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The sound environment of German preschools and preschool teachers' thoughts about sound generated by children

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ABSTRACT

Noticeably, preschool children develop language and communication, so improvement of the preschool's sound environment is important. Currently, Japanese preschool facilities have experienced problems with noise. One cause is a lack of sound absorption. Moreover, the loudness of the generated sound is a second cause because preschool teachers generally believe that children's voices should not be muted. Therefore, improvement of sound environment is important and should be approached from both facility design and child behavior philosophy. In Germany, The German standard (DIN 18041) has necessitated the same level of sound absorption in the nursery as in elementary schools since 2004. Under the influence of these factors, architectural ideas, such as increasing the equivalent sound-absorption area, are generally seen at preschools (Kawai et al., 2018). Therefore, we have researched the sound environment at German preschools and preschool teachers' thoughts about the sound generated by children to identify ways to create a more acoustically comfortable learning environment. We observed three preschools and compared them to Japanese preschools. It was found that by implementing acoustic improvements in classroom design and increasing teacher awareness of appropriate sound environment, the noise levels tend to be lower. Consequently, it is believed that a proper acoustic environment improves overall awareness, leading to the creation of a better educational environment.

Keywords: acoustic design, learning environment, noise mitigation, preschool classroom, teacher responses

1. INTRODUCTION

Preschool children generate a remarkable amount of language and communication. Because they can create noisy environments, preservation of the sound environment in facilities where they interact, such as preschools, is an important issue. Currently, Japanese preschool facilities are experiencing concerns about noise levels that may lead to negative effects on children's development. One cause of the excessive noise is a lack of sound absorption in the facility design. Because there is no building standard for acoustic performance in Japanese preschool facilities, many do not contain adequate sound-absorbing materials and insulation (1). In addition to physical considerations of noise levels in the facility, there is also the social expectation that children should be lively and full of energy. Preschool teachers tend to have a higher tolerance of noise levels (2) and allow the environment to be loud, as to not interfere with the sound freely generated by the children. Therefore, sound environment preservation of preschool facilities requires an approach that addresses both the facility acoustic environment and the sound generated by children.

On the other hand, the standards in some countries require acoustic performance equal to or better than that in elementary schools (3). In particular, Germany, which has similar preschool facility challenges as those of Japan, has found a way to address noise issues by improving both environmental and social systems. The German standard (DIN 18041) has necessitated the same

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level of sound absorption in the nursery as in elementary schools since 2004. In addition, DIN 18041 of 2016 also requires better acoustic performance for inclusive education (4). Under the influence of these factors, architectural ideas, such as increasing the equivalent sound-absorption area, are generally seen at preschools (5). On social policy, while noise problems related to children's voices occurred, a judicial decision has been made that “children's voices are not noise.” This decision has allowed legal reforms to be made (6) and guarantees the right of children to play freely.

Based on the above considerations, this study researches the actual condition of the sound environment in German preschools and teachers’ thoughts regarding the sound generated by children. It then compares this information with that of Japanese preschools to identify how a more acoustically comfortable environment can be created.

2. METHODOLOGY

The subjects of this research include three preschool facilities under different management structures in Dusseldorf, Germany. The building environment is depicted in Fig.1, and the description of each facility is shown in Tab. 1. We visited each facility for one day in February 2017 to perform a survey, which included a noise level evaluation and interview with the director of the preschool. We visited in the morning (10-12 o'clock) to conduct the research.

Preschool A implements a Waldorf style of education. Characteristics of the facility include an asymmetrically shaped room, wood finishing, cloth often used for decoration, etc. Preschool B is a converted space located a part of a multi-unit dwelling. A loft and a play corner are installed in each classroom. In addition to the classrooms, there are dedicated rooms for activities such as sports and art. A part of the courtyard of the dwelling is used for outdoor play, and the hallway is used for play during rainy weather. Preschool C is a non-authorized preschool for Japanese children and located on the lower floor of a commercial building; this part of the building has been converted for the preschool classrooms. Most of the preschool teachers are Japanese. Japanese educational activities and lifestyle culture have been kept in mind, as children in this school eventually return to Japan.

