ARCHITECTURE AND AUTISM. SHARED SPACES AND SENSORY ESCAPES

PROCEEDINGS OF THE INTERNATIONAL WORKSHOP
TRIESTE, 28 NOVEMBER 2025

EUT

The international conference *Architecture and Autism: Shared Spaces and Sensory Escapes* brings together researchers, designers, educators, and professionals to explore how architecture can support the sensory and emotional needs of neurodivergent individuals. The conference highlights the BeSENSHome Interreg Italy-Austria project, a multidisciplinary initiative developing intelligent sensory systems and adaptive environments that respond to individual preferences, needs, and neurodivergent profiles.
Through keynote lectures and four thematic sessions, the event examines multisensory spaces for care and education, participatory design and co-creation, research on auditory accessibility and comfort, and the integration of AI and smart technologies in inclusive environments. Case studies and innovative projects – from school classrooms to museums – illustrate how design can foster autonomy, well-being, and social connection.

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ARCHITECTURE AND AUTISM.
SHARED SPACES AND SENSORY ESCAPES

International workshop
Trieste, 28 November 2025
in the frame of Interreg V-A Italia – Österreich 2021–2027
https://besenshome.units.it/

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16:20 - 16:30
Q/A + greetings

introduction

The international conference *Architecture and Autism. Shared Spaces and Sensory Escapes,* arise from the growing awareness that architecture and design play a fundamental role in shaping the sensory and emotional experience of neurodivergent individuals.
The event brings together researchers, designers, educators, and professionals to explore how built environments can become supportive, responsive, and inclusive – spaces that enable autonomy, well-being, and social connection.
At the heart of this discussion lies the BeSENSHome Interreg Italy-Austria project, a multidisciplinary initiative that aims to develop an intelligent sensory system capable of supporting neurodivergent people in their daily lives. The overall objective of BeSENSHome is to bring into homes, workplaces, public spaces, and community environments a network of smart sensors that can act as a personalized sensory extension, entirely shaped by individual needs, preferences, and neurodivergent profiles.
The integration of these sensors within the designated environments is achieved using appropriate smartboxes that are dedicated and co-designed with the potential users of the BeSENSHome system.
The project analyses the environmental factors that may trigger stress – such as noise, light fluctuations, or thermal discomfort – and seeks architectural solutions to mitigate them. It also investigates the adaptive and personalized redesign of spaces, ensuring that environments can flexibly respond to the sensory and emotional requirements of their users.

The conference's program reflects this vision through four thematic sessions.
The Keynote Lecture, *Refuge as Prospect: an Anthology of the ASPECTSS of the Sensory Landscape*, by Magda Mostafa, introduces a theoretical and methodological framework for designing sensory environments that foster inclusion and dignity.

Session 1 – Sensory Room Experience explores how multisensory spaces can support care, education, and well-being. Presentations include the Wood Snoezelen prototype, an untreated wood multi-sensory room designed to support the inclusion and care of students with disabilities at a Primary School in Padua, developed by Massimo Rossetti and Agata Tonetti of IUAV. Further contributions focus on sensory environments as a strategy for inclusion, presented by Elena Bellini of the University of Firenze and Alessandro Leonelli of DU IT S.r.I., and on the Calm Space of the MUSE Museum in Trento, presented by Paolo Degiovanni, Patrizia Famà, Ivan Muscolino, and Romana Scandolari, which illustrates design approaches for well-being and restorative experiences in museum contexts.

Session 2 – Design Thinking and User Engagement focuses on participatory design processes and user collaboration. Contributions include co-designing a sense of belonging in the Wellcome Collection Library by Katie Gaudion from the Royal College of Art and Evie Jeffreys, reactivating urban memory for collective well-being in Turin by Giulia Mezzalama in collaboration with the association MinD MAD in Design, designing restorative spaces for people with neurodivergent conditions by Toar Sadia from University College London, and developing the Aural Diversity Toolkit to engage communities in inclusive acoustic design by Jemma Jones and Chris Watkins from the design firm ARUP. These presentations share insights and lessons learned from co-designing restorative and acoustically inclusive environments across educational, cultural, and urban contexts.

Session 3 – BeSENSHome Results presents the project's research outcomes across multiple aspects of sensory-inclusive design. The session covers auditory accessibility and comfort studies, led by Marco Caniato from Stuttgart University of Applied Sciences, and explores insights from sensory research presented by Suchi Priyadarshani, Arianna Marzi, and Andrea Gasparella. Requirements for implementing BeSENSHome in school environments, as well as the design of a mobile system for stress assessment and management for neurodivergent individuals, are discussed by Anna Resch, Lukas Wohofsky, Laura Kroll, and Daniela Krainer from the Carinthia University of Applied Sciences in Austria.
The session also includes experiences of co-designing sensory-friendly spaces shared by Giulia D'Argenio in collaboration with ProgettoAutismoFVG, as well as a discussion of the spatial dimension and architectural strategies for sensory inclusion, presented by Giuseppina Scavuzzo, Federica Bettarello, and Martina Di Prisco from the University of Trieste.

Session 4 – BeSENSHome Technical Aspects finally showcases the technological dimension of the project, with project partner EUREKA System s.r.l. presenting the integration of AI and smart technologies for inclusive and sensitive environments (in collaboration with project partner MCI Management Center Innsbruck).

Together, these contributions form a collective reflection on how architecture can transcend its physical boundaries to become a living, learning, and caring system – one that recognizes sensory diversity as a fundamental aspect of human experience.

SENSORY ROOM EXPERIENCE

***WOOD SNOEZELEN*: A PROTOTYPE OF AN UNTREATED WOOD MULTI-SENSORY ROOM FOR THE CARE AND INCLUSION OF STUDENTS WITH DISABILITIES AT "G. MARCONI" PRIMARY SCHOOL IN LOZZO ATESTINO, PADUA, ITALY**

Massimo Rossetti, Agata Tonetti

abstract

This paper presents the results of a research project aimed at designing an environment made of untreated prefabricated wooden components, called *Wood Snoezelen*, thought to facilitate multisensory stimulation for people with intellectual disabilities.
Numerous scientific studies confirm the effectiveness of multisensory stimulation generated within a Snoezelen room, both for elderly people (dementia and Alzheimer's disease) and for children and adolescents with various types of disabilities (autism spectrum disorder, ADHD).
The rehabilitative and multisensory effects of the Snoezelen approach is enhanced by the use of untreated wood, which, thanks to its properties, can produce beneficial effects in terms of health, comfort, and cognitive and psychological well-being.
The project led to the definition of a fully modular wooden kit integrated with multisensory equipment and to the construction of the first Wood Snoezelen prototype at "G. Marconi" Primary School in Lozzo Atestino (Padua, Italy), inaugurated on February 28th 2025.

keywords

Timber Construction, Intellectual Disabilities, Multisensory Environments, Inclusive School, Biophilia

Introduction

The care and assistance of people with disabilities represents one of the most critical challenges for Italy's near future. The ageing population, the advancement of diagnostic techniques, and the decreasing of birth rates are all contributing to an increase in the number of people with disabilities. In Italy, in 2023, people with disabilities were approximately 2,904,000, accounting for 5% of the population (ISTAT, 2025). Globally, the World Health Organization estimates approximately 1.3 billion people with disabilities, about 16% of the world's population (WHO, 2023).

The school context is particularly important. In 2023/2024 school year, over 360,000 students with disabilities were enrolled in Italian schools – an increase of more than 60% over the past ten years. This represents 4.5% of total enrolments, compared to 2.6% of a decade earlier, with an average annual growth rate exceeding 7% (ISTAT, 2025).

Despite this constant growth, Italian school buildings are still not fully prepared to accommodate all students: only 40.5% are accessible for individuals with reduced mobility; just 16.7% of school facilities are equipped with visual signaling systems for

students with deafness or hearing impairments; and only 1.1% feature tactile paths or raised maps for students with blindness or low vision (ISTAT, 2025).

According to this situation, it is clear that architectural solutions able of addressing the heterogeneity of disabilities are urgently needed. The integration of multisensory environments, such as Snoezelen rooms, offers a valuable tool for achieving the fourth goal of the 2030 Agenda for Education, known as Sustainable Development Goal 4 (SDG4). The World Health Organization (WHO) has identified schools as potential settings for long-term therapies (WHO, 2011). Similarly, the recent Italian guidelines FUTURA recommend a multisensory approach as an auxiliary teaching method in school design (Alvisi et al., 2022).

The Snoezelen approach and the potential of wood

The Snoezelen approach – derived from the contraction of the Dutch verbs *snuffelen* (to explore) and *doezelen* (to relax) – is a non-pharmacological therapy based on the multisensory treatment of individuals with severe disabilities.

These interventions take place in purpose-designed environments known as Snoezelen rooms, which are equipped with tools that stimulate different senses in a targeted manner – including bubble tubes, optical fibres, projectors, hammocks, enveloping armchairs, ball pits filled with coloured plastic balls, and waterbeds. A trained operator modulates the intensity, frequency, and type of sensory stimulus according to the individual's needs. The aim of Snoezelen environments is to find an optimal balance between the activity performed and the person's reactions to sensory stimuli, aligning sensory exploration with the individual's overall well-being.

Several studies have demonstrated the effectiveness of the Snoezelen approach in relation to dementia (Strøm et al., 2016), severe and complex disabilities (Glenn et al., 1996), autism spectrum disorder (ASD) (Germeau, 1998), ADHD (Mahendran et al., 2018), and special educational needs (Carter & Stephenson, 2012). For instance, multisensory stimulation in a Snoezelen environment has been shown to reduce aggressive and self-injurious behaviour in individuals with severe intellectual disabilities.

In Italy, the Snoezelen approach is still relatively uncommon. A systematic analysis conducted by the authors within the Wood Snoezelen research project identified approximately 206 Snoezelen environments nationwide, located in facilities such as nursing homes (RSA), rehabilitation centres, day centres, and schools. There is a particularly notable absence in comprehensive educational institutes: at the time of the research, only 80 Snoezelen rooms were documented in schools – 14 in early childhood education centres, 7 in school districts, 50 in primary schools, 6 in lower secondary schools, 2 in upper secondary schools, and 1 in a university laboratory.

School Snoezelen rooms are generally small to medium in size and are almost exclusively used by students. In some cases, they are not employed in structured and continuous activities – i.e., like therapeutic treatment – but rather on an occasional basis, for example, when it is necessary to provide a controlled environment for a student with disabilities during emergencies. However, the presence of a Snoezelen room in a school, especially if used in a structured and consistent manner, could significantly support the delicate and often lengthy process of inclusion.

Innovation aspects: the use of untreated wood
The Wood Snoezelen project integrates the non-pharmacological Snoezelen therapeutic approach with the use of untreated wood – as a construction, furnishing, and sensory stimulation material – thereby eliminating the need for paintings or chemical treatments. Wood is particularly suitable for creating multisensory rooms, as it allows for the creation of neutral environments and, thanks to its performance characteristics, enables optimal levels of acoustic, visual, and thermal comfort that directly influence the sensory performance of users.

The properties of untreated wood include, among others, the reduction of heart rate, blood pressure, and stress levels (Bringslimark et al., 2009). Its characteristic yellowish to reddish hue emits wavelengths that can enhance cognitive abilities (Nakamura & Kondo, 2007). Several studies have demonstrated that wood can positively influence the psychophysical well-being of individuals (Demattè et al., 2018). Furthermore, research shows that spending time in natural environments, such as forests, reduces stress and anxiety due to the terpenes [1] released by trees (Meneguzzo & Zabini, 2020).

The use of wood in construction has already proven effective for individuals with autism spectrum disorder (Venturini, 2010) and in residential care facilities for dependent elderly people (Bozza et al., 2019). It is therefore no coincidence that the use of wood in environments with specific rehabilitation, care, and inclusion purposes for vulnerable people and people with disabilities is becoming increasingly widespread. Significant case studies, though limited in number, include *Noverca House* – a prefabricated multisensory pavilion designed by Atelier JQTS, installed in 2017 at Maria Veleda School in Loures, Portugal – and the *Classroom Makeover for Visually Impaired Students*, designed in 2018 by Creative Crews in Pattaya, Thailand, where the Braille system was transposed onto the wooden interior cladding elements.

Research methodology and the modular kit

The research project [2] was co-financed by Università Iuav di Venezia, Consorzio Legno Veneto, and Bozza S.r.l., with I.S.R.A.A. – Istituto per Servizi di Ricovero e Assistenza agli Anziani – and the association La Nostra Famiglia of Conegliano and Treviso as project partners.

The research was structured into three main phases:
1. a state-of-the-art analysis on disability and inclusion policies, Snoezelen environments, and prefabricated timber constructions;
2. the design of a modular kit for a multisensory room made entirely of untreated wood components, named Wood Snoezelen (WS);
3. the construction of the first prototype at a primary school in Lozzo Atestino.

The kit of components
The research developed a modular prefabricated kit of untreated wooden elements for the interior envelope (floor, wall panels, false ceiling, and storage components) in which the sensory equipment is integrated, producing an environment of high architectural quality. The modules were designed in accordance with anthropometric measurements and users' movements, conceived to ensure high flexibility and dry assembly. These can be configured to create Wood Snoezelen environments tailored to different user types and functional settings.

The kit is divided into four main categories (image 1):

Raised floor: designed primarily as a tactile device through the use of different textures and finishing materials. Additionally, the modules can assume various shapes and heights – triangular, curvilinear – functional for psychomotor development.
Wall panels: featuring a multisensory system with micro-perforated and backlit wood panels for visual stimulation, and panels made of different timber species (fir, cedar, larch, oak) for tactile perception. Other panels consist of interchangeable modules that generate a wide range of sensory combinations.
False ceiling: designed both as a sound-absorbing element for acoustic control and as a device for integrating multisensory equipment – hammocks, tactile curtains, cascades of optical fibres – and the lighting system.
Storage units: modular structures designed to integrate sensory equipment, such as the vibroacoustic waterbed mattress and the ball pool, and usable as storage elements.

The choice of which components to adopt depends on the project and the use of the room. During the research, it became evident that, based on the information collected, an effective Wood Snoezelen could be composed of an entrance area – which would serve as a welcoming and concluding space for therapy – and sensory stations organized in such a way as to prevent sensory overload. Accordingly, a basic Wood Snoezelen consists of the following macro-areas:
1. Welcoming space: an area where the welcoming and final greeting moments take place, equipped with seating and storage elements for clothing and footwear.
2. Calm space: an area dedicated to sensory stimulation aimed at relaxation, equipped with a vibroacoustic waterbed, mirrors, optical fibres, and projectors.
3. Space for tactile and visual stimulation: an area where tactile and visual stimulation is performed, equipped with tactile panels, bubble tubes, and projectors.
4. Active space: an area where senses related to mobility are stimulated, equipped with a ball pool, hammocks, and balance platforms.

The Wood Snoezelen of Lozzo Atestino

The validity of the designed components was verified through their application in the design of the first Wood Snoezelen prototype at "G. Marconi" Primary School in Lozzo Atestino, in the province of Padua – a school at the forefront of the national educational landscape.

The Wood Snoezelen was built inside a 50 m² underutilized classroom located on the first floor, also accessible by lift. In accordance with the requirements for Snoezelen environments, the room can be fully darkened thanks to wooden boards placed over the windows.

The project is divided into two macro-environments: the entrance space and the sensory space. For the definition of each zone, components from the abacus were used, constructed primarily with a load-bearing structure in fir wood and panels made of planed fir boards, except for the flooring, which consists of brushed oak boards.

The sensory space is divided into six thematic "islands" (image 2):
1. Calm zone: for the relaxation of the vestibular system. It consists of a waterbed equipped with a containment structure to create an enclosed environment that enhance relaxation, and a cascade of optical fibres flanked by a soft seat.

2. Active zone: primarily for kinesthetic stimulation and proprioception. It consists of a ball pool and balance platforms. Kinesthetic stimulation is achieved through the combination of static and dynamic activities, such as the relationship between the body and its weight, and the discovery of body parts and possible movements.
3. Tactile zone: for tactile stimulation through mobile floor and wall pathways filled with foam rubber of different textures and densities. The sense of touch can be developed through bodily exploration and the diversified use of materials and surfaces.
4. Visual/acoustic zone: for visual and auditory stimulation thanks to the integration of a bubble tube flanked by a mirror and a smart TV. The sense of sight can be trained through exercises in visual information memorization, focusing strategies, and localizing a reference point. The sense of hearing is trained through localization of sound sources, sound identification, recognition of familiar sounds, and the use of musical instruments.
5. Olfactory zone: dedicated to the sense of smell through containers with cedar lids filled with wood shavings and scented with essential oils (image 3). This sense can be stimulated through the recognition and discovery of odors, the use of certain essences capable of influencing mood, and their personalization.
6. Fine motor zone: dedicated to coordination between movement, cognitive aspects, and the seven senses, consisting of a micro-perforated fir wood panel into which shapes of different geometric or natural sections can be inserted, characterized by different wood species (fir, cedar, larch, and oak). This zone enables the exploration of non-verbal languages through the use of Braille and Augmentative and Alternative Communication (AAC).

The room's colour can vary according to the colours of the sensory equipment. The Wood Snoezelen was inaugurated on February 28th 2025, same day of Rare Disease Day, and is currently used (image 4).

Conclusions and future perspectives

According to the statistics and issues previously outlined, it is clear that the number of vulnerable individuals is constantly increasing and that, in particular, the number of school-age individuals with disabilities is destined to grow over time. This scenario necessitates defining support systems for people with disabilities – not only episodically but in a sustained and continuous manner in everyday life. In this regard, school buildings can become ideal opportunities for developing situations and opportunities for assistance that many people with disabilities would otherwise not have access to. This aspect must be combined with wood's capacity to create comfortable environments and promote well-being.

The choice of wood, therefore, appeared as the logical consequence in view of creating an environment with the defined characteristics. Consequently, the design of a multisensory room made of wood – Wood Snoezelen – constitutes a real example of an inclusive space aimed at care and rehabilitation. Having in mind an increasingly comprehensive policy of integration and inclusion of people with disabilities within everyday social contexts, the construction of the Wood Snoezelen at the primary school in Lozzo Atestino represents a first step in this direction.

The building of a high-performance architectural and therapeutic environment required structured and transdisciplinary collaboration among the project partners. The synergy between technological-architectural expertise (Università Iuav di Venezia, Consorzio Legno Veneto, Bozza S.r.l.) and clinical-medical expertise (Associazione La Nostra

Famiglia, I.S.R.A.A.) was crucial in designing the modular wooden abacus and defining the sensory islands, aiming to transform the school into a place suitable for long-term therapeutic practices.

First feedback
The first uses of the room at the Lozzo Atestino school have yielded positive feedback regarding the effectiveness of the Wood Snoezelen environment for students with disabilities [3].

Regular use of the WS has also been documented within palliative care sessions for a student affected by a degenerative condition, non-ambulatory and blind. Despite the primary visual impairment, the student experienced tangible benefits from remaining in the environment – particularly related to its visual component [3]. This suggests that the ambient lighting quality and the integration of sensory equipment with the wooden envelope can generate photonic and chromatic stimulation producing a positive sensory response or neurophysiological comfort.

Another relevant case concerns G., an adolescent with autism spectrum disorder (ASD) not enrolled at the school. During his first visit, G. exhibited considerable motor hyperactivity and agitation in traditional school spaces. Upon reaching the Wood Snoezelen, he displayed a latency phase before entering, taking time to familiarize himself with the environment [3].

Once inside, the Wood Snoezelen facilitated the de-escalation of his agitated behaviour. G. began autonomously exploring the thematic islands and subsequently engaged in reciprocal social interaction with the therapist [3]. The deepest state of relaxation was achieved in the Calm Zone (Vestibular), where the enclosing configuration of the wooden structure surrounding the waterbed produced a sense of spatial safety (cocooning effect). At the end of the session, he showed reluctance to leave the room [3].

G.'s experience in the WS demonstrated success in behavioural regulation consistent with the outcomes reported in Snoezelen literature, particularly in reducing aggressive and self-injurious behaviours in individuals with severe disabilities (Lancioni et al., 2004). The persistence of environmental well-being and the generating of positive spatial memory were confirmed during a subsequent visit, when G. calmly entered the building and independently headed toward the Wood Snoezelen [3]. This initial observation validates the role of untreated-wood environments as sought-after therapeutic spaces, demonstrating that architectural quality and materiality are decisive factors in promoting autonomy and reducing anticipatory anxiety in individuals with ASD.

Future perspectives
The next phase of the research project, essential for its validation, will focus on structured clinical monitoring and evaluation of therapeutic effectiveness.

This evaluation framework was developed in collaboration with clinical specialists from the association La Nostra Famiglia, specifically dr. Gianni De Polo (child neuropsychiatrist) and dr. Sonia Bortolot (pedagogue). The methodology aims to define observation forms structured according to the ICF (International Classification of Functioning, Disability and Health), to be used over a time frame of several months during therapy sessions conducted by trained school staff.

This system will enable the systematic collection of verified data and the construction of a longitudinal record of results, transforming qualitative feedback into quantitative clinical evidence and supporting the potential replicability of the Wood Snoezelen model in other educational and care contexts.

notes

[1] Terpenes: Bioactive substances, specifically classified as Biogenic Volatile Organic Compounds (BVOCs), released into the atmosphere by trees and forest soil. They are the main constituents of essential oils and responsible for the characteristic scents of forests. These volatile compounds have been shown to have stress-reducing and immune-boosting properties in humans, forming the scientific basis for forest therapy practices.

[2] The research project entitled "Wood Snoezelen: Multisensory Environments for Assisting and Rehabilitating Individuals with Severe and Very Severe Cognitive Disabilities" (October 2021–September 2022) was co-financed by Università Iuav di Venezia, Consorzio Legno Veneto, and Bozza S.r.l. It was developed by Arch. Agata Tonetti, research fellow at Iuav, under the scientific supervision of Prof. Massimo Rossetti (Iuav). Project partners included Consorzio Progetto Legno Veneto, Enzo Bozza (Bozza S.r.l.), Dr Gianni De Polo, Dr Sonia Bortolot, therapists Chiara Novello and Marianna D'Incà (Associazione La Nostra Famiglia, Conegliano and Treviso), and Geom. Silvano Pangerc (I.S.R.A.A., Treviso). The school principal Alfonso D'Ambrosio of the Istituto Comprensivo di Lozzo Atestino also contributed to the project.

[3] Preliminary operational feedback provided by the teacher responsible for the Wood Snoezelen at "G. Marconi" Primary School in Lozzo Atestino.

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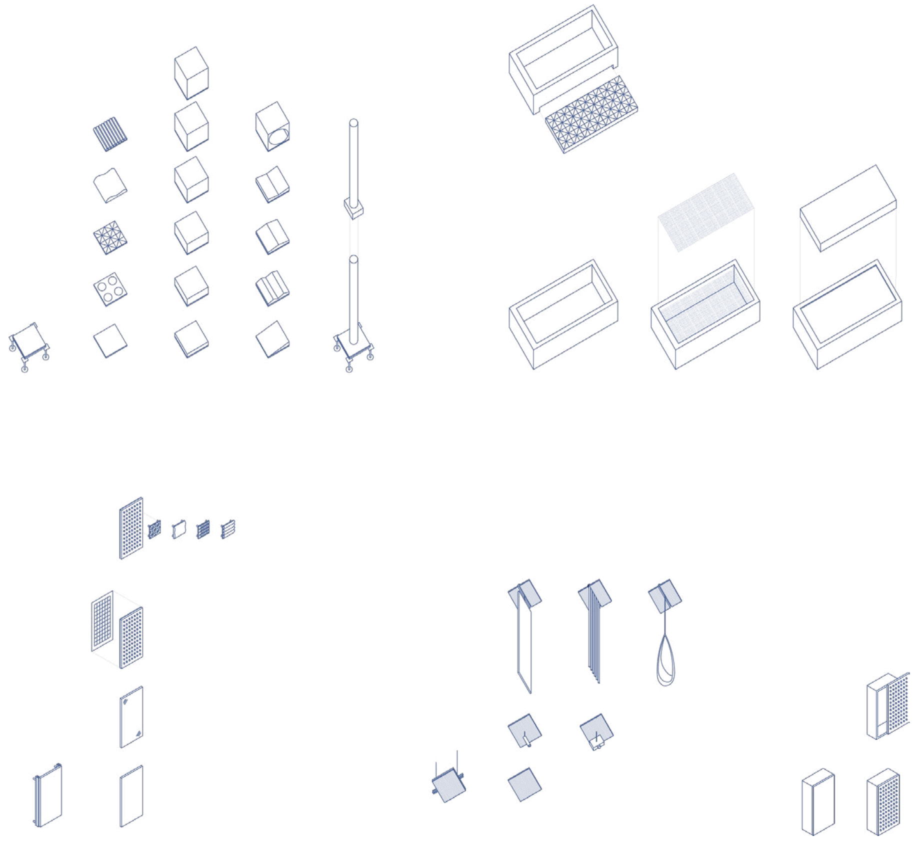

image 1

Abacus for a Wood Snoezelen, Agata Tonetti, 12 July 2022.
Abacus of untreated wood components: raised floor, wall panels, false ceiling, and containment structures. The modules allow for different spatial configurations supporting the Snoezelen therapeutic approach.

