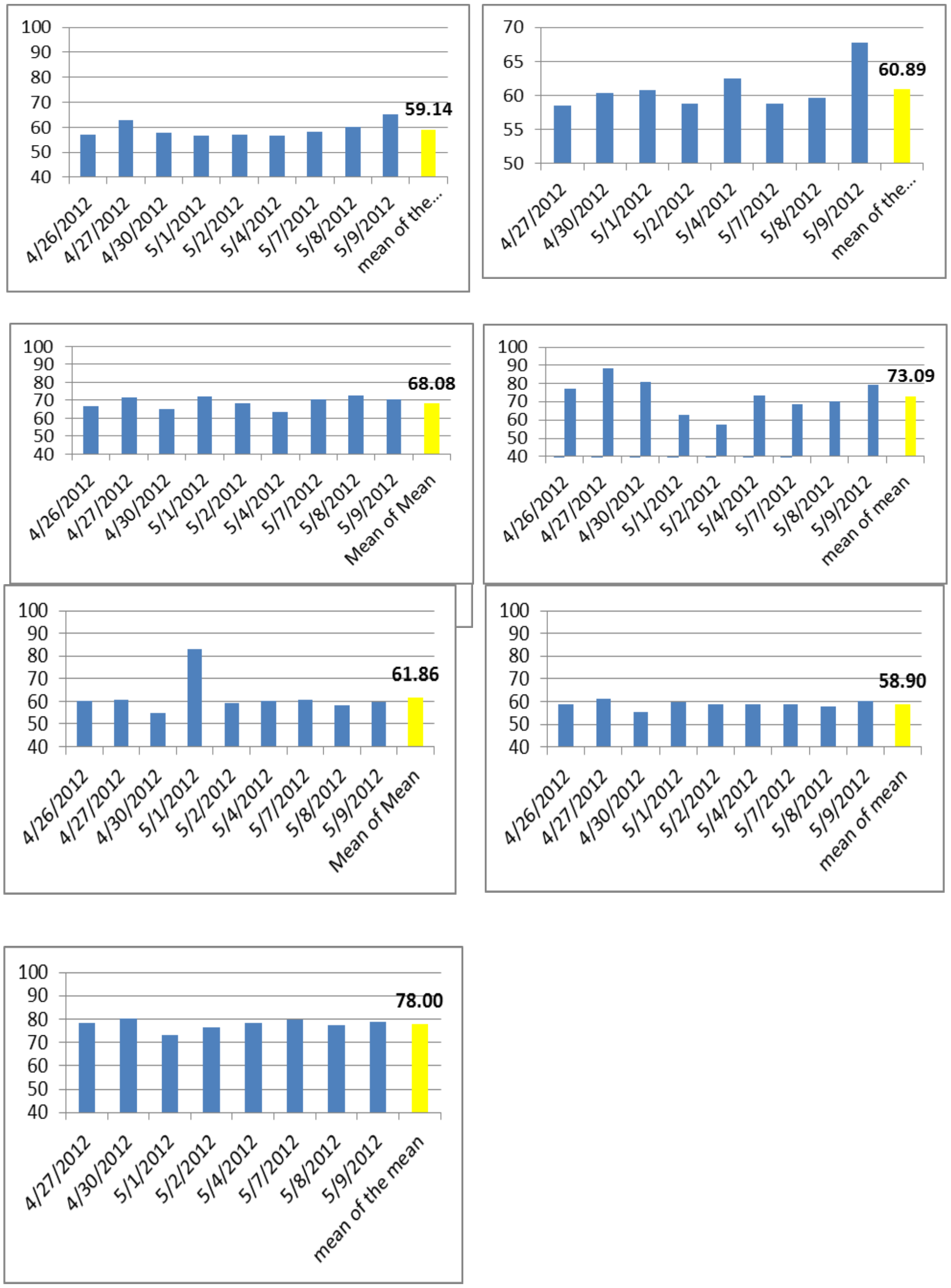

Figure 3.39 A Summary of Mean dB Values Five Seconds before Behavior was recorded in the School I Classroom I (Noisy Classroom)

3.2.2.2.2 Event Based Averaging for the School I Class II

This section discusses the mean dB levels 5 seconds before any behavior happened in the School I in Classroom II. Event-based averaging was done for all the observations in this classroom. Repetitive speech was associated with the highest dB value. The dB measurement was 69.9dB anytime this behavior was recorded. Hitting behaviors, covering ears were the next most frequent behaviors. (See Figure 3.41 & Figure 3.42 for more information).The dB level data indicates a relationship between sound and behavior when one compares each behavior with the mean dB value and considers the baseline of the dB (41dB), the correlation between increase in the sound level, and the increase of the behaviors.

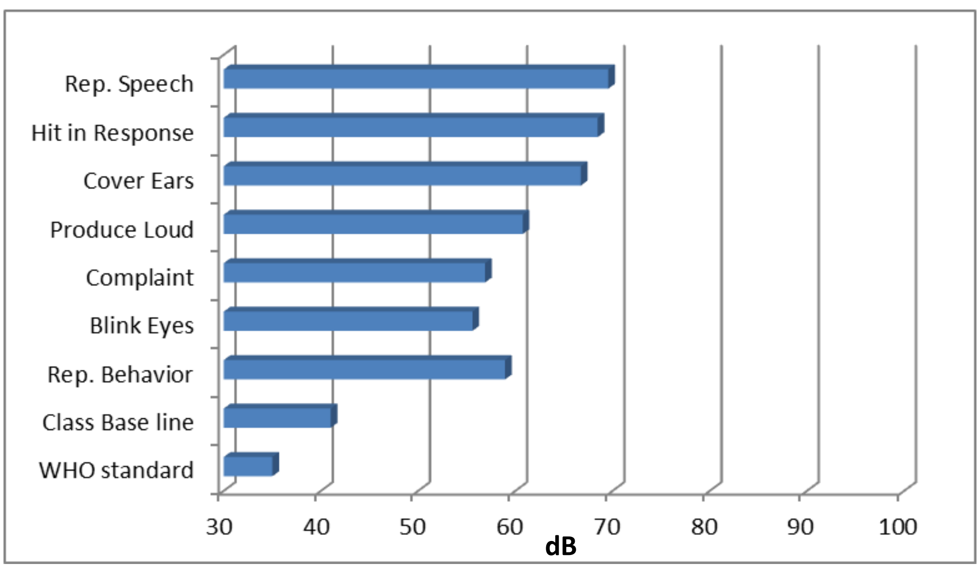

Figure 3.40 Summary of Mean of the Mean dB Values Five Seconds before Behavior in School I Classroom II (Quiet)

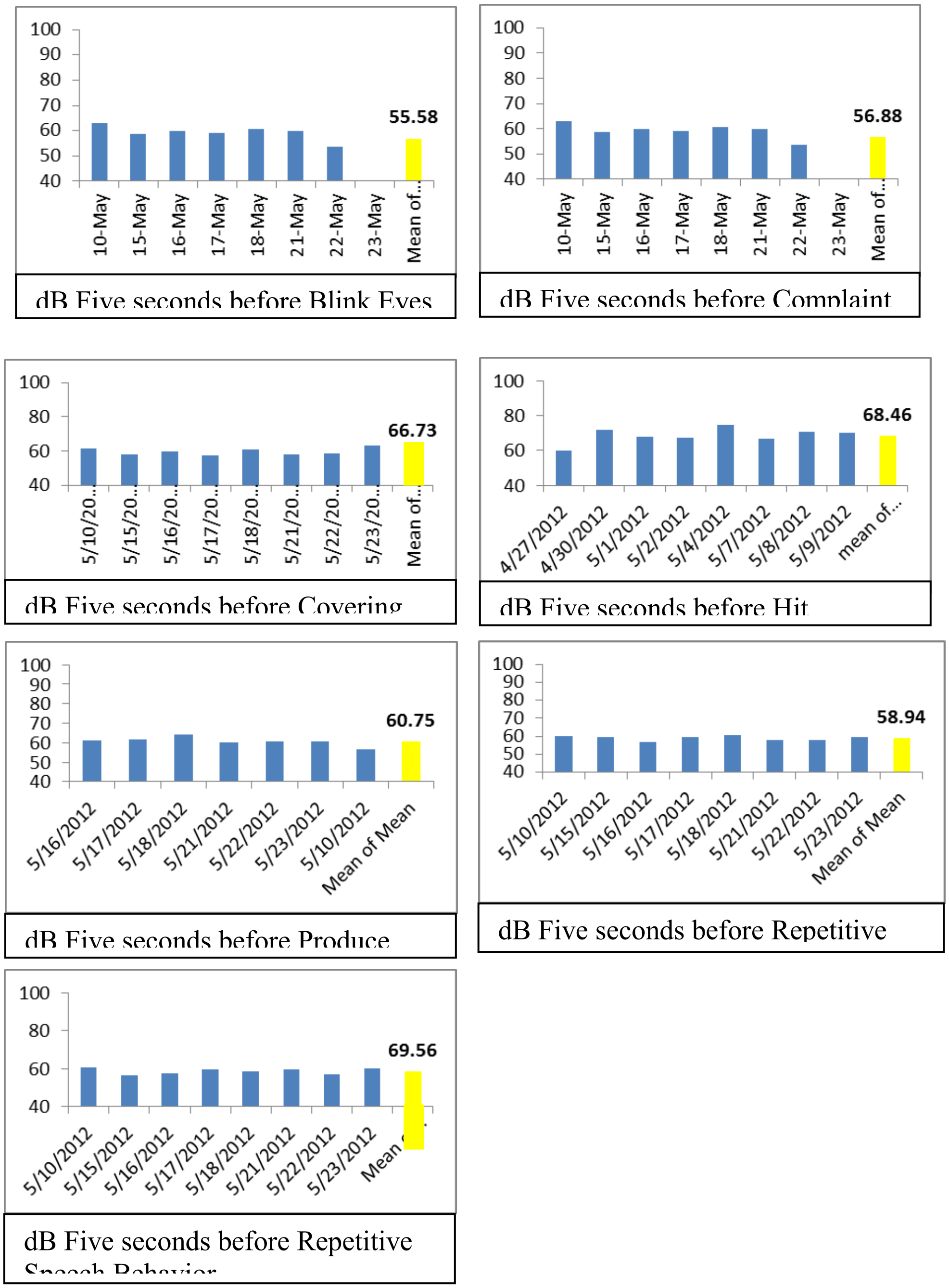

Figure 3.41 Summary of Mean dB Values Five Seconds before Behavior in School I Classroom II (Quiet)

3.2.2.2.3 Event Based Averaging for School II Class I

This section discusses the mean values of the dB five seconds before any behavior occurred in the School II I in Classroom I. An event based averaging was done for all the observations in this classroom. The figures below describe the mean dB value five seconds before any behavior was recorded. Repetitive speech scored the highest dB value, 71.9dB followed by hitting and covering ears. (See Figure 3.43 & Figure 3.43 for more information).

The dB data suggests a relationship between the sound and the behavior. When one compares each behavior with the mean dB value and considers the baseline of the dB (41dB), a correlation between the increase in the level of loudness and the increase in the behaviors is evident.

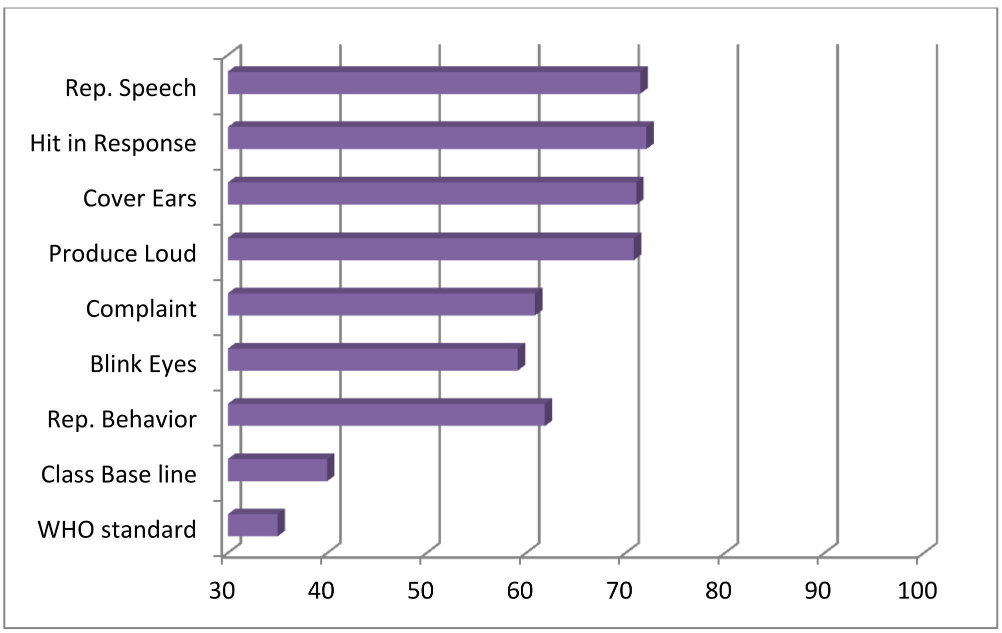

Figure 3.42 Summary of Mean of the Mean dB Values Five Seconds before Behavior has been recorded in School II Classroom I (Noisy Classroom)

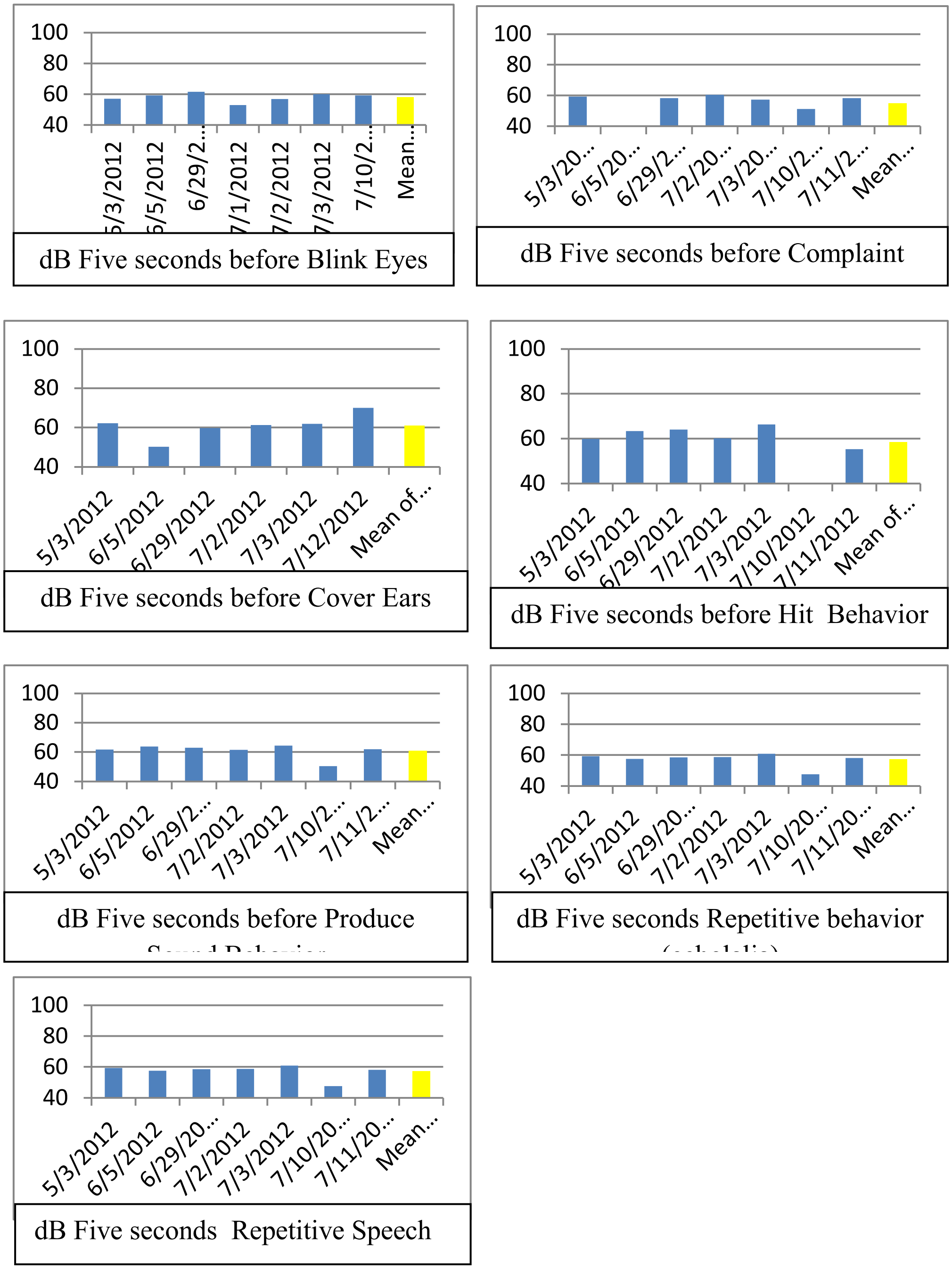

Figure 3.43 Summary of Mean dB Values Five Seconds before Behavior has been Recorded in School II Classroom I (Noisy Classroom)

3.2.2.2.4 Event Based Averaging for School II Class II

This section discusses the mean values of the dB levels five seconds before any behavior occurred in the School II in Classroom II. Event based averaging was done for all the observations in this classroom. The figures below summarize the mean dB value five seconds before any behavior was recorded. Repetitive speech scored the highest dB value, at 64.9dB, followed by hitting and covering ears. (See Figure 3.45 and Figure 3.46 for more information.)

