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CHILDREN'S ACOUSTIC PERCEPTION OF SOUNDSCAPES IN PRIMARY SCHOOL CLASSROOMS: DEVELOPMENT OF A PICTORIAL SCALE

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Abstract

Designing supportive and comfortable learning spaces requires an understanding of how children perceive their classroom sound environment. While research on classroom acoustics has traditionally focused on objective parameters, studies addressing children's perceptual responses remain limited and methodologically unclear, due to the frequent use of attributes adapted from adult-oriented questionnaires, along with heterogeneous scales. This paper presents the development of a child-centered questionnaire for assessing acoustic perception in primary school classrooms. The study employed a multi-stage approach to ensure age appropriateness. A set of perceptual attributes was initially identified through a systematic literature review and subsequently refined through focus group discussions with children. This process ensured that the attributes reflected children's own language and experiential understanding. A semantic differential scale was created by organizing the final set of attributes into 32 bipolar pairs. A 9-point rating scale was developed, combining visual anchors, verbal descriptors, and illustrative characters to support comprehension across different age groups. The use of pictorial elements enhances engagement and facilitates more reliable responses from younger children. The resulting questionnaire provides the basis for the development of a classroom soundscape model, serving as a structured and accessible tool for capturing children's perceptions of classroom sound environments.

Keywords: *primary school children, pictorial questionnaires, perceptual attributes, classroom acoustics.*

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1. Introduction

The evaluation of sound environments has increasingly moved beyond the use of objective parameters alone towards a perceptual, soundscape-based approach that considers how sound is perceived and experienced by individuals within a given context [1], [2]. Within this approach, an acoustic environment cannot be characterized through objective metrics alone but must also account for perceptual and affective responses such as comfort, annoyance, and restoration.

Although soundscape research has advanced in recent years, its application to indoor environments, and to educational settings in particular, remains limited [3],[4]. Recent school-based studies have begun to examine indoor soundscapes and their impact on children [5], [6], yet most rely on methodologies developed for adults, which may not transfer directly to younger populations [7], [8]. Children's interpretation of sound is shaped by developmental factors including attention, language comprehension, and emotional processing so capturing their perspectives requires age-appropriate, child-centered methods that let them express their experiences in ways aligned with their capabilities [9], [10].

Among subjective assessment methods, including interviews, focus groups, and questionnaires, questionnaires are widely used to capture children's perceptual responses in a systematic and structured way [11], [12]. Their use is particularly relevant in classroom acoustics, as children's perceptions of the sound environment may be associated with concentration, comfort, and overall learning experience [7]. Nevertheless, the reliability of the resulting data depends on whether the questionnaire is appropriate for the respondents' age, cognitive development, language skills, and response capabilities. The development of age-appropriate perceptual attributes and accessible response formats is therefore essential for obtaining

meaningful evaluations of classroom soundscapes from children.

Against this background, this study was conducted as part of the SOUNDkids project, which investigates children's perceptions of primary school classroom environments. The study aimed to develop a child-centered questionnaire for the assessment of classroom soundscapes by children aged 6–12 years. The questionnaire comprises a set of perceptual attributes and an accessible rating scale specifically designed for this age group. Its development followed a multi-stage process. First, a systematic literature review was conducted to identify perceptual attributes relevant to classroom soundscapes [13]. These attributes were subsequently refined through focus-group discussions with primary school children [14]. Finally, the response scale and its visual representation were designed to facilitate comprehension and use across the target age range.

2. Selection of Perceptual Attributes

2.1 Literature Review

A list of 55 perceptual attributes was identified through a systematic review of 32 literature studies [13], [15]. The review followed a systematic protocol conducted in accordance with the PRISMA guidelines. Three databases were searched, Scopus, APA PsycINFO, and Web of Science, with the search first run in January 2025 and updated in May 2026. Eligible studies were English-language journal articles and conference papers published after 1990 that involved primary school children aged 6–12 (studies with broader age ranges were also retained when at least 75% of participants fell within this range). Studies were included if they were conducted in primary school or laboratory settings recreating such environments, assessed children's perception of the classroom/school's indoor sound environment, or examined the effects of sound on children's well-being and restoration. Studies were excluded if they focused exclusively on children outside the 6–12 range; on children with hearing impairments, other sensory disabilities, or neurodivergent conditions; reported only objective acoustic measurements without subjective evaluations by children; were based on online or virtual learning environments; or reported duplicate results, lacked full-text availability, or gave incomplete documentation. The identified attributes were synthesized into 12 macro-categories spanning over sensory, affective, cognitive, and behavioral responses. Examples of the resulting macro-categories include loudness, speech perception, effects on performance, perceived control, affective responses and social interaction. Overall, it was found to have a predominance of negative and performance-related attributes, and limited consideration of positive dimensions. Moreover, most of the attributes were adapted from adult-oriented frameworks rather than being developed specifically for primary school children.