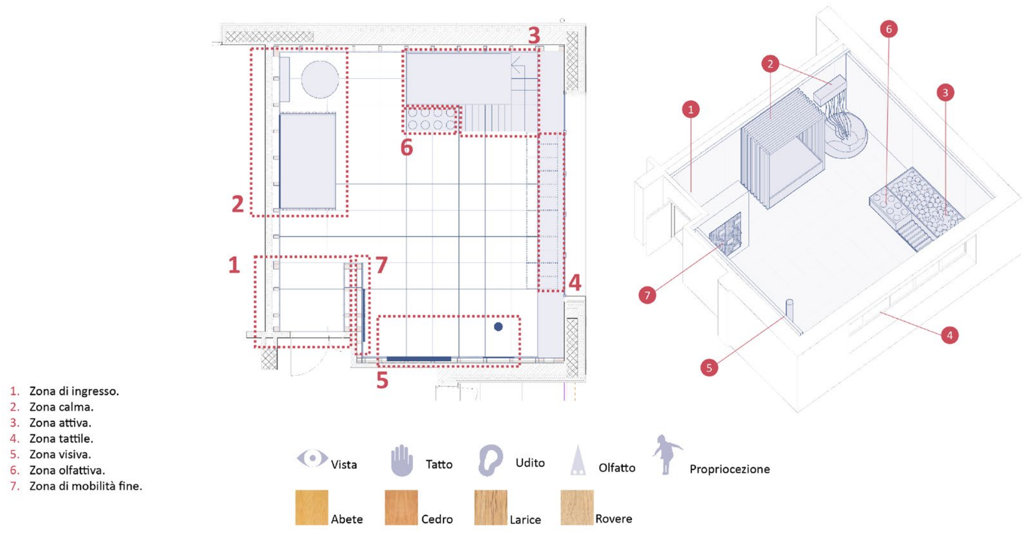

image 2

Design of the Wood Snoezelen of Lozzo Atestino, Agata Tonetti, 6 March 2023.
Layout of the interior space of the Wood Snoezelen (50 m²) showing the identification of the six thematic sensory zones. The wood species used in the prototype are fir (for the supporting structure and panels) and brushed oak (for the flooring).

image 3

Olfactory zone, Agata Tonetti, 3 October 2025.
Therapists from La Nostra Famiglia of Treviso guide the pupils of Lozzo Atestino school in experiencing the sense of smell by sniffing the cedarwood lids of the sensory containers. The olfactory zone is stimulated through the use of wood shavings and essential oils, supporting the recognition and personalisation of scents.

image 4

Wood Snoezelen of Lozzo Atestino, Agata Tonetti, 6 December 2024.
View of the visual/acoustic zone wall and the fine motor zone. The latter is dedicated to coordination and cognitive aspects, integrating shapes made of different wood species and enabling the exploration of non-verbal languages such as Braille and Augmentative and Alternative Communication (AAC).

SENSORY ENVIRONMENTS:
A STRATEGY FOR INCLUSION

Elena Bellini, Alessandro Leonelli

abstract

Multisensory environments (MSEs) allow modulating sensory stimuli according to different sensory profiles, to reduce anxiety and stereotypical behaviours, promote self-regulation and increase sustained attention in children with Autism Spectrum Disorders. In this contribution, we present an application of DU IT's co-designing approach: Andrea Bodo sensory room, at the SpazioTempo Multifunctional Centre in Vercelli (Italy), which will welcome more than 70 children currently undergoing therapy with ANGSA Novara-Vercelli. Guidelines for the design and use of MSEs are still limited and poorly systematised. This represents an example of a flexible environment, in which the user can decide how to transform the space through a technological automation system, and self-regulate senses according to individual's sensory needs and preferences, and give to the staff a fully adaptable tool to create personalised therapeutic rehabilitation programmes, promoting inclusion.

keywords

Autism Spectrum Disorder, Sensory Design, Inclusive Design, Co-design, Snoezelen

Introduction and background

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterised by impairments in social relationship - interaction and communication skills - which are often associated with cognitive and motor difficulties, alongside restricted or repetitive patterns of behavior and interests, with atypical responses to sensory stimuli (APA, 2013). The impact of the disorder also involves the family context with high levels of anxiety, stress and feelings of isolation (Salari et al., 2022). The number of children with autism is constantly increasing: 1 in 54 eight-year-old children in the US, 1 in 160 in Denmark and Sweden, and 1 in 86 in the UK. In Italy, the estimated prevalence is 1 in 77 between the ages of 7 and 9 (De Domenico et al., 2024).
Among the intervention strategies, multisensory environments (MSEs) - sensory rooms or Snoezelen rooms - are becoming increasingly popular. These spaces offer visual, auditory, tactile, olfactory, vibro-acoustic and emotional stimulation through devices such as bubble tubes, fibre optics, tactile panels and audio-visual systems, dynamic image projectors, natural sounds or music therapy, and even interactive surfaces and immersive technologies (Unwin et al., 2023). The diversification of stimuli allows the experience to be regulated according to the user's sensory profile: e.g., passive elements such as bubble columns can provide immediate visual and auditory stimuli without requiring active interaction, while tactile or sound panels stimulate direct exploration and motor activation. Since the 1970s, MSEs have been based on the principle of free and non-directive

exploration, aimed at promoting relaxation, well-being and personalised learning processes. Originally MSEs have been designed for people with intellectual disabilities, cognitive and behavioural deficits (Cameron et al., 2020). In recent years, there has been a growing number of MSEs for people with SLDs associated with intellectual disabilities, moderate to severe cognitive impairment, and neurodegenerative diseases such as Parkinson's, dementia, Alzheimer's, Huntington's, bipolar disorder, among others (Berkheimer et al., 2017; Novakovic et al., 2019; Duchi et al., 2018; Hayden et al., 2022). The use of these spaces has therefore been expanded into a wide range of contexts, such as healthcare and education (Cameron et al., 2020; Unwin et al. 2021). Sensory approaches have been advocated to reduce disruptive behaviour in people with autism, control arousal patterns and support self-management of distress, reduce seclusion and restraint (Forsyth & Trevarrow, 2018), favouring inclusion.
In children with ASD, who present sensory atypicalities in over 90% of cases, such environments are particularly important: the possibility of modulating stimuli in a way that is calibrated to the individual's sensory profile reduces anxiety and stereotypical behaviours, promotes self-regulation and increases sustained attention (Leonardi et al., 2025).
In recent years, some studies have shown that preferences for specific multisensory devices depend largely on individual sensory profiles and non-verbal cognitive abilities rather than on the general characteristics of the disorder. Moreover, the dimension and the morphology of spaces – e.g., the presence of curved lines, which are perceived as more reassuring than angular geometries – also influences the perceptual and emotional experience, with significant design implications for therapeutic environments (Palumbo et al., 2022). This evidence has stimulated research interest in developing guidelines for the design and use of MSEs, which are still limited and poorly systematised (Black et al., 2022; Bellini & Macchi, 2024).
In this context, the design of a multisensory room for children with autism is not limited to provide a rehabilitative setting, but represents an opportunity for interdisciplinary integration of neuropsychiatry, pedagogy and interior design. The goal is to create adaptable spaces according to the complexity of sensory profiles, promoting well-being, self-regulation and positive interactions from the earliest stages of children's development.
In this contribution, we present "Andrea Bodo" sensory room, designed by DU IT [1] at the SpazioTempo Multifunctional Centre in Vercelli (Italy), an example of a design approach that pays attention to perceptual, aesthetic and environmental characters of the space to involve users and influence their emotional and sensory experience. The project, funded by Biud 10 [2], will welcome more than 70 children currently undergoing therapy with ANGSA Novara-Vercelli [3].

Methodology: co-designing sensory environments

The methodology used for Andrea Bodo's sensory room was developed in several stages (image 1):

- background research of scientific literature and international case studies on the subject;
- co-designing (workshops and focus groups) with experts, educators, psychologists, psychotherapists and neuropsychiatrists from ANGSA Novara-Vercelli;
- co-designing (interviews and workshops) with users of the autism centre;
- draft proposal and critical evaluation with staff and users;
- final project and realisation.

DU IT had the opportunity to design the first Andrea Bodo sensory room in 2017.

After almost ten years, a new sensory space has just been inaugurated in Vercelli, drawing on lessons learned from feedback and results obtained from the first project.

There are not many experiences of co-design with people with autism, most of which are aimed at children or adults with verbal abilities (Hijaba et al., 2023). Due to their particular way of processing information, people with autism see and interact with the environment in a unique way, which influences experience and interaction with the world around them (Kinnaer et al., 2016). For example, Gaudion (2013) carried out a co-design project with adults with autism in their homes (even involving non-verbal individuals), taking their sensory preferences into account and showing how empathy can completely transform the ability to design for these users.

For this reason, people with autism or their supporting family members were involved in the project to obtain information about their sensory preferences and, in a second phase, to provide feedback on the designed space. In this phase, renderings of the environment were shown, and the strengths and weaknesses were discussed using co-design techniques.

Autism sensory sensitivities can have a big – and often negative – impact on people's everyday lives (Pellicano et al., 2013). Among identified challenges in co-designing with people with autism, engaging users is the most complex issue, together with the big amount of individual differences (hyper or hypo reactions to sensory stimuli, variations in motor skills and communication diseases), making it difficult to respond in a universal way to all the specific needs of children with autism (Gaudion et al., 2015; Bellini, 2019).

For this reason, the solution adopted was to create a flexible and customisable environment, in which the user can decide how to transform the space through a technological automation system, and self-regulate senses according to sensory needs and preferences. At the same time, the staff of the autism centre can have a fully adaptable tool to create personalised therapeutic rehabilitation programmes.

Results and discussion: "Andrea Bodo" MSE in Vercelli

The design of the multi-sensory environment is defined by three different zones: the area of sensory exploration; the sensory immersive area; the soft area. Separating areas for different functions was mostly appreciated by many users, as well as clear lines and elements to be easily identified and recognised.

A technological system manages and personalises the sensory experience in the room, using a tablet and an easy-to-use interface which lets children choose between different scenarios that integrate colours, lights, videos and sounds. The scenarios have been designed to convey different emotional stimuli, using images of nature and a specific soundscape. In this way, technology can support regulating senses and overcoming many of the difficulties faced by children with ASD. A smart, safe and welcoming environment has been designed with the aim of supporting overwhelming conditions. Many users were appreciating the use of automation technology because "it is essential to be able to control and customise the entire environment".
Visual and auditory stimuli have the main impact on wellbeing of people with autism (Mostafa, 2008; Bellini, 2019). For this reason, these aspects were particularly taken into account in this project.
Lighting is necessary for all humans and it can be part of a treatment, such as a way

to calm and slow down the heart rate. "Chromotherapy is a science that uses colour to establish balance and harmony in the body, mind and emotions" (Sui, 1992) and it has been shown to be effective in treating diseases (Santo et al., 2021). For this reason, a lighting design project was developed by associating colours to different scenarios to control and reduce the stress levels in children with autism, giving also the opportunity to regulate light intensity and colour by each individual.
A system of music and ambient sounds is integrated in the scenarios. The literature on autism reports that there is an intense relationship between music and emotions, as it can elicit positive and negative responses even in individuals from different cultures (Brattico et al., 2011). The therapeutic value therefore lies in music's ability to produce effects on human beings at a biological, physiological, psychological, intellectual and social level (Blasco, 1999). According to the approach of "soundscape", the aim is to enhance sound as a design resource, managing the sound environment based on people's perception. Sound is therefore used as a "resource" for creating comfortable acoustic environments by masking noise through a focus on pleasant sounds (Torresin, 2021) and influencing the atmosphere of the space, impacting on the actual psychological state of the person and its perception (Hajdu et al., 2017; Iyendo, 2016).

The entrance door opens onto a big and open central space (image 2), characterised by a high ceiling, which welcomes children into another spatial dimension made up of light, play and discovery. Here, the surprise effect is created by the coloured light of the scenes that illuminate the ceiling, composed of fabric circles. These discs modulate the intensity and glare of the LEDs, generating diffused light in the environment and soft shadows with a curvilinear design. During the interviews, many users were reporting that they suffer in cases of glare and prefer warm, soft and possibly dim light.
In the main area, there is a first interactive element on the wall: the Duitster (image 3), which is placed directly in front of the entrance. It is a sensory game where an arrow spinner indicates a sensory area to explore – touch, sight, hearing and smell – associated with a colour – red, green or blue. The tactile sensory elements feature fabric or similar surfaces that stimulate different sensations, from the softness of eco-fur to the funky fringes of eco-leather. Visual stimulation is provided by augmented reality viewers, which have been specially programmed to loop three types of videos which deal with a sense of familiarity: soap bubbles, kites and colored umbrellas flying in the sky (similar to an art installation in the city of Vercelli). The hearing is activated by a button that plays a pre-recorded sound that can induce a feeling of energy and activation or promote relaxation and calm. The sense of smell occurs through thin paper strips soaked in natural fragrances. The arrangement of the circles, designed at different heights, also induce a sense of exploration and curiosity and stimulate proprioception and motor skills by playing.

Visual, sound and touch are specifically stimulated in the immersive space (image 4), a niche bordered by two sloping walls that softly reflect the image projected onto the back wall. The audio system is the main character of this environment, equipped with six speakers for an immersive and enveloping effect. The sound vibrations are then transmitted to the wooden platform via transducers, providing the user a tactile experience on all the body.

The third functional area (image 5) is separated from the previous ones by a wall that physically defines the space. This area is designed as a safe and welcoming refuge, far from the previous stimuli, where it is possible to isolate oneself and experience proprioception and motor skills. The walls are entirely covered with cushions which makes the space soft and welcoming. Inside, there is a large and containing pouf for relaxing and listening to music through wireless headphones, and a tub filled with soft cubes flanked by a small climbing wall. According to some studies, physical activity can bring about significant improvements in emotion regulation and reduce behavioural problems (Tse, 2020).

This area still maintains a certain relationship with the other environments also by an opening that contains a waterfall fountain. This solution creates visual permeability, stimulating curiosity and anticipating what awaits on the other side. In addition, the constant sound of water and the possibility of physically touching the waterfall offer additional relaxing stimuli.

As V. said in the co-design phase: “The sound and images of a waterfall allow me to reach a state of relaxation, helping me to limit my hyperactivity linked to autism”. V. was telling that in the room, “it was the first time in her life that her brain was taking a break for a while”.

Also F. reported that “this experience was very positive and important for regulating senses” and “staying in the room for a few minutes could be beneficial for a long time, even for a month”.

notes

[1] DU IT was founded in Florence in 2015 as an innovative start-up developing MSEs with integrated assistive technologies. Today, it is an engineering company and SME specialising in inclusive and sensory design. The founders, Elena Bellini and Lorenzo Romualdi, two architects, work with a multidisciplinary team of architects, product designers, graphic designers and illustrators, psychologists and psychotherapists, software developers and partners for the supply of custom-made furniture.

[2] Biud10 is a non-profit association which pursues social solidarity goals in memory of Andrea Bodo.

[3] A.N.G.S.A. - Associazione Nazionale Genitori Soggetti Autistici - is an italian national charity supporting families of people with Autism Spectrum Disorders.

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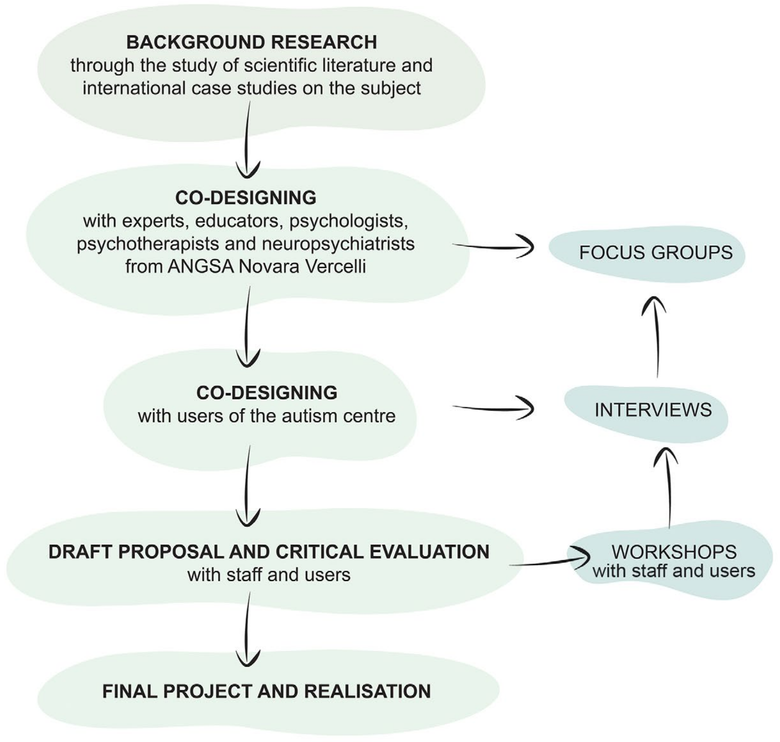

image 1

Diagram of the design process.

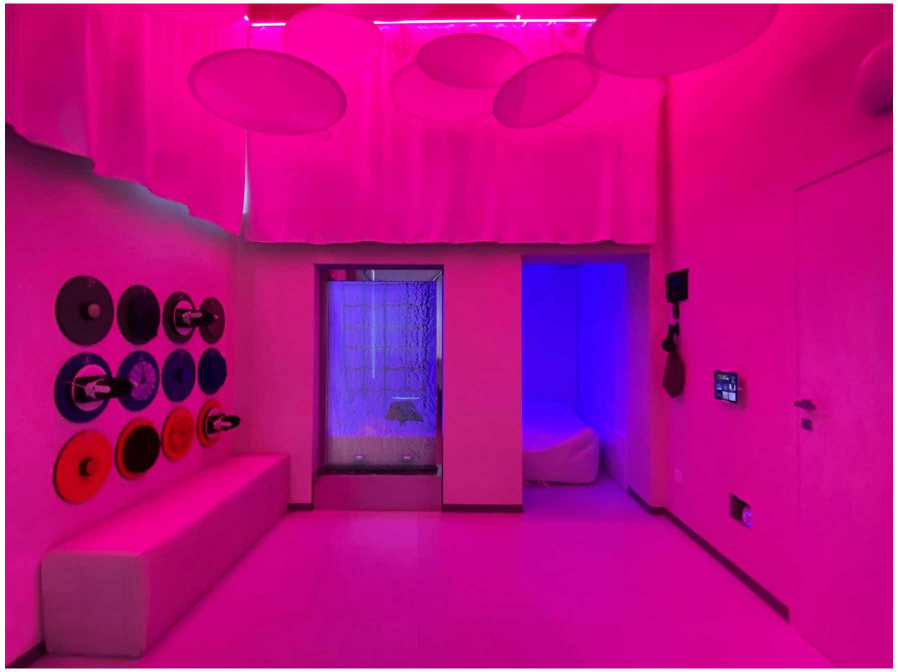

image 2

The open central space.

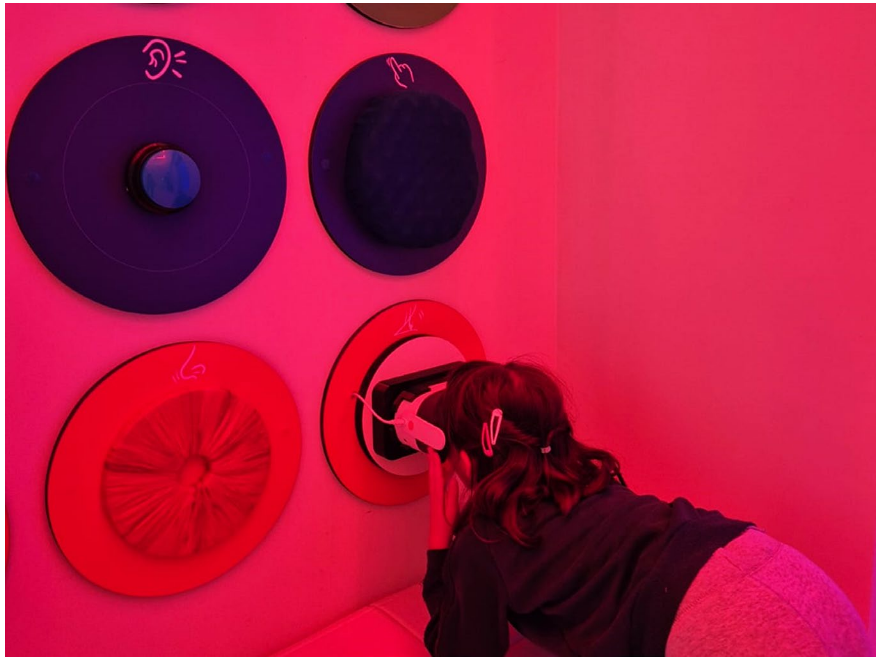

image 3

The sensory game “Duitster”.

image 4

The sensory immersive area.

image 5

The soft area.

THE QUIET SPACE IN MUSE

Paolo Degiovanni, Patrizia Famà, Ivan Muscolino, Romana Scandolari

abstract

The Quiet Space in MUSE is a sensory decompression room inspired by the Snoezelen approach that aims to foster a connection with the individual's inner world through the controlled stimulation of the senses, using light effects, colors, sounds, music, scents, and more.
The purpose is to promote relaxation, well-being, experiential learning, and new ways of engaging in relationships.
The environment is equipped with soft seating, dimmable lights, projections, a bubble tube, fiber optics, aromas, and tactile materials.
Through sensory activation, anyone experiencing this immersive environment is allowed to either relax or become energized, depending on their psycho-physical condition and individual needs.
This sensory cleansing space is primarily dedicated to people with autism spectrum disorder, but it is also open to all visitors who, for various reasons, find it difficult to continue a guided or self-guided visit or an educational workshop and need a momentary pause from sensory stimulation – such as people with dementia, for example.

keywords

Autism, Accessibility, Quiet Space, Sensory Decompression, Well-being

MUSE – Trento Science Museum, already well known for its focus on sustainability and innovation, chose to take a further step towards universal accessibility by launching a very special space that is increasingly finding important comparisons in the Italian museum scene: Science Centre Immaginario Scientifico in Trieste; Castello D'Albertis/Museums of Genoa; Egyptian Museum of Turin.
Going beyond the simple removal of architectural barriers, MUSE has created an environment that is welcoming and reassuring, a place where visitors can pause, regain their balance and continue their museum experience.
This "comfort zone" is the result of a project that combines architecture, design and neuroscience knowledge to address a theme that is becoming really important to contemporary design: inclusion through space.

The MUSE Quiet Space: when the Museum becomes an embrace

Entering a museum means losing yourself in a world full of every type of stimuli: colors that capture the eye, lights that reveal every detail, the sounds of voices and footsteps weaving together through the galleries. For many people, it's an exciting experience – but for some, this sensory richness can turn into a vortex that's hard to manage.

Barriers are not always visible. They're not just steps or narrow doors, but also overwhelming bright lights, sudden noises, or crowds.
All these stimuli, when they are too much intense, can make a museum visit experience challenging and exhausting.
It was from this all this kind of awareness that the "Quiet Space at MUSE" was created – a refuge designed for those who need to pause, breathe, and regain their balance.

An idea born from listening

The Quiet Space is not a top-down invention, but it's instead the result of many voices gathered over time: families who shared how challenging it was to visit the museum with children sensitive to noise; people who felt overwhelmed by lights and crowds; educators and experts who are deeply familiar with all the needs of individuals with neurodivergence or sensory disabilities.
To make a shape to these needs, MUSE began a co-design process together with associations, neuroscience professionals, and architects.
The result is a special environment inspired by the Snoezelen approach (image 1) – a methodology developed in the Netherlands in the 1970s that employs gentle sensory stimuli such as sounds, lights, colors, and scents to promote well-being and relaxation.
Bringing this concept into a museum setting means converting a visit into a truly inclusive experience.

What the quiet space looks like

In the few square meters of this refuge, all the senses are gently stimulated:
- *Sight* through soft lights in relaxing colors inspired by four Trentino landscapes – lake blue, forest green, amber sunset over the Dolomites, and pink Dolomite dawn – and by a bubble tube.
- *Hearing*, through the reproduction of four Alpine soundscapes that engage the visitor (the plasterboard ceiling acts as a eco chamber)
- *Smell*, through subtle scents that evoke memories (thanks to an aroma diffuser)
- *Touch*, through a wave-shaped wall designed to promote relaxation.

The chaise longue, where visitors can lie down, mimics the museum's skyline and, like the poufs, is made of soft materials in neutral tones.
The floor is carpeted to create a warmer and more welcoming atmosphere.
The room also contains a box with small anti-stress toys and a weighted blanket that can be used when needed to apply gentle pressure over the body – similar to an embrace – fostering calm and helping to ease anxiety (images 2, 3, 4).

A refuge that nurtures well-being

The Quiet Space is a welcoming place – but also a practical tool for improving well-being, as it promotes:
- Physical and psychological health, by helping to reduce heart rate and muscle tension, encouraging a state of relaxation.
- Improved communication, by fostering non-verbal interaction and the expression of emotions.
- Inclusion and awareness, by encouraging socialization, autonomy, and integration.

Who it's for

This space was conceived primarily for children and adults on the autism spectrum, and for people with neurodivergence or non-visible disabilities. But there is no "exclusive audience": the Quiet Space is for everyone.
Anyone, during a visit, can feel tired, overwhelmed, or in need of silence. Taking a break is not a luxury – it's a right. This message at MUSE is clear: culture belongs to everyone, and everyone has the right to experience it at his own pace.

Access and use procedures

Visitors wishing to use the Quiet Space should contact the floor staff (attendant/fire safety officer/educator) who is always present on the second floor (as well as the others).
The staff member will then communicate the request via radio to the Duty Manager, the person responsible for managing the daily logistics of all activities taking place in the exhibition halls.
If the space is available, the visitor is accompanied to the room by a staff member.
At the entrance, it is possible to select one of the four available colored buttons, each corresponding to a specific sensory scenario lasting 15 minutes.
If another button is pressed while a scenario is running, the new scenario will start immediately and the timer will reset, beginning a new 15-minute countdown.
Outside the room, a red light above the door indicates when the space is in use (occupied).
After approximately 15 minutes, if the visitor has not yet left, the member staff will check that everything is fine and, if necessary, will ask whether more time is needed.

More than just a room

The Quiet Space is a single part of a broader project. For example, noise-canceling headphones are available at the ticket desk for both adults and children, useful when the environment becomes too loud. There is also an AAC (Augmentative and Alternative Communication) guide, which translates contents into symbols to make it accessible for people with communication difficulties.
In 2024, MUSE's commitment was recognized with the OPEN certification, which attests the quality of services offered to people with disabilities. MUSE was the first museum in Trentino to receive this recognition, thanks in part to PNRR funding that supported new accessibility tools: tactile maps, three-dimensional models, videos in LIS (Italian Sign Language) and IS (International Sign).

Stories that matter

More than official awards, it's the stories of those who have experienced the Quiet Space that truly speak for it.
For example, families who were finally able to enjoy their visit without anxiety; children who once couldn't remain in crowded environments and now can find a safe refuge; parents who felt welcomed instead of judged.
Here are a few interesting statements taken directly from the Duty Managers' notes
"Elderly visitors, tired after a very busy day at the museum, asked for a quiet place to rest for a few minutes before continuing their visit."
"Child with autism, very agitated. The mother had read on the website about the availability of this service. At the end of the visit, she came to the office to thank the staff for the idea and the features of the Quiet Space – 'very innovative, my child felt comfortable and he cooled off, top space!'"
"Foreign visitors used the Quiet Space incorrectly, thinking it was part of the exhibition after reading about it on the website..."

Monitoring people

To keep track of the number of people who have used the Quiet Space since its opening, we have set up a shared file with the Duty Managers.
Inside the Quiet Space, there is also a questionnaire available in Italian, English, and German, accessible via a QR code (image 5).