(a) Preschool A

(b) Preschool B

(c) Preschool C

Figure 1 – Photos of preschool facilities

Table 1 – Preschool environment descriptions

	Management	Building environment	Number of children [Number of classes] / classroom style
A	Authorized, parent initiative Kita (parent participation style), Waldorf education	Single-story wooden building, dedicated for preschool, adjacent to geriatric welfare facility	51 [3] / Multi-age classrooms: 2–5 years old [1]; 3–5 years old [2]
B	Authorized, protestant Kita (management by Protestant mutual aid organizations)	Within concrete square-shaped multi-unit dwelling (RC construction, 1–3F), part of the courtyard used for the playground	80 [4] / Multi-age classrooms: 2–5 years old [1]; 3–5 years old [3]
C	Unauthorized, private Japanese kindergarten (management by Japan, for Japanese children)	Lower floor of a commercial building (RC construction, 1, 2F)	105 [4] / Age-level classrooms: 2, 3, 4, and 5 years old [1 each]

3. Survey of the sound environment

3.1 Survey method

For the sound environment observations, in order to investigate the actual activity sound, we recorded activity status and generated sounds in the classroom and large indoor space, and on the playground. A sound level meter microphone (RION NL-42) and recorder (SONY PCM-M10) were used for gathering noise levels. We set the recording devices in a place that would not disturb the activities of the children and recorded the sounds for about 2 h. The calibration signal was recorded at the start of the recording for later analysis. A typical observed classroom is shown in Fig. 2. In the analysis, the frequency analysis of the recorded sound and listening of the generated sound source were conducted to extract the characteristics of the sound environment of each facility.

Fig. 2 – Typical classroom where sound was recorded

3.2 Survey results

3.2.1 Room acoustics at various locations

Based on the interior environment and recorded sound source of the facilities, the state of reverberation is described. The reverberation time (reverb) was simply analyzed using a “clap” sound recorded in the classroom of Preschool A and in the hallway of Preschool C.

First, the reverb of the classroom of Preschool A was estimated to be approximately 0.38 s (500 Hz) and 0.40 s (1 kHz). The finishing material of the room was wood, and it was believed that a sound absorbing treatment had been applied to the ceiling. In addition, many cloth decorations were used, so we had an impression that the reverb for this room was short. When the sound source for this room was compared with the sounds emitted in the classrooms of Preschools B and C (i.e., sounds close to the impulse sound source), the impression was that the reverb was short in those classrooms as well.

Next, the reverberation time of the large indoor space (entrance hall) of Preschool C was found to be approximately 0.87 s (500 Hz) and 1.23 s (1 kHz). No sound-absorbing material was used at this location; the area was large and the ceiling was high. Therefore, the impression of the reverb was that it was very long. Because this was a large space, it seemed to be often used for physical exercise and musical activities. It was feared that such a long sound would interfere with the activity.

3.2.2 Characteristics of the sound environment during preschool activities

The characteristics of the sound environment during preschool activities were observed, which included listening to the recorded sound and frequency analysis. First, Tab. 2 shows the characteristics of the facility environment and the sound environment.

