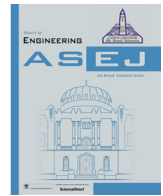




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# Multi-sensory interactive interior design for enhancing skills in children with autism



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## ABSTRACT

The sensitivity of children with autism to interior space elements differs from their healthy peers. Accordingly, there was a need to make a study on their sensitivity to internal elements, then study how to use that to enhance their skills. This paper aims to introduce different types of spatial design for children with autism and their sensitivity to interior elements and then use that to enhance their abilities through multi-sensory rooms. To achieve that aim several research methodologies were implemented starting with a literature review, and site visits to the rehabilitation centers, then a survey was conducted to measure the sensitivity of children with autism to interior space elements and how the elements of multi-sensory rooms enhance their abilities. The findings of this paper have enclosed that children with autism are more sensitive to light than any other element in the interior space, therefore, light is used to develop their skills in the multisensory room.

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## 1. Introduction

In recent years, there has been great interest in building studies for children with special needs, but only a few for autistic children according to their behavioural characteristics. Building laws focus on giving attention to physical disabilities, but they pay less attention to psychological problems such as autistic children [1]. Achieving child's satisfaction could be increased by realizing the child's rights and that is influenced by the environment and the society they live in [2]. Architectural terms in Egyptian cities for example overlook children's needs and behaviours [3]. Since, the built environment, both internally and externally, is the mediator that autistic children touch in most stages of their life [4], and

the sensitivity of autistic children to the surrounding elements differs from their peers. Therefore, the elements of the surrounding environment play a major role in influencing them. As the physical environment plays an important role in reducing or increasing the stimuli around autistic children and affects his behaviour.

Therefore, it was necessary to conduct a study that measures the sensitivity of autistic children to the elements of interior spaces and how they could be used to affect the symptoms of an autistic child or develop his skills through multi-sensory rooms. As the researchers proved that early intervention in schools, clinics, and other human service programs practices have a positive impact on the autistic child's life [5 6]. The researcher made many field visits to care centres for children with special needs to analyze the sensitivity of autistic children to interior design elements. Then we made a survey to measure the sensitivity of autistic children to interior design elements, especially the interactive multi-sensory rooms. The results of this research can help in developing the skills of children with autism through sensory spaces and internal spaces, and then reaching a set of criteria that must be considered when creating spaces for children with autism.

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## 2. Literature review

This research deals with the study of the characteristics of a child with autism and the extent of his sensitivity to interior space elements, identifying the most affecting element, then re-using them in multi-sensory spaces that develop his skills. The methods sections will outline autism spectrum disorder, the previous research on spatial design for children with autism, and after that the empirical study which contained field visits to rehabilitation centers and a survey.

## 3. Data and methods

Many field visits were conducted to some rehabilitation centers for children with autism to study many aspects. First, studying the effect of interior design elements on children with autism. Secondly, analyzing the elements of multi-sensory rooms and their influence on enhancing the abilities of children with autism. Therefore, A survey has been made to measure the influence of interior design elements on children with autism and the effect of the elements of the multi-sensory room on children with autism. There were 45 respondents (therapists/parents of autistic children) in two months.

### 3.1. Autism, definition, diagnosis, types, and cure

Autism is a complex neurobiological disorder characterized by neuropsychological and behavioral deficits [7,89]. There are other names for autism such as autism spectrum disorder (ASD) – the medical name –, autism spectrum condition (ASC), and Asperger's (or Asperger syndrome) –which is used to describe autistic people with average or above-average intelligence [10]. According to the World Health Organization, about one in every 160 children worldwide has autism of varying degrees [11,12]. Characteristics of children with autism are difficulty with social interaction and communication, atypical patterns of activities and behaviors, a focus on details, and unusual reactions to sensations [13,11]. There are different kinds of autism shown in Table 1 [14].

There is not yet a cure for autism spectrum disorder, and there is no specific treatment has emerged as the established standard of care for all children with ASD. The goal of treatment is to increase the child's ability to function as efficiently as possible by reducing symptoms of autism spectrum disorder and **supporting development and learning** [28]. Management of autism depends on the type of autism and the severity of symptoms. For instance, mild types of autism such as level 1 autism spectrum disorder can be managed through **behavior modification or social training** while individuals with Rett syndrome would require more substantial support like physical or occupational therapy [11].

### 3.2. Previous research on spatial design for children with autism

In 1943 Kanner proposed **sensory stimulation** as the main way of affecting autistic children [29]. After that, there were two branches of research on the **spatial design** of autistic children around 2010. First, Henry believed that the spatial environment for autistic children needs a targeted design to produce stronger sensory stimuli. Another view is that the impact of the spatial environment on children with autism is a gradual one. This view developed to become **a theory of spatial perception** that is more widely accepted. In 2014, this theory was discussed in detail, and design elements for autistic patients (**The Autism Aspects Design Index**) were proposed. Including acoustics, spatial sequencing, escape space, compartmentalization, transition zones, sensory zoning,

**Table 1**  
Describes different kinds of autism. source: authors, based on extant literature.

Main Types of Autism Spectrum Disorders		Childhood Disintegrative Disorder (CDD)	Kanner's Syndrome	Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS)
Name	Asperger's Syndrome	Rett Syndrome		
Definition	It is classified as a level 1 autism spectrum disorder by the DSM-5 diagnostic manual [15,16]	Known as Heller's syndrome or disintegrative psychosis. A child experiences normal development then hit a snag after age three and up to age 10 [19]. Mostly affects boys [20].	It is known as infantile autism and is described as classic autism [21].	It is a mild type of autism and it is sometimes referred to as "subthreshold autism," as it is a term used to describe an individual that has some but not all symptoms of autism.
Common symptoms	<ul style="list-style-type: none"> <li>Above-average intelligence [22].</li> <li>strong verbal skills.</li> <li>will experience challenges with social communication [23].</li> </ul>	<ul style="list-style-type: none"> <li>delayed onset of developmental problems in language, motor skills, or social function [27]</li> </ul>	<ul style="list-style-type: none"> <li>Lack of emotional attachment with others.</li> <li>A high degree of rote memory and visuospatial skills with major difficulties learning in other areas</li> </ul>	<ul style="list-style-type: none"> <li>Challenges in social and language development, walking, and other motor skills.</li> </ul>