An invitation

The Quiet Space does not require a reservation: you can simply ask the staff, who are trained to welcome visitors with sensitivity.
It is a simple yet powerful invitation – to experience the museum while respecting everyone's own needs, to pause when necessary, and to start again with renewed energy.
In an increasingly noisy and fast-paced world, MUSE has chosen to remind us that calmness is a right – and that a museum is a living space, capable of growing together with people.
The Quiet Space is a sign of the choice to place the human being – in all their complexity and beauty – at the center.

notes

Please note: There are no specific bibliographic references, as architect Ivan Muscolino based his work mainly on his own personal experience, developed through visits to wellness centers and the analysis of articles and projects published in trade magazines, within the context of SPA design for hospitality facilities.

As he himself stated:
"Architecture is also made of spatial sensations experienced firsthand."

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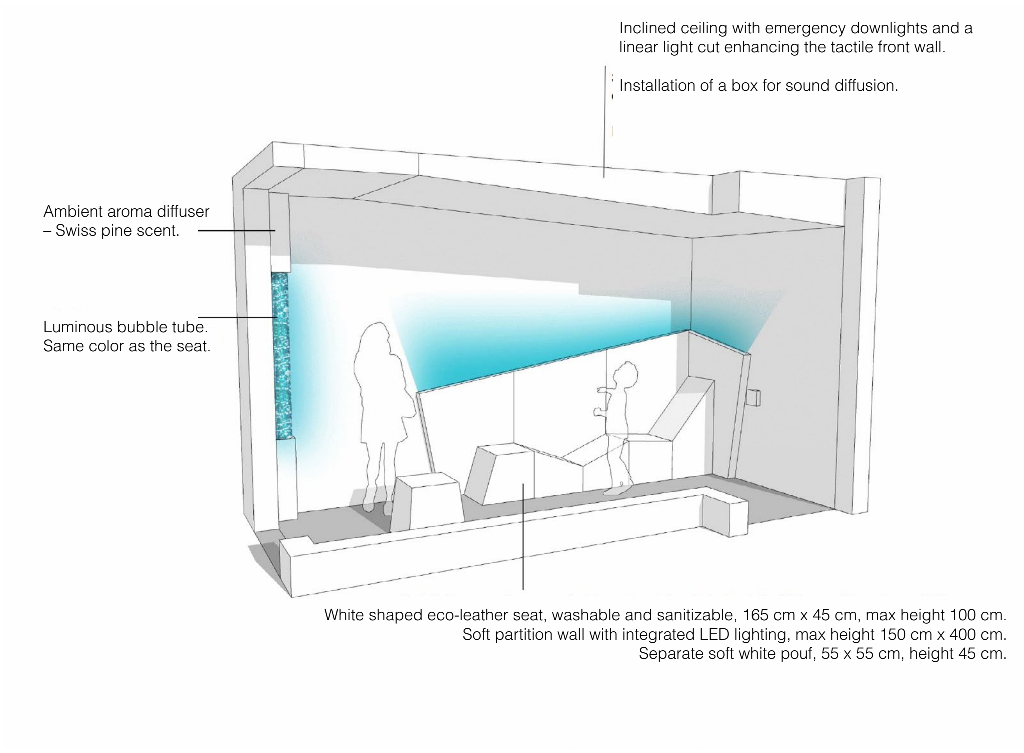
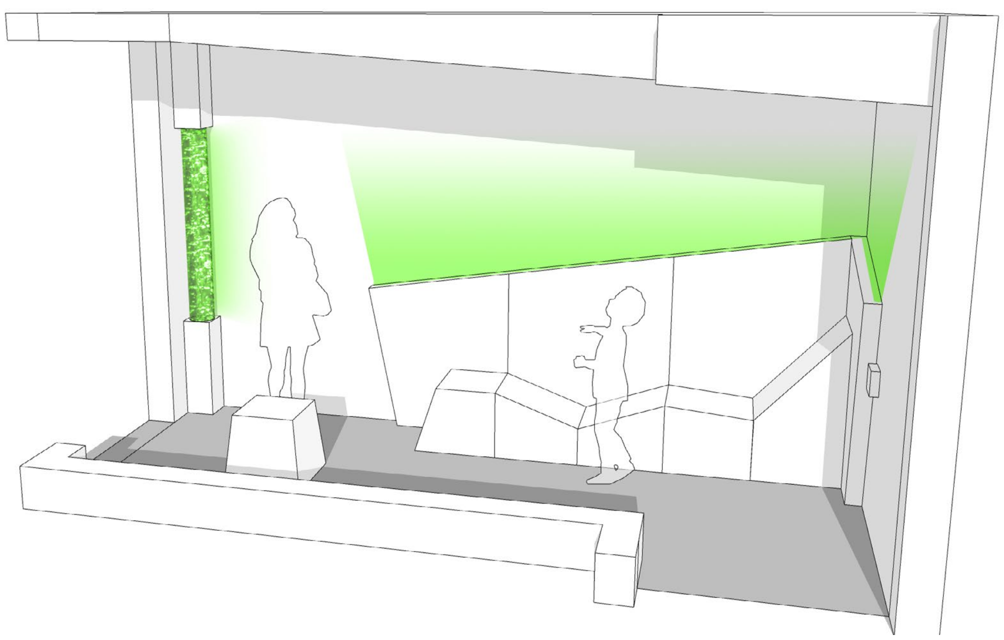
image 1

Snoezelen therapy approach, Paolo Degiovanni, 2025.
Four examples of Snoezelen approach.

images 2, 3

Quiet room design, Ivan Muscolino, 2023.
Quiet Room’s rendering drawnings made by architect Ivan Muscolino.





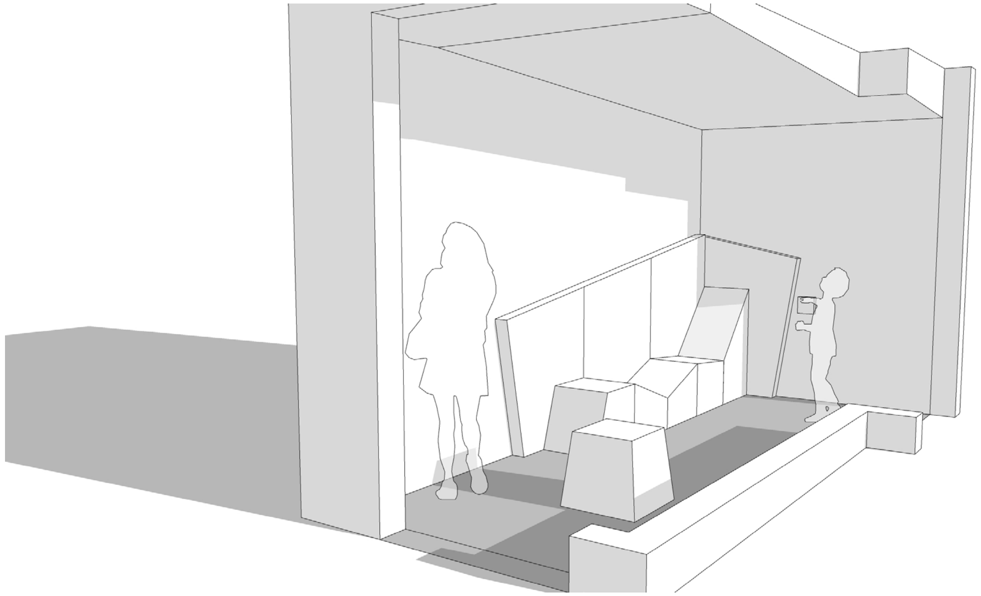


image 4

Quiet room design, Ivan Muscolino, 2023.
Quiet Room’s rendering drawnings made by architect Ivan Muscolino.

Questionario per chi
utilizza lo Spazio Calmo

Survey for
Quiet Room’s users

Fragebogen für Benutzer
des Ruheraums

image 5

Qrcodes, Paolo Degiovanni, 4th October 2023.
Three QR codes available in Quiet Room.

DESIGN THINKING AND USER ENGAGEMENT

BEYOND ACCESSIBILITY:
CO-DESIGNING A SENSE OF BELONGING IN THE WELLCOME COLLECTION LIBRARY

Katie Gaudion, Evie Jeffreys

abstract

This reflective paper explores a collaboration between two distinct organisations, Wellcome Collection and Heart n Soul in London, focusing on how individuals from both groups co-designed a more welcoming library entrance space for learning disabled and neurodivergent visitors. Inclusive design is not solely about the end result, but also the process of building relationships and ensuring people are engaged as equal partners throughout the co-design journey.
We discuss the creative and collaborative methods used, the tensions and shifts encountered along the way, and how the project evolved from addressing physical accessibility to cultivating a deeper, more nuanced sense of belonging.

keywords

Inclusive Design, Co-design, Belonging, Learning Disability, Neurodivergence, Collaboration

Introduction: Inclusive design as relationship-building

In the evolving landscape of inclusive design, much emphasis is often placed on final outputs - how a space looks, functions and accommodates diverse needs. But what if we paused to look at the process itself as an equally valuable output for the 'client'? This project between Wellcome Collection, a museum, library and archive in London, and Heart n Soul, a creative organisation co-led by learning disabled and autistic people, challenges conventional narratives about inclusive design.
This collaboration didn't begin with a clear brief or a fixed objective. Instead, it began with an open invitation, a shared curiosity, and a willingness to sit with uncertainty. What emerged was not only a reimagining of library spaces, but also a reimagining of how different minds and bodies can work together with care, humour, trust, in a creatively unpredictable environment.

The collaborators

Wellcome is a global charitable foundation that supports science to solve urgent health challenges. As part of this broader mission, Wellcome Collection offers free public access to exhibitions, library materials and archival resources that explore health through social, cultural, historical and artistic lenses. The Collection seeks to build a world where everyone's experience of health matters.
Heart n Soul is a London-based organisation supporting learning disabled and autistic

people as artists, performers, thinkers and researchers. Their work challenges societal assumptions and creates spaces where learning disabled people can lead and participate on their own terms. The collaboration between these two organisations grew from a mutual interest in making research and research spaces more inclusive, not just by changing policies or architecture, but by centring different voices in the design of the space itself.

How it all began: meeting without a plan

In summer 2022, staff from Wellcome Collection presented Heart n Soul's "What's Next?" strategy group. Crucially, they came without a predetermined plan. This openness set the tone for what would become a deeply collaborative process. Rather than arriving as experts or project leaders, the Wellcome Collection team positioned themselves as learners, willing to be shaped by the process and the people involved.
Wellcome Collection had already started acquiring Heart n Soul's archive, following Heart n Soul's two year research residency there. Staff from the library and Access, Diversity and Inclusion teams began to reflect on what the experience of accessing the archive might be like for a learning disabled visitor. Both groups began exploring what they wanted to do together, and how they might do it. Letting go of power and resisting the urge to define outcomes too early became central tenets.

Getting to know each other: building trust through play and presence

Before any physical changes were proposed, the teams spent significant time getting to know each other. Trust, it was agreed from the beginning, was not just a nice-to-have; it was foundational. The group played ice breaker games, made art, drank tea and had lunch together. These informal, human moments allowed for decompression, connection and emotional levelling, especially important for participants who were commuting long distances or arriving directly from public facing shifts.
This phase also included collective exploration of the library space itself. Many participants expressed that Wellcome Collection's library felt intimidating, unwelcoming or difficult to navigate. The entrance in particular was cited as a barrier, not just physically, but emotionally. While previous accessibility projects might have stopped here, focused on improving signage or seating, this group chose to go deeper. After deciding to explore 5 top voted design ideas further, we started engaging more with the collections for artistic inspiration.

Reframing the design brief: from accessibility to belonging

Creative sessions in small groups helped refine these design ideas. Participants drew, built 3D models, visited exhibitions for inspiration and reflected on their personal experiences of cultural institutions. However, a key turning point came during a reflective moment, when someone was asked whether they would visit the library outside of these sessions. Their answer: "I'm not sure I would."
This was a wake-up call. It signalled that physical improvements alone weren't enough. If people didn't feel like they belonged when they entered the space, no amount of improved signage, furniture or lighting would matter.
This was a moment of tension on the project. Some people already felt like the 'getting to know you phase' had lasted too long and were eager to start making something.

Personal connections with the archive

In response, the group shifted focus toward the Wellcome Collection archive. For many, this was still an abstract and unfamiliar concept. What even is an archive? And why would anyone want to spend time in one?
Together, the group discovered a wide range of materials, some historical, some humorous, some deeply personal. Items included a video about Mary Shelley, paintings of Nepal and Jamaica, a takeaway chicken shop flyer and crucially, the Heart n Soul archive itself. This moment of recognition seeing their own stories represented was profound.
For the first time, everyone on the project joined the library formally. They ordered archival items, handled rare materials, and began weaving personal connections between their lives and the collection. The library became less of an institution and more of a shared space. It began to feel like it could be "theirs."

Reflecting on power, process, and partnership

As the collaboration deepened, so too did the group's reflections. They began to interrogate the dynamics at play in their own partnership. Had they really been working as equals? Were some voices getting more space than others?The group recommitted to working as collaborators, not consultants. This meant slowing down, staying curious, and being willing to sit with creative tension. Some participants wanted to move quickly into "making" something; others wanted to keep exploring. Both instincts were valid, and the process had to stretch to hold them.

Navigating fuzziness: the double diamond and beyond

Initially, the group followed the Double Diamond framework developed by the British Design Council in 2005: Discover, Define, Develop, Deliver. The early "Discover" phase focused on relationship-building and open-ended exploration. But as the project moved forward, it became clear that this model, while helpful, couldn't fully capture the organic, non-linear nature of the work.
In fact, the journey was later represented not as diamonds, but as a sculptural tangle of colourful pipe cleaners, shaped by two collaborators, Evie and Pino. Their model included loops, bends, intersections, and knots, better capturing the unpredictability and richness of the real experience (image 1).
The lesson? Inclusive design isn't linear. It doesn't follow a brief. It's messy, improvisational, emotional, and creative.

What we learned: values that shaped the work

From this project, a shared set of values emerged, statements that didn't just describe the work, but shaped it in real time:
Be present: Don't just show up, arrive fully.
Let go of anxiety: Not knowing is part of the process.
Drop preconceptions: Expect to be surprised.
Be yourself: Bring your full self, not your 'professional' self.
Have fun: Play opens up serious possibilities.
Believe in the process: Trust takes time.
Embrace the fuzziness: Clarity comes later.
Use no jargon: Make space for everyone's understanding.
Be brave: Speak honestly, especially when it's hard.

Actively listen: Listening is a creative act.
Be flexible: Don't cling to fixed ideas.
Keep people guessing: Leave room for innovation.
Stay reflective: Pause often and ask, "Are we doing this together."

Conclusion: designing belonging

What does it mean to design an inclusive library? For this group of people, it meant resisting the urge to "fix" things too quickly. It meant noticing power dynamics and naming them. It meant shifting from a focus on accessibility (important though it is) to cultivating belonging. By prioritising relationships, creativity, and shared reflection, Wellcome and Heart n Soul began to co-design not just a space, but a culture. They learned that true inclusion isn't achieved through tick-boxes or checklists, it's created through genuine, messy, human collaboration.
This project hasn't just made the Wellcome Collection library more welcoming for learning disabled and neurodivergent people. It asked everyone involved to reflect on their own assumptions, slow down, and imagine new possibilities for how we design together.
While many creative design ideas emerged during the project in response to the physical space, the co-design team ultimately agreed that the most meaningful outcome was to create a video installation. This piece reflects their shared experience of discovering artifacts from the Wellcome archive, capturing the emotions those encounters evoked. By highlighting what an archive can be, and emphasising that the Wellcome library and archive are for everyone, the installation is both a creative expression and an invitation to belong.

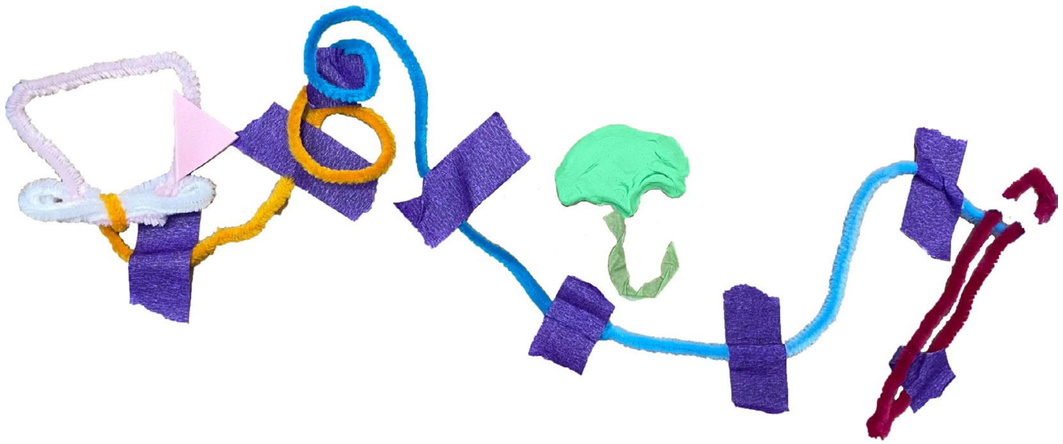


image 1

Pipecleaner representation of the co-design process, by Evie and Pino

URBAN HERITAGE AS A DRIVER FOR MENTAL HEALTH. REACTIVATING URBAN MEMORY FOR COLLECTIVE WELL-BEING IN TURIN

Giulia Mezzalama

abstract

The paper explores the relationship between urban heritage and mental health through the action-research project *Healing Heritage*, developed in Turin by the Politecnico di Torino. Framed within a biopsychosocial and salutogenic perspective, the project investigates how urban cultural heritage can support community well-being and social inclusion. The workshop focused on the Borgo San Paolo neighborhood, experimenting with participatory methods for the collective construction of urban memory. Activities combined analogue and digital tools, collaborative mapping, and digital storytelling, engaging students, young adults, and elderly residents as bearers of local memory. The experience highlights the potential of urban heritage as a medium for care, connection, and intergenerational dialogue, fostering belonging and inclusion through the reactivation of urban memory.

keywords

Urban Heritage, Urban History, Mental Health, Co-Design, Participatory Methods

The issue of mental health, already included among the Sustainable Development Goals of the 2030 Agenda (SDG 3), is today emerging as an intrinsically urban dimension – a phenomenon that affects social dynamics and, more generally, the quality of life in cities. In this perspective, mental health is understood not only in its clinical dimension, but as an essential component of *well-being*, reflecting the interconnections between psychological, social, and environmental factors that shape the quality of life in contemporary urban environments.
As recently underlined by the European Forum for Urban Security (EFUS), mental health represents a “silent crisis” that crosses Europe and directly influences the cohesion of urban communities and the perception of safety in public space (EFUS, 2025).
However, understanding mental health as an urban matter is not such a new approach. Within the principles of *democratic psychiatry*, there was already the idea of a *caring community*, capable of assuming the role of an instrument of care, in which patients are active rather than passive participants in the healing process (Basaglia, 2005). In the broader vision of the urban dimension of care inherited from Basaglia’s thinking, it is the city – with its health facilities but also with its streets, squares, courtyards, and gardens – that welcomes fragility in the name of an idea of social inclusion and participation, which are both goals and integral parts of the person’s rehabilitation path.
The city is thus entrusted with a new double responsibility: to guarantee new territorial services in newly designated places, and to enhance existing places as new spaces for socialization and opportunity.

Starting from the 1970s, with the approval of Law 180/1978, the urban dimension acquired an unprecedented role in the history of psychiatry. This represented a shift in scale – from architecture designed as a mechanism of containment and treatment to the city itself as an inclusive and therapeutic space, capable of responding to people’s needs in ways that respect and enhance their humanity. An *urban dimension of care* which, in its dynamic and transformative nature, also restores those factors that, according to Basaglia, are fundamental human rights: *planning, perspective, and the possibility of a future*.
A city that cares (Gallio & Cogliati Dezza, 2018) nevertheless presupposes another concept – that of urban proximity. This is understood not only as the condition of being physically close in space, but rather, as “a feeling derived from the awareness of sharing something with someone” (Manzini, 2015, p. 9), and therefore as a sense of human closeness, a factor that can foster greater social cohesion. This concept of proximity gains even greater value when associated with a collective recognition and shared awareness of the tangible and intangible values that characterize urban contexts. When this occurs, collective dynamics of care can emerge, drawing not so much on the sharing of services or products, but on the generative value of cultural heritage itself (Saporito & Ciaffi, 2022). This absence of a merely utilitarian dimension is made explicit in the English definition of *heritage* as: “Inherited resources which people value for reasons beyond mere utility” (English Heritage, 2008).
According to UNESCO’s definition of the *Historic Urban Landscape*, the urban area is a “historic layering of cultural and natural values and attributes, extending beyond the notion of ‘historic centre’ or ‘ensemble’ to include the broader urban context and its geographical setting” (UNESCO, 2011, p. 4). It focuses on “the entire human environment with all of its tangible and intangible qualities. It seeks to increase the sustainability of planning and design interventions by taking into account the existing built environment, intangible heritage, cultural diversity, socio-economic and environmental factors along with local community values” (UNESCO, 2011, p. 4).
Together, these aspects shape the identity of cities and historic settlements, allowing us to consider urban heritage as a resource for well-being and social cohesion:
“Urban heritage is of vital importance for our cities – now and in the future. Tangible and intangible urban heritage are sources of social cohesion, factors of diversity and drivers of creativity, innovation and urban regeneration.” (UNESCO, 2013, p. 5)
In the Anglo-Saxon context, the concept of place-shaping refers to the sense of belonging associated with historic places that contributes to reducing social isolation. *Place-shaping* is a central practice in community development, linked to the creation of local belonging and empowerment. This approach emphasizes the importance of ensuring that local people have a voice, feel valued, and can express a shared sense of identity. Culture and heritage are recognized as fundamental drivers for generating this sense of belonging and social cohesion, countering phenomena of social isolation (Historic England, 2018).
Social isolation has now become a public health issue – and not only a mental health one. In August 2025, the World Health Organization (WHO) Commission on Social Connection released its global report revealing that one in six people worldwide is affected by loneliness, with significant impacts on health and well-being. Loneliness is estimated to be linked to about 100 deaths every hour – more than 871,000 deaths annually.

Healing Heritage: An Action-Research Project on Urban Memory and Well-being

In Italy, a research project conducted between 2024 and 2025 by Arup, in collaboration with the associations *MinD Mad in Design* and *OrMe ETS Orti Metropolitani di Torino*, investigated the relationship between mental and physical health and environmental factors in the urban context.

The study, entitled *Regenerative Neighborhoods: Promoting Mental and Physical Health in the Urban Environment*, developed an analytical, qualitative, and quantitative framework applied to the case study of the city of Turin. Among the determinants of health, the research also identified cultural heritage and the presence of artistic and creative activities as key factors (Candiracci et al., 2025).
Within the same urban context of Turin, but with a specific focus on the relationship between urban heritage and collective well-being, the Healing Heritage action-research project was developed. Promoted by the Politecnico di Torino, Interuniversity Department of Regional and Urban Studies and Planning (Mezzalama, 2024), it has been active since 2023 and includes an annual workshop for university students and young adults interested in the intersections between cultural heritage and mental health.
Conceived as a participatory and inclusive design initiative, *Healing Heritage* experiments with actions and practices that enhance the role of cultural heritage in promoting mental well-being. The project recognizes the potential of involving young people in heritage-based activities as platforms for creative expression, social interaction, and the exploration of personal and collective narratives.
Through a multidisciplinary approach combining collaborative practices and psychological observation, *Healing Heritage* has revealed the psychological and social value of such practices by analysing group dynamics, interpersonal relationships, and subjective experiences. It also functions as an interdisciplinary educational space that connects students with the broader relationship between urban heritage and well-being, introducing innovative approaches, methodologies, and tools – including digital ones – for more democratic and inclusive processes of heritagization.
In collaboration with public institutions, third-sector organizations, and mental health services, *Healing Heritage* explores participatory processes for the collective construction of urban memory and its role in fostering social inclusion and collective well-being. It interprets the urban dimension of care through the lens of the *city as memory* (Comoli, 1983, p. 238), understood as a living palimpsest where the material traces of the city intertwine with collective memories and shared narratives of belonging and regeneration.

