Inclusive Soundscapes: systems for an accessible performance

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Abstract

This article explores multimodal communication in inclusive performative contexts, focusing on the potential of interactive systems for children with Special Educational Needs and Disabilities (SEND). Drawing on a theoretical framework that integrates the concepts of multimodality, new media, and inclusive education, it analyses the implementation of an interactive sound performance in an educational setting involving functional diversity. The performance, based on digital and sensory technologies, aims to provide accessible, adaptable, and cognitively stimulating artistic experiences, promoting the active participation of children with diverse sensory and motor profiles. The description of the performative system is accompanied by a critical reflection on the principles of accessibility, individualisation, and participation, grounded in direct observations and testimonials collected during its application. The results suggest that the combination of sound art, technology, and inclusive interactive design may represent a relevant pathway for the development of more equitable educational and performative practices. The article thus highlights the role of multimodality as a tool for artistic mediation and social inclusion.

CCS Concepts

• **Human-centered computing** → Accessibility; Accessibility systems and tools; Accessibility; Accessibility technologies; Human computer interaction (HCI); • **Applied computing** → Arts and humanities; Sound and music computing; • **Social and professional topics** → Professional topics; Computing industry; Sustainability.

Keywords

Biossonification, EEG, Inclusive, MAD Clarinet, PolySonicBRAIN, SEND

ACM Reference Format:
Rui Travasso, André Conde, and Marco Miranda. 2025. Inclusive Soundscapes: systems for an accessible performance. In *12th International Conference on Digital and Interactive Arts: Media Art Cultures, Communities & Territories (ARTECH 2025), November 26–28, 2025, Braga, Portugal*. ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3773699.3774366

ARTECH 2025, Braga, Portugal

ACM ISBN 979-8-4007-2001-7/2025/11
https://doi.org/10.1145/3773699.3774366

1 Introduction

Communication is an essentially multimodal process, involving a multiplicity of sensory channels that enrich the transmission and interpretation of messages. When translated into technological systems, this multimodality can acquire new expressive dimensions, particularly in performative contexts. This article is based on the hypothesis that interactive systems grounded in digital technology can serve as effective mediators of artistic communication for children with Special Educational Needs (SEN), enabling them to explore alternative forms of expression and sensory participation. The growing recognition of the importance of inclusion within the field of arts education demands the development of approaches that transcend standardised pedagogical models, favouring accessible, adaptive practices that are sensitive to functional diversity. Within this framework, the creation of performative systems that integrate sound, gesture, image, and physical interaction can serve as a bridge between art and inclusion, fostering meaningful and individualised experiences.

This article aims to analyse, based on a theoretical foundation centred on multimodality, new media, and inclusive education, the implementation of an interactive sound performance designed for children with SEND. The analysis combines a description of the developed system, direct observation, and testimonials collected during its implementation, discussing the role of technology as a facilitator of artistic participation and sensory engagement. The article is structured into three main sections: a theoretical review of the central concepts; the presentation of the performative system and its application context; and a final reflection on the pedagogical and inclusive implications of the experience, including the analysis of a questionnaire administered to participants. Finally, it is worth noting that the performances analysed were conducted at the Irene Rolo Foundation, an institution based in Tavira (Portugal) with extensive experience in training, empowerment, and support for people with SEN. Founded in 1982, the Foundation is widely recognised for its work in promoting the social and artistic inclusion of individuals with functional diversity [8].

1.1 Methodology

This article adopts a mixed-methods approach, integrating an exploratory case study as defined by Yin [25], and aligned with the methodological guidelines proposed by Benbasat et al. [2]. This approach allows for the analysis of a phenomenon within its natural setting, without manipulation of variables, drawing on multiple sources of evidence, namely interactive performances, direct observations, and surveys administered to participants and their caregivers. The application of the case study method is particularly appropriate for investigating contemporary phenomena situated in real-world contexts, especially when the boundaries between the phenomenon under study and the context in which it occurs are not clearly defined. As argued by Yin [25] and Benbasat et al. [2], this mixed methodology enables in-depth examination of agents and processes, allowing for the exploration of complexity and the production of knowledge through empirical inquiry, data categorisation, and the preliminary formulation of interpretative hypotheses.