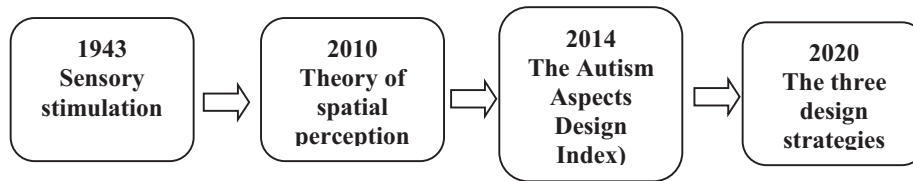


Fig. 1. Shows previous research on spatial design for children with autism. Source: Authors, based on extant literature.

safety, and safety. Previous research on spatial design for children with autism could be summarized in Fig. 1.

**The Autism Aspects Design Index**, in 2002 a survey of 100 families assessed the importance and the impact of the architectural environmental elements such as acoustics visuals, tactile and . . etc. the children with autism. That served as a basis for the later development of the Autism ASPECTSS Index. These principles are summarized as follows: **Acoustics** is ranked as the most effective feature of the sensory environment upon autistic behavior. Autistic people express a strong nuisance from acoustic so avoiding reverberation or using sound insulant materials is fundamental in designing places for people with autism [30]. Reducing noise levels helps in extending the attention, reducing response time, and behavioral treatment of children with autism. This criterion proposes decreasing background noise and echoes in spaces used by autistic children according to the level of focus required in the activity. For example, activities of higher focus need quiet controlled acoustics places [31]. **Spatial Sequencing** is concerned with organizing spaces in a logical order based on the use of each space. The circulation of movement should be a one-way direction from space to another while using transition zones. **Escape Space** pro-

vides respite for the autistic user from the over-stimulation found in their environment is the main objective of escape space. It could be partitioned areas or quiet corners in the room. **Compartmentalization** is defining and limiting the sensory environment of each activity is essential for autistic children. This can be achieved through furniture management, different floor covering, and different levels of lightning. This may help in defining the function of every space. **Transition Zones** help the user recalibrate their senses as they move from one level of stimulus to the next. It could be a distinct node or a full sensory room. **Sensory Zoning**, when designing for autism, spaces should be organized in accordance with the sensory quality from high stimulus to low stimulus, rather than functional zoning. **Safety** is very important when designing for children with autism such as fittings to protect from hot water and avoidance of sharp edges and corners [32].

**Jie Shan & Hongyuan Mei in 2020 proposed three design strategies** based on the behavioral characteristics of autistic children to improve children's abilities by strengthening the interaction between autistic children and building space. At the same time, providing autistic children with a safe, peaceful, and happy space environment makes it easier for autistic children to partici-

Table 2

**The three design strategies** of Jie Shan & Hongyuan Mei are based on the behavioral characteristics of autistic children [1]. These strategies enhance learning and conjunction in public activities by the aspects of vision, hearing, and touching therapy through promoting their mental health and improving their behavior. Source: Authors, based on extant literature.

The three design strategies based on the behavioral characteristics of autistic children of Jie Shan & Hongyuan Mei	
<b>Natural interaction design strategy</b>	
Nature not only enhances the physical health of autistic children, but also natural factors such as sunlight, wind, rain, colors, and bird songs can stimulate the senses of children with autism. The colors of nature enhance visual perception. <b>Interaction with nature, and the use of natural resources</b> make the interior space more attractive for the autistic child. Which leads to direct the attention of the child with autism to the surrounding environment rather than <b>focusing on one thing</b> .	
A-Connecting Indoor and Outdoor spaces e.g., multi-level building platform, internal courtyard, rooftop platform, increasing the window area, and push-pull walls which ensure contact with nature with difficult climatic conditions.	B-Outdooring Indoor Space e.g., increasing the height of indoor space, using the open interior space with large scale, applying outdoor construction material in indoor space, and planting green indoor landscape.
<b>The behavioral interaction design strategy</b>	
The impaired social interaction for children with autism creates a vicious circle that makes them more and more isolated from others. Thus, the inner space design should guarantee passive interaction between autistic children and other children in an effective way that does not put autistic children under pressure. sometimes, solitary space is an option.	
A-Enhance the Overall Integration of the Space e.g., linked inner spaces, and interconnected shallow spaces with high spatial correlation could provide more opportunities for children to interact and access more public activities.	B-Provide Adequate Solitary Space e.g., The solitary space with low accessibility and visibility in conjunction with the public activity space provides autistic children with opportunities to be alone to relieve the pressure caused by group activities and psychological rehabilitation.
<b>The digital interaction design strategy</b>	
Children-computer interaction can provide controllable visual, auditory, and tactile sensory stimuli, which can effectively attract autistic children; and help them understand space and talk to space through body language.	
A-Apply Digital Interaction Device The sensory interactive interfaces can interact with the autistic child by imitating light shadow and sound. This helps children to be educated and stimulates their desire to participate in activities. It's can capture the child's behavior then analyze it and interact with it to make the building interactive such as	B-Utilize Virtual Reality Interaction Virtual reality creates a multi-dimensional dynamic experience. It can customize the scene for children with autism based on their interests. Furthermore, provide a very rich interactive experience in a solitary space for children with a strong social fear [33].
<b>MEDIATE</b>	

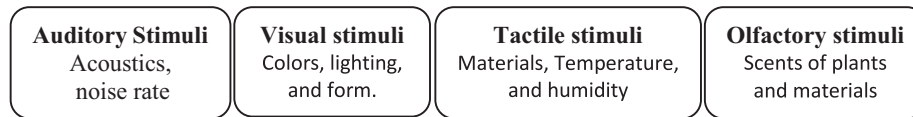


Fig. 2. Interior space elements as stimuli for children with autism. Source: Authors, based on extant literature.

pate in space experiences and collective activities. The first strategy is for single interest or repetitive behavior that could be improved by **natural interaction design strategy**. The second one is **the behavioral interaction design strategy** is proposed for the social barrier. Finally, the **digital interaction design strategy** is for the language barrier. **The three design strategies** based on the behavioral characteristics of autistic children of Jie Shan & Hongyuan Mei could be mentioned in [Table 2](#).