Collective Urban Memory and Well-being in the Borgo San Paolo Neighborhood

In Turin, the *Healing Heritage* workshop focused on the Borgo San Paolo neighborhood, located in the western part of the city. It is one of Turin's historic working-class districts, developed during the city's industrialization phase, where the process of urban identity construction unfolded over the course of a century. Since the deindustrialization of the 1980s, the neighborhood has gradually found a new urban vocation through culturally driven processes of social regeneration.
Borgo San Paolo's industrial character consolidated between the two World Wars, turning it into one of the most significant popular districts of Turin and a symbol of the city's working-class pride, largely due to the establishment of several factories – among them, the Lancia automobile plant (image 1).
From the 1980s onwards, the progressive closure of industrial activities triggered major interventions in the redefinition of the street grid and land use, leading to the construction of residential complexes and new cultural centers, such as the Fondazione Merz and the Fondazione Sandretto Re Rebaudengo, aimed at fostering culture-based urban regeneration dynamics.
As a tangible reminder of the neighborhood's industrial identity – and particularly of the Lancia factory – a single architectural landmark remains: the Palazzo Uffici Lancia, built between 1953 and 1964 by architect Nino Rosani, with Gio Ponti and Alberto Rosselli.
At the beginning of the 21st century, the areas surrounding the former Lancia site were

redeveloped into a mixed residential and commercial zone, with new apartment buildings and commercial structures. The workshop focused especially on the area of today's Giardino Piredda, which replaced the former Lancia buildings (images 2, 3). The garden preserves only a faint memory of that industrial past, yet it has become a meaningful place where mental health, memory, and community care intersect. Located between Via Issiglio and Corso Rosselli, it faces two small psychiatric residential facilities whose users, supported by local mental health services, have been involved since 2019 in participatory activities promoted by *MinD Mad in Design* to encourage shared use of the garden.
Its name, assigned in 2008 to commemorate Filippo Piredda, a young man who lost his life in 1997 while defending a woman from gender-based violence, adds a second layer of collective memory to a place already marked by its industrial past. Subsequent initiatives – such as the 2021 awareness campaign on gender violence, the planting of thirty cherry trees in 2022, and the 2024 Collaboration Pact between the municipality and *MinD* – have contributed to defining *Giardino Piredda* as a potential space of inclusion and cultural regeneration: a place whose value for well-being is still not fully perceived by the community and therefore calls for shared narratives to make its meanings visible and collectively experienced.
Both the industrial and social memories embedded in this area remain largely imperceptible to newer residents, particularly young university students, while they persist vividly among older inhabitants who experienced the neighborhood's transformations firsthand. As they say, "under the soil of Giardino Piredda, there are still traces of the tires once produced by the factory."
The workshop focused on innovative methods of collective construction of urban memory. Through the analysis of documentary and iconographic materials from local archives – including those of the Circoscrizione, the ANPI (National Association of Italian Partisans), the Monginevro Association, and the Polo del '900 Archives – participants were encouraged to view archives not merely as repositories of preservation but as active laboratories for the creation of shared narratives (image 4).
This process included co-creation and digital activities such as collaborative mapping and digital storytelling. The engagement of archives as cultural institutions to be valorized in the perspective of social inclusion aligns with the evidence produced by the *Archivi e Salute* project (Uboldi et al., 2025), particularly its experimentation with "memory boxes" in care settings and creative protocols of narrative activation.
More broadly, the workshop adopted co-creation methods and tools grounded in the awareness of the role that cultural experiences can play as forms of care within a biopsychosocial and salutogenic framework. This approach contributes to the development of tools and guidelines for assessing the social impact of culture, drawing on the growing body of evidence about the contribution of the arts and cultural participation to health and well-being (Fancourt & Finn, 2019), and on the principles of the Faro Convention (Council of Europe, 2005), which emphasizes the right of citizens to engage with cultural heritage as a resource for human development, social cohesion, and quality of life.
The Healing Heritage co-design workshop was structured in project teams led by a multidisciplinary faculty of designers, urban planners, heritage scholars, psychologists, and anthropologists, fostering an integrated perspective on the relationship between place, memory, and community well-being. Participants engaged in a range of activities aimed at increasing awareness and reflection on the historical context and urban memory, and at reframing its narrative through digital and participatory tools.
The teams experimented with innovative methodologies for analyzing cultural heritage and historicized environments, mediating between analogue and digital dimensions through collaborative mapping and visualization platforms. They also met with elderly residents as bearers of local memory (image 5), conducted site explorations in the form of "treasure

hunts" to rediscover hidden narratives, and developed digital storytelling outputs using the *StoryMap* application (image 6).
The methodology combined individual and collective actions, valuing both personal experiences – including those of young patients – and shared outcomes. This perspective highlights the importance of recognizing and celebrating diverse individual narratives while acknowledging that collective meaning emerges from their interaction. Digital tools played a crucial role in synthesizing these contributions, shaping the *StoryMap* as a product of collective reflection.
In this sense, *Healing Heritage* underscores the potential of urban cultural heritage as a medium for care, connection, and intergenerational dialogue, demonstrating how participatory and heritage-led digital practices can foster belonging, inclusion, and community well-being through the reactivation of urban memory.

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image 1

Workers leaving the Lancia factory, circa 1958
City of Turin Archives.

image 2

Lancia factories in 1962.
City of Turin Archives.

image 3

Aerial view of Giardino Piredda public park, 2018.

image 4

A workshop session during the activity “La mia Scatola della Memoria” at the Polo del ’900 Archives
Credit: Alberto Costa.

image 5

A moment from the co-mapping session at Cumiana15, former Lancia factory.
Credits: Alberto Costa.

image 6

Frames from the digital narrative created by the participants using StoryMaps, focusing on sites of urban memory in the Borgo San Paolo neighborhood.

DESIGNING RESTORATIVE SPACES FOR PEOPLE WITH NEURODIVERGENT CONDITIONS

Toar Sadia

abstract

Research has shown the theme of refuge to be a key consideration in designing spaces that are inclusive for neurodivergent populations. Restorative spaces can provide a controlled environment of refuge to reset from an experience of sensory overload or underload, anxiety or overwhelm.
Considering that neurodivergent populations are more susceptive to experiencing sensorial hypersensitivity and/or hyposensitivity, it is important that restorative spaces are designed flexibly to accommodate all needs. Research findings lead to the recommendation that restorative spaces are designed as neutral environments for the most sensitive users, with optional stimulating design features for users requiring additional stimuli, while ensuring that designing for the experience of one does not compromise the experience of the other. Sound and lighting have been shown to be key design considerations, and biophilia has been shown to be a guiding principle in their design.

keywords

Neurodiversity, Restorative Spaces, Quiet Spaces, Sensory Overload, Design Preferences

Recent research on designing for neurodiversity has shown that sensitive consideration of the themes of prospect, refuge and context has led to spaces which are more inclusive for people with neurodivergent conditions (Granland et al., 2025). Refuge can be provided in various degrees and levels of control, for instance, a cocooned seat within an open area or a private enclosed space. Restorative spaces provide a controlled environment of refuge for people seeking to reset from an experience of sensory overload or underload, anxiety or overwhelm.

Studies have shown that neurodivergent populations are more susceptible to experiencing sensory processing differences, with hypersensitivity and/or hyposensitivity to sensory stimuli, potentially leading to experiences of sensory overload or underload (Cohen & Leckman, 1992; Lane & Reynolds, 2019; Tavassoli et al., 2014; Van Hulle et al., 2019). For this reason, restorative spaces are likely to be beneficial to people with neurodivergent conditions.

A research was conducted in 2020 exploring the design preferences of neurodivergent populations for quiet spaces (another term for restorative spaces) (Sadia, 2020). The research included a global online survey with 312 responses which met the inclusion criteria for data analysis, and six interviews with various professionals in the field. The highest number of responses to the survey were provided from northern Europe, northern America and western Asia respectively.

Research findings have shown that people perceive education environments to be the most important locations for the inclusion of restorative spaces (Sadia, 2020). This was followed by workplaces, healthcare, and transportation environments respectively.

Respondents' neurodivergent conditions were noted in the survey, alongside the frequency in which they experience sensory overload (Sadia, 2020). These led to the establishment of neurodivergent groups and sensory overload frequency groups for data analysis. Correlations were tested between these groups and respondents' design preferences. It is assumed that the sensory profile of people who have frequent experiences of sensory overload is mainly hypersensitive, while the sensory profile of people who have infrequent experiences of sensory overload is mainly hyposensitive.

In order to support the process of self-regulation, the design of restorative spaces requires sensitive consideration of the various design elements of the space. Research findings have shown sound to be the most important design consideration, followed by lighting, space layout, colour, furniture and decoration (Sadia, 2020).

Research findings have shown the options of "no sound" and "sounds of nature" to be the preferred soundscapes, followed by "music" (Sadia, 2020). Correlation analysis between design preferences and sensory overload frequency groups imply a correlation between the choice of "no sound" and hypersensitivity and the choice of "music" and hyposensitivity.

Overall, research findings have shown sounds of water to be the preferred sounds of nature, including "rain" and "ocean waves" (Sadia, 2020). This may be due to their broadband qualities which may help with creating a sense of grounding and relaxation. However, it is important to note that most water-related choices were shown to be associated with hyposensitivity and may not suit hypersensitivity. Therefore, they should be carefully considered. Preferred music qualities were "soft", "instrumental" and "slow", with an association between the choices of "instrumental" and "slow" music and hypersensitivity, and the choice of "vocal" music and hyposensitivity.

In terms of lighting, there was a general preference towards dimmer or medium lighting levels and a preference for a correlated colour temperature (CCT) of about 3000K (Sadia, 2020). A warmer correlated colour temperature was shown to be associated with hypersensitivity and a cooler correlated colour temperature with hyposensitivity.

Respondents who indicated that they would like the incorporation of coloured lighting showed a preference towards bluer coloured lights (Sadia, 2020). This may potentially be explained by the biophilic qualities of the colour blue, a colour which is abundant in nature through the sky and bodies of water, or by a psychological cooling affect which may be generated by looking at cool hues. This may help relieve the sense of heat generated by an experience of sensory overload or anxiety.

Survey results have shown a preference for a "simple", "private", "informal" and "cosy" space layout, a preference for "coloured" walls, followed by "textured" and "white" walls, and a preference for "natural materials" followed by "muted colours" and "few colours" for material and colour scheme (Sadia, 2020). "Comfort" was indicated as the most important furniture quality to consider, followed by "texture" and "flexible use", and "fabric" was the preferred furniture material, followed by "wood", both of biophilic qualities. "Chairs", "pillows" and "bean bags" were noted as the most important items to provide within a

restorative space.
Decorative preferences showed a strong connection to biophilia (Sadia, 2020). Plants were by far the preferred element to include in a restorative space, with agreement across all neurodivergent and sensory overload frequency groups. This was followed by a preference for images, with the strongest preference being for images of nature.

The last section of the survey asked respondents to express their thoughts on three images of quiet spaces (Sadia, 2020). The three quiet spaces differed in their design qualities, including the level of stimuli they would provide for a user. There was only a slight difference in how the respondents rated the relaxation of each quiet space, with all three rating slightly above average.

All three quiet spaces had a design feature which the respondents disagreed on (Sadia, 2020). This includes lighting, space layout, furniture and objects, which were viewed as both highly liked and highly disliked, each in one of the example restorative spaces.

The last question in this section asked whether there was a quiet space that fully met the respondent's needs, including the option that none of the quiet spaces have met them (Sadia, 2020). The uniform distribution of responses across the four answer choices showed that there wasn't one answer that fit everyone, indicating that there isn't a one-size-fits-all design solution for restorative spaces. This is further evidenced by the previous findings which showed a lack of consensus on the design of quiet spaces.

Overall, the research did not show correlations between respondents' specific neurodivergent condition and their design preferences but has shown correlations between the frequency in which respondents indicated that they experience sensory overload and their design preferences (Sadia, 2020). This suggests that a person's sensory profile is a predictor for their design preferences in a restorative space and helps to explain the diverging perspectives on design features within a restorative space. Nevertheless, there seemed to be an agreement across respondents that biophilic features contribute positively to the design of a restorative space.

Three themes emerged as key qualities to provide when designing restorative spaces: variety, flexibility, and user control (Sadia, 2020). This can be provided by options for users to choose from, such as having the ability to adjust the lighting levels and correlated colour temperature, or having a variety seating options. Providing variety, flexibility and user control can be especially empowering for users at a time when they may feel out of control.

Summarizing the above information into a tangible design solution leads to the following general recommended design approach: provide a flexible environment with a baseline design which is neutral and passive to meet hypersensitive needs, and optional additions by choice which are more active and stimulating to meet hyposensitive needs (Sadia, 2020). It is expected that this would materialize differently for each restorative space with a consideration of the context in which it is designed. Context may include the general site and local environment, building typology, programme, adjacencies and anticipated users. If more than one space is provided, consideration can be made to designing them to different levels of stimuli, such as the provision of a more stimulating sensory space. When designing restorative spaces, it is important to ensure that designing for the experience of one type of user does not compromise the experience of another type of user.

PAS 6463:2022 "Design for the mind: Neurodiversity and the built environment – Guide" provides additional guidance to consider when implementing restorative spaces (British Standards Institution, 2022). Thermal comfort should be taken into consideration and user adjustments should be provided to enable meeting individual user thermal comfort needs. Olfaction should be taken into consideration with strong scents being avoided unless they can be provided by choice and only locally, without dispersing into the space. Providing a preview into the space is welcomed, however, user privacy should be maintained.

Additionally, it is important that a restorative space is not coupled with another use and that it is not bookable, to ensure it is readily available for reactive use (British Standards Institution, 2022). The restorative space should be accessible, should not require a key, and should include an occupancy indicator. It is also important to ensure users understand how they are expected to use the space, to ensure appropriate use and behaviour.

It is important that restorative spaces are provided in a location that is easy to access without creating a sense of exclusion (British Standards Institution, 2022), however, it is beneficial if the location is also private, to reduce any concerns about being seen entering the restorative space. Where maps are provided, including sensory maps, it is useful to indicate the location of restorative spaces so users can find them easily.

notes

The content in this section is based on the research titled "Exploring the design preferences of neurodivergent populations for quiet spaces" (Sadia, 2020).

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AURAL DIVERSITY TOOLKIT:
ENGAGING COMMUNITIES FOR INCLUSIVE ACOUSTIC DESIGN

Jemma Jones, Chris Watkins, Mei-Yee Man Oram, David Owen

abstract

Inclusive design must account for a broader spectrum of human sensory experience. We explore how engaging lived experiences of auditory difference and neurodivergence can inform acoustic design strategies that promote equity, wellbeing and accessibility. Drawing on Arup's collaboration with the Aural Diversity Network and the development of the Aural Diversity Toolkit, we examine how personas, participatory workshops, and interdisciplinary collaboration shaped more inclusive solutions. Case studies from a variety of different sectors and settings illustrate how inclusive acoustic design can help to mitigate sensory overload, enhance spatial legibility, and foster belonging. The paper argues for a shift from standardised metrics to evidence-based, user-informed approaches that reflect the complexity of human experience. By embedding community engagement into design processes, we can create environments that are not only physically inclusive but socially transformative.

keywords

Inclusive Design, Acoustics, Autism, Engagement, Design

Introduction

Inclusive design is a critical response to the growing recognition of human diversity in how we perceive, process, and interact with the built environment. As awareness of neurodivergence and sensory diversity increases, and with shifts in demographics and emerging trends, such as a global ageing population (and with that, a correlation between older age and disability, including hearing loss, and neurodegenerative conditions), designers must move beyond one-size-fits-all solutions to create environments that support the needs of all users, both now and in the future.

Globally, neurodivergent conditions such as autism, ADHD, dyslexia, dyspraxia, and dementia affect millions of people. Autism impacts approximately 1 in 100 children whilst ADHD affects an estimated 1 in 20 children and 1 in 40 adults globally. Dyslexia is thought to impact around 1 in 10 individuals (World Metrics, 2025). Dementia, including Alzheimer's disease, affects 57 million people worldwide (or roughly 1 in 143 people) and is a leading cause of disability and dependency among older adults, with women disproportionately affected (World Health Organization, 2025) (World Bank Group, 2025).
These conditions influence how individuals experience space, sound, movement, and information, and they demand thoughtful, evidence-based design responses.

Autistic individuals experience acoustic environments in ways that are often overlooked in

conventional design practices (Rosas-Pérez et al., 2025). The absence of clear information about noise levels in public spaces can contribute to heightened anxiety among neurodivergent individuals (Renel, 2022). This, in turn, can impact on people's confidence in accessing a space in the first instance; the legibility of the space, and whether the soundscape is helping people to process information or distracting / confusing them; and the ultimate experience of the individual within the space. Access to quiet spaces for sensory escape can provide necessary respite for some individuals. Guidance states an individual should be able to control the noise that they are exposed to, e.g. the option to use a variety of spaces including access to a quiet room (British Standards Institution, 2022) or to be given options to choose quieter routes.

By embedding user engagement (to gather lived experience data), together with inclusive design guidelines, into the core of architectural and urban planning processes, we can create environments that not only meet regulatory standards but also foster dignity, independence, and wellbeing. This paper explores how engaging communities with lived experience, particularly those with aural and neurodivergent profiles, can inform design strategies that are both inclusive and future-ready.

This paper begins by establishing the need for inclusive acoustic design in response to aural diversity and neurodivergence. The Background and Context section examines limitations in current acoustic standards and introduces the concept of aural diversity. The Methodology details our interdisciplinary approach and community engagement process, including the development of personas and the creation of the Aural Diversity Toolkit. The Case Studies section showcases applications of inclusive acoustic strategies across residential, charitable and commercial settings. Finally, the conclusions reflect on key insights and propose future directions.

Background and context

Designers of the built environment regularly use standards and guidance documents to inform the design. A limitation of these documents is when they account only for the 'optimal' experience. For example, acoustic criteria are commonly based on the "dBA" metric which does not account for the range of hearing experiences possible (image 1). Rather, the "dBA" metric is derived from listening tests on 'healthy' 18- to 25-year-olds (British Standards Institution, 2023). The term 'aural diversity' refers to the wide range of different hearing experiences in the human population (Drever, 2017). This can include people who are unable to hear certain frequencies, are particularly sensitive to some types of sound or experience sound in a different way (image 2). Davies proposes a conceptual framework to replace the singular model of "normal" hearing with a multi-dimensional space of aural experience but points out further steps would be needed for it to benefit acoustic design (e.g. the mapping of these variations in aural perception and research into how to most effectively tailor an acoustic design to suit a specific group or the broader population) (Davies, 2022).

Very few acoustic standards acknowledge differing hearing needs, and in inclusive design standards there is a lack of technical detail and a lack of signposting to acoustic standards (and vice versa). There is a need for designers of the built environment to widen their awareness and understanding in this area, for a more collaborative and holistic approach to soundscape design.

There is a need for the built environment to be inclusive to ensure spaces are suitable to all who use them. For example: public and commercial buildings (e.g. offices, museums, hospitals, airports etc.) should embrace the full spectrum of human diversity, across disability, age, culture, faith, gender and family or economic status; in offices, employee satisfaction, wellbeing and productivity are key considerations; in museums, the benefits to inclusive design include a fostering of belonging, dignity and equity; in hospitals safety and healing, are important factors that inclusion can contribute to, by creating a supportive atmosphere; in airports inclusive design can improve customer experience and help reduce anxiety and stress associated with travel. Inclusive acoustic design is imperative to achieving these aims, not just for deaf / hard of hearing individuals, but also for positive impact to communities as a whole. For example, in 2022, Arup published a report on the design of cities that work for women to enable the creation of safer and more inclusive spaces, which included comment on the role of acoustics in the perception of personal safety for marginalised communities (Arup, 2022).

This is a good illustration of how the role of acoustics in inclusive design is multi-faceted. There is the consideration of the overall acoustic comfort in a space which relates to key acoustic parameters such as the reverberation time, background noise levels, the sound insulation performance, and the individual's perception of these. It's also important to consider how people perceive safety, as illustrated in our women and girls' work. For example, how safe people feel when they hear voices or footsteps coming from around a corner. This perception can be influenced by context, such as poor lighting or the time of day, as well as by an individual's personal experiences and emotional state at that moment, especially if they can't see the source of the sound. Acoustics contributes to the legibility of a space. For example, a blind or partially sighted person may rely on the acoustic reflections (or absence of reflections) from nearby surfaces to understand their location in a space to aid with navigation. For neurodivergence, the reflections can be overwhelming or disorienting.

Methodology

The process was inherently interdisciplinary, driven not only by collaboration across Arup's acoustics, venues, and inclusive design teams, but also by a strong commitment to community engagement. The partnership with the Aural Diversity Network [1] was pivotal, bringing lived experience and diverse perspectives into the heart of the work. Meaningful progress was only possible through this inclusive approach, where understanding each discipline's viewpoint and engaging with the community were equally essential to the project's success.

The project began in 2022 when Professor Bill Davies of the Aural Diversity Network invited us to speak at one of their Acoustics and Psychoacoustics meetings. In preparation for the meeting, our Acoustics and Inclusive Design colleagues worked together to review the acoustics and inclusive design standards. We engaged with local charities including the Brain Charity to gather initial insights into challenges faced and how the acoustics of a space can help or hinder these. Our presentation to the Aural Diversity Network concluded, amongst other things, that a toolkit should be developed to address this shortfall in guidance, initially focussing on public and commercial buildings.
Our methodology in relation to embedding engagement to inform inclusion solutions, consisted of two parts – direct engagement to gather the data and understand lived experiences, and the creation of personas to summarise and provide easy measurement of success against objectives.

Direct engagement: We worked with the Aural Diversity Network to create a questionnaire for people who are aurally divergent. We posted the questionnaire on the Aural Diversity Network mailing list, on an auditory research mailing list and on LinkedIn. The questionnaire was completed by 49 participants. The questionnaire intentionally avoided asking about clinical diagnoses, rather focusing on people's experiences. The questions asked the participants to describe their aural divergence and which types of sounds they find challenging. The focus was to understand about the acoustic conditions which could help or hinder, in their experience. As such we asked about their confidence in terms of acoustic comfort when visiting particular spaces. Interviews were held with some participants to discuss their experiences in more detail.

The purpose of this layered approach was to (a) provide a wide-reaching platform to gather data and allow broad participation (acknowledging the broad range of aural divergence and experience), before (b) identifying particular areas where there are gaps in current knowledge, in order to explore in more detail for the purpose of the toolkit.

Personas: Personas are an evidence-based representation of a group of people. They are an amalgamation of the lived experiences captured through the questionnaire and interviews. The main purpose of the personas is to provide understanding and empathy to the designer. They enable the designer to consider how a design might be experienced and provides a tool from which outcomes of a project could be measured against.

The Aural Diversity Toolkit [2] was published on World Hearing Day in March 2024 (images 3, 4). The toolkit has been well received and was awarded the Inclusion Award at the UK's Association of Noise Consultants Acoustic Awards 2024. It was praised as an example of "how the work of acousticians contributes to improving the wider community" (Association of Noise Consultants, 2024).

Case studies

Engaging with communities for an evidence-based approach is the key to shaping inclusive design outcomes, considering multisensory experiences, including aural divergence.

On *Coral Living*, a pilot 14-unit residential building dedicated to adults with Autistic Spectrum Disorder, Arup produced design advice on how the spaces could be designed to reduce anxiety, prevent accidents and contribute towards a sense of safety, comfort and wellbeing. This included consideration of noise from building services and from outside sources to mitigate sensory overload. It also included consideration of thermal and visual comfort, safety aspects of temperature, electrical installations and water, as well as guidance around maintenance strategies.

In another example, Arup collaborated with a London based charity on the brief for their new garden project training centre building for adults with learning disabilities and autism. The project provided opportunity for all disciplines involved – including acoustics, inclusive design, mechanical, electrical and structural engineers – to interact meaningfully with end users. Arup engaged with building users to learn from their experiences in the existing space and understand their needs for the future one. Arup produced an Employer's Requirements document and advice on key considerations. This included consideration of enhanced acoustic criteria, lighting considerations to avoid glare and opportunities to provide building users with control and choice over their environment.

For the fit-out of *80 Charlotte Street*, an exemplary office project in London which won Best Commercial Workplace at the BCO Awards in 2022, multisensory design was captured through the physical design (e.g. provision of diverse workspaces with acoustic zoning to accommodate different needs; materiality to facilitate navigation and wayfinding; biophilic considerations in the design for wellbeing and health), as well as digital: The building is smart enabled, integrating live data on temperature, lighting, noise and occupancy. Its capabilities allow us to use it as a testbed and data gathering tool for new innovations in the inclusivity and access space. There are systems to report live data to occupants, so that people can make informed decisions on the type of workspace that suits them best.

Conclusions

Gaps in current research include the lack of target acoustic metrics (such as internal noise limits, reverberation times and sound insulation) tailored to the needs of aurally divergent users across different environments. Inclusion of this data in current guidance would be an improvement on the largely one-size-fits-all approach. However, even these would have limitations, as the human experience is complex with individuals often falling into more than one way of being aurally divergent.

Acoustic design plays an important role in shaping equitable environments. It can enable communication thus fostering connection and can help mitigate sensory overload. It influences concentration, wellbeing and spatial legibility. Our work on inclusive acoustics is an important starting point, but further research is needed. A multidisciplinary approach and ongoing collaboration between designers, researchers and communities are essential to creating environments that truly support diverse auditory experiences.

notes

[1] The Aural Diversity Network is a research network founded by Andrew Hugill.

[2] The Aural Diversity Toolkit is available via https://www.arup.com/insights/aural-diversity-toolkit/

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image 1

Illustration of aurally divergent people.
Illustrations by Ana Cecilia Barraza Azanza.

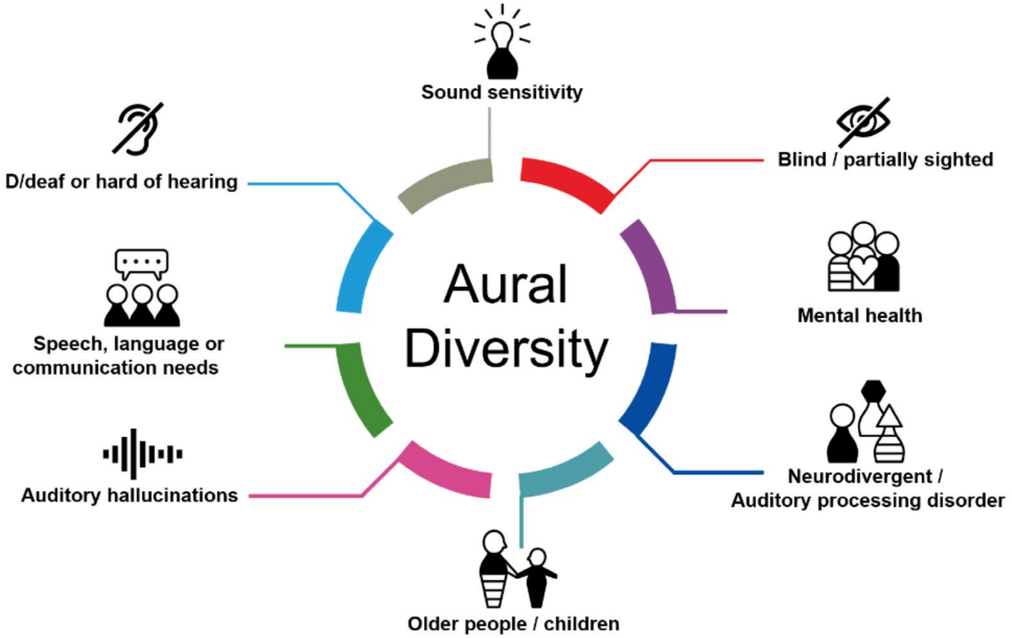

image 2

Diagram showing examples of aurally divergent experiences.

image 3

Front cover of the Aural Diversity Toolkit.
Illustrations by Ana Cecilia Barraza Azanza.

image 4

Illustration of the six personas in the Aural Diversity Toolkit.
Illustrations by Ana Cecilia Barraza Azanza.

BESENSHOME RESULTS

ARCHITECTURAL SOUNDSCAPES AND AUTISM: RETHINKING AUDITORY ACCESSIBILITY

Marco Caniato, Federica Bettarello

abstract

Architectural and acoustic design has historically not significantly considered the sensory needs of neurodivergent individuals. Anyway, research shows that the acoustic domain is a primary source of stress (stressor), because loud, sudden and rumbling sounds cause significant discomfort and problem to sensible persons. Current acoustic metrics, based on neurotypical models, are thus inadequate. A user-centered design (UCD) approach involving autistic people is essential. Key principles include controlling background noise and reverberation, acoustic zoning with refuge spaces and personalization showed to be valuable solutions. The goal is not silence, but flexible, controllable soundscapes, adopting Universal Design principles to promote well-being and inclusion for all.

keywords

Acoustics, Indoor Environmental Quality (IEQ), Neurodiversity, Accessibility, User-Centered Design (UCD)

The design of buildings has profound implications for human well-being, influencing comfort, functionality and accessibility. Historically, architectural and acoustical considerations have centred on the needs of the general, or neurotypical, population. However, a growing body of research highlights the crucial importance of inclusive design that considers the needs of neurodivergent individuals, particularly autistic people (Masiero et al., 2025). Autism is a neurodevelopmental disorder that influences how a person interacts with the surroundings and processes sensory stimuli, with differences that can manifest as hypo- or hypersensitivity to sounds, lights, smells and temperatures (Bettarello et al., 2021). This makes it essential to rethink auditory accessibility in built environments, moving from a model based on the standard user to a universal and user-centred approach.

