

Acoustic environment in classrooms for children with autism spectrum disorders: case studies in China

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ABSTRACT

Previous studies have established that children with autism spectrum disorder (ASD) display distinct patterns in auditory signal processing compared to typically developing children. However, the acoustic environment of classrooms for children with ASD has not received sufficient attention. This study focuses on Tianjin as a case study to understand the current situation of the classroom acoustics for children with ASD. Acoustic condition investigations were conducted in nine schools, with acoustic measurements taken in 18 classrooms. In addition, semi-structured interviews were conducted with 15 teachers to assess the quality of classroom acoustics. The investigation and measurement revealed that there are multiple identifiable sound sources in the classrooms, and the sound pressure level values differed greatly between classrooms. This can be attributed to the lack of proper functional zoning and room layout within schools, as well as the inadequate sound insulation in the classrooms. The interview indicated that the current acoustic environment has a negatively impact on the attention, emotion, behavior, and training of children with ASD. In summary, the current classrooms for children with ASD do not create a favorable acoustic environment.

1. INTRODUCTION

Autism Spectrum Disorder (ASD) affects around one in every 36 American children aged eight[1]. A recent survey conducted in China among children aged 4 to 6 revealed a prevalence rate of 2.5% [2]. ASD is a neurodevelopmental disorder characterized by challenges in social communication and engagement, as well as the presence of restricted and repetitive behavior, interests, or activities [3]. Individuals with ASD exhibit different auditory signal processing patterns than typically developing individuals, resulting in heightened

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auditory sensitivity [4-8]. This increased sensitivity to sounds leads to stress and difficulties in adapting to typical sound environments encountered in their daily lives [9-13].

Schools serve as the primary environment where children with ASD engage in daily routines. Research has made significant progress in studying the acoustic environment of general schools, including acoustic parameters [14-15], user evaluation [16-18], and soundscape [19-20]. Furthermore, numerous studies have delved into how schools can foster the well-being of typically developing children by creating a conducive sound environment [21-23]. In contrast, several recent studies have examined how the acoustics within schools impact children with ASD, with the aim of proposing improvements [24-28]. However, there are no standardized guidelines for acoustic design in classrooms that cater to children with ASD. Although the number of schools for children with ASD in China has increased significantly in recent years, the acoustic environment within these schools remains poorly understood.

The present study on schools aims to investigate the acoustic conditions of schools for children with ASD. The investigation was designed to identify the sound sources prevalent in classrooms and understand the building characteristics of schools for children with ASD. A secondary aim of the study was to assess the acoustic environment in classrooms. Specifically, based on the findings of the investigation, sound pressure levels were measured and compared across different areas and types of classrooms. The ultimate aim is to assess the acoustic environment quality of these classrooms through semi-structured interviews with teachers, in order to understand the performance of children with ASD in their current acoustic environment and evaluate its impact on their training.

2. METHODOLOGY

2.1. Acoustic condition investigation on schools

To gain a deeper understanding of the current situation of schools for children with ASD in China, Tianjin was selected as the study site. Up until the time of this study, a total of 31 rehabilitation training schools in Tianjin had successfully undergone the national evaluation. These schools were categorized into three tiers on student population, with an equal number of participating schools in each tier. Eventually, nine schools consented to participate in the investigation, five of which had been operation for less than two years.

The student population in the nine schools varied from 40 to 200. The investigation aimed to understand the current acoustic conditions of these schools, encompassing both sound sources and building characteristics. The investigation of sound sources included evaluating ambient noise from traffic and other external noises, as well as human-generated noises, and mechanical sounds within the school premises. Regarding building characteristics, key aspects examined were building type, room layout, specifications of doors and windows, and interior decoration (Figure 1).



Figure 1: Photo of a classroom.