The dB measurements indicate a relationship between sound and behavior. When one compares each behavior with the mean dB value and considers the baseline of dB (41dB), a correlation between increase in the sound level and increase in behaviors.is evident.

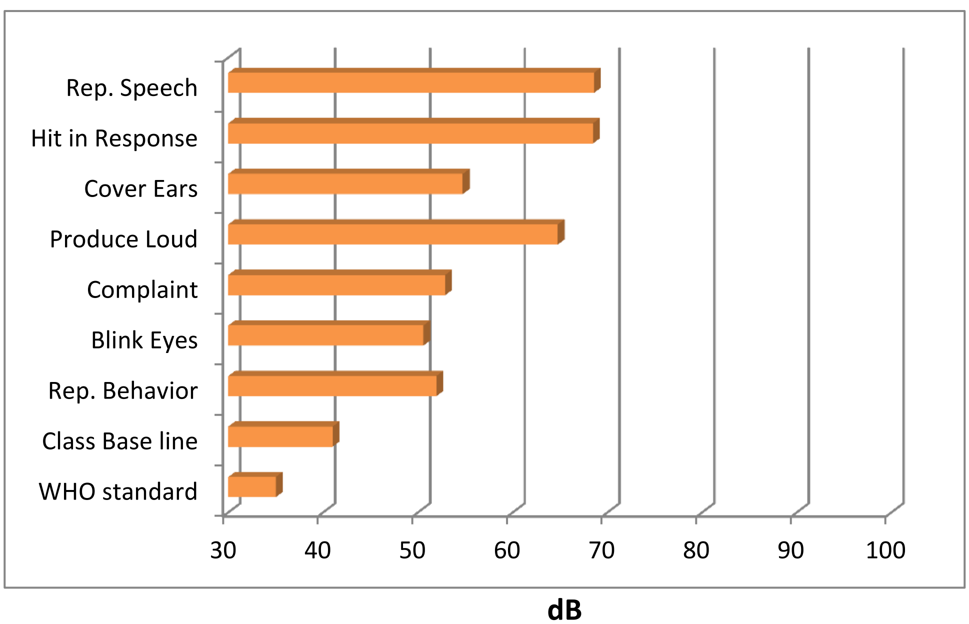

Figure 3.44 Summary of the Mean dB Values 5seconds before any Behavior was recorded in the School II Classroom II (Quiet Classroom)

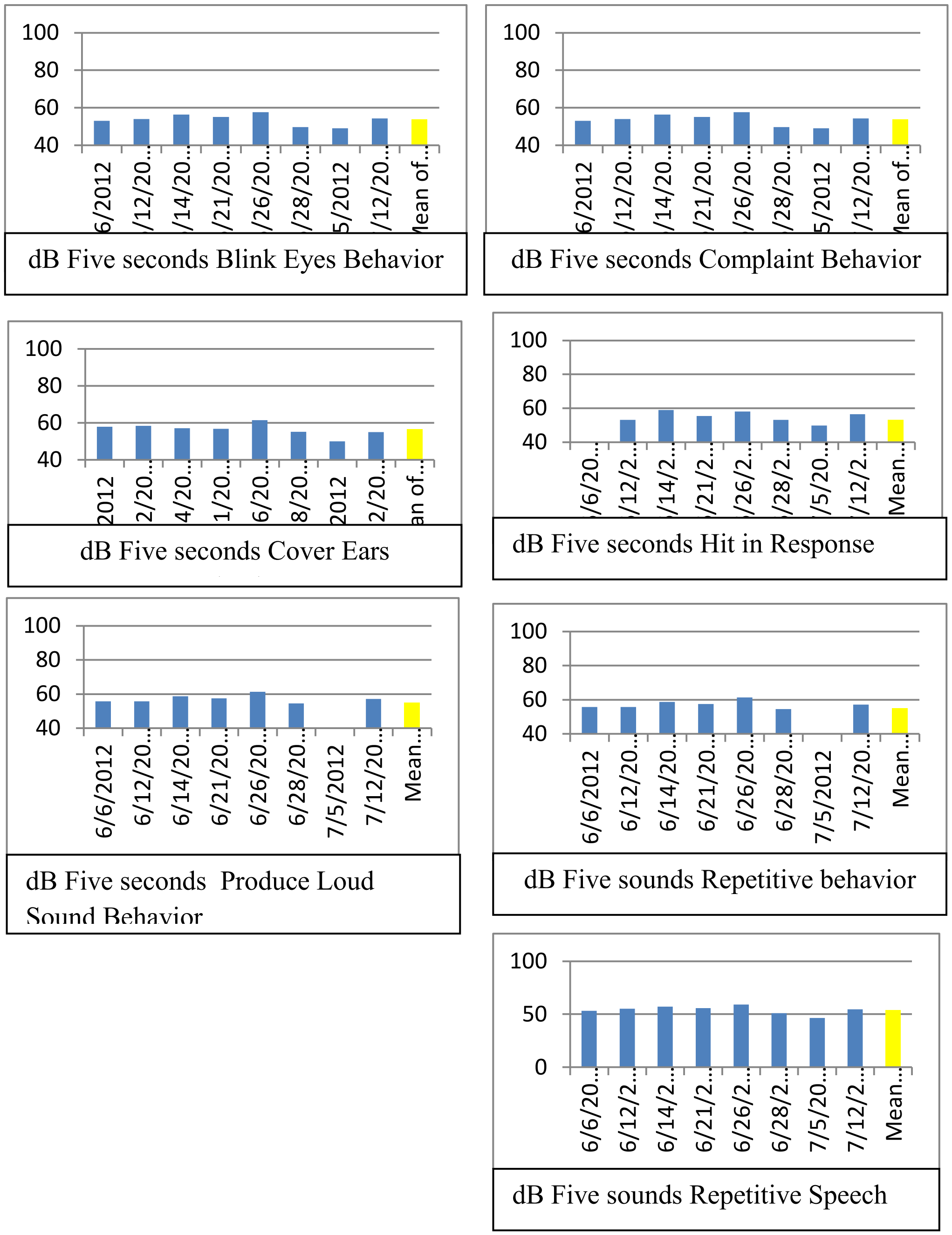

Figure 3.45 Summary of the Mean dB Values 5seconds before any Behavior was recorded in the School II Classroom II (Quiet Classroom)

3.2.2.2.5 Behavioral Analysis for the Four Classrooms

In this section, I describe the results in terms of the frequency of the seven behaviors in the four classrooms.

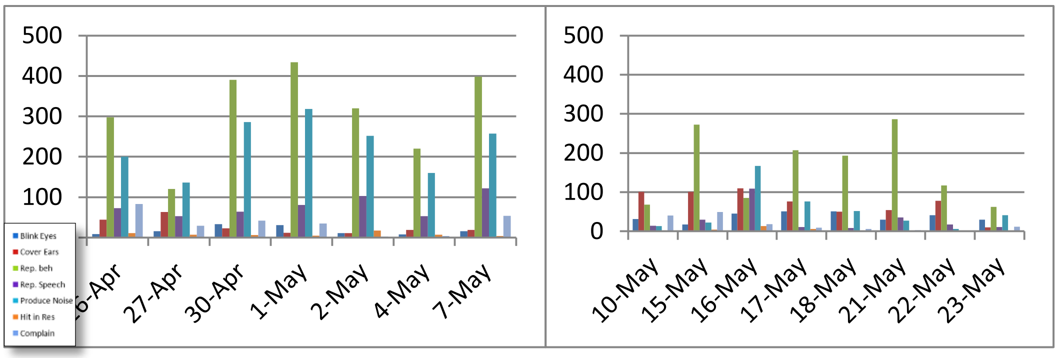

Figure 3.46 Frequency of the Behaviors in School I Class I (Noisy) vs Classroom II (Quiet)

Figure 3.47 presents the frequency (counts) observed in two different classrooms in the School I. Repetitive behavior (echolalia)s occurred with the highest frequency in both classrooms regardless of whether the classrooms were noisy or quiet. Produce loud sounds followed in frequency in both classrooms (see Figure 3.47).

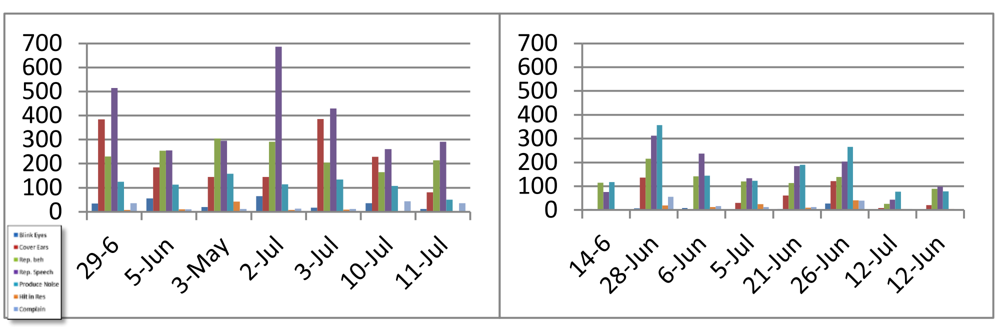

Figure 3.47 Frequency of Behaviors in School II Classroom I (Noisy) vs Classroom II (Quiet)

Figure 3.48 presents the frequency (counts) of the observed behaviors in the two different classrooms in the School II. In Classroom 1, repetitive behavior (echolalia) had the highest frequency numbers, followed by cover ears, and produce sound. The remaining behaviors varied minimally in differences in frequency level. In classroom II, produce sounds had the highest frequency numbers, followed by repetitive speech, repetitive behavior (echolalia), and cover ears (see Figure 3.48.)

Figure 3.49 compares each behavior separately in the four classrooms. Figure 3.42compares the frequency of the blink eyes behavior in the four classrooms together. The quiet classroom in School I scored the highest frequency counts. The noisy classroom in School II house had the second highest frequency counts.

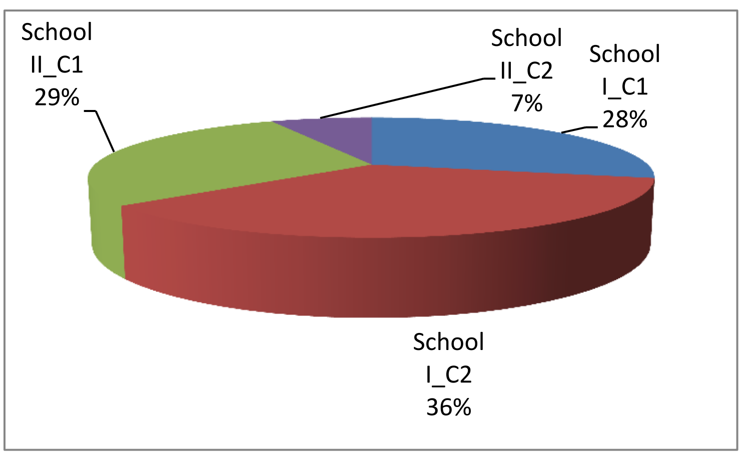

Figure 3.48 Frequency of Blink Eyes Behavior in the Four Classrooms

Figure 3.50 presents a comparison in the number of cover ears behaviors in the four classrooms. The highest counts were observed in the noisy classrooms in both schools. The lowest counts of cover ears behavior was observed in the quiet classrooms.

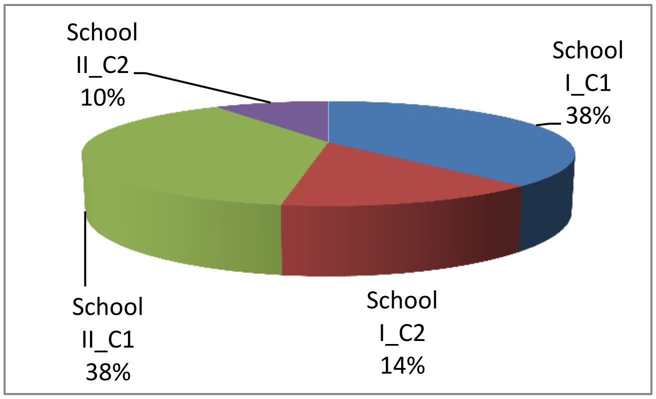

Figure 3.49 Frequency of the Cover Ears Behavior in the Four Classrooms

Figure 3.51 presents the number of the complaint behavior in the four classrooms. The two noisy classrooms had the highest counts of complaint behavior. The two quiet classrooms in both schools scored the same number of counts of complaint behavior.

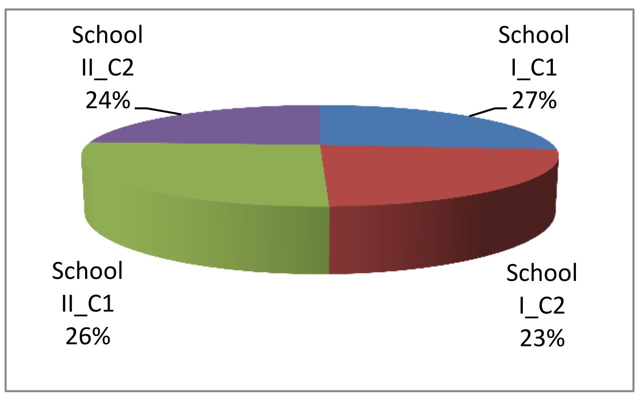

Figure 3.50 Frequency of Complaint Behavior in the Four Classrooms

Figure 3.52 presents the number of hitting behaviors in the four classrooms. Interestingly, the two noisy classrooms had higher counts for hitting behavior than the quiet classroom in both schools.

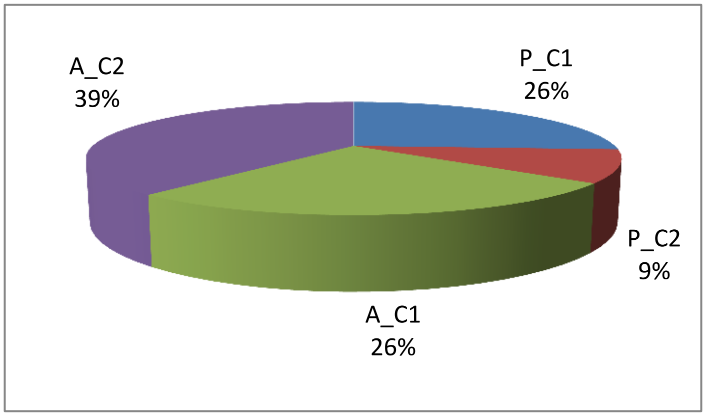

Figure 3.51 Frequency of Hitting Behavior in the Four Classrooms

Figure 3.53 presents comparison of the produce loud sounds behavior in the four classrooms. The noisy classroom in the School I scored high counts of produce loud sound, and very interestingly, the quite classroom in School II recorded a high counts.

