LIVING ENVIRONMENTS AND AUTISM: ACOUSTIC ASPECTS IN BUILDINGS

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abstract

Acoustics represent one of the most important comfort parameters for autistic people, their relatives and caregivers. Many design criteria of residential spaces related to autistic user describes the peculiarities of acoustic theme as their primary target. But an approach based specific acoustic parameters of international standards is still missing. For the SENSHome project, we had to figure out what the ideal interior acoustic conditions were for a space – a house – that could be autistic-friendly and, at the same time, accommodate smart support systems. The reverberation of a living space can be controlled by the insertion of sound absorbing elements of various types, but in the case of autistic users, literature suggests that it is necessary to follow the fundamental concept of "user centered design approach".

keywords

Acoustic; Hearing Impaired; Noise Insulation; Reverberation; UCD.

When neurotypical people experience to much noise, due to annoying neighbours as an example, or sudden events from outside the house, they get nervous, or up-set, because their physical and psychological well-being is altered. But the typical reaction after anger is to take action to solve or to decrease the causes of the discomfort in some way. People without cognitive impairment can process these typical situations through pre-acquired mental schemes (Scott, 2003). The process of selecting the arrangement to correctly manage a situation is the basis of normal understanding. Thank to this schematic memory, it is possible to recognize the world as "familiar". Anything that does not correspond to already acquired experiential data is recognized as "extraneous"; this is a very quick process. If most situation details fit well into a pattern, attention is immediately driven by unknown ones. Conversely, if most of the details are not familiar at all, a new pattern is processed.

Each pattern can also be considered as a large network of memories with potential associative connections. When events follow our expectations, some previously acquired memories reach the peripheral consciousness and arouse the sensation of being already happened. Thus, it is possible to react. This cognitive process is the responsible of everyday ordinary living.

People affected by Autistic Spectrum Disorders are characterized by severe and generalized impairment in some areas of cognitive development, including hyper or hypo-reactivity to sensory stimuli or unusual interest in particular details of the environment – DSM V-2003. For high functioning individuals – HFA –, without intellectual disability, marked difficulties in the process of social inference may be verified and, in particular, this dysfunction may occur when they have to choose which information have to be taken into account (Panerai et al., 2014).

For an autistic person with hypersensitive hearing, it can be very difficult to cope with noisy situations of everyday life. Most people on the spectrum have difficulty processing intense,

multiple sensory experiences at once. Sensory overload often becomes their sensory experience in everyday life.

In a recent study conducted in Canada involving 168 families with child with autism – 3-16 years old – the 87% of the respondents reported that their children were sensitive to noise (Nagib et al., 2018). These results are confirmed also by the first analysis of the SENSHome Project research, with an investigation on Italian and Austrian Families involved in this research: acoustics was found to be the most important comfort parameters, for autistic people and their relatives and caregivers (Caniato et al., 2022). .
Specific studies carried out on school environments with autistic children have shown that the application of interventions aimed at reducing noise coming from outside the classroom – from corridors, or neighbouring classrooms –, has allowed them to reduce behavioural temperament' – self-stimulatory behaviour – such as obsessive behaviour, specific for each child, including head-banging, biting their hands and rocking (Kanakri et al., 2017).
Within the SENSHome project, we analysed literature, institutional programs, manuals and documents that summarize design criteria, space requirements, guidelines related to autism-friendly design within the last ten years, focused on residential spaces – individual and collective ones. Many authors and designers describes the peculiarities of acoustic theme in their projects.
For professor Mostafa acoustic is the first aspect that has to be considered in the priority scale of design process (Mostafa, 2014); also for GA Architects – an architecture practice in UK specialized in the design of environments for autistic children and adults and other learning difficulties – in their autism friendly design approach, a sense of calm is essential because noise will result in anxiety. The recent book "At home with autism" (Steele & Ahrentzen, 2015) is the most recent systematic work in this field. They talk about how auditory aspect must be taken into account in several aspects of home design. Also the Michael Singer Studio has been working in the field of "Autism Design" for several years on both housing for adults with autism as well as classroom design for children with autism, repeatedly focusing on aspects of auditory sensitivity (Singer, 2014). Architect Simon Humphreys, informed by personal experience of his autistic brother, also agrees that the most essential auditory experience created by architecture is tranquillity. Humphreys suggests an interesting acoustic design way: he talks about the correct application of number to create acoustically balanced spaces, in particular using the Fibonacci proportion. He intended to apply the Fibonacci proportion – a numerical series – to the plan and section design of a building because he thinks it could provide an intuitive balance to the space and the acoustics to the space. But at present there is not scientific evidences that it may works. George Braddock and John Rowell suggest that lighting and acoustic treatments have to support caregiving not aggravating the individual. One of the sound insulation aspects they highlighted is certainly the fact that sometimes the autistic person, due to unusual hours of night-time movement for example, can become the cause of disturbance to roommates or neighbours – they like extended water play, repetitive motion, running, throwing things, bouncing, picking, sing loudly and so on. They may become active at odd times of day or night. The goal is to reduce the negative consequences of these activities on the neighbours – as much as possible – thanks to acoustic insulation treatments (Braddock et al., 2011). The Model Programme compiled by architects Andersen and Kristensen gives high priority to acoustics: they point out how internal acoustic treatment can help having a low reverberation period, supporting calm and homeliness. Allowance must also be made for limiting disruptive noise from ventilation, kitchens or engineering rooms. The Checklist for Autism-Friendly Environments by Stephen Simpson, among the basic and minimum requirements to create a more autistic friendly environment is auditory perception. The checklist consists of

