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Original Research Article

An Evaluation of the Effectiveness of Biophilic Landscape Patterns on the Sensory Integration of Autistic Children*

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Abstract | Due to the rise in the number of autistic children and their different sensory and cognitive performances in comparison to normal people, this research aims to develop the criteria of suitable therapeutic landscapes for autistic children based on biophilic landscape patterns. It also attempts to examine the effect of such patterns. Framed by theories of biophilic design theorists, this study employed a mixed-methods design to investigate if biophilic landscape patterns can influence children's senses on two spectrums of suffering namely one and three, in three functional zones outdoors. For this purpose, adaptive patterns were piloted using the experimental research method, and the effects of the patterns were evaluated by examining the senses, concentration, performance, and speech of the subjects. Some biophilic design patterns, such as visual connection with nature, presence of water, and risk/peril, could effectively improve the visual, olfactory, tactile, and vestibular senses of children of two spectrums, and such effects on the senses improved the concentrations, children's speech and mood. However, some patterns, such as ambiguity and mystery, the light and shadow game, and changes in levels, did not have positive impacts on children. The design of the pattern needs to keep the therapeutic zone away from the sensory interference of other zones. Otherwise, children's sensory perception will be disturbed, and the treatment will not be effective. The results of the research indicate that due to the different effectiveness of sensory stimuli on children with autism, it is not possible to generalize the patterns to normal people and use biophilic landscape patterns for therapeutic purposes with autistic children. Rather, before employing the strategies, they need to be tested first, and then the models of the therapeutic landscape suitable for affected children need to be developed. The suitable space, the environment, and the landscape for autistic children are different from the ones that can be used for non-autistic children, and autistic children need their own appropriate space.

Keywords | *Landscape, Autism, Biophilic, Sensory Integration.*

Introduction and Statement of the Problem| Autism is a lifelong developmental disability that usually appears during the first three years of life and affects how people perceive their environment and interact with others (Nagib & Williams, 2018, 1). According to research, autism has a direct relationship with urban life (Luo et al., 2020), and currently, the incidence of autism in the world and Iran is increasing (Mosadeghrad, Pourreza & Akbarpour, 2019). So far, this disorder has had the fastest growth rate among other disabilities since 2009, with an average annual increase of 10.9% (Li et al., 2019). In Iran, the prevalence of autism spectrum disorders has been reported at 95.2 per 10,000 people (Akbari Bayatiani, 2018). Autism spectrum disorder can be a costly disorder throughout a person's life. Due to the prevalence, range of behavioral needs, and characteristics of these people, interventions such as rehabilitation are necessary to teach social interactions and communication skills and prevent

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the development or aggravation of behavioral defects (Kodak & Bergmann, 2020). In 2021, Aarabi and his colleagues investigated the challenges of providing services and education to children with autism spectrum disorder in Tabriz and identified the structure of service providers as one of the most important obstacles (Aarabi, Abdi & Khanjani 2021). On the one hand, among the problems that autistic children currently face in Iran are the lack of appropriate educational content and the impossibility of using public urban services such as parks, and so far, no design or action has been taken to adapt urban spaces according to their characteristics and needs (Ramezanloo, Abolmaali Alhosseini, Bagheri & Robatmili, 2020, 159–160). On the other hand, extensive research proves that nature has a positive effect on humans in general and specific groups, including autism spectrum disorders. Various approaches in the field of interaction with nature in design have become common. Biophilic design is one of these approaches.

The increase in the number of sufferers, the excessive cost of services and education, the effectiveness of interaction with nature on sufferers, and the lack of adaptation of parks and urban spaces suitable for affected children are some of the current challenges in education and services. Therefore, the research seeks to answer how the criteria of biophilic landscape design can be adapted in therapeutic landscapes for special needs autistic children.

Many researchers confirm that interacting with nature is effective for children with autism (Hebert, 2003; Hussein, 2012; Barakat, El-Sayad, Bakr & Zeyad, 2019; Kaihara & Patricia, 2019). In 2009, Faber Taylor and Ko exposed 17 affected children to three different open spaces for 20 minutes: the center of the city, the residential neighborhood, and the park. After completing the questionnaire, it was proven that the concentration of children was higher in the park (Faber Taylor & Kue, 2009). In 2018, Barkat and his colleagues researched the effect of nature and garden therapy on sensory integration and its effect on the senses of touch, vestibular, depth, hearing, vision, and smell. They found that children with ASD need to be in constant contact with nature to maintain their cognitive, mental, and physical health and to benefit from nature socially and emotionally (Barakat et al., 2019, 45). Hebert observed a significant improvement in children's tendency for cooperation and less aggression by holding educational sessions for autistic children outdoors and exposing them to nature (Hebert, 2003). Mustafa investigated seven effective criteria for sensory integration in children's education. These principles are acoustics, spatial sequence, escape space, partitioning, transition zones, sensory zoning, and safety. According to him, paying attention to these principles in education leads to a reduction in noise, echo, and reverberation and improves attention span, response time, and behavioral mood (Mostafa, 2014). In the research of Andrea Scartazza and colleagues, in an open pilot study on young people with autism in 2019, it was proven that contact with nature and taking care of the garden have a significant effect on affected people (Scartazza et al., 2020, 13). Wagenfeld and his colleagues created a series of stimulating and soothing sensory experiences for children and adolescents with the careful arrangement of plants, spaces, and furniture and paying attention to details in garden design. Such experience reduced the anxiety of children, was slowly effective on their senses, including sight, smell, touch, taste, hearing, vestibule, and proprioception, and significantly strengthened their interactions (Wagenfeld et al., 2019, 7).