### 3.3. Stimuli of the interior spaces for a child with autism

Interior designers play an essential role in designing spaces that can help people with autism to understand the environment with a spatial design that is sensitive to their needs. However, the first step is to look for is the sensitivity of an autistic child against the interior design elements that can be a reference when creating interior design for children with autism [34]. According to the characteristics of an autistic child, if we need to develop and teach him, we need to rely on different stimuli. Regarding the stimuli of the internal spaces, they are divided into auditory, visual, tactile, and olfactory stimuli. These stimuli can be used to develop the skills of a child with autism if they are properly used.

**Characteristics of the interior spaces as stimuli for children with autism to enhance their abilities could be summerized in Fig. 2.**

**Auditory stimuli**, Auditory stimuli include acoustics and the noise rate. It is difficult for children with autism to deal with noise [34]. They prefer quiet spaces over noisy spaces. Therefore, the acoustical environment plays a vital role in the development of children with autism if it is used properly in their speech acquisition. Acoustics are used in the long-term in speech therapy rooms for children with autism [35]. **Visual stimuli** Colors, lighting, and the form of interior space elements are the main elements of visual stimuli. Stimuli such as flickering, high illuminance, and glare, are disturbing for people on the autism spectrum. Bright fluorescent lights may affect their visual sight for them. They may experience headaches caused by the color of the walls and bright fluorescent lights [34]. Although most people prefer curved forms in interior spaces to straight shapes, people with autism do not like them [36]. Since they might overreact to standard and routine events, individuals with autism need particular attention as regards the variations in environmental parameters. Use of suitable lightning; avoiding bulky objects, and overwhelming colors are important Factors in designing internal places for people with autism [30]. Colors can be used in the internal spaces of children, to help modify the psychological and behavioral patterns of children with autism [37]. Visual organization in the classroom creates a foundation of autonomy in the child with ASD. For instance, the classroom becomes most effective for children with autism when visual boundaries and picture labels divide the space and that encouraged them to be much more independent [38]. **Tactile stimuli**, Children with autism may experience headaches caused by the clothing worn, or heat exposure. They are sensitive to the different textures

of materials [34]. Therefore, the use of thermo-regulation is necessary when designing interior spaces for children with autism. Furthermore, sound sensors and temperature detectors are essential for the independence of people with autism in their adulthood or teenage [30]. **Olfactory stimuli**, Bad odors, and poor ventilation bother autistic children on a low scale [34]. So, the air in the room should be free of odor and the room should be well ventilated.

### 3.4. Types of internal spaces for enhancing skills for autistic

The sensitivity of children with autism varies towards the inner space elements. Therefore, interior spaces were designed to develop the skills of children with autism, such as multi-sensory rooms and Interactive interior spaces. sensory rooms are used to improve the child's abilities whereas Interactive interior spaces can be used to support independent living for people with autism when they reach a certain age by placing sensors to monitor and prevent potential risks [31]. In the next sections, the types of internal spaces for enhancing skills for autistic will be outlined.

**Multisensory rooms for autistic children (Snoezelen).** Recently, the interest in the use of multisensory environments such as Snoezelen rooms for individuals with developmental disabilities has increased. The website for the North American distributor of Snoezelen products, reports thousands of Snoezelen installations in over 30 countries, with 700 in North America.

**Historical background about Snoezelen and definition.** The Snoezelen room was created in the 1970s by two developmental disabilities therapists. "Snoezelen" is a contraction of two Dutch words, "snuffelen", to explore one's environment, and "doezelen", to relax. Snoezelen rooms vary greatly in content, from a very basic set-up costing a few thousand dollars to a very expensive multiroom Snoezelen environment. Most Snoezelen rooms include a variety of visual, olfactory, auditory, and tactile stimuli that help autistic children explore the world around them and enhance their abilities in a safe place without external pressure. These rooms have many ameliorative effects as they treat behavioral problems, including reduced self-harm -less aggressive - and "challenging behaviors." [39].

These rooms are classified as sensory integration spaces that stimulate the senses of a child with hyper or hyposensitivity. They promote improvements in communication, interaction, and, above all, behavior after the intervention [40].

**How sensory rooms (Snoezelen) work.** The Snoezelen room can provide comfort, with controlled stimuli, offering sensory stimuli, which can be used individually or in combination. These sensory stimuli help the individual with sensory problems to regulate his brain's negative reactions to external stimuli by developing coping skills with these experiences. They enhance positive therapeutic and pedagogical effects. Positive results of using Snoezelen in children with ASD are reported, such as reducing stereotypes, self-harm, and improved communication [40].

**Advantages of Snoezelen rooms.** A Snoezelen room, despite its cost, is relatively easy to implement because it does not require extensive staff training or recruiting clinicians with special behavioral skills. Researchers reported that children with moderate and severe intellectual disability showed decreased frequency and duration of maladaptive behaviors in a Snoezelen room compared to a playroom. Concentration and relaxation were enhanced during a Snoezelen session compared to a hand massage, relaxation therapy, or active therapy. Reduction in stereotyped behaviors and an increase in engagement in the Snoezelen room, but the rate of these behaviors returned to pre-Snoezelen levels once participants returned to the living area. These rooms promote learning and play, treat behavioral problems, improve balance, movement, and spatial orientation. Snoezelen rooms can positively affect the quality of life for people with autism and many institutionalized individuals enjoy using them [39].

**Components of multi-sensory rooms (Snoezelen).** A multi-sensory room offers its users a totally immersive experience through the activation of the different elements, such as lighting, music, objects, images, textures, sounds, vibration, etc., specially created and set for reaching specific therapeutic purposes. An example of the elements that can be found in a multisensory room could be the bubble tube, the optic fiber, the ball pit or ball pool, swings, projections, vibroacoustic seats, among many other elements [41]. These Sensory rooms help people with autism engage their touch, smell, sight, taste, hearing, movement, and balance. They enhance the brain's development while helping the person relax, remain calm and overcome fears in a warm and natural environment.