2.2. Acoustic measurement of sound pressure levels

Four schools out of the nine investigated were selected for acoustic measurement. The selected schools had different building types, room layouts, and other measurement factors. A total of 18 classrooms were measured in these selected schools. The location, area, function, furniture arrangement, and usage of each classroom were recorded, along with acoustic measurement conducted during both occupied and unoccupied conditions.

To measure the L_{Aeq} values, a sound level meter (AWA6228 Multifunction Sound Level Meter) was installed in the classrooms at a height of 70cm above the child seat to simulate a child's sitting position. In case where multiple seats were present in a classroom, the most centrally located seat was chosen as the measuring point. Three tests lasting three minutes each were performed in every classroom under both occupied and unoccupied conditions. The measurement results were calculated by averaging data from three measurements taken at each measuring point under identical conditions. During occupied periods, no students occupied the position of the sound level meter.

2.3. Semi-structured interview with teachers for children with ASD

Due to the challenges faced by young children with ASD in expressing themselves [29], direct interviews were not conducted in this study. Previous studies have demonstrated that semi-structured interviews with teachers are effective in exploring the emotions of children with ASD [30-31]. Therefore, experienced teachers from the participating schools were invited as interviewees. The teachers voluntarily signed the informed consent forms and agreed to be recorded during the interviews. Ultimately, 15 qualified teachers from various schools completed the semi-structured interview.

As depicted in Table 1, teachers were requested to delineate various scenarios subsequent to the children's exposure to sounds. In addition, they provided their assessment of the current acoustic environment in the classroom.

Table 1: Interview outline for the teachers in-depth interview.

Category	Question Outline
Basic Information	Age, gender, educational background, and professional qualifications
Objective Situation	Please describe the scene when the ASD child hears a sound, including the characteristics of the sound, and the child's actions, expressions, and reactions to the sound.
Evaluation	Do you think the acoustic environment in the classroom interferes with the training of children with ASD? Do you have any suggestions or comments?

The recommended outline served as a mere guide, with more detailed inquiries being conducted during the interview. Each interview had an approximate duration of 30 minutes.

3. RESULTS AND DISCUSSION

3.1. Sound sources and building conditions (by the investigation)

The sound sources outside the school were diverse. Among the nine schools, three were situated in street-facing shops on the ground floor of residential buildings, four were located in office buildings, and two were housed in standalone buildings. Most schools were strategically positioned in economically active or densely populated areas of the city, close to busy thoroughfares. The neighboring buildings included residential, commercial, and office spaces. Various external sounds could be heard in classrooms facing the street, such as traffic noise (including sirens as well as vehicle driving and honking), social activity sounds (shouting and music), mechanical sounds (construction site noise and decoration sound), and natural environment sounds (thunderstorms, raindrops, birds).

Simultaneously, there were multiple sound sources within the school that can be classified into two categories: sounds originating from inside the classrooms (such as voices, music, and electrical appliances like air conditioners, fans, and projectors) and sounds from outside the classrooms (toilet flushing noises, elevator sounds, parents' conversations, sounds from mobile phone entertainment, and footsteps during class time).

In addition to the listed sound sources, the sounds produced by other people's speech and activities in the classroom are also worth noting. The size and number of classrooms varied greatly, with classifications based on different training formats such as one-to-one, group, and body movement training. Depending on the classification, classrooms could range from as small as 10 m² to as large as 150 m². Interestingly, no correlation existed between school size and the area per capita used for classrooms. The minimum per capita use area for one-to-one sessions between teachers and children was 3.3 m², meaning that three pairs of teachers and students shared a 10 m² classroom. Therefore, the sound interference between students was obvious.

The investigation revealed that many sound sources detected in the classroom are related to the following factors: Firstly, these schools lacked clear functional zoning. In general, schools for children with ASD require various functional areas such as classrooms, a visitor reception area, a parents' waiting room, teachers' offices, restrooms, and other auxiliary rooms. However, the investigation found that the entrance area may served as a parents' waiting area, and the teachers' office and visitor reception area often shared a room (Figure 2 (a)). Secondly, some schools had an inadequate room layout. For instance, in one school,

the restroom was located at the end of a hallway and next to classrooms for one-on-one training. In another school, the parents' waiting area was positioned in the centre of a floor with classrooms surrounding it (Figure 2 (b)).