According to Kaihara, landscape architecture corrects the sensory impulses of sufferers by using natural elements, which has a positive effect on people with autism (Kaihara & Patricia, 2019, 14). In an article entitled "Design Interventions for Sensory Comfort of Autistic Children". in 2018, Gopal and Raghavan based on the opinions of autism experts in the field of differences in the processing of visual sense, proposed solutions for designing landscapes for autistic children (Gopal & Raghavan, 2018, 4). In the research of Ramshini and colleagues carried out in Iran, effectiveness, simplicity, and availability, naturopathy was announced as a complementary method along with other treatments to reduce the symptoms of affected children (Ramshini, Hasanzadeh, Afroz & Hashemi Razini, 2018). In their research in Iran, Asnaashari and Baghery Beheshty investigated park design patterns for autistic children (Asnaashari & Baghery Beheshti, 2022). In research carried out in both Iran and international context, the relationship between nature and outdoor space design for autistic children was investigated to reduce children's stress and improve their performance, but no research has been conducted on the educational and therapeutic aspects of improving sensory integration in landscape design patterns and nature therapy based on landscape therapy approaches, including biophilic.

Theoretical Foundation of the Study

• Autism and treatment

Children with autism can have sensory symptoms such as hyporesponsiveness, hyperresponsiveness, and sensory seeking. Fifty years ago, it was discovered that affected children with these sensory experiences become agitated and defensive (MD, Shurley, Toussieng, Maier & Pediatr, 2020, 1).

Many affected children suffer from sensory defects or malfunctions. In these children, sensory data received from the environment through sensory receptors is not correctly processed and perceived in the brain, which is referred to as a lack of sensory integration among autism specialists (Akbari Bayatiani, 2018 cited in Young & Rodi, 2014). Sensory integration treatment means sensory-motor treatment in autistic children, and the basis of this treatment is neural development and neural stimulation. It is believed that autistic children have all kinds of sensory problems. These problems include less or more responses to sensory stimuli or the inability to coordinate the senses with each other. In general, this method considers the cause of autism functions to be due to the inability to coordinate the senses of an autistic person. The focus of the sensory integration method in treatment is on reducing the child's sensitivity and increasing the understanding of the information he receives through his senses (Mohammadi, Salemi Khamene, Rahnejat & Donyavi, 2020, 33). Therefore, the sensory integration method is one of the most effective educational methods. It was used for the first time to solve the problems of children with learning disorders so that the child could establish balance in his environment. In treatments related to sensory integration, great importance is given to touch, depth, and vestibular sensory systems. The reason is that the sense of touch is caused by the receptors in the skin. This helps a person to be aware of pain, pressure, heat, and cold. Moreover, the sense of depth is caused by the receptors in the joints and muscles which help an individual to understand the movement of the joints and the body and create an understanding of the position of the body or body parts in space. In fact, with the help of deep sensation, a person can determine the spatial orientation of the body or its parts in space, the speed of movements, the amount of muscle force, and the speed of muscle tension, and it is because of the vestibular sense we can identify where our body parts are and touch them in the dark and even with our eyes closed, otherwise, we need to look at them to determine the location of our parts (Akbari Bayatiani, 2018, 99). If any of these senses do not work properly (or do not work at all), our understanding of the world will be incomplete, and correspondingly, our reaction to the phenomena of the world will be inappropriate (Akbari Bayatiani, 2018 cited in McPartland, 2012). On the other hand, it has been proven in therapeutic interventions, children react better to sensory stimuli than to human stimuli (Akbari Bayatiani, 2018, 100). Autism therapists generally classify children into three levels, from one to three. Level one has more abilities in sensory processing and adapting to the environment than level three.

Biophilia, as people's innate desire for the natural world, has been studied in psychology and sociology since the 1980s (Wilson, 2006). Biophilic design is one of the new approaches in the design of spaces where people live, work, and receive training and treatment. This design employs nature and natural patterns in the design of interior and exterior spaces on small to large scales.