Autistic people report several auditory differences compared to the neurotypical population. Hyperacusis (a decreased tolerance to loudness) is very common, affecting 37-45% of autistic individuals, as are misophonia (an aversive reaction to specific sounds) and phonophobia (fear of sounds). Sudden, anthropogenic sounds, as well as continuous low-frequency noises, are significant sources of stress. A study conducted using questionnaires administered to parents and professional caregivers confirmed that the acoustic domain is the primary source of stress for autistic individuals (Caniato et al., 2022a). Specifically, loud noises, rumbling sounds and particular sounds like human voices, animal sounds, and impact noises were identified as particularly disturbing.

These results, obtained from a large sample, allowed for the generalization of observations that were previously based only on small samples or single case studies (Caniato et al., 2022b). Another fundamental aspect is the difficulty with “sensory gating”, which makes it complex to distinguish speech from background noise.
In environments with high reverberation times or high levels of background noise – such as classrooms or open-plan offices – this difficulty can compromise communication and increase cognitive load. Research has shown that reducing reverberation and background noise in classrooms can positively influence the behaviour, attention and academic performance of autistic students. A research study conducted in 2019 (Keith et al., 2019) found that while background noise had a slight negative impact on the cognitive performance of both autistic and non-autistic adolescents, only the heart rates of autistic adolescents continued to rise during more difficult tasks, suggesting that managing background noise was a significant additional stressor for this group.

At the same time, the autistic auditory experience is not solely about challenges. There are also strengths, such as enhanced pitch perception, a higher prevalence of absolute pitch and a superior ability to perceive fine details in complex soundscapes or music. This duality – hypersensitivity on one hand and enhanced perception on the other – underscores the need for flexible acoustic environments that do not simply aim to eliminate sounds, but to shape them in a meaningful and controllable way.
Current building acoustics regulations and guidelines are almost entirely based on neurotypical auditory models, effectively ignoring sensory diversity. Standard metrics, like A-weighting (dBA) for sound pressure levels, were developed based on “otologically normal” people aged 18 to 25, a very limited demographic sample. Similarly, Noise Criterion (NC) curves, used to evaluate HVAC noise, were developed from responses of participants who described themselves as “neither unusually sensitive nor insensitive to noise”.
These metrics are inadequate for representing the experience of autistic individuals, who often exhibit hypersensitivity to sudden sounds or specific frequencies, particularly low frequencies, which are under-weighted by dBA or NC systems. This explains why an environment, despite complying with current regulations, can be extremely disturbing for an autistic person. Acoustic sensitivity is significantly influenced by the severity of autism, with a greater impact at more severe levels (Marzi et al., 2024). Additionally, age and the presence of co-morbidities can further modulate the perception of stimuli. The absence of quantitative data and specific thresholds for neurodivergent populations in current standards represents a fundamental barrier to designing acoustically accessible spaces.

To overcome current limitations, it is essential to adopt a User-Centred Design (UCD) approach, which actively involves autistic people, their families and caregivers in the design process (Wohofsky et al., 2023). This participatory model allows for the collection of requirements based on lived experience, ensuring that the proposed solutions are genuinely effective and relevant.
A practical example of this approach is documented by the experience of an acoustic refurbishment of an auditorium used by autistic individuals, at the site of Progettoautismo FVG (Udine, Italy). Instead of applying standard solutions, the designers directly involved the users in choosing materials and design. The users preferred to customize the sound-absorbing wall panels with images of their own paintings, demonstrating that customization and familiarity can be more important than the “simplicity” often recommended in generic guidelines. The result was an acoustically comfortable environment that also reinforced the users’ sense of belonging and identity.

Another example involves designing inclusive classrooms in some primary schools in the province of Udine. Instead of just acoustically treating the entire room, small “refuge houses” made of sound-absorbing panels were created. These spaces offer autistic students a safe and private place to reduce sensory stimuli when needed, while also helping to improve the overall acoustics of the classroom.
These examples demonstrate how a UCD approach can generate innovative solutions that combine acoustic functionality with psychological well-being.

Based on research, several guiding principles for designing acoustically accessible environments for autistic people emerge:

- *Control of Background Noise and Reverberation*: it is crucial to reduce background noise from HVAC systems, external traffic, or activities in adjacent rooms. The acoustic environment was found to be the most critical comfort domain, with over 80% of autistic individuals classified as sensitive to this factor. The goal should be a reverberation time (RT) between 0.4 and 0.7 seconds in the speech frequencies (500-2000 Hz), a clarity index (C50) of at least 2 dB and a definition index (D50) of at least 0.7.
- *Acoustic Zoning and Refuge Spaces*: since there is no single “ideal soundscape” for everyone, it is essential to offer a range of acoustic environments. This can be achieved through zoning, creating quiet areas for focused activities, moderate zones for collaboration and dynamic spaces for social interaction. The availability of “refuge spaces” or “quiet spaces” is fundamental, since they offer low-stimulus areas where people can retreat to decompress and reduce sensory overload.
- *Discreet Integration of Acoustic Solutions*: to avoid creating visually chaotic environments, which could be another source of stress, sound-absorbing solutions should be discreetly integrated into the architecture and furnishings. This can be done using panels integrated into walls, acoustic ceilings, heavy curtains, upholstered furniture and even design elements like ceiling lamps that incorporate sound-absorbing materials. This approach respects the need for visual “simplicity” while ensuring high acoustic performance.
- *Personalization and Control*: offering occupants a degree of control over their sound environment is a key principle of universal design. This can range from the ability to choose which acoustic zone to be in, to adjusting the volume of audio systems, or to use personalized solutions like sound masking.

Rethinking auditory accessibility for autistic people does not just mean creating silent environments, but rather designing soundscapes that are flexible, controllable and meaningful. The studies unequivocally show that the acoustic domain is a top priority for the well-being of autistic people. The current approach, based on neurotypical standards, is insufficient and contributes to creating disabling environments.

The future of architectural design lies in adopting the principles of Universal Design, which aims to create spaces that are inherently accessible to all, regardless of their abilities or sensitivities. A “universal acoustic design” does not refer to a single ideal soundscape, but it provides a range of sensory environments, giving occupants the freedom to choose what best suits their needs at any time. This approach recognizes autism as part of human neurodiversity, shifting the responsibility for accessibility from the individual to the built environment. Ultimately, designing acoustically inclusive environments not only improves the quality of life for autistic people, but creates more comfortable, functional and welcoming spaces for everybody.

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DESIGNING SPACES FOR AUTISM: INSIGHTS FROM SENSORY RESEARCH

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abstract

Designing environments that accommodate the unique sensory needs of autistic individuals is crucial for their comfort, safety, and well-being. This study discusses integration of sensory processing parameters across olfactory, visual, tactile, auditory, and gustatory domains into ASPECTSS framework for designing autism-friendly environments. The study highlights need for interdisciplinary collaboration and use of evidence-based guidelines to address sensory requirements of autistic individuals.

keywords

Inclusive Design, Autism, Architectural Design, ASPECTSS Framework, Sensory Processing

Introduction

The built environment not only mirrors societal values but also actively shapes the experiences and behaviors of its occupants. Consequently, the core objective of built-environmental design must be to ensure comfort and accessibility for all users. This process is inherently iterative, incorporating anthropogenic shifts and user feedback as society evolves. Given the diversity of individual preferences and requirements, creating spaces that address the needs of all users is inherently complex. The challenge goes beyond traditional notions of architectural quality: it involves creating adaptive and inclusive spaces that can respond to the heterogeneous needs of individuals (Rohde et al., 2020). Frequently, the focus on inclusivity is limited to compliance with accessibility regulations, often resulting in overlooking less visible (represented) or atypical needs. While universal accessibility infrastructure is indispensable, it is equally important to acknowledge and address other critical aspects that may remain unrecognized in conventional guidelines.
A pertinent example is the case of autism. Although the term was first introduced by Eugen Bleuler in 1908 and further clarified through Kanner's work in 1943, comprehensive recognition and standardized definitions have only emerged in recent years. Although autism has been recognized for many decades, the prevalence of diagnoses has risen sharply, with the World Health Organization (WHO) estimating that approximately 1 in 100 individuals are affected (AutismEurope, 2025).This surge, along with heightened awareness and formal recognition, has only recently led to significant advancements in comprehending the specific needs of individuals on the autism spectrum.

For autistic individuals, the built environment plays a particularly significant role, as they process and respond to environmental stimuli in fundamentally different ways compared to neurotypical individuals. Unlike neurotypical individuals, who are generally able to adapt flexibly unpredictable environments (McLeod et al., 2019), autistic people experience substantial difficulties in coping with sudden changes or unexpected sensory inputs (Talay-Ongan & Wood, 2000). These challenges often stem from differences in sensory processing, where common stimuli such as noise, lighting, or spatial layout can become overwhelming or even disabling. Depending on whether sensory input is over- or under-registered, individuals may display hypersensitivity (e.g., from stronger annoyance to aversive reactions to sounds, lights, or textures) or hyposensitivity (e.g., diminished responses, seeking stronger stimulation) (Galiana-Simal et al., 2020). These atypical patterns can significantly impact daily functioning, influencing attention, behavior, and the ability to participate in learning or social activities. Therefore, moving beyond generic accessibility measures is essential to ensure that built environments are truly inclusive (Manning et al., 2023).

Relevance
The relevance of advancing autism-specific design becomes evident when considering its relationship with medical and psychological research. Studies on sensory processing, particularly hypersensitivity and hyposensitivity, provide a fundamental understanding of the difficulties faced by autistic individuals (Black et al., 2022), yet architectural research has often developed parallelly rather than in direct alignment with these findings (Chidiac et al., 2024). This absence of synchronization is evident in built environment design frameworks, which are not consistently grounded in or updated with state-of-the-art scientific evidence. As a result, the application of guidelines often lags both current research and lived experiences.

Architecture Design Principles Relevant to Autism
Recent research highlights the growing importance of understanding the relationship between people with Autism Spectrum Disorder (ASD) and the built environment (Mostafa, 2018; Mostafa et al., 2024) particularly in designing autism-friendly spaces. Most studies focus on learning environments for children, with fewer addressing residential, care, or outdoor sensory spaces. Contributions come from architecture (Mostafa, 2008; 2014; 2018), design and psychology (Tavassoli et al., 2018), and education, using interviews, questionnaires, observations, focus groups, and mixed methods, involving professionals, caregivers, and autistic individuals (Tola et al., 2021). Several principles of inclusive and universal design exist in the broader architecture literature (Preiser & Smith, 2011; Steinfeld & Maisel, 2012). Key spatial criteria identified from these frameworks can be grouped into three main categories (Tola et al., 2021): *Sensory Quality* (reduce sensory overload), *Intelligibility* (predictable spaces), and *Orientation* (simple wayfinding) (Altenmüller-Lewis, 2017; Mostafa, 2018).

These features are expressed within the ASPECTSS framework (Mostafa, 2008), which defines seven core principles for autism-friendly design: *Acoustics*, *Spatial Sequencing*, *Escape Spaces*, *Compartmentalization*, T*ransition Spaces*, *Sensory Zoning*, and *Safety*. ASPECTSS is distinctive because it translates sensory and behavioral evidence into spatial criteria, directly linking research on autistic sensory processing to architectural decision-making (Altenmüller-Lewis, 2017; Mostafa, 2018). From a design standpoint, it is one of the most comprehensive frameworks specifically developed for autism-friendly design, and has been exhaustively utilized in professional practice (Clouse et al., 2020; Mentel & Bujniewicz, 2020; Mostafa, 2014; 2018; Mostafa et al., 2024).

While the framework is broad, it lacks quantitative metrics for evaluation. Its dependence on subjective assessments from design professionals undermines the replicability of results, making it difficult to compare alternative design approaches. There is a significant potential to incorporate evidence-based validated metrics in the scope of this framework to ensure its effective applicability.

Objectives of the study
The approach adopted in this study is based on a user-centered and multidisciplinary design framework. Insights were drawn from multiple domains like built environmental design (Mostafa et al., 2024); psychology and sensory processing and behavior (Tavassoli et al., 2018); building physics informed comfort (Marzi et al., 2025), and design parameters and user accounts of autistic individuals (Valencia et al., 2021) to highlight potential integration of sensory perception studies within built environment design approaches for autism, with potential applications for occupants and users with different needs. This approach lies at the core of projects such as SENSHome, BeSENSHome, and several other recent initiatives, all of which seek to bridge the gap between fundamental research and applied architectural practice (Maun et al, 2021; Wohofsky et al., 2023).
The present study seeks to contribute to the ongoing discourse by focusing on two main objectives:
1. To examine the importance of sensory processing parameters in relation to the ASPECTSS design guidelines, assessing their relevance for architectural design tailored to autistic individuals.
2. To identify and highlight the use of measurable indicators – particularly those related to spatial design and indoor environmental quality – that can complement or support existing and future guidelines and strengthen the reliable evaluation of autism-friendliness of spaces.

Influence of Sensory Parameters in design for autism

As discussed previously, the parameters involved in ASPECTSS principle involve multiple facets of sensory processing and perception in the built environment design for autistic individuals. Parameters like Acoustic and Sensory Zoning highlight the direct role of sensory perception in designing spaces and ascertaining its impact on everyday activities. Also, the role of sensory perception is critical in other factors including spatial sequencing, escape, compartmentalization, transition spaces and safety, however, has not been included in the framework explicitly.
Fundamental experimental studies investigating hypersensitivity and hyposensitivity in autism across various sensory domains typically focus on specific sensory parameters across all domains. These parameters may be associated with aspects of sensory detection, processing, or its associated response. A list of such parameters examined in the literature is listed in the first image (image 1).
To effectively translate findings from fundamental sensory perception research into architectural design strategies, it is essential to clearly define which sensory parameters are relevant to architectural contexts. Sensory cues play a critical role in mediating spatial perception, by accentuating specific sensory characteristics.
The subsequent sections discuss sensory parameters across multiple domains, with an emphasis on their implications for seven foundational principles of autism-friendly design “ASPECTSS: Acoustics, Spatial Sequencing, Escape Spaces, Compartmentalization, Transition Spaces, Sensory Zoning, and Safety”. This approach is a stepping stone towards developing quantifiable metrics that leverage fundamental studies pertaining to sensory perception in autism.

Smell (Olfaction)
Olfactory perception plays a vital role in the design of supportive environments for autistic individuals. A wide spectrum of olfactory factors – including odor pleasantness (Boudjarane et al., 2017), intensity, detection thresholds (Koehler et al., 2018), and individual sensitivity (Ashwin et al., 2014) – must be considered, as both subtle and pronounced smells can greatly influence comfort, focus, and emotional wellbeing. Strong or unfamiliar odours can distress those with heightened olfactory sensitivity. Strategic *Sensory Zoning* can separate areas with strong smells, like kitchens and bathrooms, from relaxation or study spaces, reducing unwanted olfactory stimulation and supporting concentration and emotional regulation.
Compartmentalisation of spaces, considering functionality and ventilation distribution in tandem can be helpful in managing and containing olfactory cues. Physical barriers, or chosen building materials can also prevent odour migration, shielding from potential olfactory triggers.
Smell or odor management is complex and is generally addressed through ventilation in buildings. Ventilation helps in dilution of a specific odorant. Studies have relied on measuring chemical concentrations of specific odorants through chemical sensors in controlled environments to establish acceptance thresholds for odor-associated air quality (Priyadarshani & Mani, 2024; Wargocki, 2001). Some studies highlight positive influence of specific odors on autistic individuals (Ashwin et al., 2014; Nováková et al., 2018).
Given that specific olfactory stimuli may facilitate positive reinforcement in autistic individuals (Ashwin et al., 2014; Lacôte-Coquereau et al., 2024; Nováková et al., 2018) HVAC systems can integrate chemical odorant sensors and implement targeted protocols for designated egress zones or sensory support environments. Determining optimal air exchange rates and appropriate odorant concentrations requires rigorous evaluation, particularly for autistic populations, and should be guided by empirical exposure assessment protocols.
The influence of ventilation on thermal conditions and energy consumption should also be evaluated. Further research is needed to establish quantitative thresholds where supportive smells enhance spatial quality and well-being. Materials and paints that release specific odors should be carefully assessed to accommodate sensory sensitivities.

Sight (Vision)
Intensity and brightness (Kopec et al., 2020), motion stimuli (Vagnetti et al., 2025), and color obsession (Ludlow et al., 2014) are visual factors that can contribute to sensory stimulation. Harsh lighting, extreme brightness, or fast-moving visuals can cause discomfort or anxiety. *Sensory zoning* can use visual elements for both calming and stimulating effects. *Spatial sequencing* needs consideration of sensory aspects like object fixation (Palmer et al., 2018), visual deviancy (Cléry et al., 2013), local visual perception (Nakano et al., 2010), attention to detail and selective attention(Stevenson et al., 2021). Organized layouts and clear flooring lines aid comfort and easy navigation, by reducing distraction.
Social vision, like face detection and emotion recognition, influences safety perceptions. Open layouts, clear sightlines, and adaptable spaces using transparent partitions and thoughtful furniture help support social comfort and control. Visual processes such as contour integration (Knight et al., 2023), motion detection (Davis et al., 2006), multi-stability (Skerswetat et al., 2022), visual precision (Stevenson et al., 2021), and visual memory (Wainwright-Sharp & Bryson, 1993) are enhanced by and reliant upon effective *Compartmentalization*.
When designing visual transitions, factors like physical barriers, colour schemes, lighting levels, colour temperature, and contrast ratios must be considered. These can be

measured objectively using metrics such as spatial frequency, CRI, and silhouette clarity. These can be controlled to meet the needs of autistic individuals or those with sensory sensitivities.

Touch (Tactile)
Tactile experiences, including sensitivity to touch, pain, temperature (Riquelme et al., 2023), and vibrations (Yaguchi & Hidaka, 2020), are crucial for comfort and well-being within a space. For individuals who are prone to tactile overload or defensiveness (Kyriacou et al., 2023) *Escape Spaces* become essential. These areas must provide soft furnishings, calming textures, and minimal physical contact with others. *Sensory zoning* can be done using textures in designated areas; tactile-rich experiences can be manipulated where desired (Kyriacou et al., 2023; Riquelme et al., 2023), while keeping other zones neutral, to provide preferential tactile stimulation.
Thermal regulation, achieved through features like adjustable thermostats and radiant flooring, is essential for occupant safety and comfort. Selecting materials with appropriate textures for furniture, walls, and flooring enhances spatial awareness and safety, while vibrations and vibrotactile devices can influence relaxation. Further research is needed on technical standards for surface friction.

Sound (Auditory)
Sound Pressure Level (Yaguchi & Hidaka, 2020), Loudness Sensitivity (Lawson et al., 2015), Speech Perception (Ocak et al., 2018), and Speech Recognition (Key et al., 2024) are key aspects of how people experience sound in buildings. Thoughtful *Acoustics* – including sound-absorbing materials, barriers, and ambient controls – helps create quieter spaces for clear communication and those sensitive to noise. Designating areas through *Sensory zoning* and quiet rooms accommodate diverse auditory needs. Buffer zones with gentle acoustic *Transition Spaces* help occupants adjust between noisy and quiet areas, utilizing sound habituation (Dwyer et al., 2023), and aiding focus. Sound response (Sturrock et al., 2022), arousal level (Song et al., 2024), and sympathetic reactivity (Chang et al., 2012) are key factors to consider when designing *Escape*, and *Transition Spaces*. Quiet refuges with sound-dampening and calming features help individuals manage sensory overload and regain balance. Spatial Audio Recognition (Johnston et al., 2022) and Sound Motion Direction (Bocheva et al., 2022) are critical factors to ensure sense of *Safety*. Auditory cues are especially vital for those who depend on sound for spatial awareness, and navigation (Grossman et al., 2009; Tryfon et al., 2017).
More research is needed to have clear understanding of which aspects of sound are relevant for comfort to autistic individuals. While Sound Pressure Level (SPL) has been widely studied, further research is needed to set comfort benchmarks and practical guidelines. It is important to benchmark design criteria such as loudness sensitivity, optimal SPL transitions, and acceptable reverberation times, ensuring alignment with both medical recommendations and building codes.

Taste (Gustatory)
Gustatory sensitivity – Flavor Identification (Clark et al., 2013), Taste Reactivity and Selective Eating (Avery et al., 2018), Food Neophobia (Stafford et al., 2017), and Misidentification (Tavassoli & Baron-Cohen, 2012) – can strongly affect comfort and wellbeing. *Sensory zoning* is useful for separating dining and kitchen areas from other spaces, with options for quiet, low-stimulation meals or more social dining.
Although gustatory input mainly affects kitchens and dining zones, its links with olfactory responses should be considered. Attention to identification accuracy, reactivity thresholds, and misidentification discomfort is essential to avoid sensory triggers in dining areas.

Discussions

A comprehensive understanding of sensory sensitivity, processing mechanisms, and responses to diverse sensory stimuli is essential for designing environments tailored to the needs of autistic individuals. Current research mainly focuses on auditory and visual processing, with less emphasis on olfactory, tactile, and gustatory domains. The interactions between sensory modalities remain complex to understand and, in some respects, unclear, yet are important for multi-sensory environments.
Individuals on the spectrum often experience unique patterns of sensory integration that can profoundly affect their comfort, navigation, and participation in everyday environments. Unlike controlled experiments, real-world settings are inherently multi-sensory, requiring simultaneous processing of multiple sensory inputs.
Multiple sensory inputs can result in amplified or dampened perception resulting in an experience that can either support or challenge autistic individuals' ability to engage, communicate, and self-regulate. For example, alliesthesia (the subjective change in perception of stimuli based on internal states) and synesthesia (the blending of sensory experiences, such as hearing colors or tasting sounds) highlight how sensory inputs are not processed in isolation but rather in dynamic interplay. Social contexts further complicate this interaction, as attention and focus can be diverted or intensified depending on environmental cues. Understanding these mechanisms is essential for designing spaces that either minimize sensory overload or harness multi-sensory cues to foster comfort and inclusion. Guidelines must also distinguish between individualized design – tailored to unique sensitivities – and universal design, which emphasizes accessibility and minimizes overstimulation for groups.
From an architectural perspective, design principles should rigorously address the sensory qualities of each environment, particularly when creating spaces for autistic individuals. Because built environments inherently communicate a range of sensory cues, architectural strategies can aid to alleviate challenges related to sensory perception.
Interdisciplinary collaboration is essential to create quantitative guidelines informed by research and practical expertise, including input from autistic individuals and families. Moving forward requires comprehensive studies to establish measurable sensory comfort thresholds and translate them into architectural standards. Ongoing research, feedback, and updates are needed to ensure these guidelines remain effective, supporting both personal and universal approaches, and ultimately improving environments for people with autism (image 2).

Conclusion

This study reviews how each sensory modality—acoustic, visual, tactile, olfactory, and gustatory—uniquely shapes spatial perception, and design. While current research focuses mainly on auditory and visual domains, the interactions among all sensory modalities warrant further study for truly inclusive environments. Architectural approaches that integrate core design principles of ASPECTSS framework while also addressing findings from foundational sensory research have been emphasized. Interdisciplinary collaboration and ongoing research are essential to establish measurable comfort thresholds, set priorities, and translate these findings into user-centered, evidence-based guidelines that adapt to evolving needs in environments for autistic individuals.

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Sensory Domain	Relevant Sensory Parameters
Smell	Odor Detection, Odor Discrimination, Odor Intensity, Odor Pleasantness, Olfactory Sensitivity, Odor Familiarization, Olfactory Perception
	Acoustics Spatial Sequencing **Escape Spaces** **Compartmentalization** Transition Spaces **Sensory Zoning** **Safety**
Sight	Intensity, Brightness, Color, Object Fixation, Visual Deviancy, Local Visual Perception, Attention to detail, Selective Attention. Contour Integration, Motion detection, Multi-stability, Visual Precision, Visual memory, Face detection, Emotion recognition.
	Acoustics **Spatial Sequencing** Escape Spaces **Compartmentalization** **Transition Spaces** **Sensory Zoning** Safety
Touch	Tactile, Pain, Thermal, Vibrotactile Stimulus Strength, Tactile Defensiveness or Preference, Texture Perception
	Acoustics Spatial Sequencing **Escape Spaces** Compartmentalization Transition Spaces **Sensory Zoning** **Safety**
Sound	Sound Pressure Level, Music Perception Loudness sensitivity, Speech Perception, Speech recognition, Sound Habituation, Sound response, Arousal level, Sympathetic Reactivity, Spatial Audio Recognition, Sound Motion Direction
	Acoustics **Spatial Sequencing** **Escape Spaces** Compartmentalization **Transition Spaces** **Sensory Zoning** Safety
Taste	Flavor Identification, Taste Misidentification, Taste Reactivity, Food Neophobia, Selective Eating, Food Selection
	Acoustics Spatial Sequencing Escape Spaces Compartmentalization Transition Spaces **Sensory Zoning** Safety

image 1

Sensory parameters studied in multiple domains in literature indicating the foundations of ASPECTSS it directly influences (highlighted in red).

