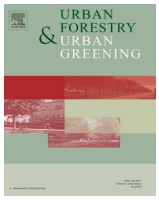
Urban Forestry & Urban Greening 115 (2026) 129181

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug



Autism-friendly public landscape architecture

Hanna Fors [a,*], Åsa Ode Sang [a], Petra N. Bengtsson [b], Jessica Svännel [c], Thomas B. Randrup [a]

[a] Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, Alnarp, Sweden
[b] The Properties, Streets and Parks Department, City of Malmö, Sweden
[c] Region Gotland, Sweden

ARTICLE INFO

Keywords:
Autism
Autism-friendly cities
Neurodiversity
Green space management
Public urban green spaces

ABSTRACT

Despite the importance of public urban green spaces for public health, traditionally marginalised groups may have limited access to them. This article focuses on the specific marginalised group of people with autism, a growing societal group that is often excluded from the use of public urban green spaces. The existing literature on autism-friendly outdoor environments is limited. Based on the literature and as a starting point for further research on the topic, we suggest *the nine design aspects of autism-friendly public landscape architecture* as an approach to redesign existing UGS for people with autism. The literature review formed part of a research project which also involved a three-year case study (2019–2022) of a design intervention in a UGS in Malmö, Sweden, where the local authorities redesigned part of a UGS to better meet the needs of people with autism. The resulting intervention was called 'The Peaceful Path'. Here, we explore the practical relevance of the nine design aspects identified in the literature by assessing whether these aspects are aligned with those that were employed by practitioners in the Malmö case to create a more autism-friendly UGS. This is done to improve understanding of how the needs of people with autism can be accommodated in a UGS. Further studies of the nine aspects and their operationalisation are necessary to explore how autism-friendly public urban green spaces differ from private gardens, as well as the more extensively studied indoor environments. Additionally, more knowledge is needed on how to operationalise the nine identified aspects to make UGS more autism-friendly, and how this implementation is affected by cultural, geographical and local contextual factors. Our findings may offer guidance to planners and managers seeking to make public urban green spaces more autism-friendly.

1. Introduction

Public urban green spaces (henceforth UGS) play a crucial role in cities and have been shown in numerous studies to positively contribute to public health (van den Bosch and Ode Sang, 2017). Several of these health benefits, particularly those related to improved affect and stress reduction, depend on socio-behavioural pathways, making it necessary to use and interact with UGS (van den Bosch and Ode Sang, 2017). In this context, accessibility becomes a key concern, and not just physical accessibility but also cultural, social and socio-psychological dimensions of accessibility, determining how accessible an area is perceived to be and how accessible it actually is (Koppen et al., 2014). Several studies have highlighted the varying use and values of UGS among different user groups, based on factors including age (Ode Sang et al., 2016; 2020; Schipperijn et al., 2010), gender (Braçe et al., 2021; Ode Sang et al., 2016; 2020; Schipperijn et al., 2010), disabilities (Stigsdotter et al., 2018) and ethnicity (Schipperijn et al., 2010). However, despite scientific evidence for the positive effects of UGS on human health and well-being, systematic efforts to increase accessibility to UGS have so far focused mainly on people with physical disabilities, while the needs of people with mental, emotional, and/or developmental disabilities have been overlooked (Clouse et al., 2020; Wong et al., 2023).

This article addresses people with autism, which is a societal group that would benefit greatly from visiting UGS for improved mental and physical health (NBHW, 2015) but is often excluded from UGS. Globally, the prevalence of autism has increased over time, but it varies widely within and between socio-demographic groups (Zeidan et al., 2022). In Sweden, 1–2 % of the population has an autism diagnosis (Zander,n.d.). Autism is a neuropsychiatric disability. The autism spectrum is wide and people with autism have diverse experiences, strengths, and support needs. People with autism may communicate and interact socially in ways that differ from neurotypical patterns and many use repetitive

* Correspondence to: Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, PO Box 190, Lomma SE-234 22, Sweden.
E-mail address: hanna.fors@slu.se (H. Fors).

https://doi.org/10.1016/j.ufug.2025.129181
Received 30 June 2025; Received in revised form 16 November 2025; Accepted 20 November 2025
Available online 21 November 2025

movements or behaviours as valuable self-regulation strategies (Bölte, 2020). Predictable environments and established routines are often valued by people with autism as they provide helpful structure and familiarity (ibid.). A majority of people with autism experience sensory processing differently, where some are hypo-sensitive, seeking sensory input, while others are hyper-sensitive, avoiding it (Gaudion and McGinley, 2012; Tola et al., 2021).