2.2 Focus Group with Children

To ensure age-appropriate terminology and contextual relevance, focus group discussions were conducted with primary school children aged 6–12 years [14]. These sessions were designed to explore how children perceive, interpret, and describe classroom sound environments using their own language. Participants were encouraged to identify the sounds they commonly experience in the classroom, describe these sounds in their own words, and reflect on how such sound environments influence their feelings and preferences.

This process enabled the identification of perceptual attributes grounded in children's lived experiences, while also highlighting several misalignments with the adult-derived terminology obtained from the literature review. Children contributed attributes that were absent from the adult set, for example, mapping loudness onto physical size or tempo (e.g. "small" vs. "large", "slow" vs. "gentle"), reporting embodied reactions ("head hurting", "ear hurting"), and framing restoration through familiarity and connection to their surroundings ("wanting to connect to the outside"). Notably, they expressed perceived control not as an abstract attribute but through actions such as "opening a window" to let in nature sounds, or "closing the classroom doors" after lunch to keep noise out whereas several adult-defined terms (e.g., "monotonous", "intrusive", "uneventful") did not surface in the children's own accounts.

2.3 Scale design and rating format

Within perceptual assessment frameworks, Semantic Differential Scales (SDS), in which participants rate stimuli along bipolar pairs of contrasting attributes, are widely used to capture multi-dimensional perceptual dimensions in a structured manner [16]. Presenting attributes as opposites provides an intuitive response format that reduces ambiguity and simplifies the evaluation task, which is particularly beneficial when working with children [6]. Accordingly, it was chosen to organize the selected attributes into contrasting pairs, as described below.

The 55 attributes from the literature review were combined with 20 emerging from the focus groups and systematically refined. The refinement process involved removing redundant or overlapping attributes, simplifying complex or abstract terminology. To preserve age-appropriate wording, the attributes were adopted directly from the child-oriented questionnaire items identified in the reviewed studies [13[. This phase resulted in a final list of 64 attributes, which was structured into 32 contrasting pairs. The number of attribute pairs was also carefully considered to strike a balance between comprehensiveness and feasibility, in order to limit the overall duration of the experiment and the associated fatigue, particularly for younger participants. A similar paired-attribute approach has been successfully applied and validated with even younger children by Ma et al. [6] in their study on preschool children's sound perception.

Examples of pairs of attributes, organized according to the macro-categories identified in the review, are:

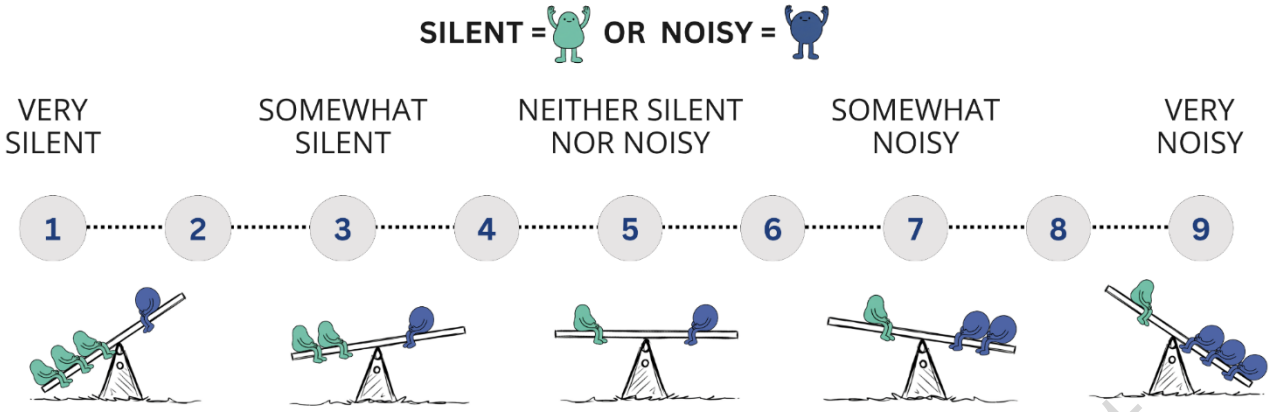

Figure 1: 9-point rating scale with visual and verbal anchors, along with illustrative characters representing each bipolar attribute