The research focuses on contemporary events, and the researchers assume an active role in both data collection and interpretation, within an epistemological framework that acknowledges the significance of interpretation in the study of social and cultural phenomena. The literature review thus plays a structuring role, providing the conceptual foundations on multimodal communication, bio-sonification, and inclusive design that guide the empirical analysis and support the construction of the study's theoretical framework. Finally, regarding the survey, it was designed to be accessible — using clear questions and emojis — so that individuals with SEND could respond to it, which they did after the performance, accompanied and supported by their educators.

1.2 Investigative Objectives

This research is guided by a central question that informs the exploratory case study: to what extent can the integration of interactive digital devices in performative environments enhance the sensory and emotional engagement of individuals with Special Educational Needs and Disabilities (SEND). Based on this question, the research team formulated a set of preliminary propositions to guide the qualitative analysis and interpretation of the collected data. It is assumed that the use of audience-oriented interactive systems provides stimulating sensory experiences for individuals with SEND, fostering their active engagement in the performative space. It is further assumed that the incorporation of non-evident biological elements, such as plants — which do not naturally produce audible sound — when digitally augmented, generates unexpected stimuli that awaken curiosity and promote participation. Lastly, it is considered that the interactive and responsive nature of these systems can trigger moments of autonomy and self-expression among participants with SEND, even within contexts mediated by educators and facilitators. These propositions reflect the epistemological stance of the research team, which views technology as a means to expand sensory experience, rather than an end in itself. The case study analysis will thus explore the extent to which these propositions are reflected in practice and how they may contribute to the design of inclusive artistic environments.

2 Literature Review

This article, while addressing interactive systems, focuses on their function as multimodal communication devices designed for individuals with Special Educational Needs and Disabilities (SEND), rather than on the technical aspects of innovation. For this reason, the literature review will centre on the concepts of multimodal communication, the definition of SEND, and projects that operate directly at this intersection.

2.1 Multimodal Communication

Multimodal communication is not a recent concept, as face-to-face dialogue between people naturally involves multiple communicative channels such as body movement, facial expressions, vocal intonation, and gestures, which complement and enrich verbal language [11]. In contemporary contexts associated with computational systems, a multimodal communication system is one that integrates a Human–Computer Interaction (HCI) interface, enabling the interpretation of multiple sensory stimuli and communication channels. These systems typically involve various modes of interaction — such as speech, writing, touch, gestures, gaze, and body movements — whose responses may be translated into different forms of digital media. What distinguishes such systems is the fusion of data from different sensory channels and their ability to process this information in real time [4]. Consequently, multimodal communication privileges the sensory and semiotic dimensions, allowing receivers to draw upon diverse cognitive and sensory capabilities in the decoding of messages [9]. Following McLuhan's distinction between hot and cool media [15], technological multimodal systems — by requiring greater participation from the receiver and articulating multiple sensory layers — may be understood as cool media, demanding more interpretive effort and thereby activating semiotic processing more intensely.

Technological multimodal communication — the central focus of this article — aligns closely with the principles for new media outlined by Manovich [14], including: numerical representation — the computer as a core element and digital medium in multimodal communication; modularity — the decomposition of communication into independent components; automation — incorporating some degree of autonomous behaviour; variability — interactions leading to different outcomes; and transcoding — the coexistence and interpretability of multiple formats. Thus, it can be affirmed that technological multimodal communication, as explored in this article, is fully embedded within the framework of new media.

In the musical domain, the experience of live performances is often inherently multimodal, as music communicates not only through sound but also through contextual, social, and aesthetic relations. Even in the absence of verbal elements, a musical work can acquire multiple meanings depending on the context and audience. For instance, a national anthem is highly contextualised and carries a socially shared meaning, whereas a contemporary instrumental piece may allow for more open interpretations. In such cases, multimodality operates across different layers — rhythm, timbre, image, text, colour, among others — which the receiver integrates individually, constructing their own meanings [9, 24]. It is precisely in this capacity to generate meaning through the interaction of sensory layers that multimodal systems reveal great potential for audiences with SEND, by enabling artistic experiences that are accessible, adaptable, and cognitively stimulating [1].

2.2 Characterisation of SEND

Special Education and Special Educational Needs and Disabilities (SEND) encompass a wide range of conditions that may affect children's learning and full participation in traditional educational contexts. The Salamanca Statement and Framework for Action on

Special Needs Education, adopted in 1994, advocate for the universal right to education, with particular emphasis on children with disabilities. This document promotes inclusive education as an essential means to foster diversity and equity within the educational system. According to UNESCO [23], responding to the educational needs of students with disabilities is not only a fundamental human right but also an ethical imperative, requiring the creation of inclusive learning environments that are adaptable to students' diverse needs. Although this article does not focus directly on formal education, the principles outlined are equally applicable to the arts, where inclusion should be seen as transversal and integrative.