**Digital technologies in interior places for autistic children.** Autistic children tend to positively engage with technology as a safe and predictable medium such as interactive screens and iPad. Technology can play meaningful alternative roles in their lives rather than narrowly assistive. It also encourages a child with autism to play with them in a creative way. Digital technologies suit children with autism who have good language skills and no other significant intellectual disabilities more than children who had severe communication problems or other comorbidities [42]. Digital technologies could be applied in interior design on walls and floors to provide a multi-sensory room supported by higher technology. These types of rooms are much safe and controllable by a specialist to achieve a certain aim [41].

**An example of Interactive interior places for autistic children is MEDIATE** which is an interactive environment that generates visual, aural, and vibrotactile stimuli for children with autism. It is a therapeutic tool that gives the children a chance to play, explore and be creative in a predictable controllable safe space [43]. Inside the space, several elements act as interaction interfaces. First, **the floor surface** reacts to footsteps generating sound.





Second, **a wall with tube-like** structures generates sound when caressed or stroked. Third, there are **two screen walls** that are the support for visual interaction as they react to the child's movement and touch. Fourth, **the impression wall** reacts to pressure and emits a vibration. Finally, the **sound interface** is a set of microphones and speakers that react to sounds emitted by the child in the space (voice, clapping, etc.) [44]. This interactive environment is designed to promote exploration in children with autism. To achieve this, the behavior of an autistic child is detected by the sensor input then the decision-maker produces stimuli that suit every child's behavior. The dialogue between the child and the environment provides the user with a sense of control. This interactive environment encourages the child to learn by playing and interacting with the space and that helps in behavior modification. The main features of this system are natural full-body interaction, adapting to each child's potential, engaging children in the interactive dialogue, controlling to achieve a sense of agency, and enhancing non-repetitive actions [43]. Interactive interior spaces can be used to support independent living for people with autism at a certain age by placing sensors to monitor and prevent potential risks. This will reduce the burden on caregivers or parents. Acoustic sensing systems can be used, for instance, considering the optimal internal acoustic parameters appropriate for people with autism. Sound and voice recognition systems represent a good compromise between privacy and support. Sensors can provide information about a person's posture and movement or detect falls, etc. Smart homes are therefore useful to monitor activities or to help with cognitive or physical disabilities in daily events [31].

#### 4. Empirical study

The application study included a number of site visits to some rehabilitation centers for children with autism to study and analyze the multi-sensory rooms locally. Then, to measure the sensitivity of the children with ASD to interior design elements a survey has been conducted to measure that. There were 45 respondents (therapists/parents of autistic children) in two months.

**The multisensory rooms locally and globally.** Multisensory spaces (Snoezelen) play an important role in improving the skills of autistic children as they stimulate the senses of a child with ASD. Due to the field visits of the researchers to the rehabilitation centers, the researchers concluded that the way sensory chambers work locally differs from the global ones.

There are many centers for people with special needs. Furthermore, there are no specialized centers for autistic patients. Whereas these centers work on all kinds of special needs. As most people with special needs need sensory rooms to develop their senses. The researchers visited a group of rehabilitation centers,

	
<p>Photo n. (1) shows <b>the water column</b> that targets the senses of sight, touch, and hearing. This column helps in reorganizing the sensory, visual, and auditory inputs. As well as, enhancing visual discrimination, direct interaction, and increasing focus and relaxation.</p>	<p>Photo n. (2) shows gradient touch panels from soft to rough for tactile stimuli and training autistic children, especially those who walk on the flicks of their fingers.</p>
	
<p>Photo n. (3) shows A unit of visual stimuli, in which sound is associated with color. The more sound the more colors for visual and auditory stimuli.</p>	<p>Photo n. (4) shows a lighting tunnel for training the autistic child with a side gaze. It works on visual stimuli because the tunnel lights up in different colors</p>

The photos show some components of the multi-sensory room locally

some of which had multisensory spaces (Snoezelen) and some did not. **The researchers made a set of observations that were as follows:**

A. There are some sensory rooms in some care centers for children with special needs, and the following pictures show some of these rooms.

B. Some care centers resort to designing alternatives to the sensory room elements at a lower cost, but they perform the same function.

C. Some care centers rely more on the trainer's skill than the sensory elements of the room, unlike the international rooms, which rely more on the elements of the multi-sensory rooms and the elements of the interior space.



Photo n. (5) shows an activity for children with autism in nature using colored balls and colored car tires to increase children's skills to distinguish between colors Promote communication between children and the natural environment and natural light. This activity could be held indoors and outdoor.

Photo n. (6) shows developing the sensory skills of autistic children by touching natural materials such as sand, as well as making several levels to increase the child's concentration when climbing this pyramid



Photo n. (7) shows an autistic child trying to water plants. This reinforces the idea of communicating with nature and raises the child's focus on things then increases his self-confidence.

Photo n. (8) shows Jumping activities inside circles with specific colors while carrying the ball and jumping to increase focus

Source: All photos are Captured by the authors in local care centers.

**Table 3**

The structure of the survey questions, the response methods available, and the objective of the question. Source: Authors. **The survey title: The sensitivity of children with an autism spectrum disorder to the elements of interior spaces.**