several questions that will have a response yes or no. After each question there is a section called solutions/discussion. From a building acoustics point of view, the questions for the designers are, for example: “have you considered the general noise level in the environment?”, Is there noise from flooring and can this be deadened if needed?”, “Have you any specific quiet and louder areas that people can choose from?”. I think it can represents a good starting point for a designer when dealing with interior acoustics and sound insulation in spaces for autistic people (Simpson, 2015).
All the analysed references confirm the necessity to take acoustic aspect into account. But an approach specifically based to those acoustic parameters that the international standards refer to – minimum insulation requirements of internal or external walls, reverberation time, “clarity” or “definition” – is still missing.

Today we can refer to calculation methods and predictive formulas to study and to support design, in order to provide what we have to expect in terms of acoustic insulation and internal sound field of a specific room.
International Building laws or regulations define the minimum acoustic performance requirements for each type of partition in terms of dedicated indexes, but these requirements may not include values higher enough to protect both normal and special users.
In same case, national regulations impose that airborne noise insulation between adjacent rooms – e.g. partition walls between apartments – offers barely a level of privacy (Rasmussen, 2006).
The requirement for façade sound insulation is often not related to the real noise conditions of the outdoor environment. This could represent a problem in case of design an accommodation for autistic user, for whom loud noises from the street can be distracting, but above all frightening.
Reverberation contributes to confusion about the source of sounds. People on the spectrum often have a lot more trouble identifying them and consequently are more confused than others. Such confusion adds to the nuisance; one can even say that the difference between sound and noise is marked by such confusion. In order to qualify the acoustic of internal environment, the parameters reverberation time, clarity and definition are certainly representative.
Reverberation time is the time required for the sound to decay in a closed space. Clarity – C50 – is an objective measure of the clarity of speech: late reflections are unfavourable for understanding speech because it causes speech sounds to merge, making speech unclear; if the delay does not exceed a certain time limit – 50 ms –, the reflections will contribute positively to the clarity. The percentage ratio between early sound reflections and overall sound energy of the impulse response is defined in terms of Definition – D50.
There is a specific range of optimal reverberation time values depending on the purpose for which an environment is intended. It is more difficult to determine an optimal reverberation time value for specific subjects. The acoustic subjective studies available today are those that some countries have conducted, independently, with regard to school environments and people with hearing impairments.

In researching the topic of acoustics and autism, we found some references on the acoustic comfort of school environments, written by professionals, audiologists and university researchers alike. An example is represented by the UK Building Bulletin 102, that contains the maximum mid-frequency reverberation time requirements for newly-built environments and refurbishments also for spaces intended for users with special hearing or communication needs. But in the case of living spaces – flats, offices – we did not find specific indications in terms of spatial acoustic requirements for autistic people.

For the SENSHome project, we had to figure out what the ideal interior acoustic conditions were for a space – a house – that could be autistic-friendly and, at the same time, accommodate smart support systems.
Microphone sensors are part of the smart system for hazardous event recognition that is one of the SENSHome project targets. The use of smart sensor systems represents a valuable support to internal design in order to achieve independent living for impaired people. Accordingly, these devices can monitor or prevent hazardous situations, ensuring security and privacy.
Acoustic sensor systems, for instance, could be used in order to realize a passive monitoring system. The correct functioning of such devices needs optimal indoor acoustic criteria. Nevertheless, these criteria should also comply with dedicated acoustic requests that autistic individuals with hearing impairment or hypersensitivity to sound could need.
In the case of autistic individuals, the low stimulus option is usually most appropriate. That's why we correlated reverberation time values obtained from some works deal-with hearing and learning impaired people's with optimal values for the functioning of microphone sensors.
Our research point out that obtaining reverberation values range from 0.4 to 0.7 seconds should represent optimal comfort conditions, both for autistic guests inside a room and for the functioning of microphone sensors (Bettarello et al., 2021).
The reverberation of a living space can be controlled by the insertion of sound absorbing elements of various types, but in the case of autistic users, literature suggests that it is necessary to follow the fundamental concept of "user centered design approach". Autistic individuals could dislike discontinuity related to vertical walls, thus micro-perforated sound absorbing panels may alter wall appearance. Accordingly, it is of paramount importance not to introduce disturbing elements such surface interruptions.
Furnishing with sound absorbing elements on dedicated areas can be considered. Some furniture elements like beds, cushions, armchairs and sofas are all intrinsically sound absorbing. This property will depend on their geometries and thicknesses.
The possible inclusion of all these elements in the indoor environment should therefore be studied in advance, in order to optimize the indoor acoustic characteristics of the room according to the likes and dislikes of individuals on the autistic spectrum.

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