The successful application of biophilic design leads to a wide range of physical, mental, and behavioral benefits. Physical outcomes increase physical fitness, comfort, and satisfaction and result in lower blood pressure fewer disease symptoms, and improved health. Mental benefits range from increased satisfaction and motivation to less stress and anxiety and effectiveness in problem-solving and creativity. Positive behavioral changes include better coping and mastery skills, increased attention and concentration, improved social interaction, and less hostility and aggression (Kellert & Calabrese, 2015, 9). In 2020, Wijesooriya and his colleagues examined the opportunities that biophilic design provides to space users based on four items: 1. Helping health and well-being 2. Positive emotional effects 3. Positive behavioral effects 4. Positive cognitive effects. Positive feelings associated with biophilia are likely due to the visual, auditory, and olfactory stimulation that accompanies it. There is evidence from research that the scent of flowers can have a positive effect on human feelings and emotions. Some studies showed that biophilia can increase creativity, memory capacity, and academic capacity. For example, students who have access to a view of nature perform better than students who have a view of a concrete wall (Wijesooriya & Brambilla, 2020, 17-18). Biophilic design, by affecting the senses of sight, hearing, and multisensory, similar to what is experienced in nature, reduces stress, improves mood, and increases cognitive performance and attention (Aristizabal et al., 2021, 11). All the features of biophilic design are experienced through different human senses, such as vision, hearing, touch, smell, taste, and movement. The visual sense is by far the dominant way people perceive and respond to the natural world. When plants, animals, water, landscapes, and nature are seen, all kinds of physical, emotional, and cognitive reactions are created. Humans also react to indirect visual contact with nature, especially seeing impressive images, natural materials, organic shapes and forms, etc. attractive nature; it arouses interest, curiosity, imagination, and creativity. On the other hand, when there is no visual contact with the natural world, such as in a space without windows, people often experience boredom, fatigue, and, in extreme cases, physical and mental abnormalities. Despite the human tendency to rely more on the sense of sight, other human sensory responses to nature are very important: the

sense of touch, hearing, smell, taste, passage of time, and movement. Hearing the sound of water, touching plants, smelling flowers, and feeling the movement of air often affect feelings and thoughts. Multisensory encounters with nature in the built environment can greatly contribute to comfort, satisfaction, pleasure, and cognitive performance (Kellert & Calabrese, 2015, 12).

Biophilic design patterns appear in three major sections:

1. Nature in the space: It includes natural elements such as plants, natural sounds, scents, and direct views of nature in the space.
2. Natural analogs: They create indirect associations of nature in a space by using patterns, colors, shapes, and natural materials.
3. Nature of the space: It aims to create a sense of security and comfort based on the landscape/shelter theory; Landscapes and spaces are created by imitating the arrangement and selective natural elements by humans (Aristizabal et al., 2021).

Zhuang divides biophilic strategies into three categories:

1. Incorporation of nature: It introduces or artificially creates natural elements, phenomena, and processes and emphasizes them through multisensory experiences.
2. Inspiration from nature: Nature is imitated (known as biomimicry) and evokes the feeling of nature by incorporating nature's characteristics.
3- Interaction with nature: Spaces are arranged based on the evolved relationship between humans and nature so that environments similar to nature can be experienced (Zhong, Schroder & Bekkering, 2022, 10-13).

In summarizing the views of theorists, three basic strategies are evident: nature in space (incorporation of nature), natural analogs (inspiration from nature), and nature of space (interaction with nature). Each of the models provides strategies that can be used in biophilic design ranging from the interior space to the urban scale. However, some strategies and solutions are specific to the interior spaces. In this research, the attempt is to extract the equivalent strategies presented in the design of external spaces based on the theories of theorists.

Research Methodology

The research is mixed methods. In the first step, in a semi-analytical way, the basics of therapy were analyzed and adapted to the biophilic therapeutic perspective, emphasizing the sensory integration of children with autism. In the second step, adaptive solutions were extracted, and under the supervision of two autism experts, three treatment-oriented functional spaces were created in the real environment from among the solutions, and the description of the treatment sessions was written. The statistical population of the study of children with autism in Fars province is the test group of children aged 3-9 years old in Fars province autism charity center in spectrum 1 and 3. The sample size was selected under the supervision of experts in the field of autism. A total of 8 subjects in two spectrums one and three were selected to participate. Two of them participated in the pilot test to assess the test conditions and 6 practiced as final samples. In the third step, the subjects were exposed to the therapeutic environment using the experimental research method, and the data were recorded using the sensory processing questionnaire "Sensory Profile" before the test (August 2022) and after the test (October 2202). The validity and reliability of the research were checked; The Sensory Processing Questionnaire is a standard questionnaire in the world that examines fourteen different factors about children including auditory, visual, vestibular, tactile, multi-sensory, oral sensory processing, physical endurance, body posture, movement, emotional responses, emotional processing and activity level, social emotional responses, behavioral consequences of sensory processing. and response threshold. They were recorded in the states before and after placing the children in the desired environment and were compared and analyzed using the paired t-test at the 95% confidence level. This questionnaire is designed based on the Likert spectrum with a five-point scale (always= 1, often= 2, sometimes= 3, rarely= 4, never= 5), and a higher score is desirable in the calculation of all factors. Before the paired t-test, the normality of the data was first checked with the Kolmogorov-Smirnov (k-s) test using "SPSS« software. All factors had a normal distribution. After ensuring the normality of the data, pairwise averages were compared. On the other hand, each child's affective process, including movement, speech, and feeling, was recorded separately in each session

Data analysis

Based on the basic research conducted by autism experts, the research attempted to test the effect of nature on the child's senses. Models proposed by biophilic theorists were examined in detail. Biophilic landscape strategies for affected children were extracted based on therapists' sensory integration methods and biophilic design patterns (Table 1).

As the table shows, some patterns and strategies overlap with each other from a biophilic perspective, and theorists expand and develop each other's ideas in completing the biophilic design patterns. Biophilic design patterns have been shown to influence the senses of people with normal cognitive function, to investigate the proven effects of designing patterns on autistic children, there was a requirement to engage the children in the tasks. Based on the strategies column in Table 1,

Table 1. The Biophilic therapeutic landscape. Source: Authors.