Earle and Curry [5] identify a broad range of special needs, including: Asperger syndrome, attention deficit, autism spectrum disorders, behavioural, emotional and social difficulties, cerebral palsy, Down syndrome, fragile X syndrome, moderate learning difficulties, physical disabilities, semantic–pragmatic disorders, sensory deficits, visual impairment, multisensory impairment, severe or multiple learning difficulties, dyslexia, dyscalculia, dyspraxia, speech, language and communication difficulties, and Tourette syndrome. In this context, it is essential to ensure that artistic and performative environments are accessible, recognising human plurality and promoting communication that can be individually decoded, while preserving the integrity and quality of the artistic experience. This requires the development of strategies that dismantle barriers, fostering inclusive and adaptive performative practices.

Katz and Mirenda [10] highlight that the inclusion of students with SEND in small groups - as opposed to whole-class settings - significantly enhances their participation and learning, exposing by contrast the limitations of traditional approaches, especially in large-group settings. Inclusive strategies prove more effective when implemented in smaller environments, where content can be more sensitively tailored to students' specific needs. The presence of educational assistants is also essential to ensure the necessary support, particularly in contexts with lower participant density [3, 13, 18, 20].

2.3 Artistic and Technological Projects with Children with SEND

The combination of technology and sound art can transform the way children with Special Educational Needs and Disabilities (SEND) interact with sound, music, and society as a whole. An example of social inclusion through interactive sonic systems is offered by Drake Music Scotland [1] and the Drake Music Project Northern Ireland [2], which promote musical inclusion through the use of devices such as EyeGaze, touchscreens, and adapted interfaces. These technologies empower children and young people with SEND to compose and perform music. These projects demonstrate that the sensitive adaptation of musical technologies, combined with inclusive pedagogical practices and meaningful interaction between tutors, participants, and devices, serves as a powerful system for enabling active participation and collective creation by individuals with SEND. Another inclusive initiative is the Paramusical Ensemble [6], system that uses brain–computer interfaces to enable individuals with cerebral palsy to compose musical scores based on their neural activity, which are then performed in real time by a string quartet. A further example is the project by Anders Lind [12], which, although not specifically designed for individuals with SEND, proposes a colour-based musical notation system that is fully functional and adaptable to anyone, requiring no prior musical knowledge. Many other examples could be cited; however, the projects presented here sufficiently illustrate that technology — when combined with sensory stimulation and interactive design — can open up new pathways for communication.

3 Performance context

The performance under analysis involved three musicians, each equipped with a distinct interactive sonic device[3]. Although designed to function autonomously, these systems were integrated into a collective performance in which the musicians, rather than relying solely on their traditional instruments, explored an expanded range of sonic possibilities mediated by autonomous computational components that had been pre-configured. Each of the three devices will be described in the following subsections. It is important to note, however, that at a specific moment in the performance — common to all three sessions held — all students were given the opportunity to engage in interaction through bio-sonification, while some also interacted with the EEG-based system. The use of the latter was limited due to technical constraints, equipment availability, and hygiene considerations related to the physical contact required by the sensors. From a performative standpoint, these interactions added an expressive layer to the performance, contributing to a descriptive sonic environment in which the interplay between environmental, instrumental, and computationally generated sounds played a central role.

3.1 MAD Clarinet 3.1, New Set

MAD Clarinet [21, 22], is a performative system that takes the clarinet as its starting point and catalytic agent, integrating it with a computational component in constant evolution. The version used in this context explores the technological dimension as a means of sonic augmentation and as an autonomous partner in performance. The system combined two software platforms — Max/MSP and Logic Pro — interconnected via Loopback. The latter enabled the creation of multiple virtual audio channels, overcoming previous limitations in the separation of sound sources. The autonomous component, developed in Max/MSP, included three main functionalities: (1) a patch based on the *ml.markov* library, which captured pitch and duration from the clarinet to generate real-time sonic responses; (2) a continuous sine wave module with frequency controlled in hertz (Hz); and (3) a sequencer with adjustable parameters, allowing manipulation of the structure and density of the sonic output. Logic Pro, in turn, received the signals from Max/MSP and processed them with acoustic effects, timbral extensions, and real-time melodic transformations. It also functioned as a player for pre-prepared samplers, further expanding the sonic palette of the performance.