Figure 2: The real picture of the schools with mixed functional areas.

3.2. Sound pressure level (by the measurement)

During the construction of the investigated schools, acoustic design was not taken into consideration. The acoustic condition investigation revealed that only two out of the nine schools had implemented sound-insulation doors and windows. Additionally, most schools were divided into functional areas based on the original structure to optimize space utilization. Consequently, there is a significant variation in the acoustic environment among different classrooms.

The median L_{Aeq} value in the unoccupied classrooms was 41.0 dB(A) (Figure 3). However, it should be noted that the lowest recorded L_{Aeq} value was 23.3 dB(A), while the highest reached 52.1 dB(A). Windowless classrooms located in quiet zone exhibited the lowest sound pressure levels with a median of 29.1 dB(A), which were below the median for all unoccupied classrooms combined. Therefore, both classroom positioning within the layout and its sound insulation capability significantly affect the sound pressure level inside the classroom.

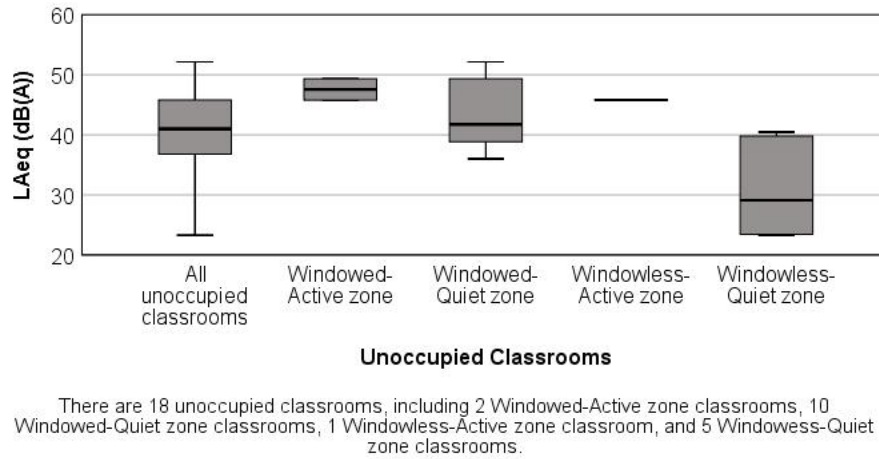


Figure 3: Box plot of sound pressure level in classrooms under unoccupied conditions.

The L_{Aeq} value in the occupied classroom ranged from 53.6 dB(A) to 74.7 dB(A). The investigation classified the classrooms as one-to-one training classrooms, group training classrooms, and body movement training classrooms. The median L_{Aeq} in the group training classrooms was slightly higher than that in the body movement training classrooms by 5.4 dB(A), and by 3.7 dB(A) compared to the one-to-one training classrooms (Figure 4). However, there were minimal differences observed in sound pressure level among the different classroom types, suggesting that training formats did not significantly influence the sound pressure levels inside the classroom.

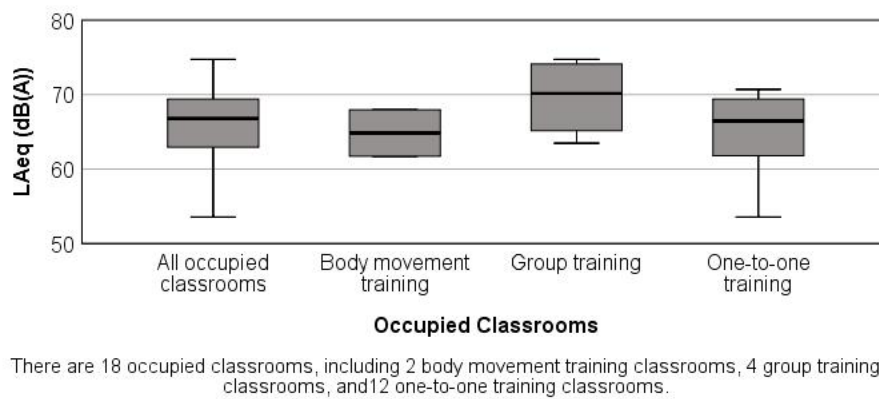


Figure 4: Box plot of sound pressure level in classrooms under occupied conditions.