Loudness (e.g., Silent – Noisy), *Restoration* (e.g., Relaxing – Stressful), *Speech Perception* (e.g., Clear to hear or understand speech – Unclear to hear or understand speech), *Effects on Performance* (e.g., Helping you concentrate – Making it hard to concentrate), *Perceived Control* (e.g., Making you feel in control – Making you feel helpless), *Affective Responses* (e.g., Happy – Sad) and *Social Interaction* (e.g., Makes you want to be with others – Makes you want to be alone). Beyond these categories of attributes identified based on the literature review, the focus group analysis revealed additional categories such as: *Spatial aspects* (e.g., Small – Large), *Physical Responses* (e.g., Feels soothing to your body – Feels painful to your body) or *Familiarity and Expectation* (e.g., Expected – Unexpected), which were particularly prominent in children's responses.

3. Development of the pictorial scale

Questionnaire formats developed for adults often rely on abstract language, complex wording, or purely numerical scales that are difficult for children to interpret [20]. Recent studies therefore incorporate visual and pictorial elements into questionnaire design [5],[6]. Pictorial scales and visual supports improve comprehension, reduce cognitive load, and increase engagement, enabling children to respond more accurately and independently [17], [18], [19], while pairing verbal anchors with a numerical scale enhances interpretability and response consistency, particularly in younger children [11], [12].

The number of response options represents a further important design consideration. Reviews of self-report scales for children indicate that younger children can reliably distinguish only a limited number of categories. For example, Coombes et al. [20] recommend a dichotomous format for ages 5–7 and a three-point format from age 7 onward, and Mellor and Moore [21] similarly caution against overly fine scales for children. Nevertheless, five-point formats were the most adopted across the studies included in the review by [13]. At the same time, scales with more categories can improve sensitivity and allow finer perceptual discrimination, provided they are adequately supported by visual and verbal cues [12], [22].

Based on this literature, the study adopted a nine-point rating scale to allow children to express different degrees of perception between each pair of contrasting attributes. The scale was designed to provide sufficient sensitivity for perceptual differentiation while remaining accessible across the 6–12-year age range. To facilitate comprehension and consistent use, particularly among younger participants, each response category was supported by clear visual and verbal anchors.

3.1 Proposed Child-Centered Questionnaire

Figure 1 shows an example of the pictorial scale. A total of five visual anchors were distributed across the scale: two at the extreme ends representing each attribute, one at the neutral midpoint, and two intermediate anchors positioned between the extremes and the center. This structure was intended to guide children in distinguishing between different levels of perception, including strong, moderate, and neutral responses. These visual anchors were complemented by verbal markers at positions 1, 3, 5, 7, and 9, corresponding to "very," "somewhat," and "neither/nor" degrees. Specifically, the endpoints (1 and 9) indicated strong agreement with either attribute, positions 3 and 7 represented moderate agreement, and the midpoint (5) reflected a neutral or balanced perception. This combined visual–verbal approach was designed to enhance clarity and reduce ambiguity in children's responses.

In addition, characters were assigned to each attribute from the pair. These characters served as intuitive, child-friendly cues to reinforce the meaning of the contrasting attributes and to make the evaluation task more engaging and relatable.

3.2 Use of the response scale across age groups

The questionnaire was applied in an in-situ listening experiment at a primary school in Ferrara, Italy. A total of 116 children across Grades 1–5 (ages 6–10) took