From an instrumental standpoint, a hybrid MIDI controller (with keyboard and launch pads) was used to trigger samplers and specific functions in both software environments. The clarinet was captured using a piezoelectric microphone installed on the barrel, connected

[1]https://drakemusicscotland.org/ accessed July 13, 2025.
[2]https://drakemusicni.com/ accessed July 13, 2025.
[3]https://postimg.cc/gallery/DK3gZRW accessed July 14, 2025.

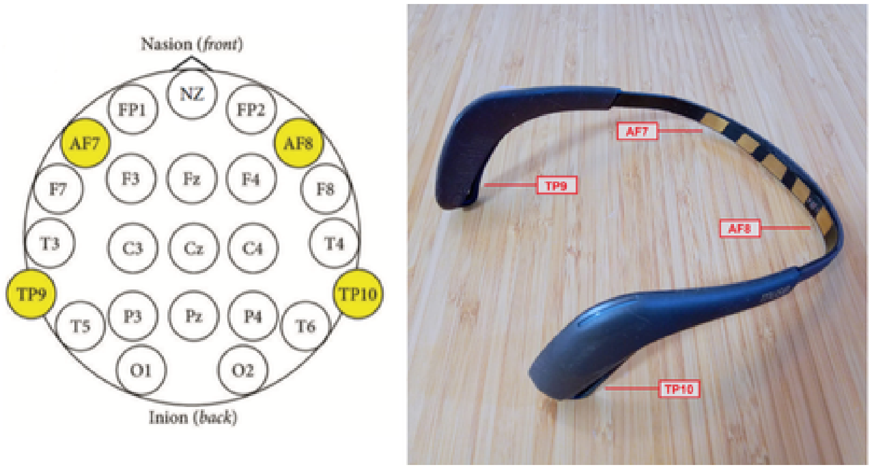

Figure 1: Electrodes position and Muse 2 headband

to an audio interface with output to an active speaker. Although incorporating a Human–Computer Interaction (HCI) component, this was accessible only to the performer, enabling the combination of traditional instrumental gesture with dynamic digital sonic responses. The resulting setup created an expressive performative environment, adaptable to the sensory participation context, in which sonic and visual elements converged in an integrated manner.

3.2 PolySonicBRAIN (v2.0.0-beta) - EEG Acquisition, Software Pipeline & Mapping Strategies (EEG → MIDI)

The PolySonicBRAIN system integrates real-time EEG signals into the construction of interactive sonic environments, exploring the potential of Brain–Computer Musical Interfaces (BCMIs) within inclusive performative contexts. Specifically, it enabled the active participation of several students with Special Educational Needs and Disabilities (SEND), who interacted directly with the performance by modulating sound using their own brain activity. Building upon previous research [7, 16], the system captures alpha-band brainwave oscillations (8–12 Hz), which are associated with states of attention and relaxation, transforming them into MIDI data that control sound synthesis parameters. EEG acquisition is carried out using a Muse 2 headband, equipped with four dry electrodes (AF7, AF8, TP9, and TP10) (Figure 1), which communicates via Bluetooth with a laptop. The BlueMuse [4] software streams the EEG data in real time using the Lab Streaming Layer (LSL) protocol.

Signal processing is handled in the BrainBay[5] environment through a custom patch performing three main operations: (1) band-pass filtering centred on 10 Hz, with amplification of alpha activity; (2) smoothing of the amplitude envelope using a moving average to eliminate abrupt fluctuations; and (3) continuous emission of MIDI messages, distributed across two channels, which control real-time synthesis and musical sequencing parameters (see Figure 2). This patch ensures low latency and also provides graphical visualisation of the EEG data through 3D spectra and real-time animations, offering continuous feedback to both the performer and facilitators.

The MIDI data generated coexist with the live performance on Portuguese guitar, which is equipped with a piezoelectric pickup connected to a Korg AX30G multi-effects pedal. The use of chorus, delay, reverb, and modulation effects creates sonic textures that engage in dialogue with the sonification of brainwaves, enabling the performer to explore both traditional repertoires and more experimental timbral zones. The combination of external instrumental gesture with internal sonic response generates a hybrid and sensorially rich environment, in which interaction with participants with SEND acquires an artistic and emotionally meaningful dimension.