N.	Questions	The available answers	The objective of the question
1	Please identify yourself	The supplied answer is a multiple choice of 2 answers (A caregiver or A parent)	To clarify whether the survey participant is a father or a specialist (caregiver) because autistic children cannot answer by themselves.
2	<b>Please determine the degree of sensitivity of your child to the following elements inside the interior spaces</b>		
A	Is your child sensitive to noise?	The supplied answer is a multiple choice of 5 answers (Extremely Sensitive - Very Sensitive - Somewhat Sensitive - Not at All Sensitive - Don't Know)	To evaluate the sensitivity of the child of spectrum disorder to the elements of interior spaces (noise – light – shapes of interior design elements - color -visual stimuli - odor)
B	Is your child sensitive to light?		
C	Is your child sensitive to the shapes of interior design elements?		
D	Is your child sensitive to color?		
E	Is your child sensitive to texture?		
F	Is your child sensitive to visual stimuli?		
G	Is your child sensitive to odors?		
3	Does your child use multi-sensory rooms?	The supplied answer is a multiple choice of 3 answers (yes – no - maybe)	To evaluate the percentage of using multi-sensory rooms for enhancing skills for children with autism
4	If yes, please indicate your child's sensitivity to the following items in the Multi-Sensory Room		
A	Music	The supplied answer is a multiple choice of 5 answers (Extremely Sensitive - Very Sensitive - Somewhat Sensitive - Not at All Sensitive - Don't Know)	To evaluate the sensitivity of the child of spectrum disorder to some elements of the multi-sensory room (noise – light – shapes of interior design elements - color -visual stimuli - odor)
B	Odor		
C	Interactive screen		
D	The water column (bubble column)		
E	Rocking chair		
F	The ball		
5	If there are other elements that draw your child's attention in the sensory development room, please mention them and their role in developing his skills	The supplied answer is a paragraph.	To determine the elements in the sensory room that affect autistic children and were not mentioned in the previous question

D. Some centers have resorted to the idea of **communicating with nature**[1], as some caregivers noticed an increase in the interest of children with autism in nature and the development of their skills when applying this idea as shown in photos n. (5), (6),(7) and (8). The photos show some alternative methods for sensory rooms that are applied for interaction with nature to enhance the senses of a child with autism.

4.1. The survey studies

**The design of the survey questionnaire.** The online survey was developed and analyzed via Google documents and the online link was published on care centers for children with autism, as well as through social media for autistic children pages and the caregiver also. The survey contains their opinions regarding the sensitivity towards interior design elements such as sound, light, color, smell, texture, and visual stimuli. The other question was about the elements of multi-sensory rooms and their ability to attract an

autistic child. The answers varied from (extremely sensitive/sensitive /somewhat sensitive) in children with autism. There were 45 respondents (therapists/parents of autistic children) in two months. **Table 3** is an illustration of the structures of the survey's questions and the methods of answers available then the objective of the question.

5. Results

5.1. Analysis of survey responses

**The first question** in the survey was asked about the identity of the respondent to the questionnaire. There were 45 participants in the survey. The number of caregivers "specialists" is 13 with 29% while the number of parents was 32 with 71% (see **Fig. 3**).

**While the second question** in the survey was asked about the sensitivity of a child with autism to the elements of interior design. **Table 4** is based on the results of the questionnaire from parents and therapists describing the sensitivity of autistic children toward interior design elements.

**The second questions analysis.**

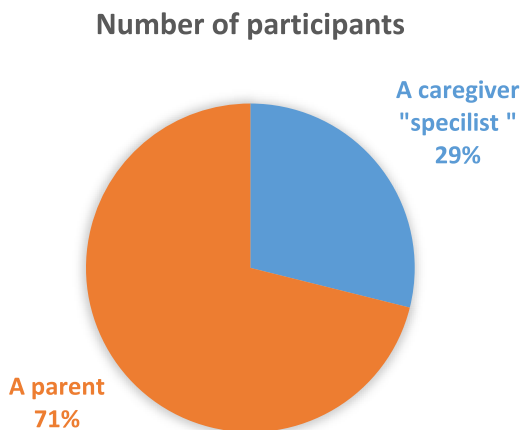
The results showed that the percentage of sensitivity of autistic children to the noise is somewhat sensitive (35.5%) and the lowest percentage is don't know as shown in **Fig. 4**.

The results showed that the percentage of sensitivity of autistic children to the light is not at all sensitive (46.6%) and the lowest percentage is don't know as shown in **Fig. 5**.

The results showed that the percentage of sensitivity of autistic children to the shapes of interior design elements is not at all sensitive (33.3) and the lowest percentage is don't know as shown in **Fig. 6**.

The results showed that the percentage of sensitivity of autistic children to the color is not at all sensitive (40%) and the lowest percentage is don't know as shown in **Fig. 7**.

The results showed that the percentage of sensitivity of autistic children to the texture is somewhat sensitive (31.1%) and the low-

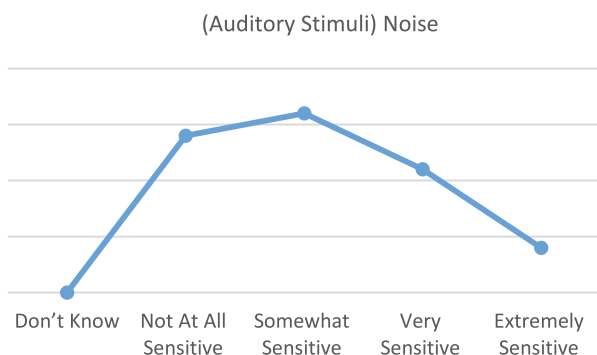


**Fig. 3.** For the number of responses. Source: Authors.

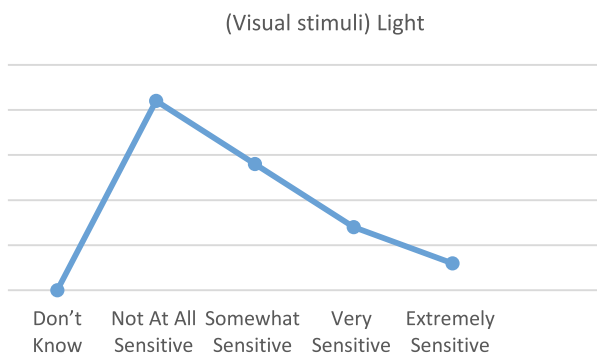


**Table 4**  
Questionnaire Result (the sensitivity of autistic children toward interior design elements). Source: Authors according to the survey responses.