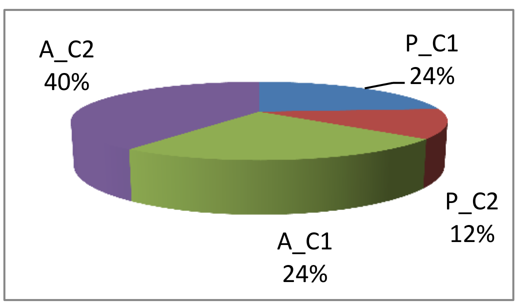

Figure 3.52 Frequency of Produce Sound Behavior in the Four Classrooms

Figure 3.54 presents a comparison of the repetitive behavior (echolalia) counts in the four classrooms. The two noisy classrooms recorded the highest counts of repetitive behavior (echolalia). The two quiet classrooms had a lower count of repetitive behavior (echolalia).

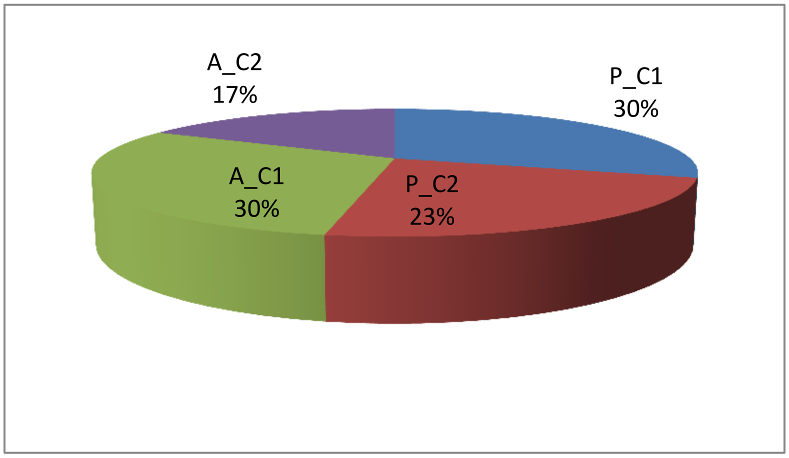

Figure 3.53 Frequency of Repetitive Behavior (Echolalia) in the Four Classrooms

Figure 3.55 presents a comparison of the repetitive speech behavior counts in the four classrooms. The two noisy classrooms demonstrated the highest counts of the repetitive speech behavior. The two quiet classrooms observed scored a lower counts of repetitive speech behavior.

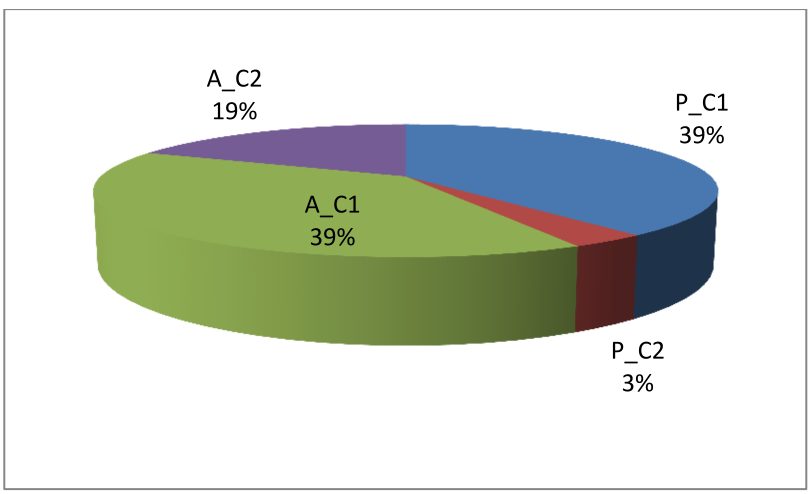

Figure 3.54 Frequency of the Repetitive Speech Behavior in the Four Classrooms

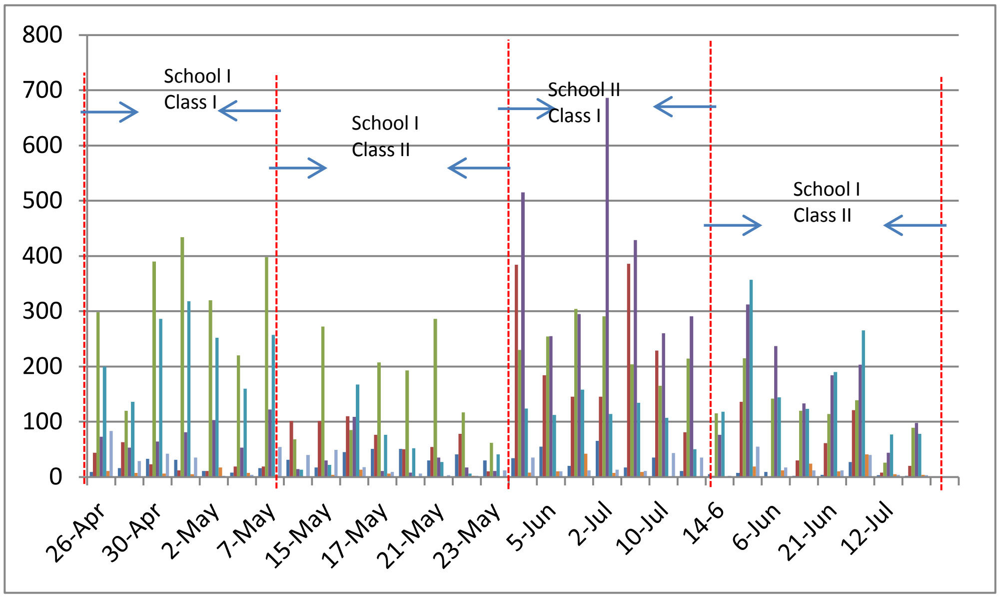

Figure 3.55 Frequency of All Behaviors in Schools I & II Classroom I (Noisy) vs Classroom II (Quiet)

3.2.3 Hypothesis Results

3.2.3.1 Hypothesis 1: There is a relationship between noise and the behavior of autistic children

To confirm the hypothesis, a dB base line was chosen to compare the results. Observer XT 11.5 was used to filter and nest the dB readings five seconds without any behavior inside the classrooms. The mean value was then taken for the four classrooms. For Classroom 1 the dB baseline was 41.0dB, for Classroom 2 it was 40.9dB, for Classroom 3 it was 40.8dB, and for Classroom 4 it was 40.8dB. The mean value for the sound baseline was (40.9dB). The maximum mean value was then taken for the four classrooms. For Classroom 1 the maximum dB was 93.0dB, for Classroom 2 it was 68.01dB, for Classroom 3 it was 88.01dB, and for Classroom 4 it was 62.05dB. The mean value for the maximum sound level was (77.76dB) (see Table 3.5).

Table 3.5 Maximum, Minimum and Mean dB Values of All Classrooms

	Maximum (dB)	**Minimum (dB)**
School I / Classroom I	93.00	40.00
School I / Classroom II	68.01	43.56
School II / Classroom I	88.01	42.56
School II / Classroom II	62.05	41.50
Mean Values (dB)	**77.76**	**41.905**

One-way analyses of variance (ANOVA) were performed to evaluate whether there was a significant relationship between the seven behaviors and the dB level. Comparing all the mean values of the dB level with each behavior, there were significant differences between the dB values and the behaviors, (*df=4, p=0.085)*. Among the behaviors there were significant differences in the degree and relationship between sound level and the frequency of the behaviors (see Figure 3.56).

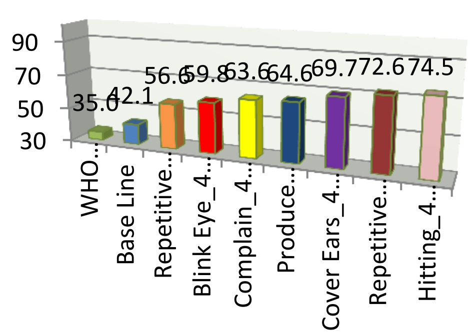

Figure 3.56 All Behaviors and the Associated dB Value in the Four Classrooms

Figure 3.56 confirms the correlation between the increase in the dB values and the increase in the seven behaviors which were observed. Hitting behavior was the only behavior which was observed if the sound dB reading was above 74.4dB. This behavior never happened if the dB values were less than 61dB. The other six behaviors were observed during different sound dB readings (see Figure 3.57).

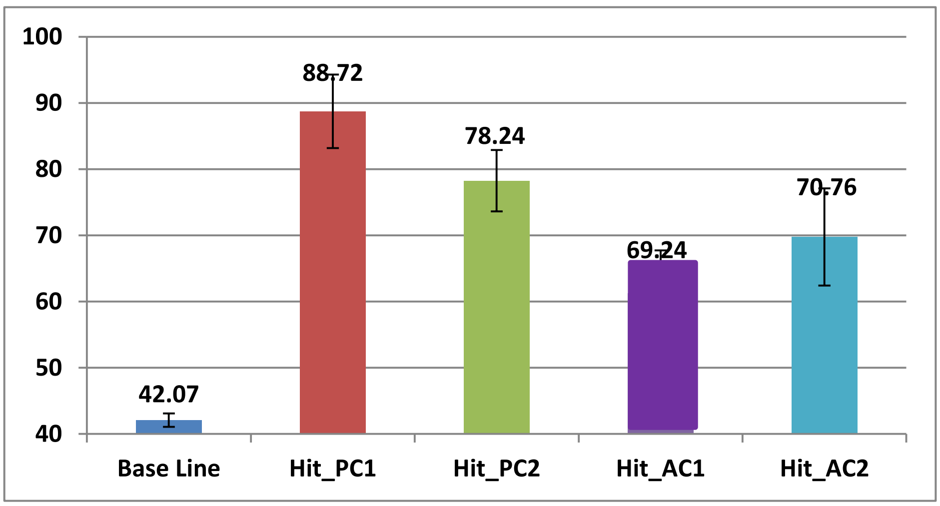

Figure 3.57 Hitting Behavior and the Associated dB Value in the Four Classrooms

3.2.3.2 Hypothesis 2: There is a correlation between destructive or inappropriate behaviors and noise levels

Pure frequency analysis for the behaviors in this study display a significant relationship between the seven observed behaviors and the change in the dB values. The results shown in previous chapter, demonstrate that there is a relationship between the number of inappropriate behaviors and increased noise level. Hitting, repetitive speech and covering ears have a correlation with the high level of noise.

A one-way ANOVA revealed that the noise level had a significant impact on the frequency of the behaviors, (*df=4, p=0.53)*. Interestingly, some behaviors did not show up until a specific noise level was recorded. For example, hitting, repetitive speech and covering ears occurred when the dB level was above 69.0dB. Therefore, it is not surprising that there is a relation between increase the noise level and increase in the frequency of the destructive and inappropriate behaviors. See Figure 3.58 for more details.

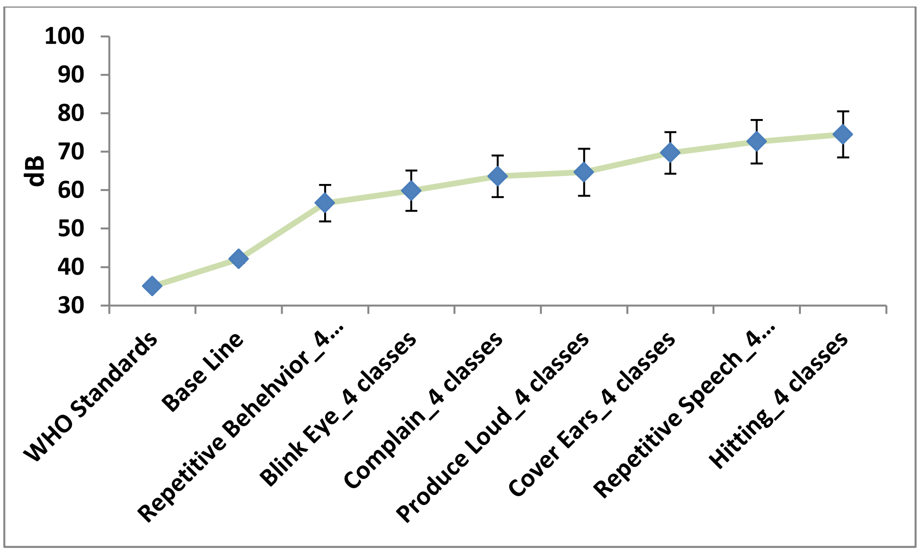

Figure 3.58 Frequencies of the Behaviors with the dB Mean Values

CHAPTER IV

DISCUSSION

While ambient noise is omnipresent, our understanding of its impact on human behaviors, particularly on children with autism, remains limited. This chapter summarizes the results of this study and discusses the relationship between the noise level and the behavior of children with autism.

4.1 OVERVIEW

In this research study, through a series of analyses, the researcher demonstrated how and why ambient noise affects children with autism. The following literature indicates that it is well known that low and high frequency noise can produce unpleasant subjective effects in some people, including such effects as nausea and feelings of panic or euphoria (Wigram, 1999). People with autism are particularly vulnerable to such negative effects, and the more clearly the autistic children understand auditory information, the better they are able to response to their environment, and have improved academic performance and in social relationships (Autism Research Institute, 2013).

The study findings suggest that high to moderate levels of ambient noise may over stimulate those children, which leads to inappropriate behaviors. This is consistent with study results of Edelson from the Autism Research Institute (2013); the better we understand autism, the better we can develop ways to intervene in an effective manner.

In Phase 1, a comparison of the results of the teachers" responses in the three schools was done. The results show that the teachers in all three schools agreed that there is a relationship between noise and the inappropriate behaviors in different percentages. This shows cross-environmental validity of the results. Teachers in the three schools felt that the noise was considered to have a negative impact on the behavior of children with autism, and they agreed to implement solutions to prevent inappropriate noise, (see Figure 4.1). This is encouraging, but, unfortunately, many of the schools designed for children with autism are designed by architects who may not be aware of the needs of these children.

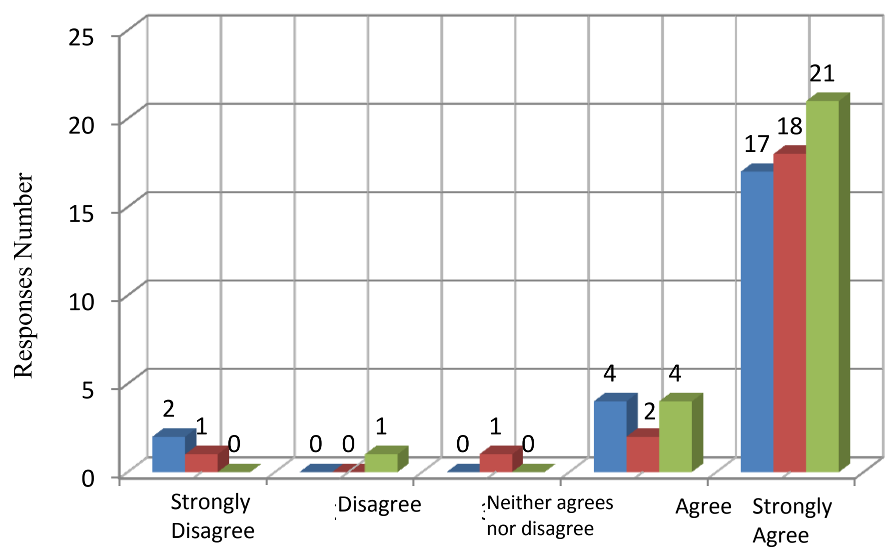

Figure 4.1 Number of Teachers in the Three Schools who Strongly Agree that Loud Sounds Affect Children with Autism

The teachers themselves added some modifications to their classrooms to decrease the noise level. For example, in the School II, one of the teachers requested that the furniture in her classroom be modified with a material would not produce noise if the children moved the chairs or the tables.