The articulation between brainwave sonification and instrumental expression not only provided a unique aesthetic experience but also proved effective in the sensory and emotional activation of participants, reinforcing the potential of BCMIs in inclusive performative practices.

3.3 Plant Music - Acquisition, Software Pipeline & Mapping Strategies

The Plant Music performative system explores the bioelectrical activity of living plants as a real-time sound source, bringing together nature, technology, and interactive musical creation. Although plants do not possess a nervous system, they emit electrical signals in response to environmental stimuli such as light, temperature, or touch. These signals, captured using conductive clips placed on leaves or stems, were amplified with the Symbiotic Biodata device and converted into digital data transmitted via MIDI to a sound creation environment. The system integrated an Arturia Minifuse audio interface, Logic Pro software for sound processing and effects, and the Playtronica sensor, which introduced a tactile and interactive dimension. The bioelectrical data were mapped onto sonic parameters such as pitch, timbre, and rhythm, allowing the generation of musical patterns directly influenced by the plant's physiological state. This process was complemented by a trombone

[4]https://github.com/kowalej/BlueMuse accessed July 15, 2025.
[5]https://github.com/ChrisVeigl/BrainBay/releases accessed July 15, 2025.

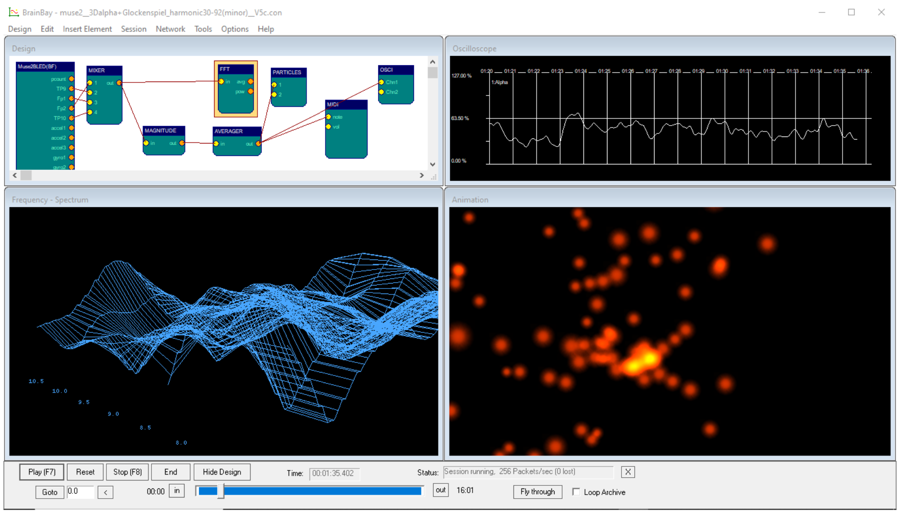

Figure 2: BrainBay

performance, using a Yamaha Silent Brass system connected to a Digitech RP360 XP effects pedal. The trombone sounds were manipulated in real time and integrated into a Boss RC-600 loop station.

The entire performance was amplified through a SONAR 12Xi portable speaker, enabling immersive listening in both indoor and outdoor spaces. The combination of plant bioelectrical activity, human instrumental gesture, and digital sound manipulation created a hybrid and sensorially rich experience in which the boundary between performer and living organism became fluid. Importantly, this performative system allowed all audience members — one at a time — to sonically interact with the performance by physically touching the plant and influencing the sound generation in real time. This dynamic proved particularly effective in the sensory activation and emotional engagement of participants, especially individuals with Special Educational Needs and Disabilities (SEND), offering them an alternative, accessible, and meaningful form of artistic expression.

4 Questionnaire

A questionnaire with two distinct branches was administered, designed to address both the students with Special Educational Needs and Disabilities (SEND) and the psychologist responsible for the group's support. Both versions began with a delimiting question to identify the respondent's profile — whether they were a student or a technical/educational staff member. The version designed for students employed simplified language and visual support through emojis, in order to facilitate comprehension and encourage responses. It included four questions: two closed-ended (yes / no / maybe) and two multiple-choice questions focused on the emotional and sensory experience during the performance. This structure aimed to ensure cognitive accessibility and foster the affective expression of participants, drawing on best practices in inclusive assessment. The branch addressed to the psychologist followed a more analytical structure and it was composed by five questions: two multiple-choice questions, one Likert scale item, one closed-ended question (yes / no / maybe), and one optional open-ended question to gather qualitative observations on the impact of the experience on the students.