	Sound / Auditory	Sight / Visual	Touch / Tactile	Smell / Olfactory	Taste / Gustatory	Key Design Considerations
***A**coustics*	• Noise masking • Sound pressure levels • Reverberation control • Speech clarity	• Acoustic material visibility • Noise source identification	• Vibration control • Material texture for sound absorption	• Air quality and its impact on sound	• Not Applicable	• Material selection for sound absorption • Room proportions and geometry • HVAC noise control • Acoustic zoning and separation
***Sp**atial Sequencing*	• Audio wayfinding cues • Acoustic transitions • Sound landmarks	• Visual way finding • Sightlines • Spatial clarity • Landmark visibility • Familiarization & Relevance of objects & colors	• Tactile navigation aids • Surface texture changes • Handrail continuity & pattern	• Familiar scent markers • Spatial Olfactory markers	• Food service areas • Dining transitions	• Clear circulation paths • Logical space organization • Intuitive navigation • Lighting control • Multi-sensory wayfinding system
***E**scape Space*	• Noise reduction • Sound isolation • Acoustic privacy	• Reduced visual stimulation (light) • Minimal visual clutter • Calming colors	• Soft textures ensuring tactile comfort • Temperature control • Comfortable seating	• Pleasant / neutral scents • Good air quality & Odor control	• Far from food preparation areas	• Immediate accessibility • Multi-sensory calming environment • Privacy and security • Flexible sensory control options
***C**ompartmentalization*	• Acoustic barriers • Activity-based zoning • Sound level control	• Visual privacy • Activity separation • Lighting zones • Visual barriers	• Material transitions • Thermal zones • Texture differentiation	• Odor containment • Ventilation zones	• Food area isolation • Kitchen ventilation	• Physical and sensory boundaries • Activity-appropriate environments • Flexible partitioning • Independent environmental controls
***T**ransition Spaces*	• Sound level transitions • Acoustic buffering	• Progressive lighting changes • Visual adaptation zones • Gradual color transitions	• Surface texture changes • Temperature gradients • Material transitions	• Smell transitions • Air quality changes • Olfactory adaptation	• Pre-dining areas • Kitchen transitions	• Buffer zones between environments • Adaptation time allowance for lighting, sound, and smell • Multi-sensory preparation
***S**ensory Zoning*	• Activity-appropriate sound levels • Quiet/active zones • Sound masking strategies	• Lighting intensity zones • Activity-based Visual stimulation levels • Color psychology consideration	• Temperature zones • Material selection • Texture & associated experiences	• Air quality zones • Odor management	• Food service zones • Dining area design	• Comprehensive sensory mapping • Activity-based design • User preference accommodation • Flexible sensory controls
***S**afety*	• Emergency alerts • Clear audio signals • Sound level safety • Communication clarity	• Emergency lighting • Clear sight lines • Hazard visibility • Wayfinding to exits	• Appropriate texture selection • Temperature safety • Sharp edge protection • Tactile warnings	• Hazardous odor detection • Air quality monitoring • Chemical safety	• Kitchen safety protocols	• Multi-sensory safety systems • Emergency response design • Hazard prevention • Accessible safety features

image 2

Matrix showing the relationship between foundations of ASPECTSS framework and sensory domains. Prepared by authors based on results from sensory perception experiments. Colors denote priority. Legend: High-Green, Medium- yellow, Low- orange, Not Applicable- Grey

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REQUIREMENTS FOR BESENSHOME IN SCHOOL ENVIRONMENTS

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abstract

As a high proportion of neurodivergent pupils' face school challenges and discomfort due to sensory difference, there is a need for solutions that support environmental wellbeing. Therefore, the BeSENSHome project aims to develop a smart sensor system to increase the wellbeing of neurodivergent individuals, following a human-centered design approach. Four focus groups were conducted to define the context of use and derive necessary system requirements. Overall, the school emerged as a setting where neurotypical pupils of all age groups can profit. The system should be quick and easy to use to fit into the fast-paced school life and should involve all user groups. Various design concepts were proposed with visual and acoustic signals as the most preferred option for receiving environmental information. Neurodivergent pupils are the main users, while teachers are central for system implementation. Several of those conception ideas were considered in the final system architecture.

keywords

Autism Spectrum, School, Pupils, Requirements, Sensory Sensibility

Introduction

Neurodivergent pupils, especially those on the autism spectrum, are disproportionately impacted by school-related distress and attendance difficulties (Connolly et al., 2023). While the causes are multifaceted, sensory processing differences have been highlighted as a contributing factor (Connolly et al., 2023; Fielding et al., 2025). Such issues in navigating sensory-rich environments have far-reaching consequences that extend beyond academic performance, impacting overall well-being (Robeyns, 2016) and limiting participation in daily activities (Loh et al., 2023). Furthermore, atypical responses to sensory stimuli have finally been listed in the ICD-11 (Greaves-Lord et al., 2022) indicating the need for its stronger recognition. Therefore, the BeSENSHome projects aims to develop and implement a system adapted to the characteristics and requirements of the school setting as one application scenario, focusing on the autism spectrum as a key area of use.

Methods

Based on a human-centered design framework (ISO, 2019), a participatory research approach was consequently applied throughout the project to ensure the systems usefulness and usability by focusing on the resources and needs of the intended users. In an iterative design process, relevant stakeholders were involved to collaboratively work on the context analysis, definition of requirements, concept development and feedback on the user interface. Due to this strict involvement, the developed innovation is supposed to have a direct link to the users´ daily needs. The main type of user interactions were focus groups, where four sets were conducted. To ensure barrier free participation possibilities, most sets were offered both on-site and online.

Results

In total, N = 38 participants took part at the focus groups. Various stakeholder groups were represented (e.g. people on the autism spectrum, teachers, psychologists and caregivers) enabling a differentiated perspective. Through the focus groups on the context of use, the school was identified as a promising application area likely to benefit greatly from the system. A typical user day in primary school was developed to identify possible application times and challenges where the system could intervene. High noise levels, crowded rooms and a lack of structure were recognized as common problems. The frequency and intensity of those challenges vary throughout the day depending on the specific activity (e.g., lesson, lunch) conducted. The system could be applied during all activities starting from arrival in the morning and extending through aftercare. An exception is made for breaks and physical education sessions, allowing both pupils and teachers to fully disengage from responsibilities.
Regarding the potential users, three distinct groups have been identified (neurotypical/ neurodivergent pupils and teacher). For each group, personas were created what are fictional characters that represent the need of real users and impact the design process (Salminen et al., 2022). Neurodivergent pupils were considered as the main beneficiaries of the smart sensor system. It was outlined that most pupils on the autism spectrum have low communication skills and require a high amount of care. While their sensory sensitivities may vary, all are likely to benefit from preventive measures aimed at mitigating sensory overload. Nevertheless, the involvement of all people in the classroom is needed to ensure that the system is functional and fulfilling its purpose. Teachers should predominantly be responsible for the system usage as they are committed to supporting their student´s wellbeing. However, their resources are limited and the time to interact with the system during or between lessons is scarce. The system structure should align with these considerations, ensuring that the technical solution is timesaving, easy to use for everybody and at least partially mobile to seamlessly integrate to the teacher's schedule.
In collaboration with the stakeholders, an initial draft of the requirements for the system structure was created building on the context characteristics and description of user groups and daily school routines. Light, hectic, air quality, temperature and noise have been reported as relevant environmental factors while the latter one was ranked as most important in the classroom. Through AI, the system learns about the comfort zones of the pupils. In the initial learning phase, both teachers and neurodivergent pupils should be able to provide feedback to the system. This could be achieved through a simple one button feedback mechanism to report about potential issues. Additionally, teachers should have the option to give more detailed feedback regarding the perceived cause of the issue at the end of each session. Therefore, an app could function as the user interface. Opinions diverged about the possibility for neurotypical pupils to report on wellbeing. On the one hand, it would constitute a risk of distraction especially for younger children while on the other hand, it would provide a meaningful educational value. However, it was unquestioned that the resulting output about the student's wellbeing should be hidden from the class in order to avoid stigmatization. In contrast, information about environmental parameters should be visible to everybody in the classroom. A visual (and auditive) feedback system

for all people in a classroom was found to be the most preferred central user interface of the smart sensor solution. For instance, this user interface could be a traffic light system or a monitor, showing the different environmental parameters e.g. through a visualization of an equalizer or with smileys depicting comfort zones. Acoustic feedback could include sounds such as a gong or beeping to signal the exceeding of a predefined threshold. A low-volume auditory signal could function as a pre-warning system, alerting users to the imminent approach of a critical threshold. To further increase the salience of the warning signal, teachers could be equipped with wearables in order to receive tactile feedback. After all, the need for a didactical concept was highlighted to provide proper feedback and to include the whole classroom in a meaningful way.

Discussion

Overall, focus group participants contributed valuable insights based on their expertise and experiences, offering a differentiated perspective that ensures the BeSENSHome system is tailored to the actual needs of the school environment. Initially, the school emerged as a context of use where neurodivergent but also neurotypical pupils of all age groups can profit. A great challenge will be the integration of the system in daily activities in the school setting and a user interface that is unobtrusive but still offers the potential to inform and motivate all people in a classroom about necessary changes. Based on collected data, implementation feasibility and priorities aligned with all project partners, a modified system architecture will be implemented and tested in a real-life scenario. The evaluation will involve all relevant target groups (teacher, pupils, parents) to enable a multiperspective view on the system efficacy and the suitability of the technology-specific design.

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DESIGN OF A MOBILE STRESS ASSESSMENT AND MANAGEMENT SYSTEM FOR NEURODIVERGENT INDIVIDUALS

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abstract

People on the autism spectrum often struggle with stress self-assessment in sensory-rich environments. Within the BeSENSHome project, a mobile app for stress assessment and management was co-designed using a human-centered design approach with users on the autism spectrum and experts. The app enables stress tracking, suggests context-based coping strategies, and visualizes stress patterns. An advanced mock-up of the app was evaluated with 16 participants, achieving an average System Usability Scale score of 81 (users on the autism spectrum: 88). Results indicate strong usability and potential as an accessible support tool for neurodivergent stress management.

keywords

Human-centered Design, Stress Management, Smartphone Application, Prototype Evaluation, Neurodivergent Users

Introduction

Especially in unknown or sensory-rich environments individuals on the autism spectrum are likely to experience stress or anxiety (McGowan & McGregor, 2023). They show stronger stress reactivity, compared to neurotypical peers, when facing everyday events and activities (Linden et al., 2021). Self-assessment of stress levels and coping with stress are challenging for individuals on the autism spectrum, who also experience higher levels of self-perceived stress (Tomczak et al., 2020). This can lead to lower independence in daily activities and thus lower quality of life (McQuaid et al., 2022). Evidence indicates that adolescents on the autism spectrum seem to struggle with effective coping mechanisms, and for example show less successful emotion regulation than their neurotypical peers (Ilen et al., 2024).

Mobile applications have shown promise in assessing stress among individuals on the autism spectrum (Linden et al., 2021). However, existing tools lack personalisation possibilities and flexibility (Hoeberichts et al., 2025).

To address these gaps, a mobile stress self-assessment and management tool was developed within the BeSENSHome project. The primary users are people on the autism spectrum, with the possibility to also be applicable or expandable to other neurodivergent groups. Neurodivergence refers to differences in neurological development, such as autism or ADHD.

Methods

Following a human-centered design approach (ISO 9241-210,2019) the system was co-designed with people on the autism spectrum and other expert stakeholders (e.g. coaches, care-givers,…).

To date, four user interactions took place: a focus group to gather ideas and discuss the context of use with ten participants (mixed group with experts, people on the spectrum and people interested in the topic); two interviews with a person on the autism spectrum regarding stress assessment; one focus group to discuss the idea of the app, its requirements and first mock-ups with two participants (one person on the spectrum and one expert), and one focus group to assess the first interactive mock-ups with two participants (two experts).

Between iterations, mock-ups were developed and adjusted according to the results. The final version of interactive mock-ups was evaluated with 16 participants (people on the autism spectrum n=4, professionals, working with people on the spectrum n= 6, others n=6) using the System Usability Scale (SUS; Brooke, 1996). An impression of the final stress assessment can be seen in image 1 (image 1).

Results

Participants identified the smartphone as the preferred platform due to ubiquity and portability. The primary user group was defined as neurodivergent (young) adults, mainly people on the autism spectrum. The context of use was defined as follows: the application supports the user throughout the day, especially when leaving the home (e.g. usage of public transport, in social engagements, while shopping). Participants prioritised features that (a) support momentary stress self-assessment throughout the day, (b) provide context-aware coping suggestions (e.g., by location/activity) with options to add strategies from users or caregivers, and (c) help identify recurring stress patterns via a history view. The use of pictograms and a clear, concise communication were raised as important design requirements.

The interactive mock-ups were rated with a SUS score of M = 81 out of 100, with a higher rating from people on the spectrum (88) than from professionals working with people on the spectrum (80) and others (78) (image 2).

Discussion

Based on the input of the user group this system has the potential to serve as a mobile, accessible solution for stress assessment and management of neurodivergent people. Mobile applications on smartphones have already shown to be a useful for this use case (McGowan & McGregor, 2023). Letting individuals add their own coping strategies and stress-relief tips should help with the lack of personalization in other applications (Hoeberichts et al., 2025), and aid the context-appropriate application of these tools. Current limitations include a small sample size recruited via convenience sampling and evaluation of mock-ups rather than a functional prototype. To ensure acceptance by the user group, it will be important to develop the app according to the diverse needs of people on the spectrum and other neurodivergent groups. Therefore, the system will be further developed into a working app and evaluated together with the users according to the principles of human-centered design.

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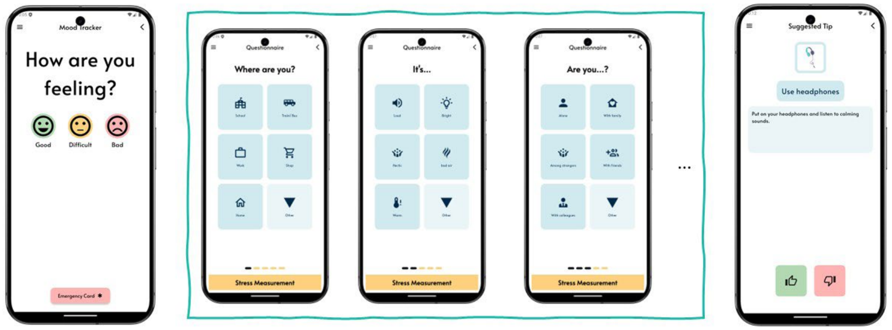

image 1

Stress Assessment of the Interactive Mock-Up.

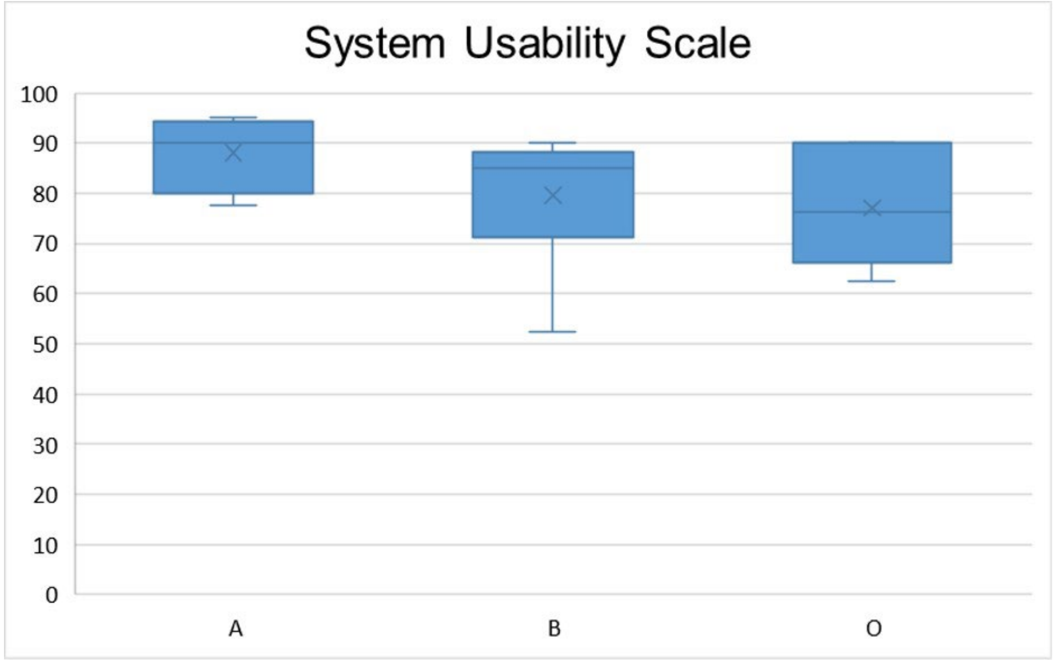

image 2

Evaluation of the Apps Usability. Description: SUS Score of individuals on the autism spectrum (A), professionals who work with individuals on the autism spectrum (B), and others (O).

EXPERIENCE OF CO-DESIGNING SENSOR-FRIENDLY SPACES: INSIGHTS FROM PROGETTOAUTISMO FVG

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abstract

Creating inclusive environments for neurodivergent people requires going beyond accessibility, embracing participatory methods that value lived experience. Within the BeSENSHome Interreg Project, a co-design workshop with autistic young adults explored how sensory-friendly spaces and "Smart Boxes" can support comfort in public places. Participants co-created refuge spaces with adjustable lighting and soundproofing, and designed emotionally reassuring devices, such as a "Penguin Smart Box" inspired by adaptability and non-threat perception. The process highlighted that autistic individuals are not passive users but active designers, offering unique insights into sensory regulation and aesthetic comfort. This experience demonstrates how inclusive co-design fosters both empowerment and innovation, aligning with the social model of disability and advancing architectural research toward environments that truly celebrate neurodiversity.

keywords

Neurodiversity, Inclusive Design, Co-design, Sensory Architecture, Autism-friendly Environments

The importance of co-design as a design process

Creating truly inclusive environments for neurodivergent people means changing how we approach design. We need to go beyond basic accessibility and actively seek out the unique perspectives that come from lived experience. As science journalist Rachel Zamzow (2021) points out, before starting any collaborative work, it's essential to have the right mindset. This means seriously considering if our design efforts truly match the needs of the autistic community. We must examine our reasons for doing this work and make sure our research genuinely helps autistic people. This thoughtful approach builds a strong ethical and practical base for real co-creation.
This shift in thinking is especially important when we look at the unique sensory sensitivities of autistic individuals, making participatory methods a clear necessity. Recent research (Wassell, 2025) shows that, for autistic people, being able to control sensory input is key to experiencing joy. His findings indicate that the main reasons for a lack of "autistic joy!" are social and environmental barriers, rather than individual autistic traits. Participants often found joy in specific lighting, textures, or harmonious sounds. On the other hand, joy was often missing or reduced in places with too much sensory input, unpredictable lights and sounds, or chaotic visuals. This clearly highlights the vital need to create sensory-friendly environments that not only reduce negative experiences but also actively encourage positive emotional states.

The present contribution describes a specific co-design workshop, evolving into a true co-ideation experience, conducted with four [1] high-functioning autistic young adults aged between 18 and 30 years old within the framework of the BeSENSHome Interreg project. This workshop, structured into four distinct sessions, took place at the Fondazione Progettoautismo FVG [2]. The process began with listening sessions to collect participants' needs and continued with drawing, modelling, and 3D prototyping phases. It was facilitated by a multidisciplinary team [3] comprising a professor and two researchers of the Department of Engineering and Architecture at the University of Trieste, supported by an educator and a psychologist, ensuring both design expertise and a deep understanding of the participants' needs.
The main objective of the workshop with the ASD young group was to jointly develop the concept for smart boxes [4]: aids for neurodivergent people, capable of housing environmental sensors while simultaneously providing comfort and reassurance, which could be placed in public places (such as waiting rooms, offices, or gyms) and be easily recognizable by people who, like them, experience difficulties in frequenting those places due to excessive light, noise, heat, or crowding. However, the participatory process allowed for a significant re-evaluation and expansion of the initial brief based on the young adults' emerging needs and direct feedback. This dynamic engagement fostered genuine co-ideation, leading the team to revisit and refine the initial proposals, the results of which – from the workshop titled "My Box and My Spot" – have been reported in some publications (Scavuzzo et al, 2025a-b).
Ultimately, participants pursued two primary objectives: first, to imagine and design "refuge spaces" suitable for public environments (Scavuzzo et al, 2025a), and second, to conceptualize the "smart box" as an emotional and technological object (Scavuzzo et al, 2025b).

The outcomes of the co-design workshop "My Box and My Spot"

The design of refuge spaces stemmed from the understanding that public environments, with their unpredictable stimuli, can be particularly challenging. These spaces were envisioned as temporary havens offering relief from sensory overload. The participants' designs frequently incorporated elements such as soundproofing, adjustable lighting, and calming color palettes. The emphasis was on providing a controllable micro-environment where sensory input could be modulated, allowing individuals to regulate their emotional state.
Key considerations included discreet locations, intuitive navigation, and a sense of enclosure without claustrophobia, with designs often prioritizing modularity and adaptability to recognize the diverse nature of sensory preferences.
The "smart box" component yielded particularly insightful outcomes. One compelling example, detailed in a participant's own words, was a design inspired by a penguin (image 1):

"The smartbox that I designed is inspired by a penguin. I chose this subject for various reasons: firstly, for the concept of adaptability, given that penguins are beings well capable of adapting to the environment. Secondly, because in the collective imagination, penguins are not seen as a threat." (A.C.)

This rationale highlights a profound understanding of psychological comfort and the impact of form on perception.
The designer further elaborated on functionality:

“The product raises its wings upwards, and these can be oriented to efficiently dissipate the heat produced by the internal components. At the base of the wing, fans can be positioned if a fanless hardware solution isn't possible. It is possible to pre-arrange additional sensors in the beak or eyes if necessary, to hide their presence. The I/O ports are placed underneath and hidden internally, to avoid unaesthetic appearances. The penguin's tail also acts as a cable cover.” (A.C.)

This “penguin smartbox” exemplifies several critical aspects of co-design with autistic individuals. Firstly, it demonstrates an innovative approach to integrating technology (environmental sensors) with a reassuring aesthetic. The choice of a penguin, associated with adaptability and non-threatening presence, directly addresses the need for comfort and predictability. Secondly, the detailed functional considerations reflect sophisticated problem-solving and awareness of practical implementation. Thirdly, the participant's concluding remark – “The workshop experience was stimulating, and it was interesting to be able to design and conceive a product that was synonymous with home and also design-oriented” – underscores the empowering nature of the project.

A completely different outcome emerged from the contribution of a young woman passionate about art and drawing (image 2):

“As the object, I imagined a lamp covered with a light, transparent material that lets light pass through. In the centre, I created an egg as a symbol of life and birth. Around it, I placed a flower because it conveys serenity. At first, I used cardboard to make it, then switched to modelling clay because it's more malleable. The experience was enjoyable because I really love painting and drawing.” (C.P.)

In her vision, the box takes the shape of a bedside lamp, with a golden and translucent surface that evokes the warmth and protection of a domestic space. It is a small, easily placeable object that blends harmoniously into the home environment, yet remains distinctive and recognizable.

The third product created was envisioned as a marble bust, reminiscent of monuments commonly found in public spaces honoring notable citizens (image 3). According to participant A.P., such a bust can be easily recognized based on its location – “for example, in Trieste, it could represent J. Joyce” (A.P.). The idea was to give the “box” a reassuring authority, adaptable to different settings by altering the facial features through 3D printing. Creating a detailed sketch of the box proved challenging for those without sculpting experience. This technical impasse led to the concept of a neutral-faced bust, stripped of specific features, evoking the essence of a monument in a contemporary style. It would be placed in a neutral, colorless space and personalized through the use of colored lighting.

The creative process was strongly influenced by the imagined location of the object: a doctor's waiting room for the penguin, a library for the lamp, and an airport waiting room for the bust. Each participant visualized the Smart Box within a specific spatial context, transforming it from a mere device into a meaningful part of an environment (image 4,5,6). This imaginative approach to situating the Smart Box led to the creation of 1:20 scale models of these environments, conceived as “refuge rooms” – small, sensory-friendly spaces designed as calm, protective micro-environments.
The subsequent phases, conducted by the research team, focused on further developing these miniature models to explore how the Smart Box could function and be experienced within such thoughtfully designed spaces.

The prototyping process involved close-range photogrammetry, 3D scanning, and digital modelling to translate the handcrafted maquettes into printable digital models, enabling additive manufacturing with a 3D printer in PLA material while preserving their tactile expressiveness and allowing for future technical development. The most advanced prototype, the Penguin Smart Box, was further developed and produced using additive printing in PLA to integrate electronic components, including light, sound, and CO_2 sensors.
Pilot installations are planned in selected classrooms at Fondazione ProgettoAutismo and the TimeAUT Cooperative [5]. Subsequent evaluations informed both the choice of colors for the Smart Box and its placement strategies, and have led to the adoption of two complementary approaches. In certain settings, the Smart Box is intended to stand out as a recognizable and reassuring presence, while in others it is designed to integrate subtly with the environment, minimizing potential visual overstimulation.

Conclusion: nothing about us, without us

The environments we inhabit and the objects that surround us are often designed without a specific understanding of how the human mind works and how diverse cognitive processes shape perception (Norman, 1988). This lack of consideration can generate frustration, confusion, and even a sense of inadequacy – especially among users with particular sensitivities.
Research indicates that participatory design is an effective method for working with autistic adults, provided that design activities are carefully adapted to ensure accessibility and effectiveness (Maun et al, 2021). It is essential that researchers and practitioners have a thorough understanding of autism to implement these adaptations and invest time in getting to know the autistic individuals involved in the study.
The involvement of neurodivergent individuals in the co-design workshop introduced into the design process not only their needs and sensory sensitivities but also their personal preferences, creativity, and technical skills. This approach challenges the traditional deficit-based view of disability and embraces a so-called social model perspective, recognizing that disability arises from the interaction between individuals and environments that fail to accommodate diversity.
As demonstrated in the “Penguin Smart Box” case, participants exhibited sophisticated reasoning, symbolic thinking, and design awareness. Their contributions highlight that neurodivergent individuals can act as genuine creative experts (Boys, 2018) in conceiving environments and objects for sensory regulation. By valuing these perspectives, the project operationalizes a core principle of the disability rights movement – that people with disabilities must be directly involved in all decisions affecting their lives, encapsulated in the slogan “Nothing about us, without us” (Charlton, 1998) – and translates it into concrete architectural and design practices.

notes

[1] Despite full attendance across all four workshop sessions, one participant did not submit the final models. Consequently, his contribution was excluded from the presentation, a decision necessitated by personal difficulties he was experiencing.

[2] Fondazione ProgettoAutismo: https://progettoautismo.org

[3] The workshop originated from the collaboration between the project partners – the University of Trieste (UniTS) and the Progetto Autismo Foundation – building on the experience of a previous co-design workshop carried out together in 2021 at the Foundation, within the Senshome project. The multidisciplinary team responsible for its organization, composed of the authors of this contribution, designed and managed the various phases of the activity within the "Asperger Group", a biweekly meeting where people with high-functioning autism take part in shared activities. In this context, the activity was adapted into a workshop, held between May and July 2024.