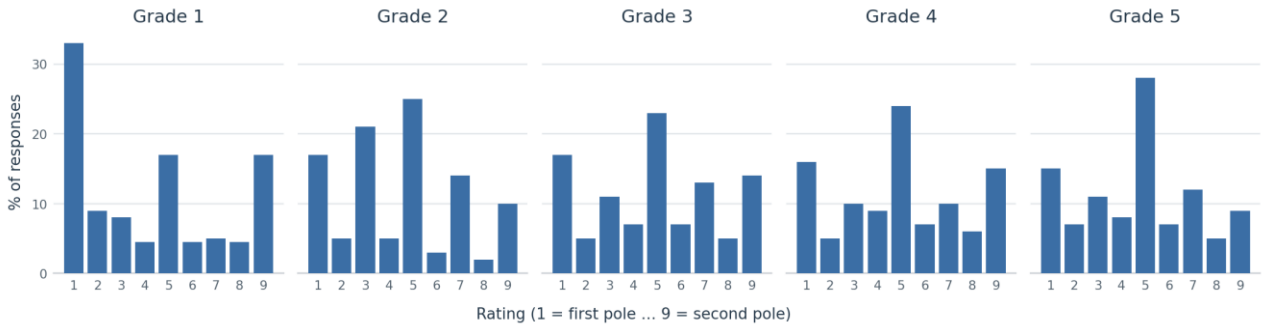

Figure 2: Distribution of responses across the 9-point scale for each grade (percentage of that grade's total responses, pooled across all attribute pairs and scenarios).

part during regular school hours, which preserved realistic acoustic and contextual conditions. Each child listened over headphones to a subset of 12 binaural recordings of different occupied-classroom scenarios and rated every scenario on the 32 bipolar attribute pairs using the 9-point pictorial scale as shown in Figure 1. The session was adapted across age groups by varying the number of scenarios assessed, to sustain engagement and limit fatigue, particularly among the youngest participants. The questionnaire was administered in English for all grades except in Italian for the youngest children (Grade 1). Moreover, researchers provided simultaneous Italian translations and clarifications to individual children whenever needed. Ethical approval for the study was obtained from the Ethics Committee of the Area Vasta Emilia Centro, Emilia-Romagna, Italy (CE-AVEC, protocol 712/2025/Sper/UniFe, 11 December 2025).

To examine how children of different ages used the response scale, the distribution of all ratings pooled across the 32 attribute pairs and the classroom scenarios were computed separately for each grade (Figure 2). A clear age-related shift in response style emerged. The youngest children (Grade 1) concentrated their answers at the two poles of the scale, selecting the extreme "1" in about 33% and the extreme "9" in about 17% of responses, while making little use of the intermediate points. From Grade 2 onward the intermediate categories began to be used, and from Grade 3 the full 9-point range was employed, with an increasing tendency to center responses on the neutral midpoint; by Grade 5 the poles were chosen in only about 15% ("1") and 9% ("9") of responses. The youngest children thus treated the fine-grained semantic-differential scale in a more categorical, near-binary way, and graded use of the scale matured with age. Moreover, across every grade the labelled positions (1, 3, 5, 7, 9) are used far more than the unlabeled ones (2, 4, 6, 8). Those were exactly the points where verbal and visual anchors were placed, this validates the use of verbal/visual anchors, as they guided the children's responses.

This methodological finding suggests a questionnaire design implication: for the youngest respondents a coarser response format (e.g. 3–5 points) may be more appropriate. Where a finer scale is retained for comparability across ages and that younger children's responses should be interpreted with their tendency toward extreme, categorical use. This pattern is consistent with the developmental literature on children's use of rating scales [12], [20], [21] and reinforces the value of the visual and verbal anchors built into the scale.

4. Concluding Remarks

This paper presented the development of a child-centered questionnaire for assessing primary school classroom soundscapes. Combining a systematic literature review with focus-group insights, 32 bipolar perceptual attribute pairs were defined and paired with a 9-point pictorial rating scale designed for children aged 6–12. The questionnaire was applied in an in-situ listening experiment using ecologically valid binaural classroom scenarios presented to the children via headphones. The resulting data is being analyzed to identify the perceptual dimensions underlying children's evaluations and to inform an indoor classroom soundscape model.

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References

[1] Ö. Axelsson, M. E. Nilsson, and B. Berglund, "A principal components model of soundscape perception," *J. Acoust. Soc. Am.*, vol. 128, no. 5, pp. 2836–2846, 2010.

[2] J. Kang, F. Aletta, T. T. Gjestland, L. A. Brown, D. Botteldooren, B. Schulte-Fortkamp, et al., "Ten questions on the soundscapes of the built environment," *Building and Environment*, vol. 108, pp. 284–294, 2016.

[3] S. Torresin, R. Albatici, F. Aletta, F. Babich, and J. Kang, "Assessment methods and factors determining positive indoor soundscapes in

residential buildings: A systematic review," *Sustainability*, vol. 11, no. 19, art. 5290, 2019.