The questionnaire was administered at the end of each of the three performance sessions, in a calm environment and with the support of specialised staff, ensuring that participants were in a suitable state for reflection and expression. It was conducted in digital format, with direct support provided to students, allowing for greater flexibility and individual assistance.

From an ethical standpoint, the process ensured informed consent from responsible institutions, confidentiality of responses, and respect for the cognitive specificities of the participants. The collaboration of the psychologist and staff members was crucial for the linguistic and visual adaptation of the content. Although the sample size was small and the performance setting emotionally engaging, the data obtained provide a meaningful basis for reflecting on the sensory, expressive, and inclusive impact of the artistic experience on participants with SEND. Figure 3 presents a summary of the questionnaire structure.

4.1 Sample Characterisation

The sample in this study consisted of a total of 17 participants, distributed across three distinct sessions, which were organised to maintain small groups and ensure closer and more controlled interaction. Sixteen students with Special Educational Needs and Disabilities (SEND), aged between 22 and 64, participated, along with one specialised professional — the institution's psychologist — who accompanied the students throughout the entire process. The students presented diverse cognitive and functional profiles, including conditions such as autism spectrum disorders, mild to moderate intellectual disabilities, communication difficulties, and global developmental disorders. This diversity allowed for the observation of differentiated responses to the performative experience, particularly in terms of sensory, emotional, and expressive engagement. As previously mentioned, the sessions were held at the facilities of

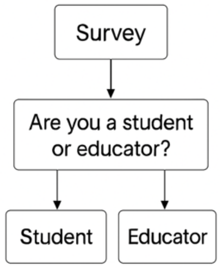

Figure 3: Questionnaire branches

the Irene Rolo Foundation in Tavira (Portugal), in a space adapted to the needs of the participants, and each session lasted approximately 30 minutes. The small-group format allowed for individualised support and more accurate data collection, while respecting the communication rhythms and modes of each participant.

5 Results and Discussion: Sensory and Expressive Impact

This section presents a self-analysis of the performances by the authors, along with an examination of the questionnaire results completed by the participants.

5.1 Self-Analysis

The authors reflected on the creative process and aesthetic decisions, emphasising that music is widely recognised for its therapeutic and cognitive potential in SEND contexts. Building on that foundation, the project's aesthetic proposal aimed to promote empowerment, sensory engagement, and social inclusion — objectives clearly outlined in the initial plans.

It was observed that students primarily responded to the sonic elements, interaction, and visual stimuli, confirming the multimodal effectiveness of the performance. During the sessions, many participants communicated non-verbally and expressed curiosity and surprise at the sounds produced. Most of them reported positive emotions (e.g., "happy", "surprised") and expressed a desire to repeat the experience. These preliminary results suggest that the multimodal activity supported moments of autonomy and expressiveness among the students. Notable moments included interactions in which environmental or musical sounds were triggered by the students, establishing playful dialogues between music and nature. For example, one student smiled upon hearing sounds emanating from the plants, highlighting the emergence of unexpected sensory connections. In short, the multimodal integration fostered student expression and autonomy, aligning with the idea that inclusive bio-sonic environments enhance sensory participation in both artistic and educational contexts.