Micro-scale	Biophilic landscape		Adaptation to sensory integration	
	Pattern	Strategies	Empirical Strategies	Effectiveness on the senses
Nature in space	A visual connection with nature	- Communication with sunlight (Mazuch, 2017, 3) - Green wall (Zare, Faizi, Baharvand & Masnavi, 2021,10) - Experiencing light in motion (Kellert & Calabrese, 2015, 13-15) - Green paths and the use of blue, yellow, and green colors (Peters & D'Penna, 2020, 7) -Soil (Browning, AIA, Ryan & Clancy, 2014, 25)	- Basic geometric shapes with light and shadow, green walls in the movement path, use of soil in hard landscapes, and water features	Visual, tactile and auditory
	Non-visual connection with nature	- Walking in nature The texture of natural materials (Zhong et al., 2022, 17) - The sound of water and its touch (Zare et al., 2021, 10) - Agricultural landscape (Zhong et al., 2022, 15; Xue, Gou, Lau & Lau, 2019, 3)	- Use of sand, wooden surfaces, agricultural landscapes, watering plants, fountains, and water sound	Tactile, auditory, olfactory, gustatory (Browning & Ryan, 2020, 05)
	Non-Rhythmic Sensory Stimuli	- The rustling of leaves, the swaying of grass in the field (Peters & D'Penna, 2020, 6-7)	- Space for movement and exploration (Browning et al., 2014, 50) - Winding paths and curves in the path (Zhong et al., 2022, 19) - Ambiguity in space (Browning & Ryan, 2020, 5)	Multisensory approach (Aristizabal et al., 2021, 12)
	Non-Rhythmic Sensory Stimuli	- Subtle changes in air temperature, and relative humidity (Browning & Ryan, 2020, 5)	- Water usage in volume - Exposure to sunlight to change the temperature using evaporative cooling	Reducing carbon dioxide and increasing memory (Browning & Ryan, 2020, 05)
	Presence of water	- Construction of water landscapes such as fountains, constructed lagoons, ponds, water walls, rainwater fountains, and aquariums (Zhong et al., 2022, 14)	- Using water ponds, and fountains and creating water sounds	Multisensory approach (Browning et al., 2014, 34) Visual, auditory, and tactile (Kellert & Calabrese, 2015, 13)
	Dynamic and Diffuse light	- High-contrast lights (Zhong et al., 2022, 14)	- Playing with light and shadows using geometric shapes - Top of Form	Improvement of emotions (Zare et al., 2021, 11)
Natural Analogues	Connection with Natural Systems	-Natural elements and fractal patterns (Aristizabal et al.,2021, 5) - Lines and patterns of living beings (Zhong et al., 2022, 16-17) - Curve patterns (Browning & Ryan, 2020, 5)	- Using different geometric patterns such as circles with fractal patterns and their natural and opposite geometry, rectangles with regular geometry pattern	Emotional pleasure is achieved by fractal forms or curves that create natural balance through symmetry (Salingaros et al., 2015, 11)
	Material Connection with Nature	- Materials available in nature such as wood and stone (Peters & D'Penna, 2020, 7) - Clay and the use of natural colors (Zhong et al., 2022, 18) - Wood, stone, wool, cotton and leather (Kellert & Calabrese, 2015, 16)	-	Visual and tactile (Kellert & Calabrese, 2015, 16)
	Complexity & Order	- Forms, patterns, and natural geometries and fractals (Zhong et al., 2022, 18)	- Creating Maze	Visiual (Zare et al., 2021, 12)
Nature of the Space	Prospect	- An unobstructed landscape from a distance, for monitoring and planning (Browning & Ryan, 2020, 05)	- Placement of spaces in positions that create a view around and use the natural slope of the land	Improved comfort and safety awareness (Browning et al., 2014, 14)
	Refuge	- A smaller part of a larger space (Browning et al., 2014, 48,49) - Open views and a sense of closure (Zhong et al., 2022, 18)	- Creating canopy and corners in the maze	Improving concentration, attention, and sense of security (Browning et al., 2014, 14; Zare et al., 2021, 12)
	Mystery	- Space for movement and exploration (Browning et al., 2014, 50) - Winding paths and curves in the path (Zhong et al., 2022, 19) - Ambiguity in space (Browning & Ryan, 2020, 5)	- Maze and desire to move along green walls, moving on the edges created with wood	A great sense of pleasure (Browning et al., 2014, 14; Zare et al., 2021, 12)
	Risk/ Peril	- A console walkway over a rock and the risk of getting wet with water (Browning et al., 2014, 52) - Experiences or objects that are thought to defy gravity (Zhong et al., 2022, 19)	- Contact with water and moving on woods high above the ground	Experiencing a strong dopamine response (Browning et al., 2014, 14)

a different spatial pattern was proposed after examining the biophilic design patterns and therapeutic approaches to sensory integration of autistic children in a closed space. The selected strategies were finalized and built on a real scale under the supervision of autism experts. The three patterns are:

1. Maze: A winding path with green walls was created to stimulate the coordination among the eyes, hands, and feet and direct the child's vision to the desired areas for the development of exercises in each session. The purpose of the exercises was to improve the child's vision, depth, and vestibular senses, and the effect on the senses was also evaluated by the child's speech and performance (Figs. 1, 2 & 3).