Based on the literature, this article suggests *nine design aspects of autism-friendly public landscape architecture* as an approach to redesign existing UGS for people with autism. The literature review formed part of a research project which also involved a three-year case study (2019–2022) of a design intervention in a UGS in Malmö, Sweden. In the intervention, the local authorities redesigned part of a UGS to better accommodate the needs of people with autism and increase their opportunities to become users of UGS. The design intervention was not informed by the literature review, as the two processes were carried out separately. Here, we explore the practical relevance of the nine design aspects identified in the literature by assessing whether these aspects are aligned with the actual design aspects that were employed by practitioners in the Malmö case to create a more autism-friendly UGS. This is done to improve understanding of how the needs of people with autism can be accommodated in a UGS. The findings may offer guidance to planners and managers seeking to make existing UGS more autism-friendly.

1.1. How people with autism may benefit from UGS and nature

In this article, we explore how UGS can be adapted to the needs of people with autism through landscape architecture. Much of the literature on how people with autism may benefit from spending time in nature and UGS concerns children with autism. For these children, spending time in nature may have sensorimotor, emotional and social benefits (Li et al., 2019), including supporting play, social communication, and mentalisation (Byström et al., 2022). In a study of tree canopy coverage, Barger et al. (2020) found that natural environments may support emotional regulation and reduce expressions of anger and aggression in youth with autism. In addition, spending time in nature reduces stress, creates calm, arouses curiosity and interest, spontaneously attracts attention, supports imaginative play (Byström et al., 2019; Galbraith and Lancaster, 2020).

Given these benefits, careful design of environments is important for teachers, therapists, and parents of children with autism, since thoughtfully designed spaces that accommodate sensory needs enhance interactions and learning opportunities (Clouse et al., 2020). However, some natural environments may require sensory considerations to ensure accessibility (Byström et al., 2019; Galbraith and Lancaster, 2020). While children with autism may benefit from spending time in wild nature, research on their access to this is scarce (Blakesley et al., 2013; Galbraith and Lancaster, 2020).

Beyond the direct benefits of nature exposure, environmental factors during early development may also play a role. A Canadian study by Lavigne et al. (2024) showed that living close to a neighbourhood UGS during pregnancy was associated with lower prevalence of autism in young children. Further, tree cover in areas with high road density has been found to be associated with lower prevalence of autism in elementary school children (Wu and Jackson, 2017).

1.2. Challenges of and barriers to recreation in UGS for people with autism

A wide range of physical and social barriers, especially related to high occurrence of sensory stimuli and social encounters, hinder people with autism from recreation in UGS (Li et al., 2019). In a study by McAllister et al. (2022), parents of children with autism described the usefulness of knowing in advance when lawn mowers, leaf blowers and other machines would be used in the UGS, enabling them to plan ahead, since they could only visit the UGS with their noise sensitive children when it was quiet there. Personal safety is another central concern to parents of children with autism and in order to ensure safe design, outdoor play spaces for children with autism need to be enclosed and secure (Shannon et al., 2021).

According to a Chinese study, parents and caregivers of children with autism aged 4–18 had concerns about accessing UGS, including safety considerations such as road safety and physical hazards, sensory accessibility such as managing intense visual and acoustic input or unfamiliar environments, social acceptance including fear of judgement about their children's communication styles and emotional expressions, and environmental barriers such as potential social exclusion from others, when taking their children to UGS (Li et al., 2019).

2. Method

2.1. The literature review

Planning and design of physical environments that accommodate the needs of people with autism and other types of neurodiversity will lead to restorative environments that benefit everyone living in the city (Kenna, 2022; Clouse et al., 2020). Despite this, little is known about how to create inclusive UGS for people with autism (Kenna, 2022; Li et al., 2019), and therefore, there is a need to define and study autism-friendly public landscape architecture. To this end, a scoping review (e.g. Mak and Thomas, 2022) of peer-reviewed literature was conducted, searching the three databases Scopus below 'title-abstract-keywords', Web of Science Core Collection below 'topic' and PubMed below 'title/abstract'. The following search terms were used alone and in different combinations: "autism-friendly", "autism friendly", "autism", "green space*", "greenspace*", "garden", "landscape architecture" and "architecture". The search was limited to the document types 'article' and 'review' and articles written in English only. Then, a manual screening of titles and abstracts was performed. This was combined with citation chaining, following relevant citations mentioned in identified articles for review. The criterion for including an article in the final review was that it dealt with design of autism-friendly indoor or outdoor environments. General aspects about these environments were first extracted (see section 'Autism-friendly spaces'), after which 11 articles were selected for in-depth analysis specifically focused on identifying design aspects central to autism-friendly UGS.