[4] The BeSENSHome project (Interreg Italy-Austria 2021–2027) aims to make environments for people with neurocognitive disabilities more welcoming and safer through the integration of smart sensing technologies and AI, masked within dedicated smart boxes.

[5] TimeAUT - Società Cooperativa Sociale Onlus:. https://www.timeaut.it/

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image 1

Concept ideation phase and outcome of the "Penguin Smart Box" model created by participant A.C. during the workshop. The sketch was made using expanded polyurethane foam, useful for defining soft, rounded volumes, and Cernit clay to model details such as the beak, feet, and tail. Photographs by the authors.

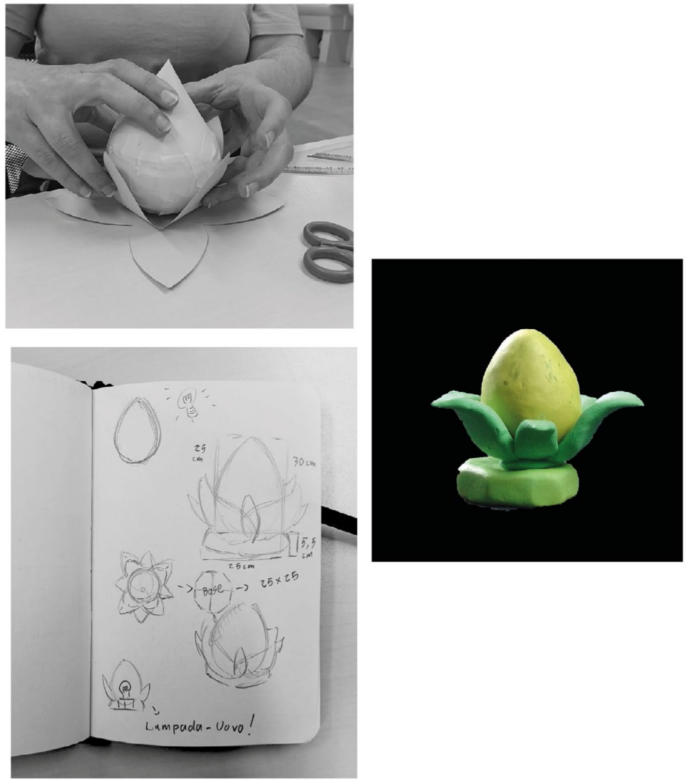


image 2

Concept ideation phase and outcome of the “Lamp Smart Box” model created by participant C.P. during the workshop.
Photographs by the authors.

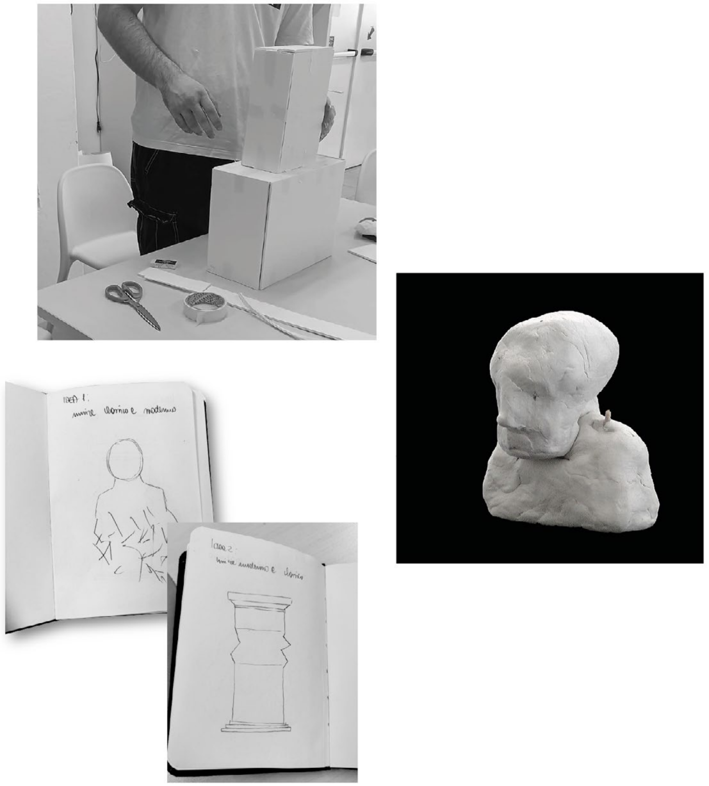
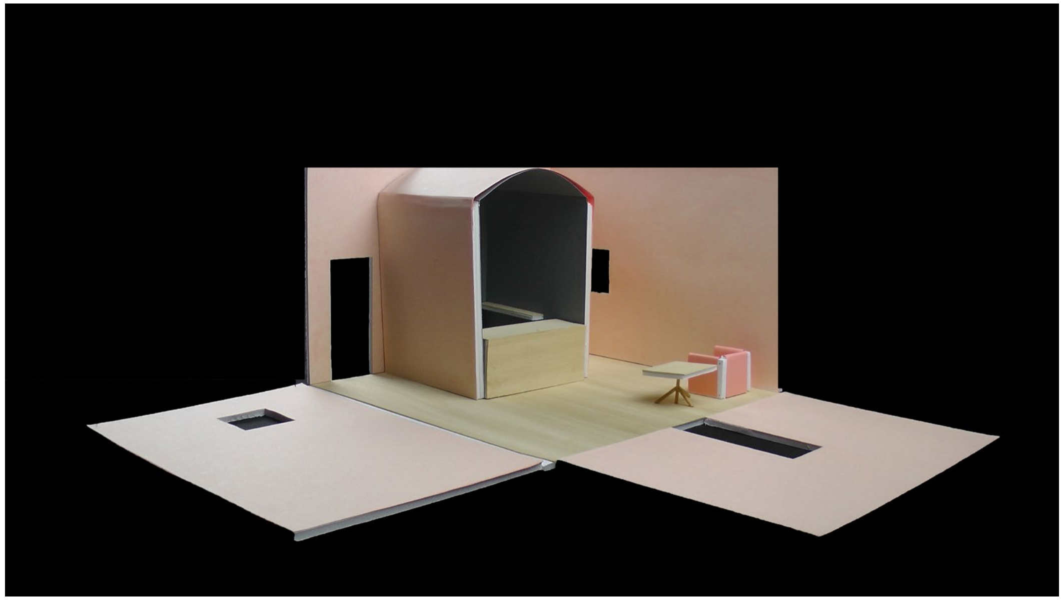


image 3

Concept ideation phase and outcome of the “Bust Smart Box” model created by participant A.P. during the workshop.
Photographs by the authors.



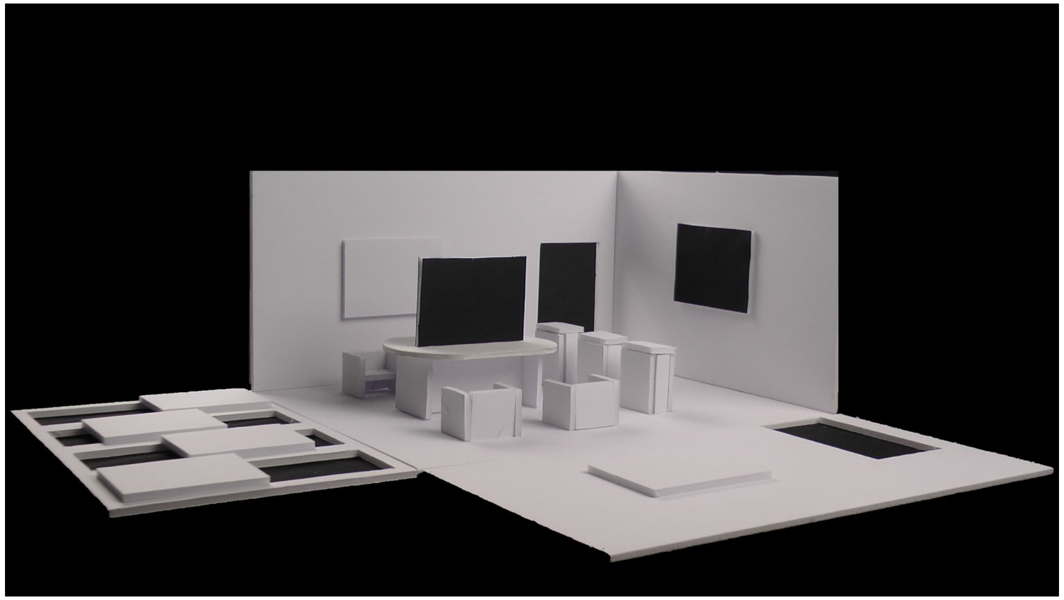


image 4, 5, 6

1:20 scale models of the “refuge space” scenarios created during the workshop.
Photographs by the authors.

BESENSHOME AND THE SPATIAL DIMENSION: ARCHITECTURAL STRATEGIES FOR SENSORY INCLUSION

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abstract

In contemporary architectural research, the relationship between space, perception, and sensory diversity is central to design theory, environmental psychology, and neurodiversity studies. The BeSENSHome project (2023–2026), building on the earlier SENSHome initiative (2019–2022), explores how architecture can support sensory inclusion through adaptive environments, participatory processes, and smart technologies.
Working with young adults on the autism spectrum, the researcher investigates how spatial affordances can regulate sensory balance and foster well-being. The project combines architectural experimentation with "smartboxes" that monitor environmental parameters such as light, sound, and air quality. Through co-design workshops My Box and My Spot, participants created prototypes and spatial scenarios, later realized as three "Refuge Spaces," each demonstrating strategies of comfort, protection, and personalization. These spaces mediate between overstimulating and calming environments, creating sensory refuges in public settings such as museums, airports, and libraries.
The project proposes an expanded vision of inclusive design, integrating environmental and artificial intelligence with emotional intelligence. By treating the built environment as a living system that learns from its users, it positions architecture as an active agent of sensory well-being and inclusion.

keywords

Sensory Inclusion, Refuge escape, Participatory Design, Adaptive Environments, Neurodiversity

Introduction: space, perception, and sensory diversity

In contemporary architectural research, the relationship between space, perception, and sensory diversity has become a crucial topic, intersecting design theory, environmental psychology, and neurodiversity studies. The built environment is not a neutral container: it constantly interacts with the human body through sensory stimuli – light, sound, texture, temperature, and smell – that shape emotional states and cognitive performance. For neurodivergent individuals, whose sensory thresholds differ from the neurotypical norm, these interactions can become sources of discomfort, anxiety, or even exclusion when the environment fails to acknowledge their perceptual specificities (Singer, 1999; Kinnaer et al, 2016; Robertson et al, 2015).
Many contemporary art installations exemplify this tension. Immersive experiences aimed at expanding bodily awareness and multisensory engagement often neglect the diversity of perceptual profiles. Warning signs at exhibition entrances – "strobe lights", "intense sounds", "may cause discomfort" – reveal the absence of a broader reflection on the mechanisms of exclusion embedded in spatial experience. This selective accessibility

highlights an essential paradox: spaces designed to speak to "the body" do not necessarily speak to every body.
The same mechanisms operate in large-scale public and commercial environments – airports, shopping malls, or transit hubs – where surfaces are saturated with stimuli competing for attention. These places transform perception into a commodity, treating the body as a surface for consumption and sensory overload as an inevitable by-product of efficiency and entertainment (Mostafa, 2014). For individuals with conditions such as autism, ADHD, or other profiles affecting sensory processing, such environments can generate disorientation, loss of orientation, or behavioral shutdown.
Even apparently benign spaces – science museums, educational environments, cultural venues – can become sites of sensory excess. Their mission of interactivity and engagement often translates into bright lighting, multiple sound sources, and dense visual communication. This condition has prompted an increasing number of designers and researchers to experiment with new spatial typologies capable of mediating, filtering, and balancing sensory stimuli rather than merely adding more of them. Within this framework, sensory comfort emerges as a relational, dynamic state rather than a measurable constant. It depends on the capacity of the environment to adjust its affordances to the user's fluctuating needs and emotional states (Spence, 2020).
In parallel, the field of neuroarchitecture has begun to recognize the importance of sensory inclusion as a design paradigm. Research in this area highlights the embodied nature of perception: the built environment is experienced through the full spectrum of the body's sensory channels and cognitive responses. Architectural space thus functions as both a container and an active medium – a cognitive prosthesis capable of supporting regulation, self-awareness, and social participation. The move from accessibility toward sensory inclusion implies a paradigmatic shift: rather than removing barriers after the fact, architects must anticipate differences as a fundamental design variable.
This epistemological shift situates BeSENSHome within a broader discourse on "sensory decolonisation" (Mostafa, 2021) – a process that challenges the hegemony of visual and normative comfort metrics by acknowledging multisensory diversity as a constitutive aspect of human experience. Designing for neurodiversity therefore means designing for uncertainty, for perceptual variance, and for the coexistence of multiple sensory worlds.

From SENSHome to BeSENSHome: experimental spaces and adaptive environments in sensory inclusion

The BeSENSHome Interreg project (2023-2026), building upon the outcomes of SENSHome (2019-2022), develops an integrated research trajectory that redefines the relationship between people and space through architectural, technological, and participatory strategies. The first phase, SENSHome, introduced the concept of the "sensitive home", a domestic environment that learns from users' sensory preferences through sensor networks and adaptive systems [1]. Within the SHELab – the experimental domestic mock-up at NOI Techpark in Bolzano – three archetypal spaces (entrance, kitchen, and living room) were equipped with sensors monitoring acoustic, thermal, and visual comfort. The design of furniture elements, such as the Alone-Together seat and table, incorporated sound-absorbing materials and movable partitions to allow users to regulate proximity and exposure to stimuli, fostering autonomy and psychological well-being.
The transitional space of the SHELab entrance embodies the principle of controlled adaptation: small thresholds, filtered light, and adjustable surfaces enable the gradual passage between exterior unpredictability and interior reassurance. This notion of gradual sensory transition – moving from stimulating to calming environments – recurs throughout the project's spatial experiments. Reverberation analyses and ray-tracing

acoustic simulations were used to model the propagation of sound and anticipate sensory perception, ensuring that comfort could be both measurable and experiential.
One of the most significant applications of this research is the sensory decompression space realized in 2024 at the Immaginario Scientifico museum in Trieste. Conceived as a refuge along the museum path, it integrates architectural and educational dimensions. The installation includes a cocoon-like Alone-Together seat covered in sound-absorbing fabric and surrounded by modular panels that reduce reverberation while maintaining visual openness. Informational panels explain the diversity of sensory processing and describe the acoustic materials used, transforming the space into both a resting area and a didactic device. This decompression area, located at a transitional point of the exhibition route, allows visitors – especially those with autism or sensory hypersensitivity – to slow down and recalibrate, mitigating the cognitive fatigue induced by interactive exhibits and crowded spaces.
This installation continues a design path that began with *Uni(di)versitas*, promoted by the University of Trieste, a series of interactive exhibits promoting diversity and inclusion within the same museum [2]. The evolution from informational displays to embodied sensory experiences reflects a shift in design thinking – from communication about diversity to spatial enactment of inclusion. The Alone-Together seat and related installations embody the core principle of BeSENSHome: inclusion must be designed into the material and atmospheric qualities of space, not simply added through signage or technical aids. In this way, the installations achieves a dual goal, enhancing the museum's accessibility while promoting greater awareness of perceptual diversity.
The research project has also made it possible to carry out acoustic surveys in educational settings, aiming to identify sources of noise that may cause discomfort or anxiety. Studies in architectural acoustics were conducted in primary schools across the Friuli Venezia Giulia region, confirming that reducing background noise and creating gradients of sensory intensity not only benefits neurodivergent users but also enhances comfort and engagement for the entire school community (Bettarello et al., 2025).

In parallel with these architectural applications, participatory research carried out within the BeSENSHome project played a fundamental role, involving young adults on the autism spectrum as active contributors in the creation of calm and sensory refuge spaces in public settings, while integrating smartbox technological devices: discreet objects equipped with sensors designed to monitor and regulate environmental parameters such as light, temperature, air quality, and sound.
The co-design laboratory "My Box and My Spot", based on a methodology combining art-based design and 3D modeling, enabled participants to express their sensory needs and aesthetic preferences, translating them into tangible design prototypes [3].
The workshop "My Box" demonstrated how participatory processes can generate not only technically effective but also emotionally meaningful artefacts – objects perceived as familiar, reassuring, and aesthetically pleasing, capable of mediating sensory experiences rather than merely controlling them (Scavuzzo et al, 2025a). The "My Spot" phase expanded this exploration to spatial scenarios, imagining micro-environments of sensory retreat within public spaces. These "necessary and sensitive refuges" (Scavuzzo et al, 2025b) are conceived as architectural microcosms that integrate smart sensing systems into adaptable spatial configurations. Rather than isolating the user, they aim to offer controlled transitions between overstimulating and quiet zones, supporting the rebalancing of sensory and emotional states. From this perspective, the architectural space itself becomes a cognitive prosthesis – an active interface between body, perception, and environment.

Architectural prototypes: shared spaces and sensory escapes

The three refuge space projects developed in the "My Spot" laboratory, although differing in context and formal language, highlighted several consistent aspects regarding environmental comfort, spatial perception, and personalization.
The project by A.P., conceived as a resting area within an airport, is based on the idea of a locus amoenus emphasizing order and tranquillity. Symmetry, modular regularity, and the possibility of controlling light through movable panels contribute to creating a stable, legible, and reassuring environment. The proposal by C.P., a room for relaxation and isolation within a public library, stands out for its use of natural materials, warm colors, and nature-inspired decorations – such as tropical-patterned wallpaper, wooden furniture, and soft textiles – which together create a welcoming, domestic atmosphere conducive to concentration and well-being. The project by A.C., designed for waiting areas in healthcare settings, is characterized by a symmetrical and orderly layout, the use of tactile materials and soft colors, and a central architectural element that functions as a visual and functional filter, providing a sense of protection and retreat.
Despite the variety of approaches, the final models highlighted the uniqueness of each project and the participants' ability to translate sensory and creative needs into tangible solutions, emphasizing flexibility and personalization to create safe, reassuring, and easily usable environments.

These spaces were subsequently reinterpreted by the research group as architectural refuges – flexible environments adaptable to various public contexts and designed to promote users' sensory rebalancing.
The redesign was guided by a set of recurring principles that emerged during the workshops:
- a preference for symmetrical and easily readable configurations, enhancing the perception of safety and control over routes and access points;
- the importance of openings toward the outside – ideally onto open spaces or green areas – as sources of emotional relief;
- the creation of an intimate, home-like atmosphere through rugs, curtains, artworks, and natural materials;
- and the possibility for users to personalize the environment by adjusting light and color according to their sensory needs, while avoiding invasive or overstimulating solutions.

The three refuge spaces reinterpreted conceptually by the research group incorporated these principles, integrating acoustic and comfort-related features, smart technologies derived from the "smartbox" concepts proposed by users, and flexible environmental control systems. The research group intends to further develop these projects through more detailed studies of architectural elements and technology-integrated design, with the goal of refining the identified spatial and sensory solutions.
The materials and textures used include wood, soft fabrics, acoustic panels, and tactile surfaces. Light and colours are mainly chosen from the shades indicated by the workshop participants, diffused or adjustable lighting, and visual connections with the outdoors. The proportions and geometries favor enveloping forms and compact or symmetrical layouts that convey order and comfort. Ergonomic furnishings – including integrated seating, comfortable chairs, and reclining options – are complemented by sensory interactivity, allowing users to modulate light, sound, air quality, and tactile and visual stimuli, thereby promoting calmness and concentration.

Intimacy and protection

The first Refuge Space (image 1) developed from the model inspired by participant A.C.'s project during the workshop, is conceived as an intimate and welcoming environment, shaped by soft surfaces and rounded corners that envelop the user in a protective shell. The room is configured as a suspended refuge — a place of introspection and pause — designed to be inserted within larger contexts, such as a shopping mall or a hospital waiting area, while maintaining its own perceptual and sensory autonomy.

Access is provided through large glass doors with variable transparency, capable of shifting between opacity and transparency to modulate privacy and natural light. These surfaces open toward a wide glass wall that enhances the visual connection with the exterior, expanding the perception of the room's physical boundaries.

The Pinguin smartbox, placed on a small table, serves as the technological core of the environment.

The lowered ceiling and the sound-absorbing materials integrated into the walls create a muffled atmosphere, where acoustic stillness and diffused light merge into a dimension of comfort and contemplation.

The rectangular floor plan, which gradually narrows toward the back, enhances the visual perspective, guiding the gaze toward a focal point of calm. Along one wall extends a continuous seating area, composed of modular units separated by side tables or shelves that define small resting zones. The seating gradually widens toward the back, allowing full body relaxation.

Pastel tones and light-colored walls, combined with recessed coves featuring warm, diffused lighting, amplify brightness and convey a sense of suspension and lightness. The result is a soft, contemplative environment where body and mind can regain balance.

Transparency and balance

The second Refuge Space (image 2) is characterized by its symmetrical geometry and transparent enclosure, defined by modular walls that evoke a sense of balance and proportion, supported by a self-bearing white iron structure. The transparent surfaces, conceived as responsive membranes, integrate movable shading and sound-absorbing panels attached to horizontal tracks running along the main frame. Some fixed, backlit panels are placed at the top, near the roof, and together these elements allow the modulation of light, transparency, and privacy within the space. This system makes it possible to generate variable chromatic atmospheres or shaded zones, adaptable to the user's needs, who can directly modify the configuration of the enclosure.

The intimate space, designed for a limited number of users, allows seating to be oriented according to the desired view, encouraging concentration, meditation, or silent dialogue. The use of neutral-toned materials and soft furnishings enhances the perception of calm and continuity. Technology, integrated into sculptural smartbox elements, introduces an almost museal and contemplative dimension.

Surfaces and materials interact with light and sound, creating an environment in continuous transformation, suspended between transparency and introspection. This refuge also originates from a concept proposed by a workshop participant (A.P.), who envisioned a quiet and secluded space to be placed in the hall of an airport or a large train station.

Warmth and immersion

The third Refuge Space (image 3) is an intimate and enveloping environment, defined by soft fabrics, rich textures, and warm hues. It can be conceived either as a micro-enclosure within a larger context or as an independent unit. The wooden floor provides a natural and welcoming base, while a soft green carpet introduces tactile and acoustic comfort. At the center, a red velvet armchair becomes the visual and emotional focal point of the space, inviting pause and contemplation.

The spatial configuration includes a structure with a partially curved base and two perpendicular fixed walls enclosing a self-supporting cylindrical element, completed by a fabric curtain that can be fully closed or left partially open, thus modulating the degree of privacy and perceptual protection. The ceiling, composed of suspended sound-absorbing materials positioned above the cylindrical core, filters the diffused light from above, imparting lightness to the environment while preserving its intimacy.

The fabric walls, adorned with floral or tropical motifs, create an immersive, dreamlike microcosm inspired by the space developed by participant A.C. during the workshop.

A round table hosts an interactive smartbox shaped like a water lily, a harmonious furnishing element in dialogue with the surrounding materials, forms, and colors.

This refuge is designed to foster meditation and concentration, where the tactile quality of materials, modulated light, and warm tones become tools for wellbeing and inner reconnection. It offers an intimate, immersive, and regenerative experience, ideal for larger contexts such as shared study spaces, busy museums, or school libraries.

Conclusion: architecture as a medium for sensory inclusion

These findings confirm what has emerged in previous research experiences of the group: designing spaces for people on the autism spectrum requires participatory verification, integrating theoretical literature with direct experimentation and taking into account diverse living cultures and individual spatial imaginaries.

Through these experiments, a common thread emerges: the spatial dimension is the key mediator of sensory inclusion. Architectural form, material composition, and acoustic configuration can act as filters or amplifiers of perception, shaping emotional and cognitive responses. "Architecture, through its unique means, can offer refuge to our extended body and provide a foothold on which the imagination can rest." (Robinson, 2011, p.31).

The project's research demonstrates that sensory inclusion cannot rely solely on assistive technologies; it must be grounded in spatial affordances that anticipate and embrace diversity. Intelligent sensing systems provide valuable feedback loops, but the ethical and experiential value of inclusion depends on how architecture translates data into atmosphere, embodiment, and relational meaning.

Ultimately, BeSENSHome proposes an expanded notion of inclusive design, merging environmental and artificial intelligence with emotional intelligence. By integrating adaptive technologies, participatory processes, and architectural strategies, it defines a new paradigm of sensory architecture – one that views the built environment as a living system capable of learning from its inhabitants. Through this lens, the spatial dimension becomes not merely the stage of sensory experience but its most powerful agent: a medium through which architecture can restore agency to every body.

notes

[1] The results of the first project and the furnishings of the experimental domestic environment, SHELab, are partly published in “Architecture and Atypical Sensitivities” (Scavuzzo et al.,2023)

[2] The authors are members of the research group EQUIS - Equity, Quality, Inclusion, Spaces. Design strategies to challenge social and spatial inequality at the University of Trieste, which focuses on design strategies to address social and spatial inequalities, with particular attention to neurodivergence.
Over the years, the EQUIS research group has created three installations along the exhibition path of the Immaginario Scientifico, promoted by the University, with the aim of highlighting and celebrating diversity.
The first two installations, titled Uni(di)versitas, are interactive: the first presents a desk illustrating the study opportunities offered by the University; the second showcases research projects from various disciplines exploring different aspects of diversity. The third installation consists of a sensory decompression space and an exhibition dedicated to neurodiversity, designed to raise public awareness of the importance of inclusive and accessible environments for everyone.

[3] The phases and outcomes of the co-design laboratory are illustrated in the contribution “Experience of Co-designing Sensor-Friendly Spaces: Insights from Progettoautismo FVG” in this volume. For further details, reference can be made to the published articles listed in the bibliography (Scavuzzo et al., 2025a-b).