2. Tent structure: creating a game of light and shadow on the surface of the ground, learning the fundamental levels, and developing and expanding the exercises with an emphasis on visual and tactile effectiveness. A canopy with geometric shapes was exposed to the sun, which is the scope of attention and concentration, as well as the child's speech, which was evaluated during the sessions (Figs. 4, 5 & 6).

3.Agricultural landscape: the placement of a water basin in the center of the space and gardens for planting plants, on a larger circle, the radius of which was the place where the child passed, creating a sense of suspense. The child should go over the woods to take water from the pond go back over the woods and give water to the sapling he planted. In this exercise, the effectiveness of the child's visual, vestibular, depth, hearing, smell, and taste senses and the effect of sensory stimuli was evaluated by evaluating the child's performance, concentration, and speech (Figs. 7, 8 & 9).

The number of sessions and the description of the sessions were written under the supervision of an autism specialist so that during the test, the maximum effectiveness can be observed according to the opinions of the therapists, and on the other hand, the research can be carried out within a specific framework. The description of the meetings in 18 meetings over two months for the three proposed solutions was written as follows:

Maze: sessions 1 and 2: familiarization with the environment, Sessions 3-5: finding colored balls and throwing them in the basket, Sessions 6–8: drawing a circle on the floor of the maze for children to jump in the circle, session 9-11: doing 2-item tasks It was: jumping in circles and finding the balls that were on the wall of the maze and throwing them in the basket; session 12: jumping in circles and placing the animal and the ball on the ground at the same time; and the child had to choose the animal and throw it in the basket. Session

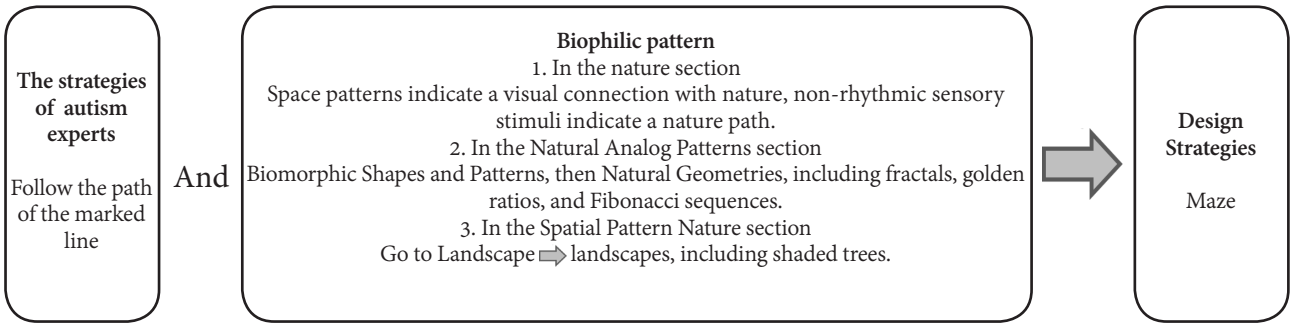

Fig. 1. Adaptation of autism experts' strategies for coordination of eyes, and limb movements (proprioceptive sense) with biophilic landscape patterns. Sources: Authors.

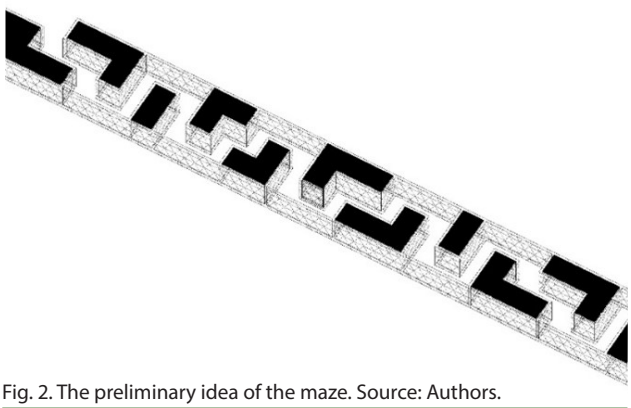

Fig. 2. The preliminary idea of the maze. Source: Authors.

Fig. 3. The maze made for the experiment (Autism Charity Center of Fars province, the construction process until the test from the beginning of August to the end of October 2022). Source: Authors' archive.

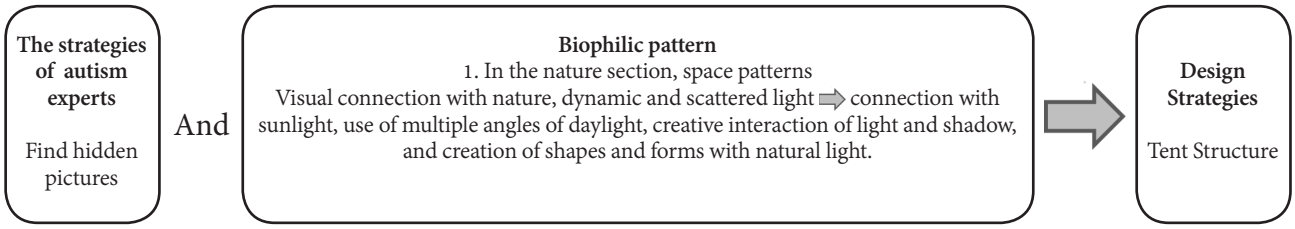

Fig. 4. Adaptation of the strategies of autism experts for visual sense with biophilic landscape patterns. Sources: Authors.