Table 2 – Sound environment characteristics based on facility environment

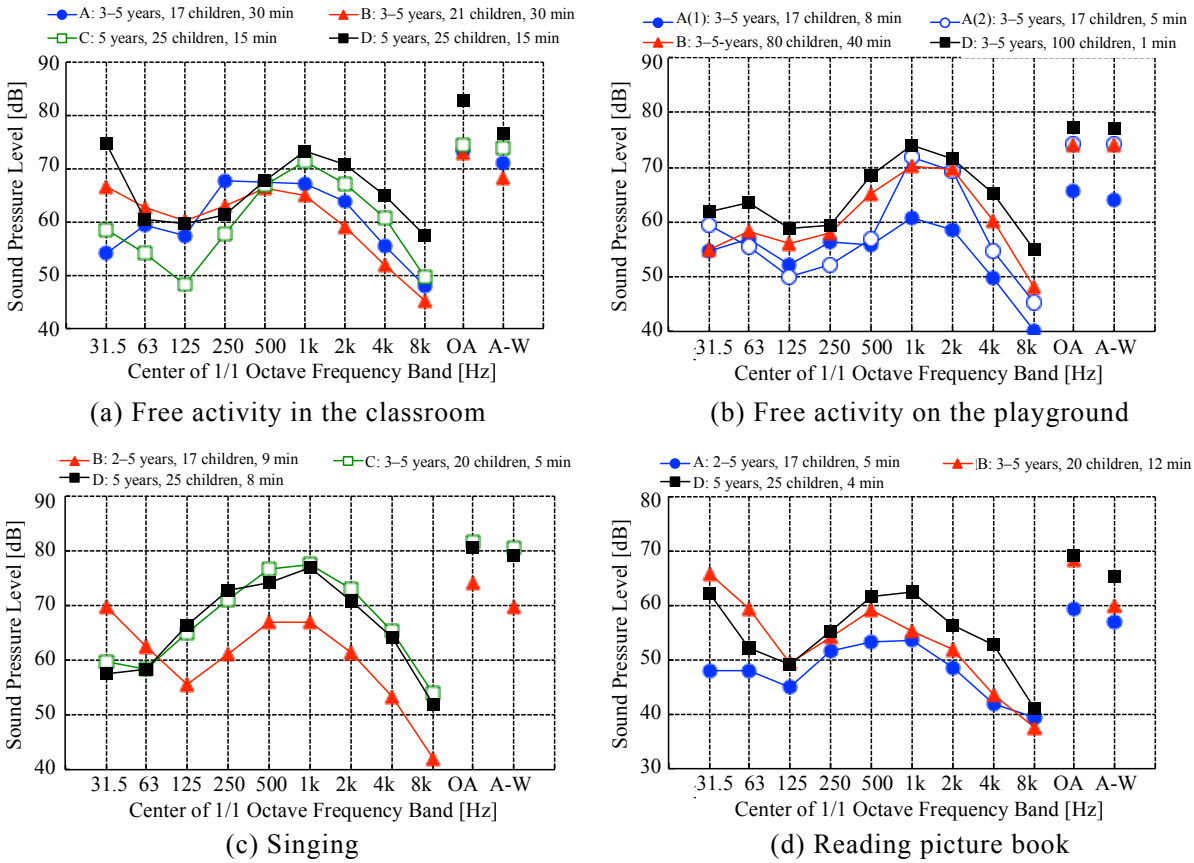
	Facility environment	Generated sound / Impression of reverb / Noise condition
A	Wood finishing Wooden furniture and play equipment Play corner setup Cloth decoration Warm light environment	Lots of sound generated from wooden floors, furniture, and toys Short reverb Mixing of sounds is small, it is easy to hear
B	Play corner setup Wooden furniture Loft, mat, and sofa permanent setup Additional dedicated rooms for sports or art Hallway used as play space	Little noticeable sound Sound absorbing material on ceilings of the rooms other than the staff room and toilet Short reverb Mixing of sounds is small, calm impression
C	Includes a hallway and a multipurpose space Room configuration changes based on group activities	Children's voices are the main sound source Short reverb in classrooms, long reverb in hall Impression that sound was mixed overall

Play corners were always set up in the classrooms of Preschools A and B; in Preschool C, only desks and chairs were included, and the furniture was moved around according to each activity. In terms of play equipment, furniture, and materials for decoration, the classrooms in each facility differed. This is likely due to the differences in education approaches. Regarding generated sound, only Preschool C emitted loud sounds all at once in the classroom; this might have been during greetings when all the children used loud voices, teachers making loud sounds or playing music, etc. In contrast, there were no situations where particularly loud sounds or voices were used in Preschools A and B.

Next, the sounds during the activity are described. In the analysis of sound pressure level, we calculated the equivalent continuous sound level every minute ($L_{eq,1min}$), listened to the recordings, and classified which activity each data element corresponds to. Fig. 3 shows the analysis results of L_{eq}. The analysis time is the energy average of the sound pressure level of each activity time. The sound environment characteristics summarized by listening are given in Tab. 3. In order to compare these results with those of preschools in Japan, the case in Japan (Preschool D) is also described. The reverberation time in Preschool D was approximately 0.78 s (500 Hz) and 0.81 s (1 kHz). Note that this reverberation time was longer than Preschool A.