[4] F. Aletta and J. Kang, "Promoting healthy and supportive acoustic environments: Going beyond the quietness," *Int. J. Environ. Res. Public Health*, vol. 16, no. 24, art. 4988, 2019.

[5] C. Visentin, S. Torresin, M. Pellegatti, and N. Prodi, "Indoor soundscape in primary school classrooms," *J. Acoust. Soc. Am.*, vol. 154, no. 3, pp. 1813–1826, 2023.

[6] H. Ma, H. Su, and J. Cui, "Characterization of soundscape perception of preschool children," *Building and Environment*, vol. 214, art. 108921, 2022.

[7] M. Klatte, J. Hellbrück, J. Seidel, and P. Leistner, "Effects of classroom acoustics on performance and well-being in elementary school children: A field study," *Environment and Behavior*, vol. 42, no. 5, pp. 659–692, 2010.

[8] J. Einarsdóttir, "Research with children: Methodological and ethical challenges," *European Early Childhood Education Research Journal*, vol. 15, no. 2, pp. 197–211, 2007.

[9] M. Fargas-Malet, D. McSherry, E. Larkin, and C. Robinson, "Research with children: Methodological issues and innovative techniques," *Journal of Early Childhood Research*, vol. 8, no. 2, pp. 175–192, 2010.

[10] T. Ragelienė, "Reviewing methodological approaches for research with children in the social sciences: Strengths, challenges, and considerations," *Child Indicators Research*, pp. 1–43, 2026.

[11] N. Borgers, J. Hox, and D. Sikkel, "Response quality in survey research with children and adolescents: The effect of labeled response options and vague quantifiers," *Int. J. Public Opinion Research*, vol. 15, no. 1, pp. 83–94, 2003.

[12] N. Borgers, D. Sikkel, and J. Hox, "Response effects in surveys on children and adolescents: The effect of number of response options, negative wording, and neutral mid-point," *Quality and Quantity*, vol. 38, no. 1, pp. 17–33, 2004.

[13] C. Visentin, S. Syed, and S. Torresin, "Towards a child-centred perspective on classroom acoustics: A systematic review of perceptual attributes, methods and contextual drivers," *Applied Acoustics, **254**, 111471.*

[14] S. Syed, S. Torresin, and C. Visentin, "Investigation perception of children in primary school classrooms: A thematic analysis," in *Proc. Forum Acusticum 2026*, 2026.

[15] S. Syed, S. Torresin, and C. Visentin, "A systematic review of perceptual attributes for indoor soundscape assessment in primary school classrooms," in *Proc. Forum Acusticum–Euronoise 2025 (11th Convention of the European Acoustics Association)*, 2025, pp. 4897–4904.

[16] B. C. Wesolowski and D. J. Musselwhite, *The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation*. Thousand Oaks, CA: SAGE, 2018.

[17] J. C. Read and S. MacFarlane, "Using the fun toolkit and other survey methods to gather opinions in child computer interaction," in *Proc. 2006 Conf. on Interaction Design and Children*, 2006, pp. 81–88.

[18] T. C. W. Tang, M. Wong, J. B. Li, and D. K. C. Chan, "Pictures versus words: Can we use a pictorial scale to measure child health-related quality of life?," *Frontiers in Public Health*, vol. 12, art. 1398944, 2024.

[19] A. Plava, "Tailor-made for children. Designing a pictorial questionnaire to explore eating habits, lifestyle, and body perception," *Quality & Quantity*, pp. 1–26, 2025.

[20] L. Coombes, K. Bristowe, C. Ellis-Smith, J. Aworinde, L. K. Fraser, J. Downing, et al., "Enhancing validity, reliability and participation in self-reported health outcome measurement for children and young people: A systematic review of recall period, response scale format, and administration modality," *Quality of Life Research*, vol. 30, no. 7, pp. 1803–1832, 2021.

[21] D. Mellor and K. A. Moore, "The use of Likert scales with children," *Journal of Pediatric Psychology*, vol. 39, no. 3, pp. 369–379, 2014.

[22] Ü. Alan and K. A. Kabasakal, "Effect of number of response options on the psychometric properties of Likert-type scales used with children," *Studies in Educational Evaluation*, vol. 66, art. 100895, 2020.