First, each of the 11 articles was searched for descriptions of design aspects of autism-friendly indoor or outdoor environments (see Online Supplementary Material 1). Subsequently, the design aspects identified in the 11 articles that were assessed as translatable into autism-friendly public landscape architecture were listed in the bottom row of the table. Those aspects deemed non-translatable and thus not transferred to the bottom row include those relating to environments designed exclusively for children with autism, rather than for adults (e.g. some of the aspects highlighted by Harris et al., 2024; Li et al., 2019; Mostafa, 2008; 2014; 2015); and design aspects that are relatively straightforward to implement in a private setting but present significant challenges in a public space. An example of the latter is the design of flexible spaces, where non-fixed elements can be rearranged and customised with ease to subdivide the room for group or individual work, or where modular templates can help to sequence a classroom more efficiently (Tola et al., 2021). Furthermore, only design aspects open to a landscape architect or green space manager were extracted for the bottom row. For example, the design aspects "create homelike environments" (Kinnaer et al., 2016) and "unobtrusive monitoring" (Gaudion and McGinley, 2012; Lowe et al., 2014) were excluded. Nine tentative design aspects of autism-friendly public landscape architecture were identified through this analysis. The literature review was carried out from June 2020 through February 2023.

2.2. The case study

Independently of the literature review, we undertook a three-year case study (2019–2022) of a design intervention in a UGS in Malmö, Sweden. Swedish municipalities are responsible for ensuring compliance with the *Act on support and services for people with certain disabilities* (SFS, 1993:387; Swedish acronym: LSS), e.g. by providing municipal group residences or service housing – so-called LSS accommodation – for people with autism who need it. The National Board of Health and Welfare states that the physical environment at the LSS accommodation should be designed to minimise individual stressors and avoid intense sensory environments, and that regular individualised physical activity should be stimulated (NBHW, 2015). While LSS accommodation often has a small private garden, residents do not use UGS as they are not adapted to their needs. Access to UGS would increase the likelihood of meeting physical activity recommendations in a non-stressful environment, potentially improving the health and well-being of the user group.

In 2019, the Department for Disability Support (DDS) at the City of Malmö contacted the Swedish University of Agricultural Sciences to express an interest in exploring ways to improve accessibility to UGS for people with autism living in LSS accommodation. This resulted in the initiation of a research project. In Malmö, UGS management is handled by the Park and Street Environment Unit at the Properties, Streets and Parks Department (PSPD). As shown in Fig. 1, the project built on novel and close cross-departmental collaboration between PSPD and DDS, with nature pedagogues from Malmö Museum (allocated under the Department of Culture (DoC)) also involved to some extent.

The participants identified Bulltofta Park as a suitable UGS for the redesign. It is a large natural area located on the site of Malmö's former main airport. The intervention was carried out in the northernmost part of the UGS – one of the least visited parts, with several existing LSS accommodation facilities close by (Fig. 2).

The participatory process model employed in Malmö was the ParkLIV model, which was developed as part of the research project (Randrup et al., 2024). The model is cyclic and includes an analytical phase for setting goals and analysing existing place qualities, a design phase including a co-design workshop, an implementation phase, and short evaluations after each phase. The cycle then repeats with renewed analysis, design, implementation, and evaluation. An additional criterion inherent to the ParkLIV model was that the project should be implementable within existing management regime and budget constraints, in terms of both processes and cost solutions, in order to align participation closely with daily work (Randrup et al., 2024). The project was carried out within the existing job descriptions of the staff involved from the City of Malmö. The researchers facilitated the participation process by introducing the ParkLIV model and guiding execution of its methods for participation. As shown in Fig. 3, researcher involvement gradually decreased over time, while DDS and PSPD department involvement correspondingly increased.