In Phase II, the study included two schools. Each school consisted of two classrooms, for a total of four classrooms. Two of those classrooms were considered noisy because the mean dB values were between 73db and 78db. The other two classrooms were considered quiet classrooms because the mean dB values were between 68.01dB and 62.05dB. This comparison depended on a dB baseline value for each classroom; this value was between 41dB to 42dB. By refereeing to figures from previous sections, a strong correlation can be seen between the increase in the noise level and the increase in the inappropriate behaviors. However, each of these behaviors correlated at different percentages relative to the increase in noise level.

One of the most frequent behaviors was repetitive speech, which correlated with increased noise level. Most of the time this behavior occurred when the dB level was 72.6dB. Hitting behavior occurred infrequently, but was most likely to occur when the dB level above 74.4dB. The third most frequent behavior was covering ears and was most likely to occur when the dB level was above 69.68dB.

This is consistent with study results of multiple researchers (e.g., Ando & Nakane, 1975; Crook & Langdon, 1974; Dixon, 1976; Green, Pasternak, & Shore, 1982; Ko, 1979; Koszarny, 1978; Lehman & Gratiot, 1983; Sargent, Gidman, Humphreys, & Utley, 1980) who agree that background noise can compromise the academic performance, reading and spelling skills, concentration, attention, and behavior in typical children. Also, Koszarny (1978) reported that noise levels tend to affect concentration and attention more seriously in children with lower IQs or high anxiety levels. Green et al. (1982) reported that background noise levels in classrooms were significantly related to reading scores in elementary school-age children. Specifically, the higher the background noise level of the classroom, the poorer the reading scores exhibited by students in that classroom.

4.1.1 Sound and Behaviors

Noise could affect the behavior of children with autism. This effect can be reflected in the frequency counts of each behavior and on the children performance.

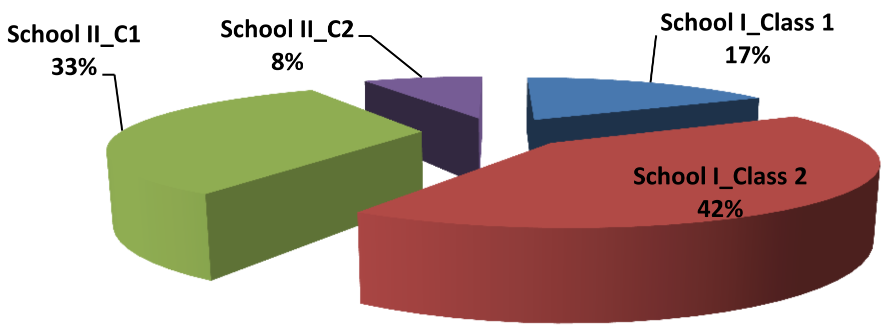

Figure 4.2 Frequency of Blinking Eyes Behavior in the Four Classrooms

The results shown in Figure 4.2 present the frequency of the blink eyes behavior in all four classrooms. The quiet classroom in the School I scored the highest frequency. The noisy Classroom in School II House was second. For the high percentage of blinking eyes behavior appeared in the quite classroom, that mean other factors may be play a role on the appearance of this behavior. Those factors could be; they type of the children, other environmental factors like lighting in the classroom. More research needs to be done in this area.

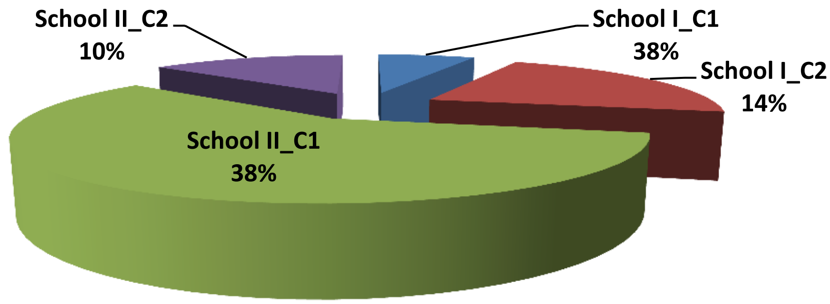

Figure 4.3 Frequency of the Cover Ears Behavior in the Four Classrooms

Figure 4.3 presents a comparison of the frequency of covering ears behavior in the four classrooms. The highest frequency counts were observed in the noisy classrooms in both schools. A low frequency of covering ears behavior was observed in the quiet classrooms. Covering ears behavior correlates with the sound level in the four classrooms. This gives strong evidence that covering ears behavior effect with noise change during the day.

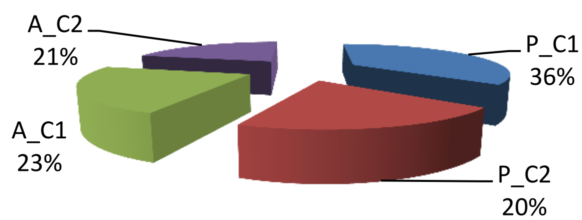

Figure 4.4 Frequency of the Complaint Behavior in the Four Classrooms

Figure 4.4 presents the frequency of the complaint behavior in the four classrooms. The two noisy classrooms were observed to have the highest frequency counts of complaint behavior, while the two quiet classrooms in both schools scored the same, lower, frequency counts of complaint behavior. This gives strong evidence that complaint behavior is impacted by noise change during the day.

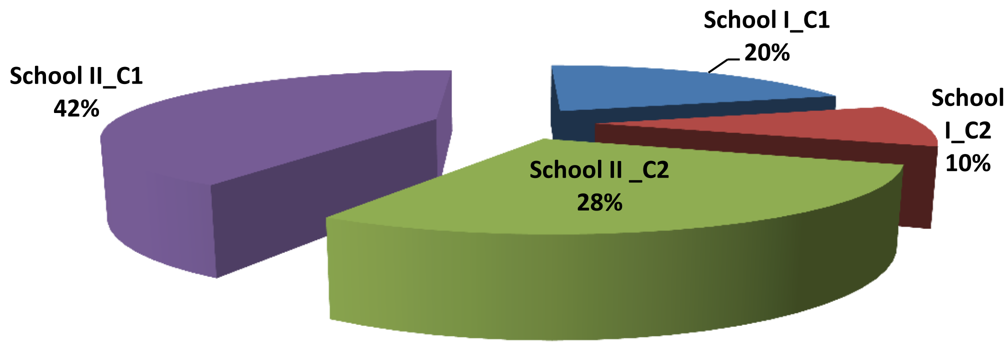

Figure 4.5 Frequency of the Hitting in Response Behavior in the Four Classrooms

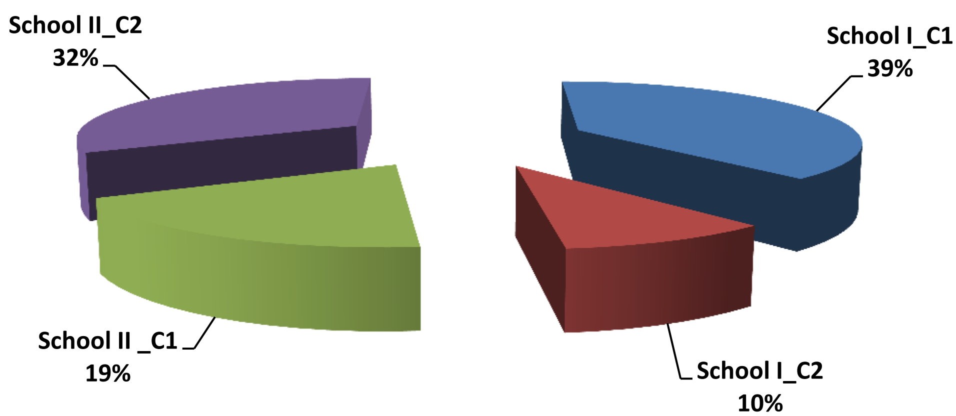

Figure 4.6 Frequency of the Produce Sound Behavior in the Four Classrooms

Figure 4.5 illustrates the frequency of hitting in response in the four classrooms. The two noisy classrooms were observed to have the highest frequency counts of hitting behavior. Interestingly, the two quiet classrooms in both schools scored the same, lower, frequency counts of hitting behavior. This gives strong evidence that hitting behavior is influenced by noise change during the day.

Figure 4.6 illustrates the frequency comparison of the produce loud sounds behavior in the four classrooms. The quiet classroom in School II scored the highest frequency counts of produce loud sound; the two noisy classrooms in the two different schools were observed to have the same frequency counts. For the high percentage of produce sound behavior appeared in the quite classroom, that means other factors may be play a role on the appearance of this behavior. Those factors could be psychological factors such as; the type of the children, the differences in the degree of autism functioning, the way that those children in that classroom cope with over-stimulation. Environmental factors could be: lighting in the classroom, heating and the temperature of the classroom, smells of some type of food or other things inside the classroom, and the quality of the fresh air in the classroom. More research needs to be done in this area. Other factors such as, having another teacher every few days, changing the daily schedule every few days and having many visitors on a particular day may be impactful and needs to be addressed in future research. These results are consistent with Militerni, Bravaccio, Falco, Fico and Palerm (2002) who stated “in general, the amount of environmental stimulation was not necessarily correlated with any behavior of children with autism”. (p.45)

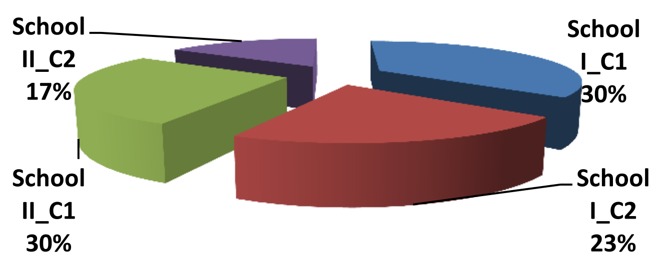

Figure 4.7 Frequency of the Repetitive Behavior (echolalia) in the Four Classrooms

Figure 4.7 illustrates a comparison of the repetitive behavior (echolalia) frequency in the four classrooms. The two noisy classrooms were observed to have the highest frequency of repetitive behavior (echolalia). The two quiet classrooms observed had a lower frequency of repetitive behavior (echolalia). This gives strong evidence that repetitive behavior (echolalia) is impacted by noise change during the day.

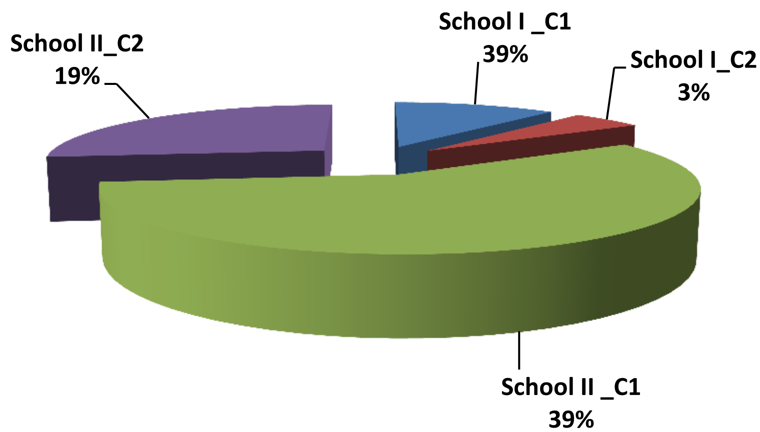

Figure 4.8 Frequency of the Repetitive Speech Behavior in the Four Classrooms

Figure 4.8 illustrates the comparison of the repetitive speech behavior frequency in the four classrooms. The two noisy classrooms were observed to have the highest frequency of repetitive speech behavior. The two quiet classrooms had a lower frequency count of repetitive speech behavior. This suggests that repetitive speech behavior may be impacted by noise change during the day.

4.1.2 Classroom and Home Design

An important part of school design is the classroom environment, and one of the most important features in any educational environment is quietness in the classroom. To reach this goal schools typically teach the students to be well-behaved so that the classroom environment will be healthy for academic and behavioral learning. Lehman and Gratiot (1983) reported that reductions in classroom noise (via acoustical modification) had a significant effect on increasing concentration, attention, and participatory behavior in typical children. Interestingly, noise levels were reduced from typically reported noise levels of 35–45dB (A) to the suggested guideline of 30dB(A), (Lehman and Gratiot,1983).

From the previous figures and discussion of our study, we note that the majority of the inappropriate behaviors occurred with high percentages in the noisy classrooms (Classroom 1(C1)) in both schools. From this study, we can conclude that the side effects of the noisy classroom environment on the children with autism can prompt these children to do inappropriate behaviors and have low academic performance. These results should give designers the impetus to focus more on the acoustical design inside the classrooms (see Figure 4.9).

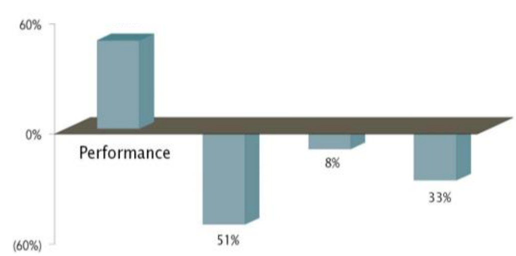

Figure 4.9 Improvements Resulting from Decrease in Noise Level

One of the most interesting results is related to the layout of the classrooms and the furniture arrangement. Among the four subject classrooms only one classroom was not designed with an open furniture layout plan (School II Classroom II). Rather, it was designed with a structured furniture layout. The noise level recorded in that classroom was the lowest and the inappropriate behaviors occurred less frequently there than in the other classrooms. Literature shows that most families who have an autistic child will realize quickly that the best is to simply homeschool there child. There are so many reasons why parents prefer do this, one of these reasons is minimizing distractions and control noise level will be easier in the home environment (Crandell et al, 1995; Sapienza, Crandell & Curtis, 1999).

Many autistic children are affected of distractions in the environment and noise impacts them strongly (Caldwell, 2006). In a typical school classrooms there are many environmental distractions and a large classroom is has a high level of noise. Autistic children do not tolerate with this environment well, and have difficult achieving their maximum ability. However, if the autistic child is homeschooled the parents will be able to control the noise level and make the environment quiet; they will minimize distractions, and help their child succeed at their abilities and improve their skills (Nabelek & Nabelek, 1994).

There are no statistics showing the number of families who homeschool their children with autism. Obviously, these learning environments are important for children and more research is needed on these environments.

4.1.3 Theoretical Contributions

In summary, findings from this research make several theoretical contributions. First, they contribute to the noise literature by providing valuable insights into the noise-autism relationship. No previous research has reported conclusive findings with respect to the effect of noise on the behavior of children with autism. By studying the noise level that is commonly present in the classrooms for children with autism, this research suggests that a high to moderate level of noise impairs encourages inappropriate behaviors. We might also conclude that a rather low level of noise enhances positive behaviors, which is likely a result of the decrease in overstimulation of the surrounding environment on those children.

As discussed above, a clear understanding of how noise affects the behavior of children with autism is lacking in the extant literature. Different scholars hypothesize about the various mechanisms to deal with over-stimulation in children with autism (e.g. arousal, coping, stress), but do not provide rigorous empirical evidence (Khare & Mullick, 2009). This research covers the effects of high noise levels on the behaviors in children with autism using empirical evidence. The results show that increasing noise levels leads to a higher discomfort level, overstimulation and inappropriate behaviors. That is, both moderate and high noise levels lead to more negative behaviors as compared to low noise levels.

4.2 RELATIONSHIP TO PREVIOUS STUDIES

This purpose of this study was to determine if there was a relationship between noise and the behavior in children with autism. From the results of this study, a correlation was found between noise and inappropriate behaviors in children with autism. Temple Grandin (1998) stated

> An autistic child will cover his ears because certain sounds hurt, almost like an excessive startle reaction, in the same way as a sudden noise (even a relatively faint one) will often make my heart race. (p.81)

Noise plays an important role in the feelings and comfort of children with autism. Other researchers have noted the importance of noise in the general population. Nelson and Soli (2000), found that less than acoustically optimal conditions in the classroom affect the academic performance and effort of all students, but they leave a particular difficulties for students learning in a non-native language, coping with learning disabilities, or having hearing problems. Nixon in (2002) discussed that such students suffer socially and behaviorally as well as academically. How big is the problem? Experts believe that as many as one-third of all students miss up to 33 percent of the verbal communication that happen during their day in the classroom.