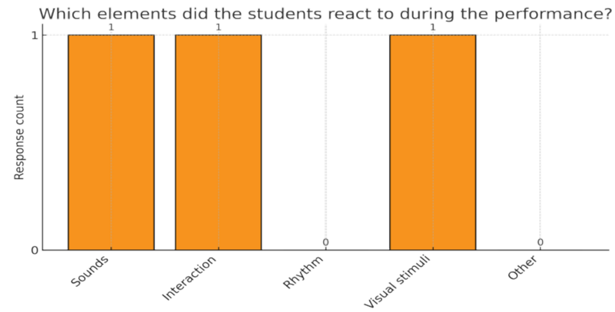

Figure 4: Question 1

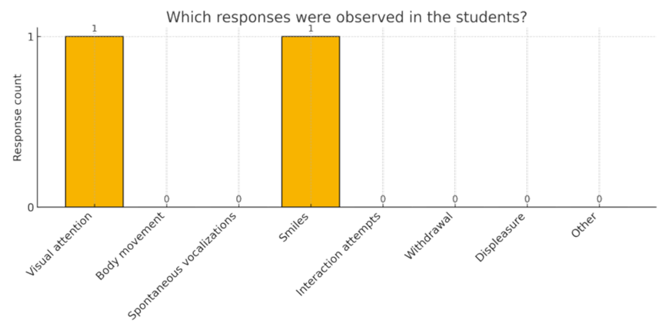

Figure 5: Question 2

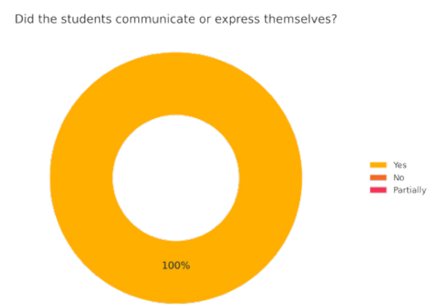

Figure 6: Question 3

5.2 Questionnaire Results

5.2.1 Psychologist. In the questionnaire addressed to the psychologist, the first question was: "Which elements did the students react to during the performance?" Five options were provided, of which she selected sound, interaction, and visual stimuli (Figure 4).

In the second question, which presented multiple options she was asked which responses she observed among the students. She selected *visual attention* and *smiles (*Figure 5*)*.

In the third question, which was another Yes, No, or Maybe item, the psychologist indicated that the students had communicated and expressed themselves throughout the performance (Figure 6).

The fifth question consisted of a Likert scale with four levels — *disagree*, *neutral*, *agree*, and *strongly agree* — regarding four statements, specifically that the computer-based music supported: non-verbal

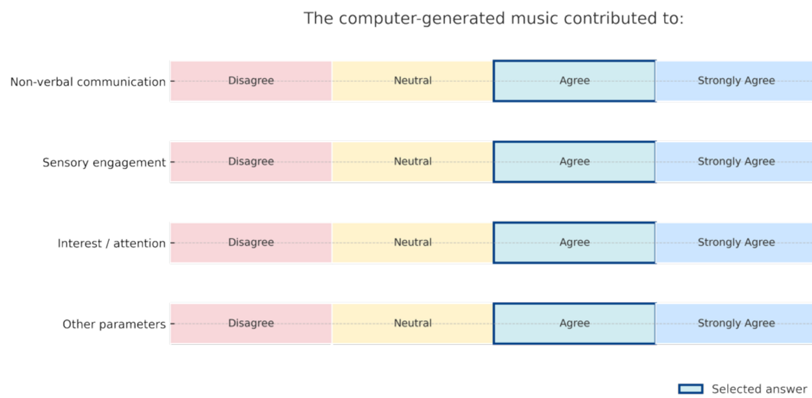

Figure 7: Question 4

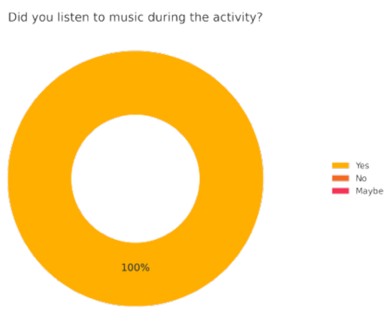

Figure 8: Question 5

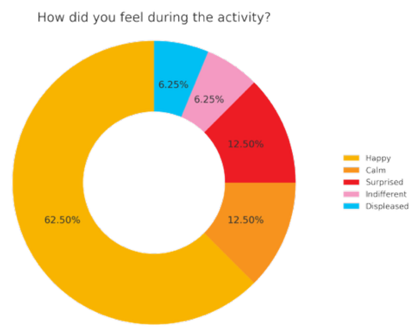

Figure 9: Question 6

communication; sensory engagement; interest/attention; and multiple parameters. To all items, the respondent answered *agree* (Figure 7).

Finally, the last question in the questionnaire was optional and invited an open-ended final comment. The respondent chose not to answer.

5.2.2 Students. With regard to the students, the first question asked whether they had heard music during the activity. All 16 participants responded to this question, and among the available options — *Yes*, *No*, and *Maybe* — all respondents answered *Yes* (Figure 8).

In the second question regarding how they felt during the activity, 10 participants answered happy, 2 answered surprised, another 2 answered calm, 1 responded indifferent, and finally 1 responded displeased (Figure 9).

In the question about whether they wanted to participate, 8 responded that they only listened, 5 said they wanted to play, 1 said they wanted to dance, and 1 stated they did not enjoy it (Figure 10).

In the final question, regarding whether they would like to repeat the experience, 13 answered *yes*, 2 answered *no*, and 1 responded *maybe* (Figure 11).