2.3. Phase 1 - analysis

The goals for the intervention were formulated jointly by DDS and PSPD as follows:

- To develop concrete ideas for good UGS for people with autism
- To test these ideas in practice in a UGS in Malmö

At the beginning of the project, a place quality analysis was conducted to enable evaluation of changes in place quality after the intervention for both people with autism and the general public. Due to Covid-19 restrictions, the place quality analysis took place as a preset walk with an online meeting to discuss participants' impressions. It focused on existing qualities of the UGS in terms of the quality aspects *management*, *accessibility*, *nature*, and *facilities*, as well as identifying what was important to keep, see Table 1.

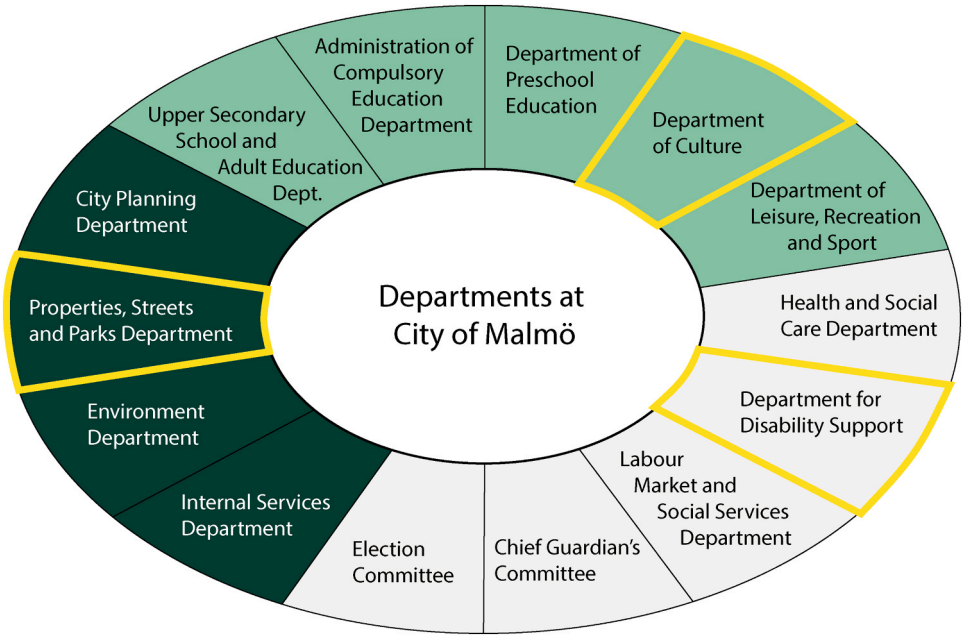


Fig. 1. Organisation scheme for the City of Malmö. Dark green denotes departments with main responsibility for some aspect of UGS development, namely the City Planning Department, which is in charge of the overall role of UGS in the wider city; the Properties, Streets and Parks Department, which is in charge of UGS management; the Internal Services Department, which is responsible for the outdoor environment surrounding schools and pre-schools; and the Environment Department, which often has a role in specific UGS related projects and themes. The light green denotes departments with minor responsibility for UGS, mostly in terms of being responsible for the activities taking place in UGS, schoolyards and sports facilities. Grey indicates departments with no or a marginal role in UGS development that focus on people rather than space. The project built on cross-departmental collaboration between three departments, as indicated by the yellow frames.

Fig. 2. The site used for the intervention is located in Bulltofta Park in Malmö, in the south of Sweden. The area is dominated by two large lawns with some trees, surrounded by mature natural planted vegetation. Several smaller pathways run through the natural plantations, providing shortcuts between the large southern lawn and the road. In the northeast corner, there is a permanent BBQ area with picnic tables. Close to the entrance of the area, there is an allotment area and a small pond.

2.4. Phase 2 - design – developing suggestions for changes

The aim of the co-design workshop was to develop ideas and solutions for adapting Bulltofta Park to the specific user group. Before the workshop, participants completed a survey. Five overarching themes for facilitating and enhancing the user group's access and experience of UGS were identified:

- Enhancing cognitive accessibility
- Enrichment of the UGS for all members of the user group
- Importance of UGS visitors without autism being considerate, i.e. they need to be made aware that people with autism are a sensitive user group
- Making small changes to the UGS as the user group is sensitive to change
- Supporting the user group in preparing themselves for the UGS visit

Using a Miro board (www.miro.com), suggestions were made on how the five themes could be developed, either through changes to the physical environment or as activities to be carried out to prepare for the visit or during the visit. In the end, four specific actions were agreed on for the physical environment:

- Identifying suitable signposting for a path
- Providing access to toilets to accommodate basic needs
- Upgrading the BBQ area to ensure access for all members of the user group
- Implementing changes in vegetation management

After the co-design workshop, walking interviews were conducted in March 2022 to discuss the solutions from the co-design workshop on site.