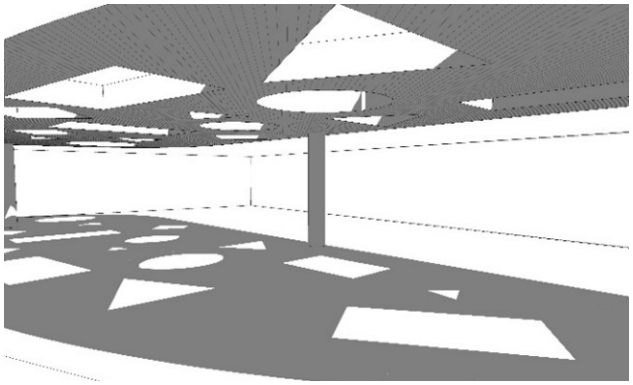

Fig. 5. The preliminary idea of the tent structure. Source: Authors.

Fig. 6. The tent structure built for the experiment (Autism Charity Center of Fars province, construction process to test from early August to October 2022). Source: Authors' archive.

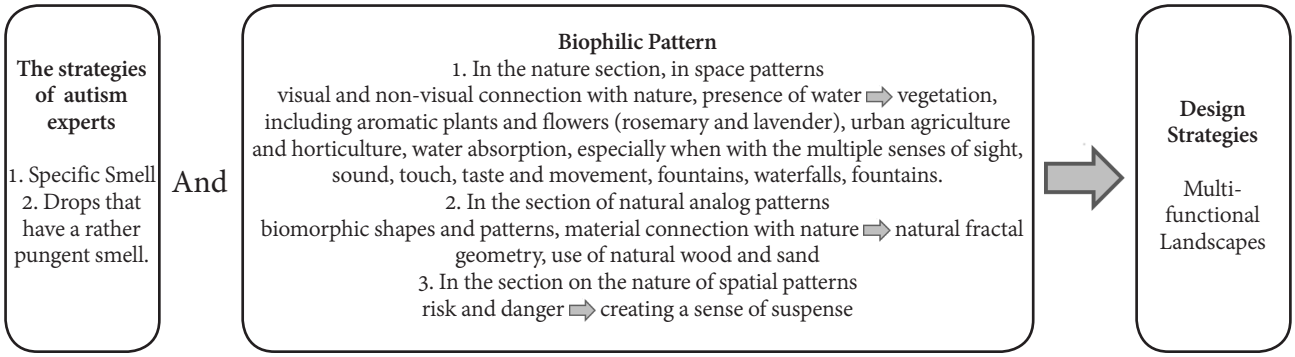

Fig. 7. Adaptation of the strategies of autism experts on the auditory sense with biophilic landscape patterns. Sources: Authors.

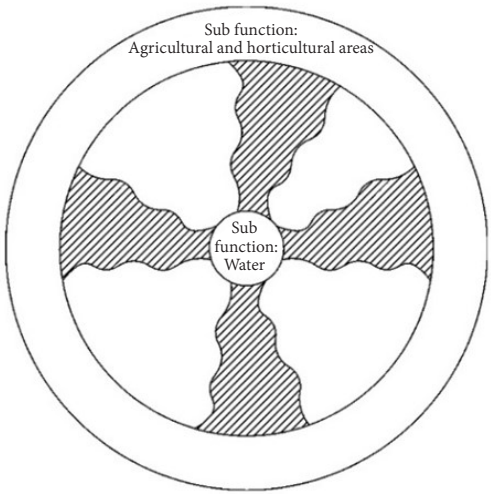

Fig. 8. The preliminary idea of the multifunctional landscape. Source: Authors.

Fig. 9. Multi-functional landscapes built for the experiment (Autism Charity Center of Fars Province, construction process for the experiment from early August to October 2022). Source: Authors' archive.

13–15: Color the inside of the middle circles completely red, and put a series of colored tires in parts of the maze so that the child can pass through them. Session 16–18: Doing the 3-item task: jumping in colored circles, passing through colored tires, stepping on footprints.

Tent structure: Sessions 1 and 2 familiarizations with the environment; Session 3-5: placing natural stones around the shadow of geometric shapes; Session 6-7: placing colored stones around the shadow of geometric shapes; Session 8: picking up stones and placing them in the shadow of the circle, rectangle, and triangle and vice versa; session 9-11: pouring flour around the shadow of geometric shapes; session 12: putting hemp around the shadow of geometric shapes. Session 13–14: Two different geometric shapes were placed inside the shadow of the figure, and the child had to remove shadow similarity. Session 15–18: Finding the shadow-like shape from the basket between two geometric-shaped items.