Hearing tests indicated that hearing was normal for all of the students in this study. “Many autistics have problems with modulating sensory input; they can't modulate incoming auditory stimulation” (Ornitz, 1985, p.55). They either overreact or under-react. Ornitz (1985) suggests that some cognitive problems could be caused by distorted sensory input. Autistics also have profound abnormalities in the neurological mechanisms that control the ability to control their attention between different distractions in their environments (Courchesne, 1989).

From these few studies, it is clear the relation between the surrounding environment and the common occurrence of overstimulation that the autistic child will have during the daily life activities is a serious issue. According to Rebecca Landa, director of the Center for Autism & Related Disorders at Kennedy Krieger Institute in Baltimore (2012) stated that

> There's a growing body of information that young children with autism are not paying attention to or extracting information from social sequences in the same way as typical kids. However, she also stated that "environments that break down such information into smaller bits, as well as making sure kids with autism are repeatedly exposed to such situations, may help them start to comprehend the emotional aspects of social interactions." By reducing the sounds in the classroom to a more coherent environmental experience, we may be actually reducing the "bits" of information experienced. (p.67)

4.2.1 Blinking Behavior

Different behaviors are connected to an increase or decrease in noise level. One of the behaviors is the blinking eyes. One of the few studies regarding blinking eyes has been done by Warren Jones, director of research at the Marcus Autism Center and an assistant professor in the department of pediatrics at Emory University School of Medicine in Atlanta. In the study, researchers had 93 typically developing children and children with an autism spectrum disorder, all aged two, watch short videos of two children in a wagon who get into an argument over whether the wagon door should be open or shut. Using eye-tracking technology, the researchers tracked when and how often the kids blinked (Jones, 2011).

Researchers found that both children with autism and typically developing kids blinked less during the video. However, typical kids blinked less during the emotional exchange between the kids, while the autistic kids blinked less when there were moving parts, such as the wagon door being slammed (Jones, 2011). Rebecca Landa, director of the Center for Autism & Related Disorders at Kennedy Krieger Institute in Baltimore (2012), said the blinking eyes study uses a "*novel*" technique to examine how kids with autism process information and respond to things they see.

> The more evidence that we have about the nature of the information that children with autism are either delayed in deciphering in this case, through visual pathways or that they have certain preferences or biases for, the more informed we can be in the development of interventions. That‟s why this is important. We try to take ever more precise steps into understanding what children with autism understand and how they extract information from the world around them. (p.87)

Geraldine Dawson (2012), chief science officer for Autism Speaks, said “ it's well established that unlike typical kids, young children with autism pay more attention to objects than people, however, this is the first study to my knowledge that has used blinking to assess how engaged a child is with what he or she is viewing.” (p.12)

Our research study shows that blinking behavior has been observed frequently in the quiet Classroom II in School I. The mean dB level in this classroom was 56.0dB. Depending on Marcus Autism Center study findings - typical kids blinked less during the emotional exchange between the kids, while the autistic kids blinked less when there were different events- we will assume there was many emotional exchanges between the children in the School I Classroom II and there is less different events in the same classroom. For example from my observation this classroom was quiet and there wasn"t too much moving for the furniture.

Comparing the results of Marcus Autism Center with our research study, noise could be one of the factors that impacts blinking behavior. Also, we can conclude that there might be other factors impacting engagement of the child on what he or she is watching like the number of objects around, number of people, and number of distractions in the environment. Lighting and noise could be distractions which factor increase the blinking eyes behavior.

4.2.2 Repetitive Behavior (Echolalia)

Autism is associated with a wide range of repetitive behavior (echolalia"s). These behaviors, although diagnostic for the disorder, have been the subject of far less attention than social and communication deficits (Lewis & Bodfish, 1998). Although repetitive behavior (echolalia) is a core diagnostic domain for autism spectrum disorder, research in this area has been neglected (South, Ozonoff & McMachon, 2005).

The type, frequency, and intensity of repetitive behavior (echolalia) in individual children with ASDs vary widely but often persist over time. In addition, repetitive behavior (echolalia) is the strongest predictor that an early ASD diagnosis will endure (Richler, Bishop, Kleinke and Lord, 2007).

Retuning back to our findings in this study, repetitive behavior (echolalia) correlates with the noise level. On the same time, in noisy classrooms high frequency level of repetitive behavior (echolalia) has been counted. These findings consistent with the Militerni et al., (2002) study, in which they studied the relationship between repetitive behavior (echolalia) and behavior reactivity to environmental stimuli, in a group of 121 consecutive autistic children, aged 2-4 and 7-11 years. Results demonstrated that younger autistic children displayed more motor and sensory repetitive behavior (echolalia)s in noisy environments. One of the results was repetitive behavior (echolalia) possibly associated with situation avoidance or attention seeking.

Another interesting result from our study was once any interrupt have been done for any repetitive behavior (echolalia) during the school day, we will see a hitting or complaining behaviors will expect to happen. These results of our study are consistent with Dougle and Price (1995) results study; repetitive behavior (echolalia) may involve stereotypical movements, inflexible routines, repetitive play, and perspective speech, often interfering with many facets of life. Anxiety, protest, aggression, and self-injury may occur when these behaviors are interrupted.

4.2.3 Repetitive Speech

Children with autism could present two types of repetitive speech behavior; repetitions of what the child says him/herself (self-repeats) and of what is uttered by an interlocutor (echolalia) (Richardson, 2010).

Our study indicates that there is a correlation between the sound level and the repetitive speech behavior in all the classrooms in this study. There is a gap in the literature and the rigorous research studying the effect of the environment and the repetitive speech behavior on the children with autism.

4.2.4 Cover Ears

One of the most well recorded challenges for people with autism spectrum disorders (ASDs) is hypersensitivity to sound (Stiegler & Davis, 2010). Adults with ASDs have noted that sounds affected them as children. Individuals with ASDs have been observed to cover their ears and run or hide from situations that might include inappropriate sounds (Stiegler & Davis, 2010).

In our study, covering ears behavior was one of the most frequent behaviors that were observed. All the classrooms with high level of sound presented high counts of covering ears behavior. Teachers and school-based speech-language pathologists also make special adaptations for children with ASDs who cannot tolerate the noise of the gym, cafeteria, class parties, or playground. Many movie theaters offer special, quieter showings for children with autism and their families. Hypersensitivity to sound is one of the most permanent symptoms of autism (Stiegler & Davis, 2010).

Tang, Kennedy, Koppekin and Caruso (2002) they studied the social or nonsocial stimuli that maintained ear covering. The results showed no unusual sensitivity to auditory stimuli presented at 60dB or under, but frequent ear covering occurred when the noise level was above 80dB (Tang, Kennedy, Koppekin & Caruso, 2002). These results match our study results regarding the covering ears behavior. Our results indicate that no ear covering was observed at levels less than 58dB, but most of the covering ears behavior happens once the sound level is above 68dB. In aother study, Tharpe et al. (2006) found no evidence that children with ASDs have more sensitive hearing than typical peers, although in the majority of cases, parents reported that their child experienced pain or distress when exposed to certain sounds. In addition, clinical reports of children with autism show that many people with ASDs show a strong avoidance reactions to sounds that are neither high-pitched nor extraordinarily loud (e.g., the ticking of a ceiling-fan chain against a glass light fixture or someone saying a non-preferred word).

Retuning to our findings, cover ears correlates with the noise level most of the time. But, sometimes students didn"t show any negative reaction to undesired sounds. These results also have been shown by Jackson and King (1982), in which they noted that people with ASDs sometimes do not have a negative reaction when they hear the undesired sounds outside of the normal context (e.g., an audiotape of a toilet flushing played in a clinical setting). This result needs to be studied more deeply to find the explanation for this phenomenon.

4.2.5 Impact of Noise on Communication

Communication is the use of nonverbal (eye gaze, facial expression, body posture, gestures) and verbal (speech or spoken language) behavior to share ideas, exchange information, and regulate interactions (Autism Speak, 2007, p.01).

Speech produced in one place in a room should be clear and intelligible everywhere in the room (Nabelek & Nabelek, 1985). Depending on this simple statement, as researchers, designers and educators we should create classrooms with minimal acoustics barriers; a well-designed learning classroom should have low noise level and minimal reflections. Our effort should focus on providing an appropriate education in excessively noisy and reverberant rooms, a good acoustics room design with no acoustics barriers will cover the needs of the teachers and the students in their learning environment as a user‟s of the classrooms. To this end, the American National Standards Institute (ANSI) has approved a standard for maximum levels of classroom noise and reverberation (ANSI S12.60-2002. Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools) (Nelson,Soli & Seltz, 2002).

Adults have sentence thresholds of about -4dB signal- to-noise ratio, or SNR, and understand familiar sentences perfectly at 0dB SNR. Young children, children with hearing loss, children learning a second language, and children listening in reverberant rooms require a higher signal-to-noise ratio in order to understand the spoken message (Nabelek & Nabelek, 1985). From this evidence, we can see that it makes sense that children with autism who are over-stimulated will be affected by high noise levels. This research study was done in schools focused on teaching children with autism, and the results of the data show the strong side effects of the high sound levels. At the same time we can imagine that if the noise level is decreased, behaviors will be observed and student performance increased.

Other evidence of the effect of the high dB level of noise was studied by Mohr et al. (1979). The results of the Mohr study suggested that a high dB level will lead to serious problems in the human behavior (see Figure 4.10).

Tolerance data	
Exposure	**Observed behavior**
0 to 50 Hz Up to 145 dB	Chest wall vibration, gag sensations, respiratory rhythm changes, post-Exposure fatigue; voluntary tolerance Not exceeded
50 to 100Hz Up to 154 dB	Headache, choking,coughing,visual blurring and fatigue; voluntary Tolerance limit reached
Discrete	Tolerance limit symptoms
100Hz at 153 dB	Mild nausea, giddiness, sub-costal Discomfort, cutaneous flushing
60 Hz AT 154 dB 73 Hz at 150 dB	Coughing, severe sub sternal pressure choking respiration, salivation, pain On swallowing, giddiness

Figure 4.10 Relationship between Low Frequency Noise with a High dB Level on Human Behavior, source Moher et al (1988)

One neurobiology research study has shown that children with learning problems experience difficulty understanding speech sounds in noisy environments. Cunningham et al. (2001) measured brain responses to speech sounds that are often confused („da" and "ga"). The children with documented learning problems were no different from typical children in their discrimination "da" and "ga" in quiet settings. They were, however, poorer than other children in their discrimination of the sounds in noisy settings. These results support the general impression that background noise causes excessive difficulty for children who have learning disabilities and attention deficit disorder (Nelson, Soli & Seltz, 2002).

As (Nelson, Soli and Seltz, 2002, p.55) mentioned "schools are places of learning where speaking and listening are the primary communication modes. Until recently neither school planners nor were the general public aware of the significant negative effect of noise and excessive reverberation on learning process."

The positive effects of low noise levels are shown in the literature. Young children are ineffective listeners for speech in noisy environments until they reach the adolescence (Johnson, 2000). Also, young children do not effectively listen and understand speech in reverberant conditions in the classroom or any other environments (Johnson, 2000). A deep understanding of the ANSI S12.60 standards criteria indicates that communication will occur at a clear signal-to-noise ratio (SNR). One of these required standards is reducing the background noise to 35dB(A) in an unoccupied classroom. In this research study the researcher used this number 35dB(A) to compare it with the baseline that was measured in the four classrooms. From the comparison, the base line was higher, 5dB(A) to 7dB(A) more than the standard. This means that all the classrooms had a high level of background noise which affected the children behavior.

4.3 TRIANGULATION OF RESULTS: PHASE I AND II

Triangulation of the data refers to the use of more than one approach to the investigation of a research question in order to enhance confidence in the ensuing findings (Denzin,1977). This research study contained two main phases. Before running the two phases informal interviews were done with parents and teachers dealing with children with autism. (See Figure 4.11).

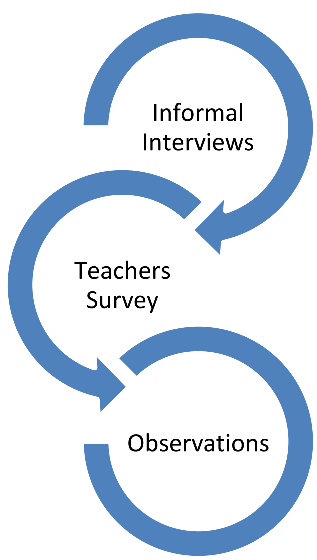

Figure 4.11 Shows the Relationship between the Informal Interviews, the Survey & the Observations

Table 4.1 Comparing the Findings during the Three Stages

		Step 1: Informal Interviews with Parents, teachers & Temple Grandian	Step 2: Teachers Survey	Step 3: Behavioral Observation
Noise Sources	➢ Outside the Classroom Noises; Traffic, other classroom sounds	✓	✓	✓
	➢ Inside the Classroom Noises; HVAC, Students Voices & Moving Chairs & Tables	✓	✓	✓
Types of Behavior	• Hitting in Response	✓	✓	✓
	• Covering Ears	✓	✓	✓
	• Produce Loud Sounds	✓	✓	✓
	• Complain	✓	✓	✓
	• Repetitive behavior (echolalia)			✓
	• Repetitive Speech			✓
	• Blinking Eyes			✓
	• Other Behaviors	✓		
Relationship between Noise & Behaviors	➢ Yes	✓	✓	✓
	➢ No			

In phase I a comparison of the results of the teacher‟s responses in the three schools was done. The results showed that a majority of the teachers in all three schools agreed with different percentages that there is a relationship between sound level and inappropriate behaviors in children with autism. In phase II, the results presented the relationship between the noise and the behaviors of children with autism. The findings presented the degree of correlation between sound and noise. The most frequent behavior was the repetitive behavior (echolalia). This behavior was observed by teachers and parents as one of the most common behaviors connected with the noise.

By comparing the findings of this study during the three different stages, we can see the shared results among all three parts. This intersection between the results increases the validity of the results and the importance of the findings (see Table 4.1).

4.4 RECOMMENDATIONS

The impact of noise on children‟s health and development in schools is a major public health concern but is even more important for the health of children with autism. These children have sensory issues such as hypersensitivity to environmental features such as noise, textures, smells, lighting and taste. The increase in the number of children who are diagnosed with autism means that even more children are being negatively impacted by their environment. The impact could be greatly reduced if noise problems were taken into consideration as early as possible when a school is being designed. According to Sergeant and Dewsbury (2004) sounds commonly identified as causing stress to the hypersensitive are those associated with heating systems, domestics appliances, and ventilation fans.

From this study the HVAC equipment is one of the sources of noise in the classroom, but it is often the biggest source of noise. Schools commonly in this study choose HVAC systems that place equipment within one room shared with both classrooms, rather than opt for more expensive centralized systems. The researcher recommends that the schools use the central HVAC because it is more efficient and easier to acoustically isolate than the other HVAC systems.

Discussing these conditions and simplifying the sensory environment is critical and important. A specific level of stimulation will keep people involved and focused. A neutral sensory environment can be designed so that elements and features can be added to accommodate the sensory sensitivity of children in their schools (Ahrentzen & Steele, 2009).

Solutions include arranging classroom and non-classroom spaces to minimize the effect of occupancy, equipment, and environment related noise that originates beyond the walls of the classroom and specifying construction that provides ceilings, floors, and partitions (including doors and other openings) with suitable STC ratings, ANSI/ASA S12.60-2002.

It may be necessary to avoid the open-plan classroom layout. The more structured the layout, the more acoustical barriers will be created. Also, this structured layout will seriously upgrade the speech intelligibility and will result in a low level of the background noise that fits with the maximum limit set by ANSI/ASA S12.60-2002.