2.5. Phase 3 – implementation of small interventions

During summer 2022, the following design solutions from the co-design workshop and walking interviews were implemented:

- Renovating of the BBQ area, including providing access for wheelchair users
- Renovating of benches throughout the area, as well as associated pruning
- Pruning of vegetation to improve accessibility and create sight lines
- Arranging access to toilets through the local allotment association
- Creation of the main intervention of 'the Peaceful Path'
  - o A sign showing a nine-piece jigsaw puzzle was put on bollards to guide the user along the path. Each bollard passed adds another piece to the puzzle until both the puzzle and the walk are complete. This may provide the user with a sense of excitement, but in an ordered and structured way.
  - o QR code on some of the bollards for further information and on-site activity suggestions
  - o Development of preparatory material to support users in preparing themselves for the UGS visit

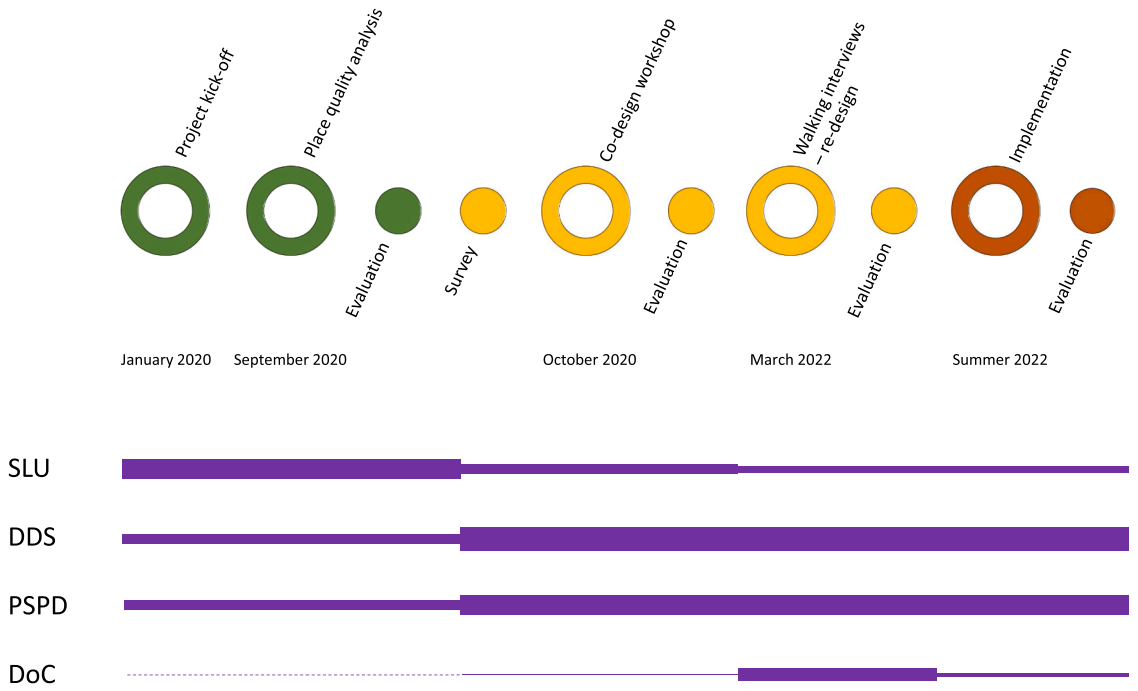


Fig. 3. Key phases and activities of the participatory process in the Malmö case. Green, yellow, and brown represent the analysis, design, and implementation phases respectively. Larger rings indicate major events, while smaller circles indicate intermediary activities. Purple bars show partner involvement where the width of the bar represents the partner's degree of involvement in each phase. SLU (Researchers), DDS (Department for Disability Support, pedagogues and support staff), PSPD (Properties, Streets and Parks Department, Landscape architects), DoC (Department of Culture, nature pedagogues).

3. Results of the literature review

3.1. Autism-friendly spaces

The term 'autism-friendly' is used in a number of contexts relating to situations rather than the physical environment, such as autism-friendly dental care (Kind et al. 2016), health care (O'Hagan et al., 2023), eye care (Parmar et al., 2022), public bus transport (Dirix et al., 2022), and that of teaching non-autistic people how to have a more autism-friendly attitude (Jones et al., 2021).