Table 3 – Sound environment characteristics based on activity

Activity	Sound environment characteristics
Free activity in classroom	A, B: Calm play with little movement C: Craft scene, children are working while talking C, D: Many children's voices
Free activity on the playground	A: (1) Generally quiet, (2) Noise level goes up following the loud voice of one disabled child B: Children play actively and are relatively lively, influence of building reflections is inferred because of courtyard setting
Singing	B: Voices only, children sing quietly C, D: Includes piano accompaniment, C's children participate in lively singing
Reading picture book	Common: A generally quiet environment compared to other activities for all Difference: The difference between A, B, and D is the children's voices (1–2 kHz octave band). A, B: The voice of the teacher is primary, quieter sound environment



(a) Free activity in the classroom

(b) Free activity on the playground

(c) Singing

(d) Reading picture book

Figure 3 – Sound pressure level for each activity

It can be pointed out that the sound pressure levels are higher in Preschool C and in Japanese preschools than in Preschools A and B. From the generated sound observations, it was found that the center of the liveliness was the children's voices (1–2 kHz octave band) and sounds of toys (250–500 Hz octave band).

During the free activity in the classroom, there was a tendency of each person's voice becoming louder in Preschool C because there were a large number of children in the room, population density in the facility was high, and nearby voices were mixed. In addition, it is believed that this tendency became louder because the reverb of Preschool D was long. On the other hand, at Preschools A and B, children were also talking, but they had an environment where they could talk independently, without mixing with other play and talking voices; this prevented their voices from becoming synergistically loud. Consequently, in Preschools A and B, the level of the noise and the voice (1–2 kHz octave band) were lower than those in Preschools C and D, and there was a calm impression.

During the free activity on the playground, the sound environments of Preschools B and D were similar, and the sound pressure level tended to increase as the children played actively. In Preschool A, the number of children was small, and the surrounding environment was quiet; therefore, it also tended to be quiet outside. During playing time, one disabled child used a loud voice for about 5 min (Fig.3 (b): A(2)); at that time, the noise level was temporarily raised to the same level (L_{Aeq}) as in Preschools B and D. However, the level of the generated sound itself was low, and the calm environment was maintained.

During the singing activity, there was a noticeable difference between Preschools B and C. In Preschool C, a piano was used, and everyone was singing loudly. In Preschool B, accompaniment music was not used, and the teacher sang quietly in the circle with the children. Comparing with the cases in Japan, Preschool C seemed to enjoy the songs at the same level as Preschool D, while children at Preschool B sang calmer than Preschool C and D.

During the reading picture book activity, the environment for listening quietly was similar. The difference was the amount of the children's vocalization. In Preschools A and B, the voices of the children were low and the teacher's voice (500 Hz, 1 kHz octave band) was the most prominent. However, in Preschool D, the level of the children's voice (1–2 kHz octave band) was high, and

multiple children were actively responding at the same time.

The above observations suggest that the generated sound differs depending on the style of education, such as how the preschool teachers relate to the children, the number of children, and the preschool activities. A long reverb in the facility amplifies the sound level; however sound absorption design makes it possible to avoid the mixing of sounds to maintain a calm environment. For comparison, sound absorption in building design has been implemented in Germany, whereas it has not been implemented in Japan. Therefore, there are still many preschool facilities in Japan where the reverb is long. Because of this and the difference in the style of education, it is believed that German preschools tend to have a quieter and calmer environment than Japanese preschools.

4. Preschool teachers' thoughts about sound generated by children

4.1 Survey method

To investigate preschool teachers' responses to sound generated by children, an interview was conducted with one director at each facility; these were semi-structured interviews with two interviewers and one interpreter. The questions involved considerations about early childhood education, such as educational philosophy, current activity status, sound environment during the activity, behavior of children, influence of neighborhood, and associated issues. Example questions on the sound environment during the activity are given in Tab. 4.

Table 4 – Example questions on the sound environment during activity

1) The sounds that the teachers are concerned Are there any scenes where the sounds concern?
2) Voice of children Have you ever felt that children are noisy? / How do you respond when you feel that children are noisy? / Do children ever shout or use loud voice during the activity?
3) Instruction about children's voicing Do you teach children how to vocalize or sing? / When do you feel that children's vocalization is a problem? How do you respond then?
4) Vocalization of the preschool teacher Is there anything that you take care about with respect to vocalization? / Have you ever had specialized training for vocalization? / What kind of education did you receive on educational behavior?
5) Comparison with Japan Have you ever been concerned about with the reverberation of the classroom? / Do you adjust the environment considering the sound environment?

4.2 Survey results

The result of the interview is given in Tab. 5.