The American National Standards Institute has not put any specific acoustical design standards for children with autism. From this research study we can see the need for paying attention to the effect of noise on the children with autism. Designers, parents and schools should increase their insistence on greater attention to this issue.

CHAPTER V

CONCLUSIONS

In summary, the learning environment should support the brain of the learners. The learning environments that reduce the level of noise distraction and help children with autism focus on learning tasks, speech therapy and behavioral therapy will support the learning brain. A critical component of the learning environment is the acoustical design.

The results of this study include significant differences in the relationship between behaviors and the increase in the dB level. For example the hit in response didn‟t occur unless the dB value rose above 74.4dB. Repetitive speech behavior didn‟t occur until the dB level was above 69 dB. The rest of the other behaviors appeared once the dB value was 49dB and above. The correlation between the noise level (dB) and the inappropriate behaviors of children with autism indicated that the repetitive behavior (echolalia) frequency is considerably higher than the rest of the other behaviors. After that the produce sound, repetitive speech, covering ears, blink eyes, complain and hit, in this order, were observed.

The most important conclusion from this research study is that some of the most difficult to control noises have the largest impact. The noises that come from the children themselves, HVAC, other classrooms, teacher voices and the sound from lighting fixtures should be controlled (See Figure 5.1.) An excellent way of doing that is to create quieter classrooms using contemporary technology (advanced design practices, construction materials, and equipment).

The other important conclusion from this study is to decrease the inappropriate behaviors in children with autism by decreasing the noise level inside the classrooms.

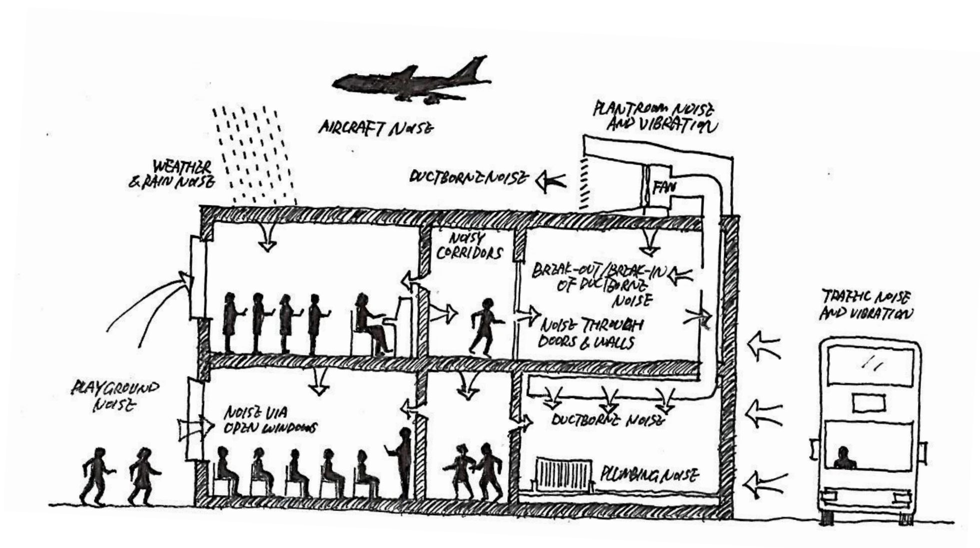

Figure 5.1 The Sources of the Noise in most Schools of this Research Study (Source; http://www.tandfebooks.com/doi/abs/10.4324/9780203879801)

5.1 LIMITATIONS OF THE STUDY

5.1.1 Research Type

This study is considered a quasi-experimental study. The researcher could not change the environment or choose specific subjects or put those subjects under specific noise situations. Further, the children were not randomly assigned to classrooms.

Refered to Shadish & Heinsman (1997), Quasi-experiments are studies that aim to evaluate interventions but that do not use randomization. Similar to randomized trials, quasi-experiments aim to demonstrate causality between an intervention and an outcome.

The research was limited to seven behaviors as point events for children with high function autism. The researcher was unable to record the behaviors as continuous events due to the complexity of the behaviors. Activities happened quickly and overlapped. The researcher would have preferred having more observers and recording the seven behaviors in the ten children in each classroom at the same time. That would have enabled the gathering of continuous rather than event point data.

5.1.2 Site Selection

Classrooms were different in more ways than acoustical control, which was another limitation of the study. The researcher couldn"t choose identical classrooms for the study because each school setting had different designs and layouts for their classrooms. Regarding the social environment, often the teacher would leave the classroom and be replaced by a different teacher. This may have impacted the children"s behavior.

When a student was absent during the observation day that mean the number of children who have been observed was decreased and this effected the frequency of the observed behaviors because no observation of behaviors was recorded for that absent student in that day. Another challenge was that the classroom daily activities were changed many times during the observation period.

5.1.3 Behaviors

The findings of this research only support the seven behaviors previously mentioned. The researcher believes further research is needed to examine whether in other contexts, such as with different types of noise, other behaviors might be related to the increase or decrease in the noise level.

5.1.4 Sample Size

The sample size of 20 was slightly smaller than the recommended size of 30 or more per group (Bollen,1989). To generate larger statistical power, to detect real differences among study groups, there needs to be a larger sample group to detect small differences, (Bollen, 1989).

5.2 PRACTICAL APPLICATIONS

The relationship between noise and behaviors of children with autism was tested in this study supporting the theory that a high level of noise will affect negatively the behavior of children with autism and make them over-stimulated in their classrooms. The inappropriate behaviors were fewer in the quiet classrooms. Designing quiet acoustically controlled classroom environments may have a high positive effect on the behaviors, comfort and performance of children with autism. Architects, school administration and acoustical consultants should work as a team and use different type of methods to create quieter environments for those children. The following recommendations and methods have been proposed to modify the environments that have been designed to support children with high functioning level of autism. As children with lower functioning level of autism would not benefit from a desk orientation that is not U-shaped or focused toward the teacher. Some of these methods are;

Acoustical Ceiling

- First the ceiling should have a high AC rating, the AC ("articulation class"). Rating is a measure of its performance in limiting the sound reflection off the ceiling plane over an angle of approximately 45 to 60 degrees (American Society of Interior Designers, 2005).
- Second, the ceiling should have a high NRC rating. Classroom interiors should provide surfaces that can absorb or reflect sounds. The NRC and sound absorption coefficients over the frequency range of speech are the most important rating (American Society of Interior Designers, 2005).

It is important to avoid both the use of large air diffusers and flat lens lighting fixtures that can become significant reflectors of conversational noise. A better alternative to these are liner air bars for supply air and recessed 18-or 24-cell 2-by-4 parabolic lighting fixtures (American Society of Interior Designers,2005) (See Figure 5.2)

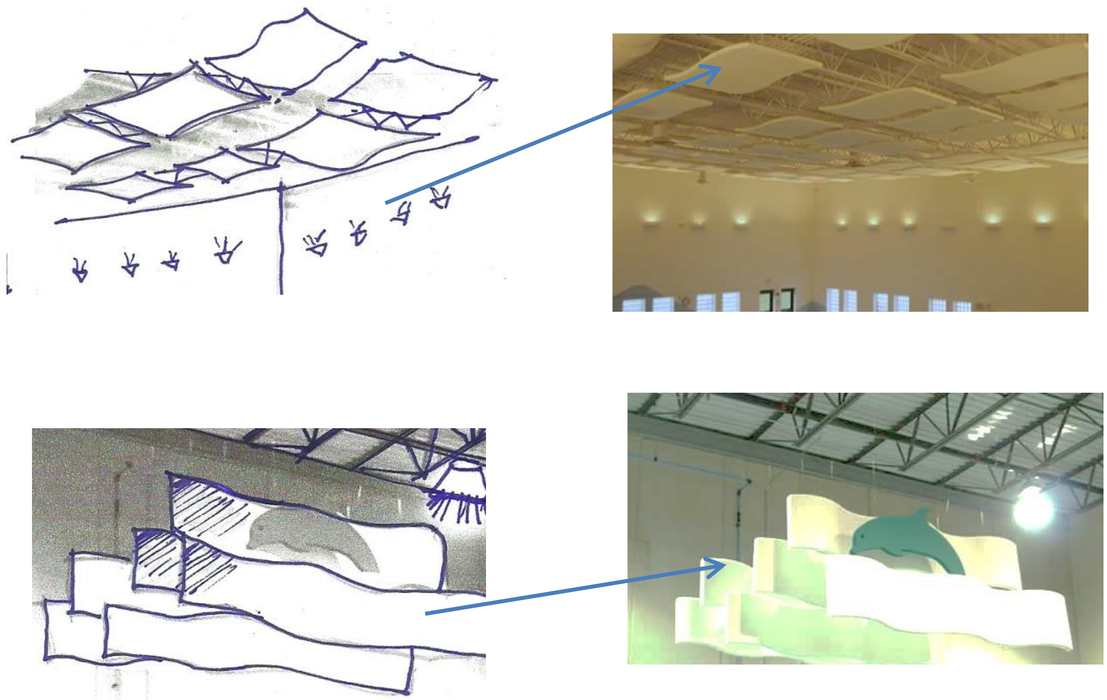

Figure 5.2 Ceiling Design with A high Absorbing Sound Materiel **(Source; http://www.tandfebooks.com/doi/abs/10.4324/9780203879801)**

Perhaps the most dramatic finding of observing behaviors of children with autism was the significant correlation between hitting behavior when the noise dB level above 69.0dB and between repetitive speech when the noise dB level above 69.5dB. Providing sound masking may help to absorb the sound vibration once the noise level above 69.0dB. Designers and acoustical consultants could use different techniques to create improved sound masking. The following are sound masking techniques;

- Sound masking

- Careful placement of absorptive and non-absorptive materials can direct the teacher's voice to students without inappropriate reflections (ANSI/ASA S12.60-2002).
- It is important that before the sound masking system can be used, the architectural system must have been designed “to provide the capability of achieving the desired level of noise.” (See Figure 5.3)

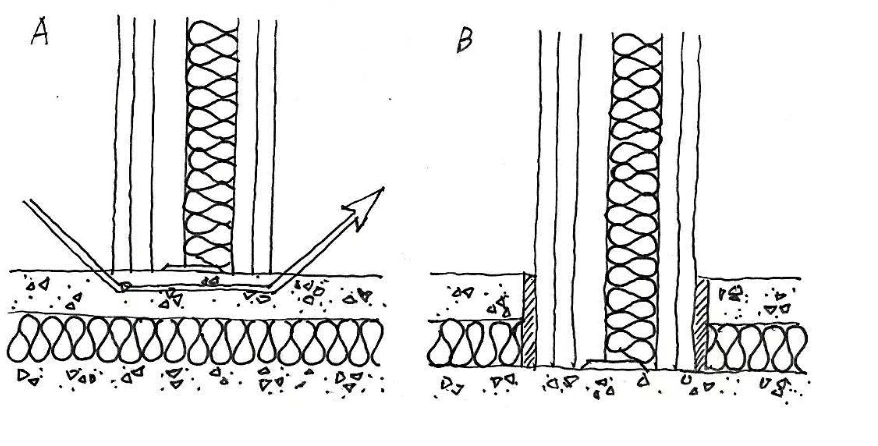

Figure 5.3 Flanking Transmissions Via Floating a) Incorrect Detail, b) Correct Detail
(Source; http://www.tandfebooks.com/doi/abs/10.4324/9780203879801)

- Employing a low-voltage electro-acoustic background sound system of proven quality that has qualified professionals to improve the acoustics of classrooms (Sykes, 2004).
- The materials that we use on the floors, walls and all the classroom features should absorb the sound energy, so the careful choice of the material as absorptive or non-absorptive can directly

affect the voice of the teacher without inappropriate reflections (Sykes, 2004).

The comparison of the properties and type of using the HVAC system in the four classrooms shows that the two classrooms which were connected to the HVAC room recorded a high level of dB and a high frequency of all observed behaviors. The disadvantage of the currently used HVAC is the increase in the noise level and inappropriate behaviors. Decreasing the inappropriate behaviors by selecting central HVAC system that allows for more acoustical isolation will likely decrease the noise level. The recent change in industry standards regarding HVAC is an advantage to using central HVAC in classrooms environment. The dramatic differences in decrease the noise level values show central HVAC to have the advantage over the other HVAC that currently used in the classroom.

The flooring material specified in classrooms for children with autism should enhance the acoustical environmental quality. One of the findings in this study presents that the frequency of the observed behaviors was higher in the two classrooms at the School II, which didn‟t have carpets or any floor covering. Providing carpets or floor covering in the classrooms of autistic children may have an effect on improve their behaviors and performance. When considering using carpets or floor covering different features should be discussed as in the following;

- Carpets

  Serves to absorb airborne sound, reduce surface-generated noise (often called "football noises") and help block sound transmission and reflection. It is recommended using carpet in the classroom areas. The new technology for manufacturing commercial carpet with integrated cushion allows for the greater use of cushion in the classroom environment, and it offers superior acoustical and ergonomic properties and benefits (Schmitz, Liu, Jaeger & Horne, 1997).

- Floor Covering

  Floor covering, like ceiling tile and systems furniture, is NRC rated- the higher the NRC rating, the greater the ability of the floor covering to absorb airborne noise.

- Sound Absorption in Corridors, Entrance Halls and Stairwells. The objective is to absorb sound in these areas so that it does not interrupt the teaching and the study activities inside the classrooms. The amount of additional sound absorption should be calculated (see Figure 5.4). We can use pin-boards and noticeboards with absorption coefficients suited to the area and the volume of the classroom. Just a note -- the absorption coefficients vary from one space to another because it depends on the area and volume of the studied room (Schmitz, Liu, Jaeger & Horne, 1997).

- Noise-canceling window sensor, is noise-cancelling tool that can convert a specific unpleasant background noise into a pleasant sound, such as calm music, (Roach, 2013).. The device sticks to the window because the glass surfaces will senses the noise vibrations .In this method the noise-cancelling window sensor generate a signals to cancel out the unpleasant background noises, (Roach, 2013).