3.3. Acoustic environment quality assessment (by the interview)

The sharing of a one-on-one training classroom is not conducive to the training of children with ASD. The investigation has revealed that these classrooms were often used simultaneously by multiple teachers and students. Additionally, teachers also used higher tones, rhythmic intonations, and reward measures such as toys and music to maintain the attention of children with ASD during training. These practices also drew the attention of other children in the classroom. During interviews, teachers have reported that many

children with ASD were easily distracted by other noises in the classroom, such as *'following instructions from other teachers'*, *'being interrupted by other children's crying'*, and *'being drawn to the sound of others playing with toys'*. These unsuited sounds can make it challenging for children with ASD to concentrate during their training.

The study revealed that the well-being of children with ASD is influenced by the complex acoustic environment in classrooms. The investigation and measurement conducted in this study demonstrated that classrooms contained multiple sound sources, with significant variations in sound pressure level across different classrooms. In interviews conducted in this study, teachers mentioned the impact of these sound sources on children with ASD. On one hand, children with ASD displayed behaviors such as *'covering him ears when he hears the sound of a flushing toilet'*, *'refusing to enter classrooms where he has previously heard the sound of an electric drill'*, *'repeatedly asking the same question to the teacher after hearing a sound'*, and *'seeking out a police car after hearing its sirens'*. On the other hand, teachers observed that children experienced emotions such as *'curiosity'*, *'fear'*, *'anger'*, and *'excitement'*. These behaviors and emotions were considered to *'impede training progress'* and could even *'continue to affect children with ASD for several days'*. Previous studies have suggested that individuals with ASD struggle to anticipate changes in their surroundings, while complex environments could increase cognitive pressure for them [32-35]. Research by others has indicated that children with ASD prefer simple and familiar sounds [26]. Consequently, it can be inferred that the current acoustic environment in classrooms does not provide an ideal setting for the development of children with ASD.

4. DISCUSSION

In summary, schools for children with ASD often lacked proper acoustic design, leading to multiple sound sources and significant differences in sound pressure levels within classrooms. Therefore, this study recommends that schools for children with ASD undergo acoustic design before being put into service. The following recommendations are suggested:

- 1) To improve school functionality, establish distinct functional zoning for different activities.
- 2) In classrooms, especially for one-to-one training classrooms, appropriate layouts should be implemented to incorporate quiet areas. Auxiliary rooms like elevators, equipment rooms, and restrooms should be situated away from classrooms.
- 3) Furthermore, it is advised to install adequate sound insulation measures such as soundproof doors and windows in classrooms, especially those facing streets. To further minimize noise interference, active zones should be separated from quiet zones using soundproof doors. Additionally, it is recommended to install self-closing doors in parents' waiting rooms and visitor reception areas.

5. CONCLUSIONS

Through investigation, measurement, and interviews, it was discovered that the acoustic environment in classrooms for children with ASD present several issues:

- 1) Inadequate functional zoning and room layout resulted in various sound sources being audible inside the classroom.
- 2) Sound pressure levels in the classroom varied significantly depending on their location and the effectiveness of the sound insulation in doors and windows.
- 3) The acoustic environment in the classrooms had a negative impact on the attention, emotions, behavior, and training of children with ASD

In the case of Tinjin, the current environment for children with ASD failed to meet the necessary requirements, creating an unsupportive acoustic environment that can negatively affect the well-being and health of children with ASD.

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