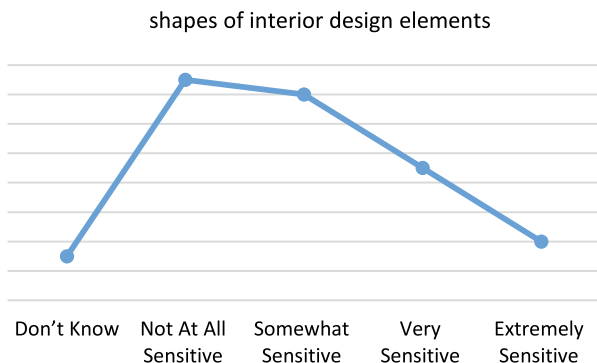
Sensitivity		Extremely Sensitive	Very Sensitive	Somewhat Sensitive	Not At All Sensitive	Don't Know
<b>Auditory Stimuli</b>	Noise	4	11	16	14	0
<b>Visual stimuli</b>	Light	3	7	14	21	0
	shapes of interior design elements	4	9	14	15	3
	color	6	6	15	18	0
<b>Tactile stimuli</b>	texture	4	12	14	11	4
<b>Olfactory stimuli</b>	visual stimuli	10	12	9	10	1
	odors	7	7	12	15	4



**Fig. 4.** The sensitivity of autistic children to the noise.



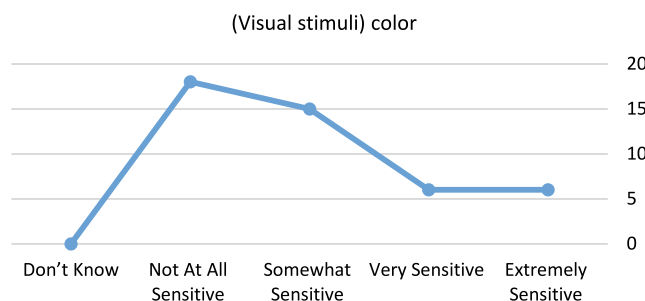
**Fig. 5.** The sensitivity of autistic children to the light.



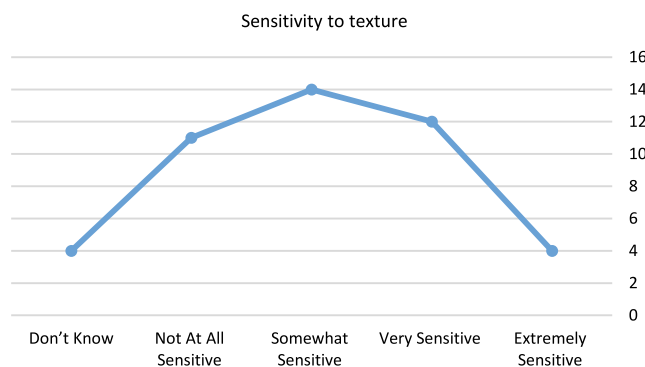
**Fig. 6.** The sensitivity of autistic children to the shapes of interior design elements.

est percentage is don't know and extremely sensitive as shown in Fig. 8.

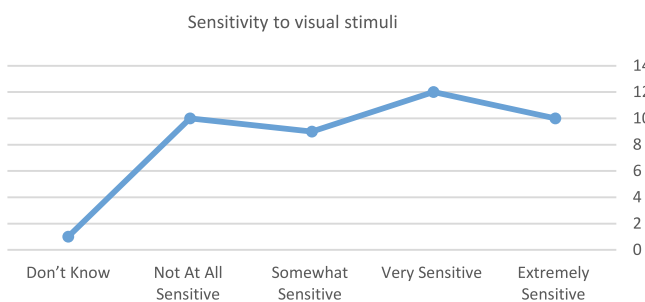
The results showed that the percentage of sensitivity of autistic children to the visual stimuli is very sensitive (26.6%) and the lowest percentage is don't know as shown in Fig. 9.



**Fig. 7.** The sensitivity of autistic children to the color.



**Fig. 8.** The sensitivity of autistic children to texture.



**Fig. 9.** The sensitivity of autistic children to visual stimuli.

From the results of the questionnaire, produced a conclusion that autistic children are sensitive to the texture as tactile stimuli and very sensitive to visual stimuli as shown in Fig. 10.

The results showed that the percentage of sensitivity of autistic children to the odors is not at all sensitive (26.6%) and the lowest percentage is don't know as shown in Fig. 11.

**The third question** asked about if the child uses the multi-sensory room to enhance his abilities, the yes answer was 34% as shown in Fig. 12.

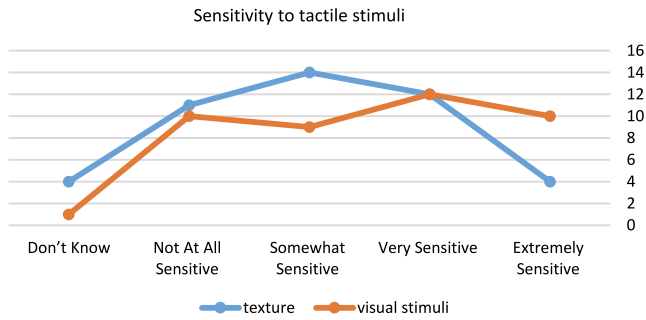


Fig. 10. The sensitivity of autistic children to.

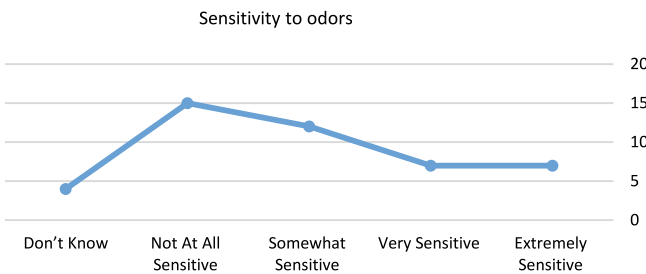


Fig. 11. The sensitivity of autistic children to odors.

Does your child use multi-sensory rooms?

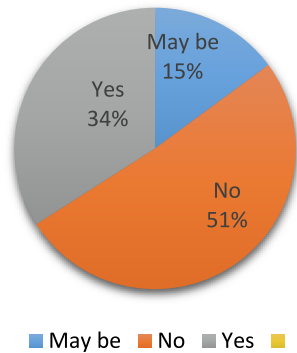


Fig. 12. Shows the percentage of using multi-sensory rooms for children with autism. Source: Authors according to the survey responses.