Participatory perspective: Session 1 and 2 familiarization with the environment; Session 3-5: moving towards the water from the wood and picking up a colored glass from the water and throwing it into the water; Session 6–8: moving towards the water from the wood and filling colored glasses; Session 9–11: moving towards the water from the wood and filling the colored glasses and pouring water into the pot by the pond; and Session 12–18: planting seedlings and watering the plant.

The pilot group was examined in the initial sessions to examine the conditions of the research. After the pilot group solved the problems of the test, the main group was exposed to the same problems from the beginning of September 2022 to the end of October 2022 for 30 minutes in each session with the help of a trainer. In each session, the session report was written separately for each child. The findings obtained from the analysis and reports of children's meetings were analyzed, and the results of the research were presented.

Discussion

Level three children: in terms of vision, the children's attention was drawn from the fourth session onwards in the Maze exercise; their visual sense was stimulated, and saw colored balls. From the ninth session onwards, they could throw balls, and from the 11th session, they could jump completely. From the fourteenth session on, the child recognized the shape of the circle and the sound of the circle and could move on his own and jump on the circles. In the last session, the child, in addition to recognizing the sizes and shapes, could find colored traces with his eyes. The latest effectiveness was observed in the space of the tent structure. From the seventh session onwards, the children were able to sit on two legs, which, of course, seemed to be the effect of jumping in the maze section. They did not have much understanding of the change of light and shadow. It seemed that the less use of the body and the non-dynamic nature of this space affected their performance. Children were more interested in dynamic spaces. Children were more emotionally affected in spaces that were more dynamic and required more active physical participation. In examining children's performance at level three, the participatory perspective had the fastest impact on children due to risk and danger and the presence of water from biophilic design patterns. They started to move alone and without the help of a coach in the third session, designs seemed to have a significant effect on children's proprioceptive and vestibular senses, and from the fourth session onwards, they went beyond the description of the sessions. They looked at the water, moved towards the water basin, and picked up the colored glasses inside the basin. From the 8th session onwards, they were able to move alone along the wooden path and fill the water glass, and in the 16th session, the child was able to plant and water the plant with the help of the trainer.

Level 1 autistic children: Level 1 children interacted more with the maze in the first sessions, paid attention to the green walls, and tended to touch them. In the third session, they saw the balls and put them in the basket. In the sixth session, children paid attention to the circles on the ground and were able to jump in the circles. In the ninth session, the children were confused in the dual-task test of jumping at the same time and finding the ball. According to the teacher, in the test of closed spaces, they got confused when performing dual-functional tasks at the same time. But from the eleventh session onwards, the children's concentration increased, and they saw the ball and jumped in the circle at the same time. From the teacher's point of view, sensory integration and increased children's concentration happened earlier in the outdoor space than in closed spaces. From the thirteenth session onwards, in addition to doing the exercises, the children also interacted in terms of speech. The noteworthy point in this section was the better performance of children's vision on volume changes. For example, they had a better grasp of tire volume compared to surface circles drawn on the ground and colored footprints. In the section of the tent structure, children of the first level were not very interested in the treatment process; they knew the shapes and did not pay attention to light, shadow, or surface changes. In the two-function exercises, where they had to simultaneously recognize the geometric shape and put the hand or foot in a specific shape, they were confused at first and did not pay attention to the change of surface due to light and shadow. But by using the tactile sense, especially when there were

volume changes, the children's attention to geometric shapes increased. For example, using flour due to its superficiality and lack of differentiation with the surface of the soil, did not tend to define the border of light and shadow, but with wood and changes in volume, or by using volumetric geometric shapes and placing them on the surface was separated by light, and they noticed the shape change more. Perhaps it can be said that in children, the level of a change in volume in landscapes is more important than surface changes, and harder textures and surfaces such as wood have a better impact on children than textures and soft surfaces such as soil. On the other hand, whenever the child's interaction with the environment becomes more dynamic, such as picking up volumes or finding levels, the child's concentration increases in terms of vision, hearing, and vestibular. From the collaborative perspective, the children first experienced suspension on the wood with the help of the coach, and from the third session onwards, they moved from the woods with fear and bent over. Even one of the children was whispering to himself from the fourth session onward. Do not be afraid. Do not be afraid. In terms of listening, children's concentration was low. From the seventh session onwards, children's auditory concentration and adaptation of the colored glass and the fruit in the pond happened, which happened faster than similar exercises in closed spaces without the presence of nature, according to the coach. From the 9th session onwards and after the multi-functionality of skill learning, the children could easily move on the wood and enjoy it. In the thirteenth session, the children planted and watered the seedlings easily. Children had a strong desire to touch the soil and dig holes to plant plants. Due to the interaction in outer space, the proposed solutions are often not single-functional, or rather, single-sensory, but stimulate several senses at the same time. For example, in landscape design, due to the presence of hard and soft landscapes together, if the emphasis is on the sense of sight, the path is winding, and the senses of smell and hearing are also affected due to the presence of plants and the sound of nature. Therefore, the effects of nature on solutions often affect several senses. In the treatment of sensory integration in children with autism, according to experts, the emphasis is on the effectiveness of several senses at the same time. Some of the biophilic design patterns and strategies have a positive effect on the senses of people with normal sensory perception, disturbed concentration, and effectiveness on the senses of autistic children with different sensory perceptions including the perspective that seeing other scenes during the exposure to a specific function would disturb their concentration. Ambiguity and mystery in the environment used to hurt children. According to the observations, the change in levels such as the light and shadow game did not have much effect on their visual performance and attention, and in the spaces where the change was due to the difference in level and volume of the space, the children were more inclined to continue learning skills and treatment. According to the review of the reports, the effect of the performances on children in the spectrum of one and three diseases was different; the children of level three mostly benefited from the experiment. This was reflected in reporting the sessions in the daily time frame, and it caused more effectiveness in their speech and cognitive performance. According to the reports, level 1 children were not affected as much as level 3 children due to their better cognitive performance. As for the vestibular sense, creating a sense of danger by being suspended in the path where the biophilic landscape was used, was reported to be extremely effective on all children of two spectrums, and landscape therapy using the element of water attracted the attention of children in two levels at a high level. It seems that in the setting specific to autistic children, the interference of functions with each other leads to the distraction of children. For example, the sound of a fountain in a collaborative scene next to a winding path caused the child to have less concentration on the path, and the desire to reach the water disturbed the child's senses.