Table 5 – Sounds that teachers are concerned about and their responses

	◇The sounds that teachers are concerned about ▲Sounds pointed out by outsider	◎Educational behavior ＊Environmental modifications
A	◇Play sound when the children are not calm ◇Tidying up time ◇Behavioral sounds of autistic children ◇Sound of objects (especially the sound of wooden chairs and toys hitting wood floors)	◎Humming with commonly known songs to encourage children's independent behavior (e.g. cleaning up) ◎Talk privately to bustling children ◎Keep teacher's calm ◎Do not stop the behavior of disabled children ＊Set a calm lighting environment
B	◇Sound during indoor play when stress tends to build up, such as when it rains ▲Active play sound when outside playing (voices, laughter, etc.)	◎Teachers wait for lively children to notice group behavior first and talk to them individually if needed ＊Modify the hallway ceiling with sound-absorbing material so that it can be used as a active play space ＊Apply soundproofing measures to wheels of playground equipment (bicycles, etc.)
C	◇Crying voices ▲Excited voices when carrying pool outdoors	◎Respond individually to crying children ◎Talk with the children to calm them down when excited

At Preschool C, there was a tendency to generally accept the voice levels of the children, which is common in Japanese early childhood educational culture (2). In contrast, in Preschools A and B, it appeared that teachers thought that too much liveliness was an issue. In these preschools, teachers seemed to be involved with children who are talking loudly, such as waiting for their awareness or talking personally. In other words, even if the noise was caused by a child's voice, it was understood that teachers treated the voice as "noisy" when it was inappropriate; they would then show the child the desirable behavior.

At Preschool B, there was a case where teachers suggested modifying the sound absorption specification of the hallway so that it could be used for more noisy activities. Such vocal examples are rarely found in Japan. This indicates that the teacher recognized the importance of sound absorption. It was believed that this recognition might be because this teacher had experienced the effectiveness of high sound absorption efficiency and understood how a noisy environment can influence educational activities.

At Preschool A, which carries out Waldorf education, the importance of educator behavior, such as, “We try to create a sound environment that sounds can be transmitted as such,” or “Teachers should first appreciate the importance of remaining calm when speaking to children,” was discussed. The sound environment of Preschool A was calm, and it was an environment where each child's voice could be heard without sound mixed. It has been suggested that such environment helped the teacher to work better with children and deepen their play.

From these observations, it was found that teacher awareness of noise and their responses to the sounds generated by children differ between Germany and Japan. It is also believed that in Germany, there is a purposeful educational intent in controlling sound levels in the classroom so as to improve collaboration with the educational environment and other children.

5. CONCLUSIONS

In this study, we investigated the sound environment and teachers’ thought about sounds emitted by children in German preschools to identify how a more acoustically comfortable environment can be created. The German preschools were found to differ from Japanese preschools in aspects such as facility acoustic design, social systems, and early childhood educational culture. First, as described in our previous study (5), Germany has implemented a sound-absorption design requirement for indoor activity spaces in preschools. Because of this, not only acoustic experts but also preschool teachers recognize the need for sound absorption in teaching spaces. This recognition may be because noise disturbances and the associated negative effect on children’s activity are more noticeable once a calm, quieter, and higher-efficiency environment becomes the norm. An educational environment with better sound environment also allows the preschool teacher to be more aware of the disturbance by noise and long reverberation, and can help them to adjust their behavior appropriately. These approaches to mitigating preschool noise in areas of facility design, play equipment, furniture, etc. as well as teacher responses to sounds generated by children were implemented in the German preschools. As a result, the sound environment in the German preschools was quieter.

This study suggests that differences in preschool environmental standards and teacher behaviors are driven by differences in the cultural views of education and children; ultimately, this causes noise levels in the preschools to be different. This study also suggests that a proper acoustic environment improves human awareness and leads to the creation of a better educational environment.

Finally, in Germany, while the voices of children are legally not considered noise, this does not mean that disruptively loud voices should be accepted; it only means that the normal activities of children (and associated noise) should not be limited. That the liveliness of the children should be tolerated was likely determined by professionals of early childhood education. Therefore, to create a better sound environment for children in Japanese preschools, we are now working on the development of acoustic performance standards. Future research is expected to include expanding discussions on the sounds emitted by children in the field of early childhood education.

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