While the fourth question in the survey asked about the sensitivity of a child with autism to some elements in the Multi-Sensory Room. Table 5 is based on the results of the questionnaire from parents and therapists describing the sensitivity of autistic children toward some elements in the Multi-Sensory Room.

The results showed that the percentage of sensitivity of autistic children to the music in the multi-sensory room is extremely sen-

Table 5

Questionnaire Result (the sensitivity of autistic children to some elements in the Multi-Sensory Room. Source: Authors according to the survey responses.

ELEMENTS	Extremely Sensitive	Very Sensitive	Somewhat Sensitive	Not At All Sensitive	Don't Know
Music	13	8	10	7	7
Odor	7	4	14	9	11
Interactive screen	15	10	7	5	8
The water column	8	6	16	5	9
Rocking chair	7	7	13	7	11
The ball	7	8	12	10	8

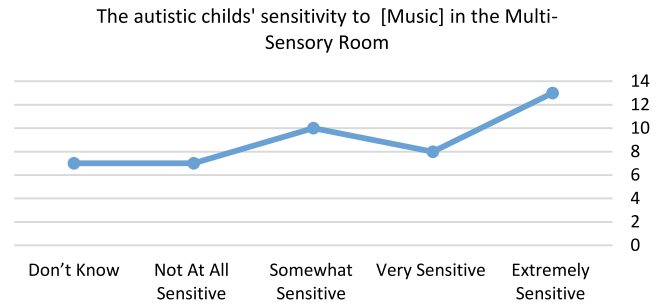


Fig. 13. Sensitivity of autistic children to the music in the multi-sensory room.

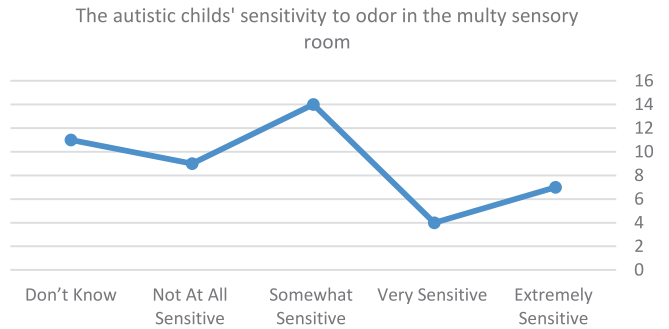


Fig. 14. Sensitivity of autistic children to the odor in the multi-sensory room.

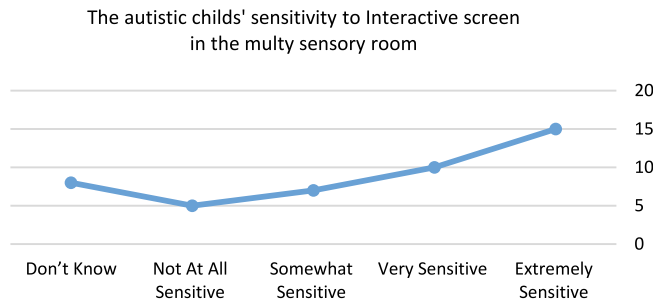


Fig. 15. Sensitivity of autistic children to Interactive screen.

sitive (28.9%) and the lowest percentage is don't know as shown in Fig. 13.

The results showed that the percentage of sensitivity of autistic children to the odor in the multi-sensory room is somewhat sensitive (31.1%) and the lowest percentage is very sensitive as shown in Fig. 14.

The results showed that the percentage of sensitivity of autistic children to the interactive screen in the multi-sensory room is extremely sensitive (33.3%) and the lowest percentage is not at all sensitive as shown in Fig. 15.

The results showed that the percentage of sensitivity of autistic children to the water column in the multi-sensory room is some-

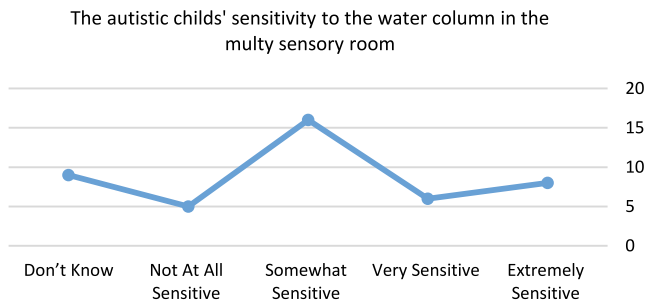


Fig. 16. Sensitivity of autistic children to the water column.

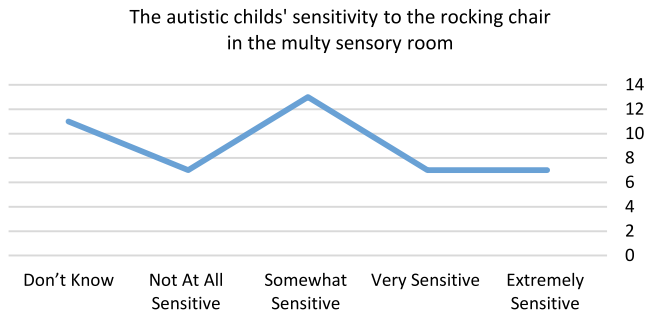


Fig. 17. Sensitivity of autistic children to the rocking chair.

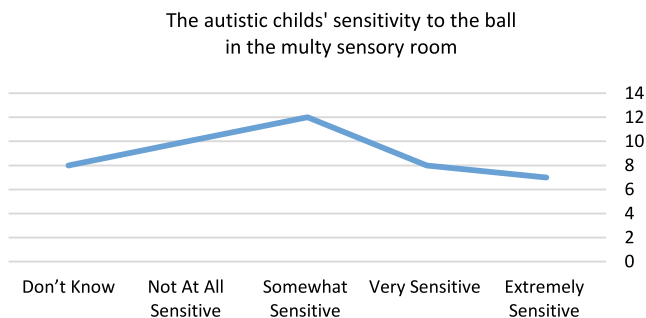


Fig. 18. Sensitivity of autistic children to the ball.

what sensitive (35.5%) and the lowest percentage is not at all sensitive as shown in Fig. 16.