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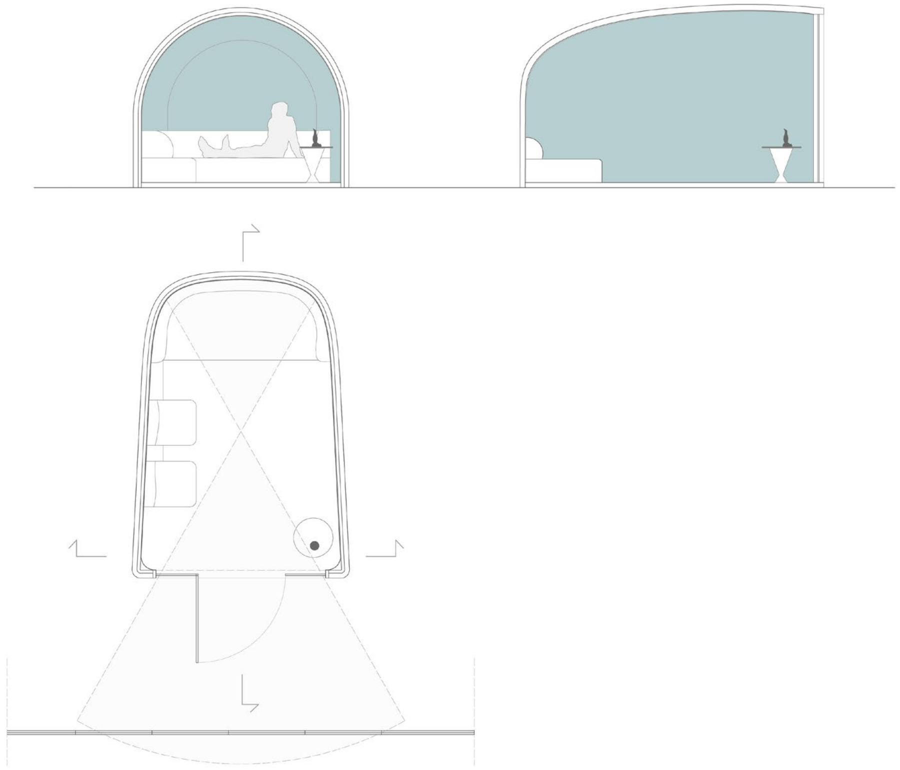

image 1

Design of “Refuge Space 1”, developed by the authors based on the refuge space model created by workshop participant A.C.
The drawing highlights the characteristic elements of curved walls and smooth surfaces in soft tones. The floor plan also reveals the potential to integrate the refuge space within an existing environment, where glass walls allow for a visual connection with the exterior, expanding the perception of the space’s physical boundaries.
Graphic design by the authors, 2025.

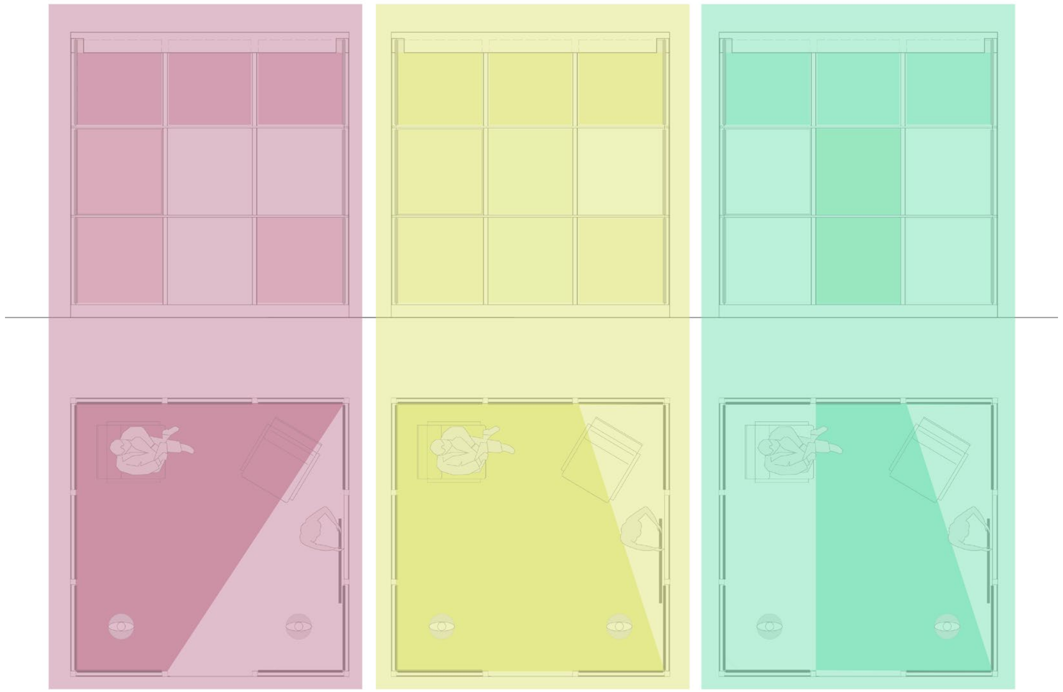

image 2

Design of “Refuge Space 2”, developed by the authors based on the refuge space model created by workshop participant A.P.
The drawing conceptually highlights the floor plan and the elevation of a wall with modular panels, showing how their composition can modify the environment, light and shadow, combined with color changes.
Graphic design by the authors, 2025.

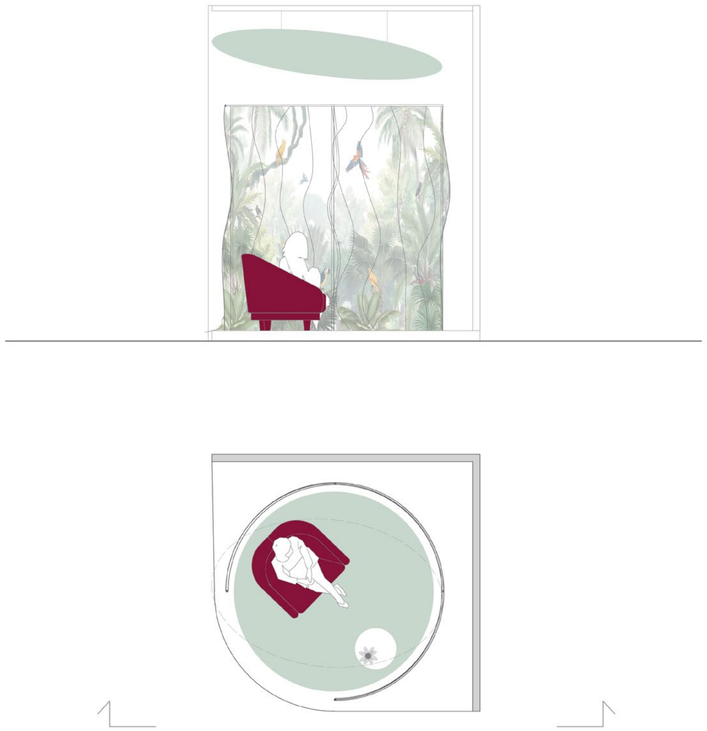

image 3

Drawing of “Refuge Space 3”, developed by the authors based on the refuge space model created by workshop participant C.P.
The design highlights the fabrics, colors, tactile qualities, and acoustic features that give the space a cozy and intimate dimension.
Graphic design by the authors, 2025.

BESENSHOME TECHNICAL ASPECTS

BESENSHOME IN ACTION:
AI AND SMART TECHNOLOGIES FOR INCLUSIVE AND SENSITIVE ENVIRONMENTS

Valentina Passarella, Marco Raffael

abstract

This text outlines the software and user-interface strategy of BeSENSHome, an Interreg Italy–Austria project that combines distributed sensor networks and explainable AI to make living, educational and care spaces more inclusive for neurodivergent people. Emphasising the human-centred design, Eureka System describes the overall software and user-interface, highlighting the edge-aware data pipelines, concise annotation workflows, a graded alerting service and privacy-by-design safeguards. The BeSENSHome application interface supports human-in-the-loop validation and progressive personalisation. Pilot deployments at Fondazione ProgettoAutismo FVG, TimeAUT and a primary school in Carinthia are assessing usability, detection performance and social impact.

keywords

BeSENSHome, Software development, Sensor networks, AI, Neurodiversity support

BeSENSHome is an Interreg Italy-Austria initiative that integrates distributed sensor networks and artificial intelligence to render living, educational and care spaces more inclusive for neurodivergent individuals. The software developed by Eureka System supplies the data collection, analytics and application services required to operate heterogeneous indoor sensors, to execute inference engines and to present actionable insights to caregivers and facility managers at pilot sites including Fondazione ProgettoAutismo FVG, TimeAUT and an elementary school in Carinthia. Emphasis has been placed on user-centred design, modular architecture, real-time processing and privacy-preserving AI.

The BeSENSHome software architecture has been devised to reconcile stringent requirements of privacy, interpretability and operational robustness with the practical necessities of deployment in constrained and diverse care environments. The overarching aim is to produce context-aware recommendations and timely warnings that support caregivers and facility managers in tuning room conditions to the sensory profiles and sensitivities of the neurodivergent individuals they care for. To that end the software orchestrates a continuous pipeline that begins with distributed environmental data collection and ends in human-facing visualisations and alerts.

The software stack is organised to reflect a clear separation of concerns. Edge components are responsible for local acquisition, deterministic preprocessing and short-term buffering; central services handle persistent storage, model training, orchestration and the policy engine that issues automated interventions or notifications; the human-facing application

supports session handling, concise annotation, alerting and retrospective analysis. Such separation preserves operational continuity under intermittent network conditions, reduces the volume of telemetry forwarded to central services and keeps personally identifying information local wherever practicable.

At the edge level, compact smart-box units are collocated in the rooms to be monitored. Each smart-box can easily be associated with the system via a Bluetooth connection from the dedicated interface page. These devices acquire an array of physical quantities, including particulate matter, volatile organic compounds, oxidising gases, relative humidity, indoor temperature, luminous intensity and acoustic metrics. Sampling cadence is adapted to signal dynamics: thermal and hygrometric variables are sampled at modest rates while acoustic and luminous channels use higher frequency acquisition to capture rapid changes. Edge-side computation performs deterministic preprocessing, feature extraction, event detection and short-term buffering to enable near-real-time responses and to reduce central processing needs.

The data model intentionally combines high-resolution, time-indexed environmental streams with structured contextual metadata. Environmental traces are stored in a time-aware repository that supports efficient temporal queries and visualisation while session metadata, pseudonymised user identifiers and caregiver annotations are kept in a relational store that supports role-based access control, audit and structured reporting. This hybrid organisation facilitates both signal-oriented analytics and the contextual interpretations that underpin supervised AI learning and training and per-site calibration.

Communication between distributed and central components follows lightweight, reliable patterns designed for constrained environments. Telemetry and status indicators are exchanged using an authenticated, topic-oriented protocol that permits constrained, pseudonymised payloads for near-real-time monitoring. A controlled channel exposes curated operations to the web front end and to authorised third-party services. The system usage is allowed through authentication and a subsequent verification of the actual user permissions.

The backend orchestration layer, developed in C# and Python, manages ingestion pipelines, performs data validation and enforces authentication and authorisation policies. It hosts an automation controller that acts as a deterministic safety layer, enforcing configurable thresholds for the environmental parameters and issuing immediate, comprehensible notifications whenever critical conditions arise. The rule-based fallback guarantees baseline responsiveness independent of AI availability and thereby aligns with operational safety expectations in care settings.

The decision-support capability of BeSENSHome rests upon a supervised learning pipeline designed to reflect the socio-technical realities of caregiving environments. AI training data are constructed by pairing temporally synchronised environmental traces and contextual descriptors – time of day, activity identifiers, room occupancy indicators – with short, standardised annotations entered by caregivers that record perceived comfort or distress across a concise set of environmental dimensions. The labelling interface is intentionally succinct to reduce cognitive load and to sustain annotation fidelity in situ. The AI architecture emphasises transparency and progressive personalisation: initial inference layers embody simple, interpretable mappings that align with clinical or operational heuristics, thereby producing recommendations that are predictable and justifiable; subsequent training iterations incorporate accumulating supervised examples to refine per-room and per-profile parameterisations so that alerts and suggestions better reflect recurring patterns and individual sensitivities.

Outputs are represented to users as a graded severity index together with concise, actionable recommendations. Every suggestion is coupled with an explanatory trace that clarifies the principal factors driving the inference, including the salient sensor readings and the temporal window of evidence. This explainability-first stance is central to establishing trust and to enabling iterative improvement through human feedback: caregivers can evaluate, validate or contest automated suggestions and thereby generate higher-quality labelled data for model refinement.

The user interface of BeSENSHome has been developed not as a mere visual tool but as an operational layer that mediates data collection, human judgement and machine inference (image 1). Its design attends to three intertwined objectives: to minimise the cognitive burden placed on caregivers, to preserve the fidelity of labelled data used for supervised AI learning, and to make algorithmic outputs legible and contestable. To achieve these objectives the design process was driven by participatory methods and successive validation cycles with domain practitioners. Prototypes were iteratively refined to simplify common workflows, to reduce the number of explicit choices required of users during sessions, and to provide contextual affordances that ease rapid decision-making.

The front-end is implemented as a responsive React web application with differentiated experiences for mobile and desktop contexts.
Session management is streamlined: when a session involves a single occupant the application applies some context-aware defaults and reduces interaction overhead, while multi-user scenarios expose compact, discoverable selection flows. Annotation instruments are brief and standardised to promote consistent data labelling; they capture categorical judgements on constrained environmental dimensions and permit optional free-text notes to contextualise atypical events. To mitigate retrospective annotation drift and to preserve provenance, annotations are timestamped and linked to the synchronised telemetry window used for model training; caregivers may add or amend notes within a defined post-session window to accommodate operational realities.

Alerts and recommendations are delivered in a graded, human-centred manner. Critical events generate concise, unambiguous messages with a clear severity index and an immediate suggested action; lower-level alerts are framed as suggestions that the caregiver may accept, defer or dismiss with a brief rationale (image 2). Each AI-derived suggestion includes an explanatory trace that highlights the major environmental contributing factors and the temporal window of evidence, enabling professionals to appraise the model's rationale and to provide corrective annotations when necessary. The explainability layer supports a human-in-the-loop workflow in which machine adaptation and practitioner expertise iteratively converge.

Alerts are also designed to be unobtrusive. Delivery modalities for alerts are configurable to respect contextual needs and sensitivities: visual, auditory and haptic signalling can be enabled or suppressed according to device capabilities and site preferences, for example discreet delivery modes may be selected when overt signalling would be inappropriate.
Visual presentation emphasises clear iconography and a dashboard layout (image 3) that focuses on current room status and recent trends. The interface also shows metadata for each recommendation, enabling caregivers and administrators to trace back from an alert to the underlying sensor states, session context and annotation history.

The desktop variant of the application exposes supervisory functions – historical exploration, reporting and settings configuration – while the mobile variant concentrates on immediate operational tasks and simplified annotations (image 4). Transitions between the two interfaces are designed to be frictionless so that supervisory activities may be performed on larger displays without disrupting the operational mobile experience.

Operational deployment constraints have materially influenced hardware and software choices.
Edge units (smart-boxes) are compact, self-contained and replaceable, enabling incremental installations and straightforward maintenance; central software services are designed to be hosted on modest local hardware to preserve data locality and minimise external exposure.
Network and power contingencies are mitigated by ephemeral buffering at the edge, configurable retention policies and operational dashboards that report device health and data-flow integrity. Multi-site provisioning permits association of data with facility and room identifiers while preserving pseudonymity at the user level, enabling aggregated monitoring and comparative analysis when authorised. Moreover, external access for research partners is mediated by governance processes and by technical safeguards that restrict connections to pseudonymised, consented channels.

Collectively, the BeSENSHome software stack represents a pragmatic synthesis of privacy-aware data engineering, human-centred interaction design and interpretable AI practice. By anchoring initial functionality in deterministic automation and progressively introducing adaptive, personalised AI models, the system aims to provide caregivers with a predictable, transparent decision-support tool that evolves with deployment-specific experience. The software is intentionally conceived not as an autonomous decision-maker but as an accountable, privacy-preserving assistant that augments caregiver judgement with contextualised, data-driven insights. In this sense, deterministic safeguards ensure predictable baseline behaviour while supervised learning and human-in-the-loop mechanisms enable the platform to become more responsive and personalised over time. This blended approach seeks to balance safety, transparency and adaptability and thus can support indoor environments that are at once inclusive and sensitive to the comfort needs of neurodivergent individuals.

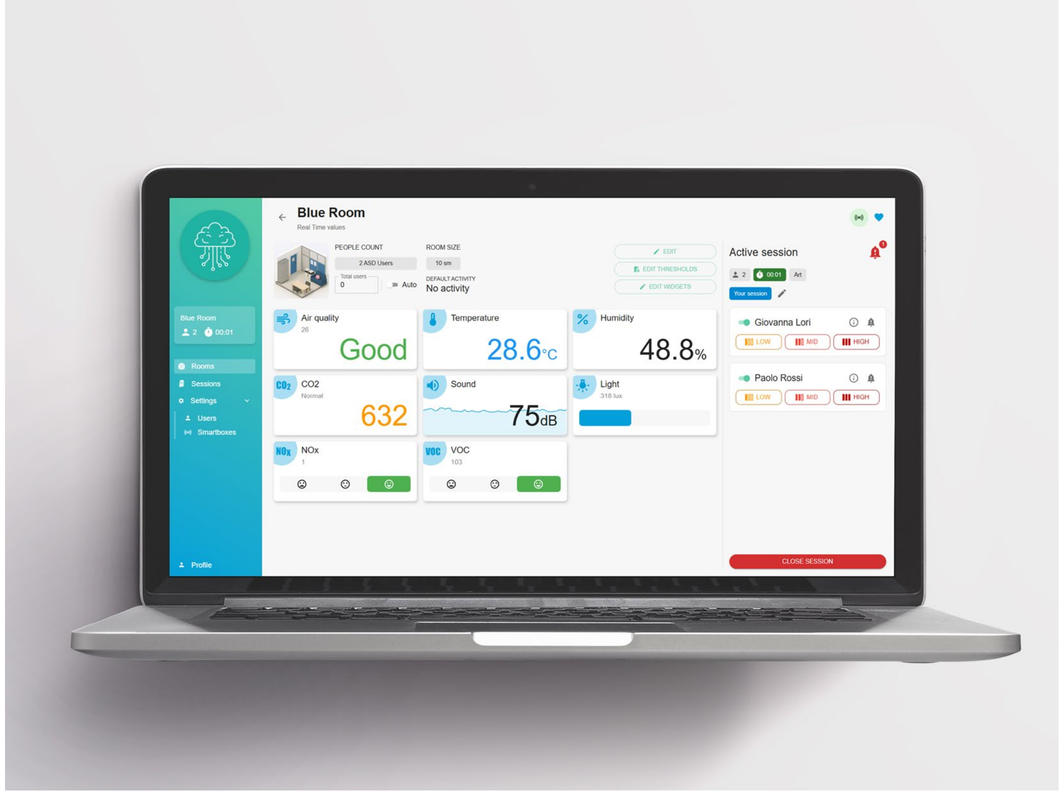

image 1

Desktop version of BeSENSHome User Interface dashboard.

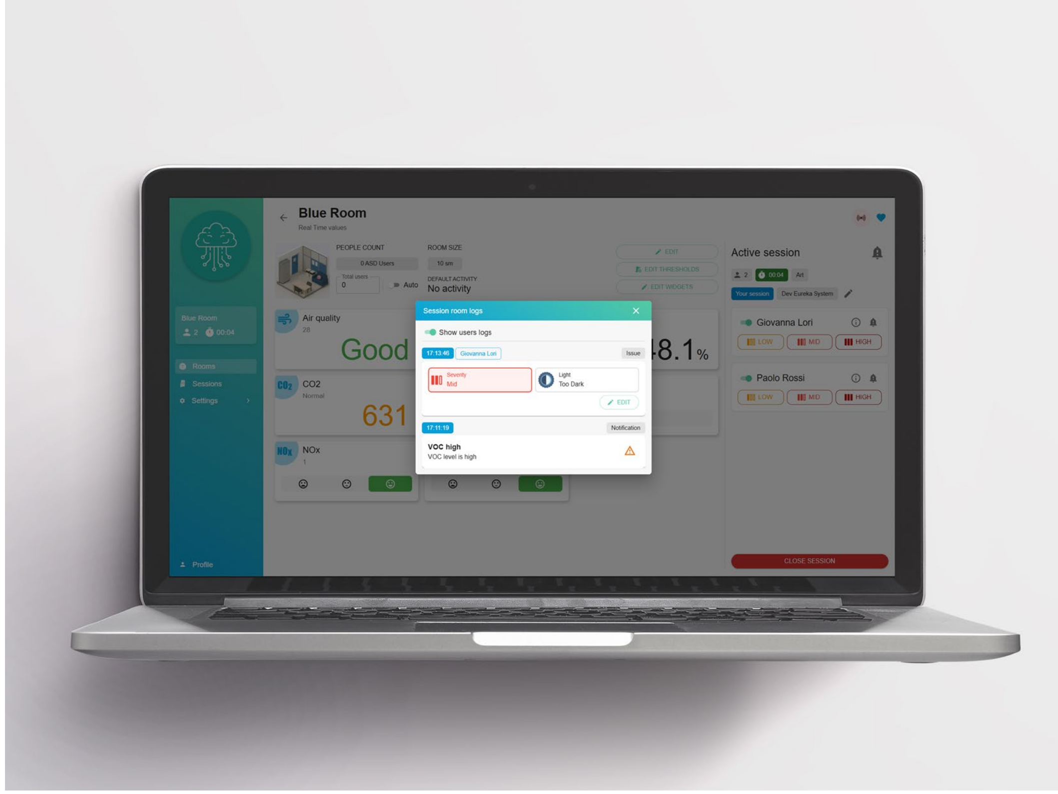

image 2

Desktop version of BeSENSHome User Interface alert logs.

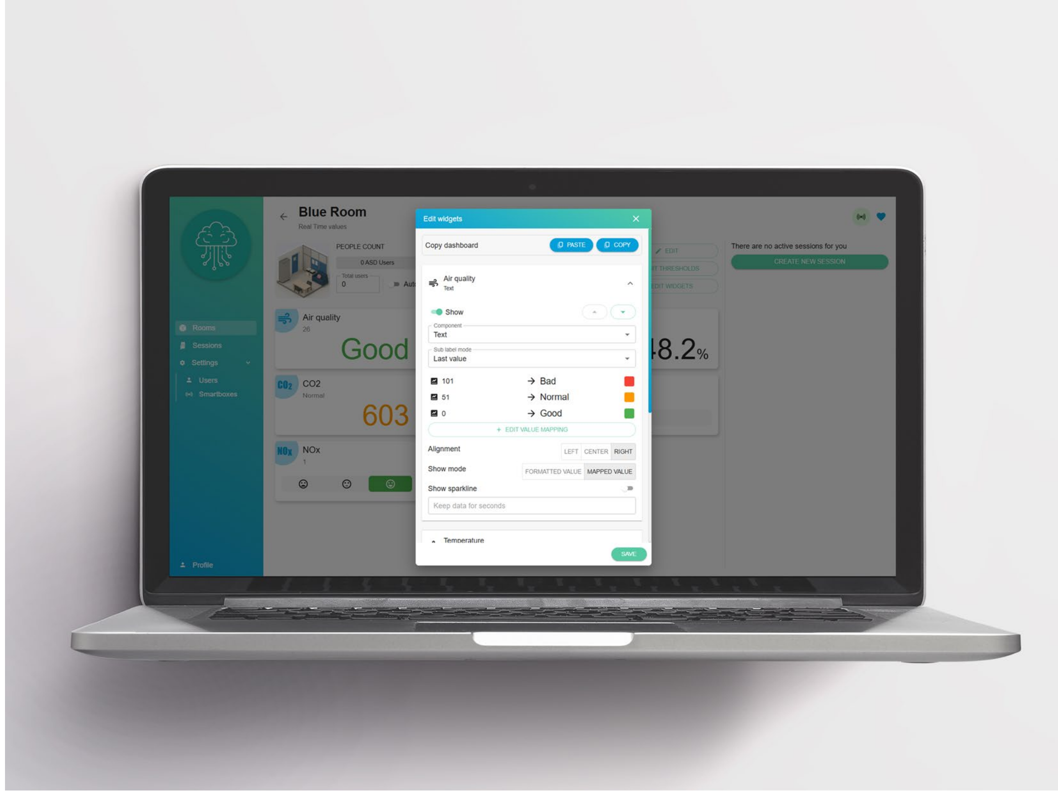

image 3

Desktop version of BeSENSHome User Interface dashboard editing.

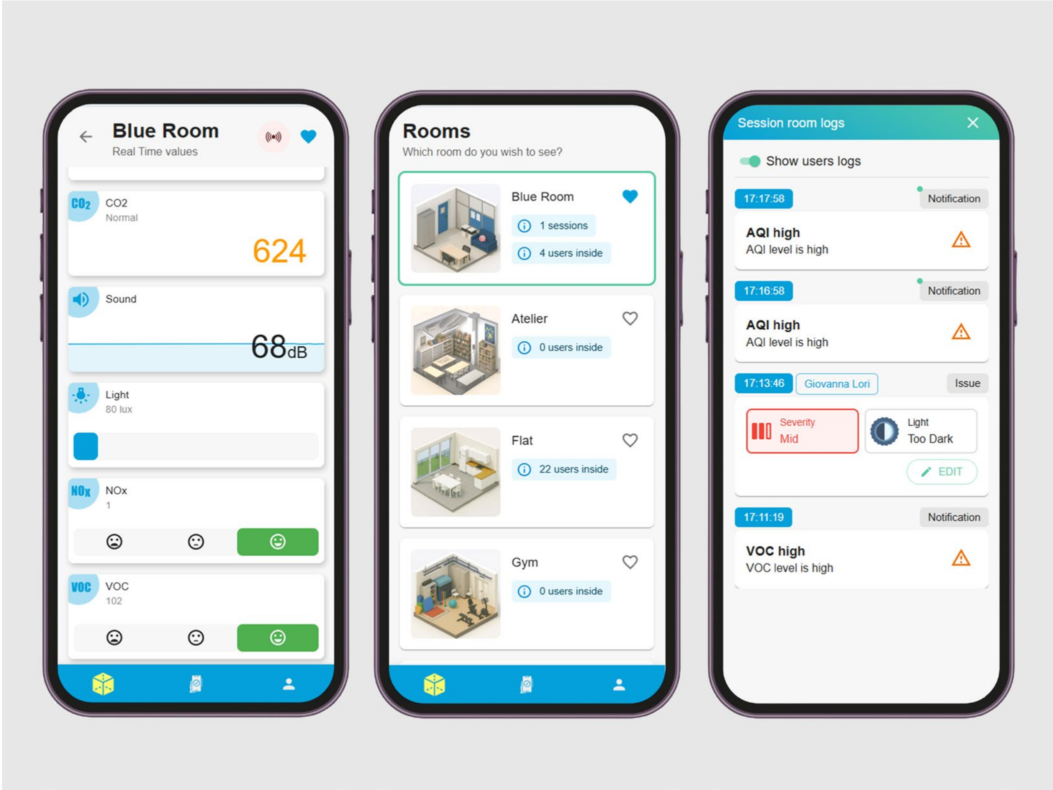

image 4

Mobile version of BeSENSHome User Interface.

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