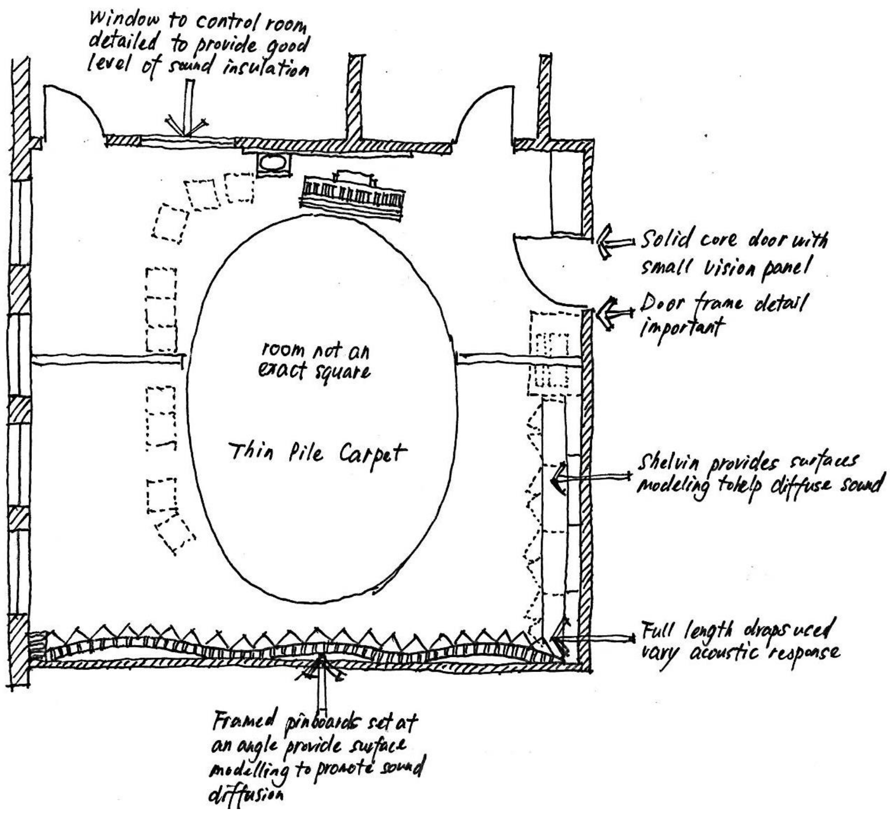

Figure 5.4 Flooring and Walls Material Recommended Reducing Noise

The differences in furniture material and shape effect the level of noise inside the classrooms. One of the classrooms has wood chairs and tables; however the other three classrooms have steel furniture. The wood furniture in the classroom made a lower level of noise on all the observation days and like resulted in fewer inappropriate behaviors. Providing wood furniture to reduce the noise is recommended. (See Figure 5.5 and Figure 5.6)

Figure 5.5 Wood Furniture Recommended to Reduce Noise, **(Source; http://www.tandfebooks.com/doi/abs/10.4324/9780203879801)**

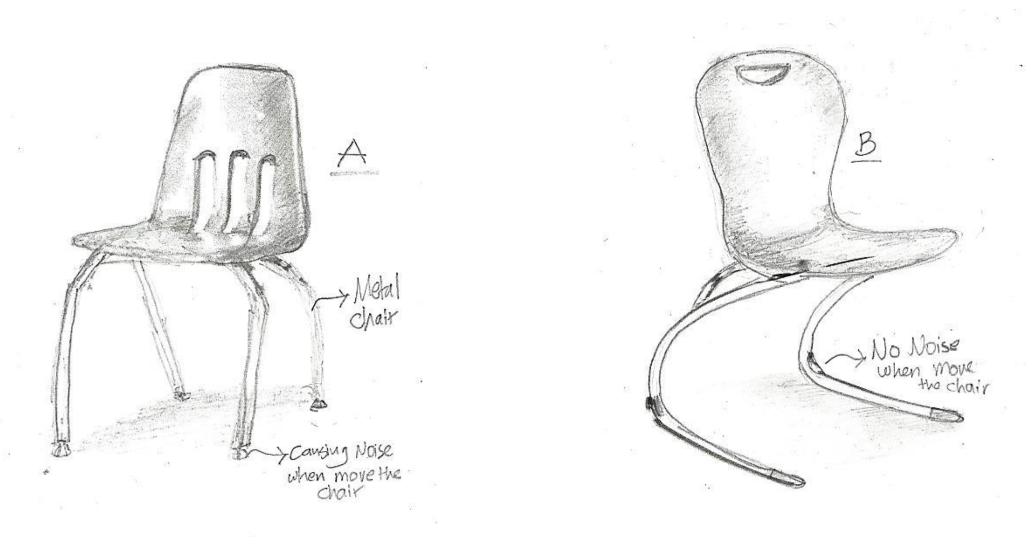

Figure 5.6 Chair **A** Not recommended but Chair **B** Recommended because it didn‟t Produce Noise

The differences on the furniture layout affect the behaviors of children with autism and affect the level of noise inside the classrooms. One of the classrooms has a structured furniture layout; however the other three classrooms have an open furniture layout. The structured furniture layout classroom has low level of noise on all the observation days and fewer inappropriate behaviors. Providing a maximum enclosure by orienting the furniture and use panels to divide the spaces and observe the noise is recommended. (See Figure 5.7 and Figure 5.8).

Figure 5.7 3D Layout Recommended Reducing Noise

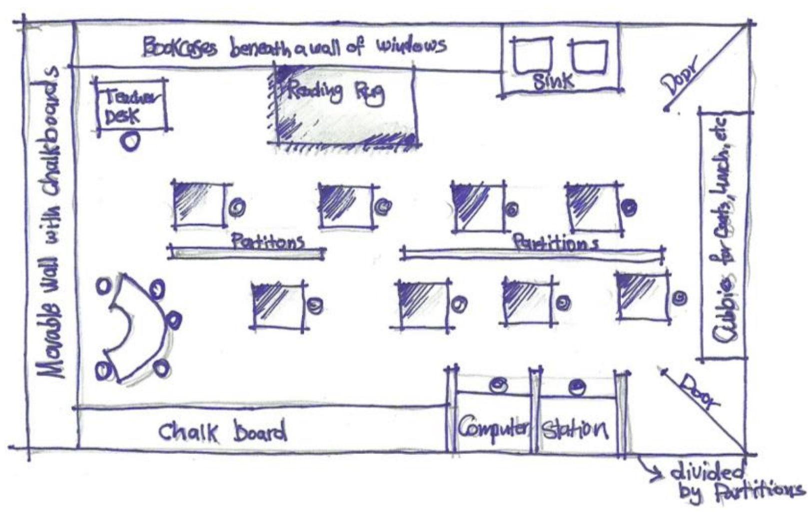

Figure 5.8 Layout Recommended Reducing Noise with Movable Partitions Allow Visual Access while Controlling Sound

5.3 FUTURE STUDIES

The researcher has studied the overall impact of loudness on the behavior of children with autism; future studies could elaborate on this research by studying the effects of every feature of noise, for example; sound frequency, pitch, musical tone, echo and reverberation, on the behavior of children with autism. The findings from this study could be further strengthened by doing environmental interventions to study the impact of different acoustical environments on the behavior and performance of children with autism. The economic implications of acoustical design could also be explored in future studies. Other environmental factors that impact children with autism such as light, art, colors and air quality should be studied.

This research study is expected to be of interest to a wide audience. This is because the study provides evidence based on an argument for universal acoustical implications for the environment of children with autism. Similar research processes may be adopted to explore the potential of acoustical design on and for children with other cognitive disabilities by identifying universally beneficial enabling acoustical features for them in their environments. This research could be also applied to other environmental design elements, such as lighting design, furniture design, or in other types of buildings, such as residential care buildings or rehabilitation centers.

While the findings of this study are intriguing, they offer avenues for future research. First, future research might investigate whether or not different types of noise will produce similar effects on the behavior of children with autism. For example, does the frequency of noise, in addition to its decibel level, affect the behaviors and performance of children with autism? The findings from this research study confirm that the increase in the noise level can affect the behaviors in children with autism negatively. However, what about more pleasant types of noise (e.g., serene music)? Will they affect the behaviors positively? And, if so, in what direction? It may possible that pleasant noise will actually increase the wanted behaviors.

Another avenue for future research would be to study the effects of the types of sounds in spaces which children with autism commonly use such as kitchens, bathrooms playground areas, parks, theaters, airports and restaurants.

Another research topic might be studying the open furniture layout plan versusthe a structured furniture layout and the effect on inappropriate behaviors I think this is an amazing result and should be the subject of one of the future research studies in this area.

Another interesting finding from the second phase of this research study is that covering ears is one of the main effects of high noise but was present only among, gifted autistic children. Although these results align with prior findings (Grandin 1981), they merit further attention.

Lastly, future research might examine the seven behaviors individually with more children with autism. For example, studying blinking eyes in different environments with a larger sample size of children might provide additional insights.

5.4 CLOSING STATEMENT

Ultimately, although it is impossible to predict when, or even if, a specific classroom‟s sound requirements will be mandated for schools of children with autism, the researcher would like to say that this body of research confirms that the link between learning and the acoustical character of classrooms is extensive.

However, there is still a gap in the body of knowledge between acoustics and the behavior and performance of children with autism. As the numbers of children diagnosed with autism increases the, interest in the importance of classroom acoustics should become more widespread. On this basis, it is reasonable to conclude that quieter classrooms will soon become a requirement in any educational environment in general, and more specifically for classrooms for children with autism. The number of variables in an acoustically appropriate design makes it almost impossible to cover all the needs and requirements in one design. But a "good" listening and learning environment can be created if the classroom‟s acoustical features are considered at the outset of the design process with the early collaboration of teachers, parents, school planners, architects, contractors, and suppliers. Accurate sound data, acoustical analyses, detailed specifications, appropriate materials, and careful construction can help to assure that the classroom environment is more supportive of this special population.

REFERENCES

Ahrentzen, S. & Steele, K. (2009). *Advancing Full Spectrum Housing: Designing for Adults with Autism*. Research Report, Arizona State University.

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorder*. (4th text revision). Washington, DC: American Psychiatric Association.

American Society of Interior Designers, (2005). Available: http://greenhomeguide.com/residential/partner/267

American Speech Language-Hearing Association, (2008). Available: http://www.asha.org/

Anderson, J. M. (1998). *Sensory Motor Issues in Autism, Therapy Skill Builders*. The Psychological Corporation Texas, USA.

Anderson, G., Lindvall, N., Hursti, T., & Carlbring, P. (2002). Hypersensitivity to sound (hyperacusis): a prevalence study conducted via the Internet and post. *Int J Audiol.41(8)*, 545-54.

Ando, Y., & Nakane, Y. (1975). Effects of aircraft noise on the mental work of pupils. *Journal of Sound and Vibration, 43*, 683–691

ANSI S12.2-1995, *American National Standard* . Criteria for Evaluating Room Noise.

Appropriate, G. (2011). *Evidence-Based Practice and Autism in the Schools*. The National Autism Center‟s. Randolph, Massachustts, USA.

Architects and Building Branch, Department of Education and Employment (1) (1999). Access for Disabled People to School Buildings, *Building Bulletin 77*, United Kingdom.

Atmaca, E., Peker, I., & Altin, A. (2005). Industrial Noise and Its Effects on Humans. *Pol. J. Environ. Stud. Vol. 14*, No. 6, 721-726

Autism and Development Disabilities Monitoring Network (ADDM) (2007). *Prevalence of the Autism Spectrum Disorders in Multiple Areas of the United States, Surveillance Years 2000 and 2002.*

Autism Society, (2013). Available: http://www.autism-society.org/get-involved/conference/

Autism Speaks, (2013). Available: http://www.autismspeaks.org/School II house, (2011). Available: http://www.School IIhouse.org/

Baguley, D. (2013). Audiology Matters. *ENT & audiology news, 21*. Pinpoint Scotland Ltd, UK.

Baron-Cohen et al., (1985). Does the autistic child have a "theory of mind"?. *Cognition, 21*, 37–46

Baron-Cohen, S. (2003). *The Essential differences: Male and Female Brains and the truth about autism.* New York: Basic Books.

Baron-Cohen, S. (2007). *The Rise of Autism and the Digital Age*. The World Question Center 2007. New York: Edge Foundation.

Belmonte, M. K., Allen, G., Beckel-Mitchener, A., Boulanger, L.M., Carper, R.A., and Webb, S.J., (2004). Autism and abnormal development of brain connectivity. *J Neurosci 24*, 9228-9231.

Bies, A., and Hansen, H. (2004). Defusing the global warming time bomb. *Sci. Amer., 290*, no. 3, 68-77.

Brock et al. & Just et al., (2004). Autism and Abnormal Development of Brain Connectivity. *The Journal of Neuroscience*, *24(42)*: 9228-9231; doi: 10.1523/JNEUROSCI.3340-04.2004.

Bollen, K., (1989). *Structural Equations with Latent Variables*.Wiley Series in Probability and Statistics. ISBN-10: 0471011711,ISBN-13: 978-0471011712.

Caldwell, P. (2006). *Finding You Finding Me*. Jessica Kingsely Publishers, London, UK.

Campbell, M. & Shay, J. (1995). Pervasive deveopmental disorders. In H. I. Kaplan & B. J. Sadock (Eds.), *Comprehansive textbook of psychiatry, Vol.2*, pp.2277-2293). Baltimore, MD: Williams & Wilkins.

Candappa, R., (2000). *Autobiography Of A One Year Old*. Publisher, Ebury Press; New Ed edition. ISBN-10: 0091880696, ISBN-13: 978-0091880699.

Centers for Disease Control and Preventation, (2007). *Autism Spectrum Disorders (ASDs) Report*. CDC Division of Media Relations, USA.

Cha, S-H., & Srihari, S. N. (2002). Individuality of Handwriting. *Journal of Forensic Sciences*, *47(4)*, 1-17.

Chakrabarti, S. & Fombonne, E. (2001). Pervasive Developmental Disorders in Preschool Children. *JAMA. 2001;285(24)*:3093-3099. doi:10.1001/jama.285.24.3093.

Chambers, R. (1947). *Inventory*. Manuscript Collections Division. National Library of Scotland.

Charan, S. H. (2012). *Childhood disintegrative disorder*. Case Report, 7, Issue 1, 55-57.

Cheung, C., K. (2004), Organizational influence on working people‟s occupational noise protection in Hong Kong. *Journal of Safety Research*, 35,465.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Psychology Press, Psychology - 567 pages.

Courchesne, E. (1989). *Neuroanatomical systems involved in infantile autism: The implications of cerebellar abnormalities*. In: G. Dawson (Ed.), Autism: New Perspectives on Diagnosis, Nature and Treatment. The Guilford Press: New York, pp. 119-143.

Crandell et al, (1995). Classroom Acoustics for Children With Normal Hearing and With Hearing Impairment. *JARA, CRANDELL:An Update on Counseling Instruction*,77-86.

Crispino, L. & Bullock, T. H. (1984). Cerebellum mediates modality-specific modulation of sensory responses of midbrain and forebrain in rat. *Proc Natl Acad Sci U S A*. PMCID: PMC345184, 81(9): 2917–2920.

Cronholm, P. F., Fogerty, C. T., Ambuel, B., Harrison, S. L. (2011). Intimate Partner Violence. *Am Fam Physician 83(10*): 1165-72. Notes: Selected as cover article.

Crook, M.A. & Langdon, F.J. (1974). The effects of aircraft noise in schools around London Airport," *J. Sound Vibration, 34*, 23-44.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., et al. (2004). Early Social Attention Impairments in Autism: Social Orienting, Joint Attention, and Attention to distress. *Developmental Psychology, 40*, 271-283.

Deasy, C.M., and Laswell, T. (1990). *Designing Places for People- A Handbook on Human Behavior for Architects, Designers and Facility Managers*. Watson Guptill Publications, New York, USA.

Delacato, C. H. (1974). *The Ultimate Stranger- The Autistic Child*. Academic Therapy Publications, Novato, California, USA.

Denzin, N. K. (1977). *The research act: A theoretical introduction to sociological methods*. Publisher, McGraw-Hill (New York). ISBN 007016360X.

Dixon, D. N., McKee, C. S., McRae, B. C. (1976). Dimensionality of three adult, objective locus of control scales. *J Pers Assess. 40(3)*,310-9.

Edelson, J. L. (1999). *Children witnessing of adult domestic violence*. Journal of Interpersonal Violence, 14, 8, 839-870.

Errede, R. Houser, J.R., Ford, E., Chatterjea, S.M., Maleri, S., Elston, T.C. (2013). An improved short-lived fluorescent protein transcriptional. *Reporter for Saccharomyces cerevisiae, 12*, 519-30.

Evans, G.W., Steffan, H., & Bullinger, M. (1995). A Prospective Study of Some Effects of Aircraft oise on Cognitive Performance in School Children. Research Report, *Psychological Sciences, vol.13*, no.5.

Field, A. (2005). *Discovering statistics using SPSS*. (2 nd ed.). London: Sage. Sandra C. Duhé. University of Lousiana.

Finegold, L.S., Harris, C.S., & Gierke Von H.E., (1994). Community annoyance and sleep disturbance; Updated criteria for assessing the impact of general transportation noise on people. *Noise Control Eng. J. 42*

Fombonne, E. et al (2005). *The Epidemiology of Autism Spectrum Disorders*. In proceedings of: AWARES Autism 2005, Online www.awares.org/ conferences.

Frith, U. (2012) Why we need cognitive explanations of autism. *QJExp Psychol, 65(11),* 2073-92.

Gilbert, S., Kotidis, S., Guha, P., Muthukrishnan, M. J., Indyk, Y., and Strauss, F. (2002). *QuickSAND: Quick Summary and Analysis of Network Data*, DIMACS Technical Report 2001-43.

Glasersfeld, E. von (1974**)** *Piaget and the radical constructivist epistemology*. In: C. D. Smock & E. von Glasersfeld (eds.) Epistemology and education. Athens, GA: Follow Through Publications, 1–24.

Golashani, N. (2003). Understanding Reliability and Validity in Qualitative Research. *The Qualitative Report. Vol. 8, no.4*597-607.