The results showed that the percentage of sensitivity of autistic children to the rocking chair in the multi-sensory room is somewhat sensitive (28.8%) and the lowest percentage is extremely sensitive and very sensitive as shown in Fig. 17.

The results showed that the percentage of sensitivity of autistic children to the ball in the multi-sensory room is somewhat sensitive (26.6%) and the lowest percentage is t extremely sensitive as shown in Fig. 18.

## 6. Discussion

**To investigate** the Sensitivity of children with autism toward visual stimuli in Interior Design elements we designed a survey and published it online to the parents and caregivers to measure and notice the children's sensitivity toward visual stimuli in Interior Design. We found that autistic children are most sensitive to light as a visual stimuli element with a percentage of (46.6%). This is similar to the global ratio in other studies which is (45.4%) in Bandung city, Indonesia, and (50%) in an autism-related research journal [34]. We found also that autistic children are sensitive to

color with a percentage of (40%) This is similar to the global ratio in other studies which is (59.6%) in an autism-related research journal, and (70,9%) in Bandung city, Indonesia [34]. While the sensitivity to the shapes of interior design elements is with a percentage of (33.3). But, researchers haven't yet to find out the factors that may result in such sensitivity. This suggests the importance of choosing suitable light as visual stimuli that makes them feel comfortable. Furthermore, This reflects the importance of visual stimuli for children with autism within the interior spaces and supports **the theory of spatial perception named (The Autism Aspects Design Index)** which focuses on the importance of **sensory zoning** that assumes organizing spaces in accordance with the sensory quality rather than functional zoning. The Sensitivity of children with autism toward visual stimuli of interior design elements such as light, color, and shapes are shown in Fig. 19.

**To investigate** the Sensitivity of children with ASD toward interior design elements. We found -from the survey- that autistic children are most sensitive to light (the visual stimuli) than other elements as shown in Fig. 20. This is the same result of research conducted on children with autism in the city of Bandung with a percentage of (74.4%) [34]. This suggests the importance of design criteria for children with autism to choose suitable visual stimuli that make them feel comfortable. This supports **sensory stimulation** as an essential method of affecting autistic children through interior spaces (see Fig. 20).

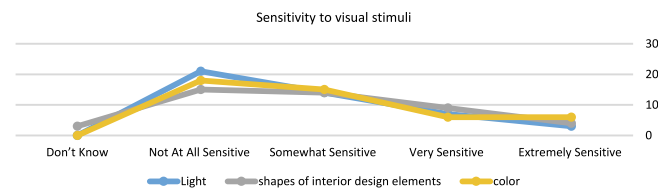


Fig. 19. The sensitivity of autistic children to visual stimuli.

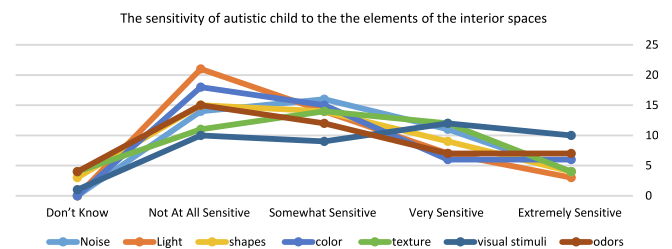


Fig. 20. Sensitivity Towards Interior Design Elements.

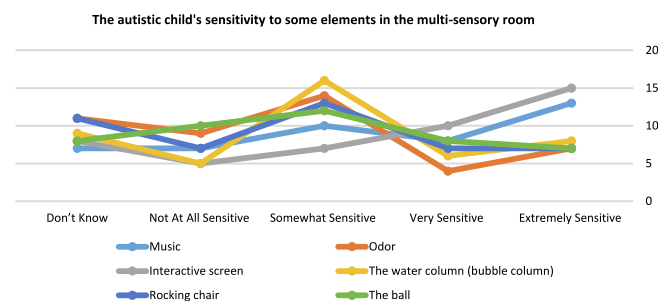


Fig. 21. Shows the sensitivity of multi-sensory room elements to children with autism.

**To investigate** the autistic child's sensitivity to some elements in the multi-sensory room. We found -from the survey- that the most sensitive element to autistic children in the multi-sensory room is the Walter column (35.5%) and the lowest effective element to autistic children in the multi-sensory room is the ball (26.6%) as shown in Fig. 21. This suggests the importance of designing multi-sensory rooms and equipping them with the appropriate elements for the disability that the child faces. Some spaces are designed for motion disabilities and others for mental ones, and so on. This reflects the importance of the **sensory stimuli** in the internal spaces, such as audio, visual, tactile, and olfactory stimuli, on developing the skills of a child with autism.

**To investigate** the local multi-sensory room, many field visits were conducted to some care centers for people with special needs, and some days were spent with autistic children and specialists. We found that some care centers have sensory rooms that contain elements that stimulate the senses of the autistic child well and based on studies interior design elements as sensory stimuli such as auditory, visual, and olfactory sensory stimuli.

**To investigate** the different types of local multi-sensory rooms, we designed field visits to some care centers for people with special needs and spent some days with autistic children and specialists. We found that Sensory rooms are equipped in these centers targeting a specific disability, whether physical, mental, or social. And there are rarely comprehensive rooms for all types of disabilities. This is due to the high cost of preparing these rooms. We suggest that the state should give more attention to this category of children through building laws, as well as establishing state institutions equipped with multi-sensory rooms to care for these children.

**We have faced some limitations during the applicant part** of the paper such as there are no specialized centers to care for children with autism, but there are general centers for people with special needs. As a result of the poor awareness of some parents of autism, they neglect to develop the skills of their children due to their wrong belief that it is an incurable disease. We suggest raising awareness among parents and the community on autism spectrum disorder and the importance of providing care for these children through the surrounding spaces.

## 7. Conclusion

It can be concluded that there are many types of spaces for children with autism, such as sensory rooms. Children with autism are sensitive to interior design elements so this must be taken into consideration when designing a built environment for children with ASD. Furthermore, children with autism are sensitive to certain elements in the interactive multi-sensory rooms so when designing these rooms, the needs of children with autism must be taken into consideration to achieve the best results.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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