Conclusion

It seems that in designing therapeutic spaces for children with special conditions, despite the many limitations, the mixed research method provides a more detailed picture of healing landscapes, and currently it is less used in the therapeutic landscape, especially in Iran. Usually, the design of such landscapes is based on the ideas of design theorists. However, the strategies for healing landscapes, which are specific to ordinary people, need more investigation for groups with special conditions. It can be said that this is a small-scale post-evaluation, which is neglected in the formation of landscape projects. In general, based on the experiment of adaptive strategies of biophilic landscapes-sensory integration of autism, in choosing the geometry that governs the design of landscapes for autistic children, movement paths, zoning, treatment oriented functions, vegetation, water, and the selection of materials are recommended. because they affect the treatment and recovery and have a greater impact on the sensory integrity of the child (Table 2).

Treatment and effectiveness of sensory integration using nature have a significant impact on autistic children and affect children's concentration, speech, and social interactions. However, due to the difference in sensory

Table 2. Examination of landscape design components with emphasis on effectiveness in sensory integration and comparison with biophilic landscape patterns. Source: Authors.

Components of interest in design	Design strategies with effectiveness on sensory integration	Adaptation to biophilic landscape patterns
Geometry	Simple lines, without complexity and ambiguity	-
	Curved lines with simple geometry	+
Path	Being indicative of the beginning and the end and avoiding complexity	-
	Not creating a visual corridor on the way to environments outside of any function	-
	Low width suitable for children's visual perception.	+
	Separation of paths and functions using surface and height changes and texture changes instead of surface color and geometry changes	-
Treatment-oriented functions	Multi-sensory involvement in every function, especially stimulating the sense of touch	+
	Safe functions along with creating a sense of risk and danger	+
	Non-interference of visual and auditory sensory stimuli with each other	-
Vegetation	Visual continuity in each function using short, shallow, or tall vegetation with a canopy above	+
	More greenery and the use of colorful plants	+
	Visual cover using dense plants between functions	-
Water	Using the sound of water in such a way that the sound of water does not exceed one function to adjacent functions.	-
	Contact with water	+
	Using water on small scales without conveying the sense of infinity	-
Material	Use of natural materials	+
	Predominance of soft landscape	+
	The juxtaposition of various textures of materials adjacent to each other in one function creates a contrast in the sense of touch (example: sand-wood)	+

perception between children with autism and non-afflicted groups and the therapeutic landscape plays an important role in acquiring special skills for children, some biophilic design patterns are effective on affected children, and some are not effective and disrupt the treatment. Considering the importance of the visual sense it seems that the strategies regarding mystery, ambiguity, and discovery in the design of landscapes where the biophilic approach is used, are more effective on the senses and performance of people with normal needs than autistic children. Such strategies even disrupt autistic children's concentration, and according to the cognitive function of affected children, it is better to use simple and unambiguous scenes for the autistic ones with level 3. Also, changing the color and changing the surface has no obvious effect on the sense of sight if the change is in volume, for example, the change in height, stimulates the child's sense of sight and subsequently has an effect on the child's speech and interaction with the people present. In biofilm design patterns, the emphasis is generally on the use of curved and curved lines derived from natural geometry. According to the results of the research, children with the disease are more inclined to curve and round geometric lines in the environment, and in the treatment process, they are less inclined to right-angled geometry such as rectangles and triangles. Children are very interested in spaces with higher risk, and the riskiness of the space affects their activity, dynamics, and attention. On the other hand, due to the low concentration of affected children, in the design of outdoor spaces for these children, educational functions should be arranged separately, so, the visual and auditory senses of children are not aroused through the process of learning skills otherwise students will be distracted. To achieve generalizable suggestions is needed to replicate this research with subjects of different needs as this research was limited to (children aged 3–9) and a small sample size of 8 people.

Endnotes

* This article is extracted from the master's thesis in Landscape Architecture Engineering by Samar Dami titled "Designing a Therapeutic Garden for Children with Autism in Shiraz with a Biophilic Approach." The thesis was conducted under the guidance of Dr. Maryam Esmaeeldokht in the year 2022 at Hafez Institute of Higher Education in Shiraz.

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