Grandin, T. (1995), (1996). *Thinking in Pictures; and Other Reports from my Life with Autism*. Random House, USA.

Grandian, T. (2011). *The Way I See it*. Publisher: World Future Horizons. ISBN-13: 9781935274216.

Green, K., Pasternak, B., & Shore, B. (1982). Effects of aircraft noise on reading ability of school age children. *Archives of Environmental Health, 37*, 24–31.

Grinker, R. R. (2007). *Unstrange Minds: Remapping the World of Autism*. Publisher: Basic Books; First Paperback Edition edition (January 29, 2008).

Hagberg, B., Aicardi, J., Dias, K., & Ramos, O.(1983). A progressive syndrome of aut of purposeful hand use in girls: Rett"s syndrome-report of 35 cases. *Ann, Neurol, 14.*

Hagberg, B. (1989). Rett syndrome: Swedish approach to analysis of prevalence and cause. *Brain and Development, 7(3),* 277-280.

Hagberg, B. (1989). Rett syndrome: Swedish approach to analysis of prevalence and cause. *Brain and Development, 7(3),* 277-280.

Haidamous, A. (2011). *School I*. Available: Reference deleted to protect the anonymity of the school

Hill, E., & Frith, U. (2003). Understanding autism: insights from mind and brain. Philosophical Transactions. *Biological Sciences,358(1430),* 281-289.

Hughes, T. P. (2003). Climate Change, Human Impacts, and the Resilience of Coral Reefs. *Science,* vol. 301, no. 5635, 929-933, DOI: 10.1126/science.1085046.

Jackson, H.,& King, N. (1982). The therapeutic management of an autistic child's phobia using laughter as the anxiety inhibitor. *Behavioural Psychotherapy, 10*, 364–369.

Johnson, C. M. (2000). A survey of current research on online communities of practice. *The Internet and Higher Education*, *vol. 4*, Issue 1, 1st Quarter 2001, Pages 45–60.

Jones, W. & Landa, R. (2011). *Blink Patterns May Be a Window Into Autistic Mind Watching a video, toddlers with autism reacted to action, not emotional content*. HealthDay Reporter. Available: U.S. National Institute of Mental Health.

Kanakri, S. (2012). *The effect of Noise on Children with Autism Behavior*. EDRA Proceding 2012.

Kanner, L. (1943). Autistic disturbance of effective contact. *Nervous Child, 2*, 217-250.

Kaplan, A., (1964). *In The Conduct of Inquiry: Methodology for Behavioral Science*. San Francisco, CA: Chandler.

Kaplan, H. et al (2006). *Snoezelen Multi-Sensory Environments, Task Engagements and Generalization. Research in Developmental Disabilities*, 27, 443 – 455.

Khare, Rachna, and Abir Mullick (2009). *Incorporating the Behavioral Dimension in Designing Inclusive Learning Environment for Autism*. in ArchNet-IJAR: International Journal of Architectural Research, vol. 3, issue 3.

Ko, H-S. (1979). Occurrence on Mitogen- and Antigen-Activated T Cells. *ExP. MED. © The Rockefeller University Press*, vol.150, 246-255.

Koszarny, Z. (1978). Effects of aircraft noise on the mental functions of school children. *Archives of Acoustics, 3*, 85–86

Lang, J. (1987). *Creating Architectural Theory; the Role of Behavioral Sciences in Environmental Design*. Van Nostrand Reinhold Company, New York, USA.

Lehman. A. & Gratiot, A. (1983). Effects du bruit sur les enfants a l‟ecole. *In Proceedings of the 4th Congress on Noise as aPublic Health Problem* (pp. 859–862). Milano: Centro Ricerchee Studi AmplifonLewis and Bodfish (1998

Martin, P., & Bateson, P. (1993). *Measuring Behaviour: An Introductory Guide*. Publisher: Cambridge University Press; 3rd edition (September 3, 2007).

Militerni, R., Bravaccio, C., Falco, C., Fico C., and Palermo, M. T. (2002). *Handbook of Autism and Pervasive Developmental Disorders, Diagnosis*. Publisher, JOHN WILEY & SONS. INC.

Minshew et al., (1997). The *Neuropsychology of* Autism. Oxford University Press.

Mohr et al., (1979). *Clinical manifestations and pathogenesis*. Oxford University Press.

Mostafa, M. (2008). Architecture for Autism: Concepts of Design Intervention for the Autistic User. *International Journal of Architectural Research, 2*, 189-201.

Myler, P. A., Fantacone, T. A., & Merritt, E.T., (2003). Eliminating Distractions. The educational needs of autistic hildren challenges approaches to shool design. *Amarican school & university, special– use facilities*, 314-317.

Nabelek, A. K., & Nabelek, I. V. (1994). "Room acoustics and speech perception" in *Handbook of Clinical Audiology*, 4th ed., edited by J. Katz (Williams and Wilkins, Baltimore), pp. 624-637.

National Centre on Birth Defects and Developmental Disabilities. Online http://www.cdc.gov/ncbddd/dd/ addmprevalence.htm Accessed on June 16, 2007.

National Institute of Mental Health (2007). *Autism Spectrum Disorders (Pervasive Developmental Disorders*. Available: http://www.nimh.nih.gov/health.

National Institute of Mental Health, 2013. Available: http://www.nimh.nih.gov/about/director/2013/transforming-diagnosis.shtml

Nelson, P. & Soli, S. (2000). *Classroom Acoustics II. Acoustical Barriers to Learning*. A publication of the Technical Committee on Speech Communication of the Acoustical Society of America.

Nixon, R.D. (2002). Treatment of behavior problems in preschoolers: A review of parent training programs. *Clinical Psychology Review*. 525–546. [PubMed]

Ohrstrom, E. (1989). Sleep disturbance psycho-social and medical symptoms a pilot survey among person exposed to high levels of road traffic noise. *Journal of Sound and Vibration,133*, 117.

Ornitz, E. (1985). Neurophysiology of infantile autism. *Journal of the American Academy of Child Psychiatry, 24*, 251-162.

Ozonoff S., et al. (1991). Executive function deficits in high-functioning autistic individuals: Relationship to theory of mind. *Journal of Child Psychology and Psychiatry*. 32:1081–1105. [PubMed]

Park, Y. D. (2001). The effects of vagus nerve stimulation therapy on patients with intractable seizures and either Landau–Kleffner syndrome or autism. *Epilepsy & Behavior,* vol. 4, Issue 3, 286–290

Parke R. D. & Gauvain M. (2009). *Child Psychology A Contemporary Viewpoint*. 7th edition, McGraw Hill, avenue of Americas, New York, NY 10020.

Patterson A. & Rafferty A. (2011). Making it to work: towards employment for the young adult with autism. Int J Lang. *Commun Disord*, *36*, 475-80.

Pennington, B. F. (2005). *The development of psychopathology: Nature and Nurture*. New York: Guilford Press.

Plagiarism, (2009). *I Paradigms, LLC*, Retrieved February 2009, URL: http://www.plagiarism.org/learning_center/what_is_plagiarism.html

QUET Manual, (1999). Available: http://ashtead-technology.com/product/instruments/quest_2900_type_2_w_calibrator/

Richardson, E.A. et al. (2010). Role of physical activity in the relationship between urban green space and health." *Public Health 127*: 318-324.

Richler, J., Bishop, S.L., Kleinke, J.R., and Lord, C. (2007). Restricted and repetitive behavior (echolalia)s in young children with autism spectrum disorders. *J Autism Dev Disord. 37*(1) 73-85.

Rimland, B. (1964). *Infantile Autism*. Appleton Century Crofts, New York, USA.

Rimland, B. & Edelson, S.M. (1995). Brief report: a pilot study of auditory integration training in autism. *J Autism Dev Disord*. 25(1), 61-70.

Rogers, S.J., Pennington, B.F. (1991). A theoretical approach to the deficits in infantile autism. *Dev Psychopathol, 3*, 137-162.

Rosenthal, R.L. & Rubin, D.B. (1982). Contrasts and correlations in effect-size estimation. *Psychological Science* , *11*, 446-453.

Rubenstein, J.L. & Merzenich, N.M. (2003). Model of autism: increased ratio of excitation/inhibition in key neural systems. *Genes Brain Behav, 5*, 255-67.

Sanoff, H. (1991). *Visual Research Methods in Design*. Van Nostrand Reinhold, New York, USA.

Sapienza, C., Crandell, C., & Curtis, B. (1999). Effects of sound-field frequency modulation amplification on reducing teachers' sound pressure level in the classroom. *Journal of Voice, 13(3),* 375-381.

Scheuermann, B. And Webber, J.(2002). *Autism Teaching Does Make a Diffrence*. Canada: Wadsworth Group.

Schwandt, T. A. (2007). *The SAGE Dictionary of Qualitative Inquiry.* 3rd ed.University of Illinois, Urbana-Champaign, USA.

Sekul, E. A. & Percy, A. K. (1992). Rett‟s syndrome: Clinical features, genetics considrations, and the search for a biological marker. *Curr Neurol, 12*, 173-1980.

Schultz, P. W. (2011). Conservation means behavior. *Conservation Biology, 25*, 1080-1083.South, Ozonoff & McMachon.

Spiker. D., & Ricks, M. (1984). Visual Self-recognition in autistic children: Developmental Variations. *Child Development, 55*, 214-225.

Stlegler, L. & Davis, R. (2010). Managing Sound Sensitivity in Individuals With ASDs. *Audiology Journal, 27*, 299-312. The ASHA Leader.

Suter, R. (1989). An insider's perspective: Teachers observations of creative thinking in exceptional Children. *Roeper Review*, Issue 4.

Tammet, D. (2006). *Born on a Blue Day. Inside the Extraordinary Mind of an Autistic Savant*. A Division of Simon & Schuster, Inc. New York, NY 10020.

Tang, J-C., Koppekin, A., Caruso, M., & Kennedy, C. (2002). Functional analysis of stereotypical ear covering in a child with autism. *Journal of Applied Behavior* Analysis, 35, 95-98.

Tharpe, A., Bess, F., Sladen, D., Schissel, H., Couch, S., & Schery, T. (2006). Auditory characteristics of children with autism. *Ear & Hearing, 27*, 430–441.

Turkington, C. & Anan, R. (2007). The A to Z of Autism Spectrum Disorders. Publisher: Checkmark.

Turner, M. (1999). Annotation: Repetitive Behaviour in Autism: A Review of Psychological Research. *Journal of Child Psychology and Psychiatry, 40*, 6, 839–849.

Volkmar FR. (1996). Childhood and adolescent psychosis: a review of the past 10 years. *J Am Acad Child Adolesc Psychiatry, 35(7)*,843-51.

Ulrich, R. S. (1981). Natural versus urban scenes: Some psychological well-being. *Environment and Behavior*, 13, 523-556.

UN Global Program on Disability (1993). *Mandates of the UN Global Program on Disability: Standard Rules on the Equalization of Opportunities for Persons with Disabilities*. Target Areas for Equal Participation: Accessibility, United Nations General Assembly resolution 48/96, annex, 20/12/1993.

United States Environmental Protection Agency, (1974). Available: http://www.epa.gov/

Wigram, A.L. (1987). *The effects of vibroacoustic therapy on clinical and non-clinical Population*. PhD Dissertation, ST. Georges Hospital Medical School, London University.

Wigram, T. & Gold, C. (1999). Music therapy in the assessment and treatment of autistic spectrum disorder: clinical application and research evidence. *Child: care, health and development, 32, 5*, 535 – 542. Blackwell Publishing Ltd,

White, G.B., & White, M.S. (1987). Autism from the inside. Medical Hypothesis, 24, 223-229

Woodcock A, Woolner A, Benedyk R. (2009). *Applying the Hexagon-Spindle Model to the design of school environments for children with Autistic spectrum disorders*. Work 32(3):249-59.

Zeisel, J. (1981). *Inquiry by Design: Tools for Environment-Behavior Research*. BrooKs/Cole Publishing Company.

APPENDIX A

"To Whom it May Concern,

The attached survey represents the first stage in the research for my doctoral dissertation. We hope that the results will be useful to organizations and architects who design environments for children with autism.

Once completed, please return the survey by email or a drop box in the reception area. We are hoping to have all responses by Friday 26 2011."

We are grateful for your participation.

Sincerely,

Shireen Kanakri

PhD student

Architecture Department

Texas A&M University

College Station, TX"

The Impact of Acoustical Environmental Design on Children with Autism

1. Gender of rater (please circle): male female

2. How long have you worked with children with autism (years/months)? ____/_____

3. How long have you worked at your current school (years/months)? _____/_____

4. Level you currently teach (please circle): Preschool Pre-K Kindergarten Lower Elem. Upper Elem. Middle School

5. What type of classes do you teach (e.g. Music, Math, General, etc.) _____________

6. What is the room number of your classroom? _____________

7. How many hours do you spend with your students each week: _____________

8. How many children are in your class? ______________

9. In addition to air conditioner sounds, echoes, sounds from children in the classroom, sounds from other classrooms, and traffic noise, are there other acoustical environmental conditions that you feel negatively affect children with autism? Please describe. Examples may include:

____

____

____

10. Please rank the following regarding how negatively they impact the children‟s behavior. Please add the items you mention in Question 9 to this list and include

them in the ranking. (The most negative impact should be ranked number 1).

a. Air conditioner ____________
b. Echoes ____________
c. Sounds from children in the classroom ____________
d. Sounds from other classrooms ____________
e. Traffic noise ____________
f. ____________________________ ____________
g. ____________________________ ____________
h. ____________________________ ____________
i. ____________________________ ____________
j. ____________________________ ____________

11. Are there aspects of the physical environment that you believe reduce the noise levels? Please describe. Examples may include: carpet, rugs, curtains, etc.

____
____

____

12. Describe the positive and negative acoustical qualities of the following types of rooms:

Activity Zone	**Positives**	**Negatives**
Classroom	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………... ………………………………	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………...……………… ……………………………….. ………………………………

	……………….. ……………………………… ……………….. ……………………………… ………………....	……………….. ……………………………… ………………....
Common Area	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………....	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………....
Art Room	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………....	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………....
Computer Lab & Library	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………....	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………....
Music Room & Drama Room	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………....	……………………………… ……………….. ……………………………… ……………….. ……………………………… ………………....
Art Room &	………………………………	………………………………

Pe Room	……………….. …………………………….. ……………….. ……………………………… ………………...	……………….. …………………………….. ……………….. ……………………………… ………………...

13. As a teacher for children with autism, please evaluate the importance of these aspects of the learning environment.
    a. <u>Noise Control is an important issue for children with autism:</u>

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5

b. <u>Having a carpet on the floor of the classroom is an important issue for children with autism:</u>

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5

c. <u>Having wood panels fixed over the wall is an important issue for children with autism:</u>

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5

d. <u>Using wood chairs and tables rather than steel chairs and tables is an important issue for children with autism:</u>

Strongly   Somewhat   Neither agree   Somewhat   Strongly

disagree	disagree	nor disagree	agree	agree
1	2	3	4	5

e. Thick or Sound Proof walls are an important issue for children with autism:

Strongly	Somewhat	Neither agree	Somewhat	Strongly
disagree	disagree	nor disagree	agree	agree
1	2	3	4	5

14. Please, can you provide your answer for these question:

a) What types of behaviors do you see children doing that indicate that they are impacted by Noise

……………………………………………………………………………………… ……………………………………………………………………………………… ……………………

Do the children in the class ever attempt to reduce the noise by covering their ears or using 'ear defenders?..

APPENDIX B

1. As a teacher for children with autism in this classroom, please indicate whether you observed the following behaviors in response to sound today?

a. <u>"Covering ears" was observed in the class today:</u>

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5

b. <u>"Producing sounds" was observed behavior in the class today:</u>

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5

c. <u>"Hitting in response to sound" was observed behavior in the class today:</u>

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5

d. <u>"Blinking eyes in response to sound" was observed in the class today:</u>

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5

e. <u>"Complaining in response to sound" was observed in the class today:</u>

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5