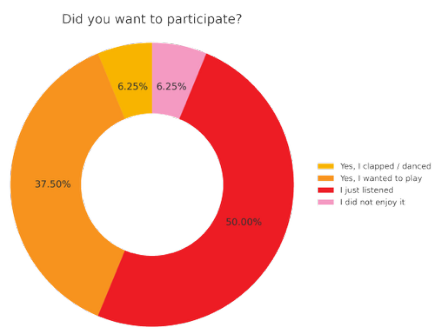

Figure 10: Question 7

5.3 Data Analysis

Based on the questionnaire results, it is possible to confirm that the psychologist accompanying the students identified positive reactions to the performances, including cognitive aspects such as attention to the surrounding environment and attempts to communicate and interact. The students themselves reported similar reactions, perceiving the performances as a positive, distinctive experience that encouraged interaction and communication. These findings support the idea that corporeal or biological sonification

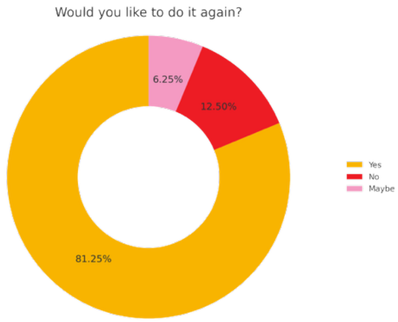

Figure 11: Question 8

fosters a more accessible and intuitive form of mediation, as anticipated by McLuhan's concept of *cool media [*15*].* The results also indicate that participants with SEND clearly valued the experience, particularly in terms of feeling they had actively contributed to the sound creation. This engagement — even when mediated by brain signal technology or biosonification — was perceived as both authentic and expressive, reinforcing the notion that BCMIs can function as communicative extensions of the body and mind. This observation aligns with previous research that highlights the potential of such interfaces not only as control tools but as mediators of meaningful aesthetic experiences, capable of transforming brain activity into perceptible and sensorially integrated sound expression. In this case, technological mediation did not hinder the emotional connection to the performance — on the contrary, it enhanced it, promoting a form of listening centred on the body itself and facilitating the integration of participants with diverse profiles into shared artistic practices [17]. Finally, emotional states reported by the participants — such as happiness and smiling — support the notion that multimodal communication is not redundant but complementary, conveying various forms of content through distinct yet interrelated modes [19]. his also resonates with Jewitt's [9] view of multimodality as a social practice that integrates visual, auditory, and gestural modes in the construction of meaning — which, in this context, was further amplified by the sonification of biological and brain signals.

6 Conclusion

This exploratory case study aimed to understand how the integration of interactive digital devices in performative contexts could enhance the sensory and emotional engagement of individuals with Special Educational Needs and Disabilities (SEND). Although preliminary, the collected data partially confirm the proposed hypotheses: the use of biosonified and interactive systems appears to have supported moments of non-verbal communication and autonomy among participants, stimulating curiosity and emotional involvement. While the limited sample size and the qualitative nature of the data preclude generalisations, the findings suggest that artistic environments based on biosonification and multimodal interaction may play a meaningful role in promoting sensory participation within inclusive educational and artistic settings.

7 Limitations

One of the main limitations of this study lies in the fact that the sample was drawn from a single institution, resulting in a narrow data scope. Although the response rate was 100%, the pool of respondents was small, particularly regarding educators — in this case, limited to the psychologist accompanying the students. In addition, because the performance involved three distinct HCI systems with different interactive paradigms and sonic models, it was not possible to disentangle the specific impact of each device on participants' responses.

8 Future work

Future research should consider expanding the sample and diversifying the application contexts, allowing for a more comprehensive analysis of the sensory and emotional impacts of these systems on neurodiverse populations. It will also be important to further develop biosonification and sound-mapping processes, and to adopt mixed methodologies that combine quantitative physiological measurements with qualitative analyses of behaviours and interactions over time. Lastly, implementing semi-structured interviews with educators, rather than relying on optional open-ended survey items, would provide more reliable and nuanced insights into their perspectives.

9 Ethical considerations

This study was conducted in accordance with the ethical principles established by the Declaration of Helsinki. All participants, or their legal guardians, provided informed consent prior to data collection. Confidentiality and anonymity were ensured, and all data were used exclusively for scientific research purposes.

Acknowledgments

This research was funded by national funding through the Portuguese Foundation for Science and Technology, I.P., under project UID/CED/04748/2023.

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