Within architecture, Mostafa (2008) was one of the first to demonstrate that altering indoor learning environments could increase attention span, improve response times, and reduce emotional dysregulation for children with autism. Building on sensory design theory, she developed the Autism ASPECTSS Design Index, a framework for creating autism-friendly homes, schools, and other built environments (Mostafa, 2014; 2015). This index identifies seven key design criteria: Acoustics, Spatial sequencing, Escape spaces, Compartmentalisation, Transition spaces, Sensory zoning, and Safety (Ibid.). Clouse et al. (2020) expanded the ASPECTSS framework by incorporating design considerations for all sensory modalities, emphasising the importance of flexible lighting options, natural materials, and effective ventilation in creating sensory-friendly environments (Clouse et al., 2020).

A literature review by Tola et al. (2021) on the autism-friendly built environment showed that the majority of existing studies concern the design of learning environments for school children with autism. Further, autism-friendly residential home environments, care environments and the indoor environment in general have been studied to some extent, while only three studies were found on the outdoor environment for people with autism and more specifically design of private sensory gardens (Tola et al., 2021). Black et al. (2022) conducted another scoping review on the topic, but unlike Tola et al. (2021), they focused solely on indoor environments. They identified key factors for autistic accessibility, including design and construction (e.g. building materials and ceilings), lighting, sound (e.g. disruptive noise from heaters and ventilation fans), aesthetics (e.g. patterns, colour, textures), indoor temperature and air quality (Black et al., 2022), i.e. mainly aspects non-applicable to UGS design.

Kenna (2022) calls for a widened research agenda within urban studies that moves beyond autism-friendly cities and attends to the multiplicity of neurodiversity more broadly, focussing on other neurodivergent neurotypes as well, e.g. ADHD, Sensory Processing Disorder (SPD), and dyspraxia. Urban planning should consider the diverse needs of neurodivergent people, including different sensory processing patterns, social communication styles, executive functioning approaches, coordination abilities, motor skills, and activity preferences (Kenna, 2022). Further, Kenna (2022) advocates expanding research beyond the design of closed or devoted indoor environments for people with autism, to consider the urban environment at large, including retail, transport and public space, to inform urban planning and policy. If environmental barriers that prevent neurodivergent people from fully accessing the city could be removed, such as inaccessible public transport design, this could positively impact their independence and quality of life by facilitating access to health care and participation in employment and education (Kenna, 2022).

Kinnaer et al. (2016) analysed autobiographies written by adults with autism in order to reveal what autism-friendly architecture can mean from the perspective of people with autism, thereby showing that the material environment cannot always be reduced to a set of design guidelines. While a number of concepts related to autism-friendly architecture found in the literature were also found in the autobiographies of people with autism, such single concepts can be interpreted in different ways, which means that concepts can reinforce but also counteract each other, thereby requiring a delicate balance (Kinnaer et al., 2016). As an example, some people with autism prefer open spaces since it affords an overview of an area, while others prefer the space to be subdivided into several separate spaces, reducing the sensory inputs in each smaller space (Kinnaer et al., 2016). Kinnaer et al. (2016) conclude that design guidelines do not necessarily cater for the needs and views of an individual and thus it is still important for designers to put design guidelines in a personal context. Similarly, Harris et al. (2024) emphasise that since each child with autism is unique and has

Table 1
The result of the place quality analysis that was conducted during phase 1 of the participation process in Malmö.

	Positive	Negative
Management:	The level of management is in line with the area's function, use and character	Worn down, though not unsafe equipment
Accessibility:	The park is easily accessible by walking or cycling and car parking is available nearby. There are multiple routes to the area used, which is beneficial for the user group who may experience autistic shutdowns, as they can adapt their visits using shortcuts. The entrances have potential for improvement, but it is important to balance this with not making them too welcoming for other user groups, since increased visitor frequency could make it impossible for people with autism to visit the UGS.	The location of the area at the edge of the city, surrounded by major roads, causes physical barriers to accessing it via public transport. Some paths have an uneven surface, which can make them challenging for people with limited mobility.
Nature:	There are odour experiences, but no negative smells are likely to occur. The area features mundane and natural vegetation, including a characteristic row of Swedish whitebeam and constructed mounds, providing a moderate level of biodiversity. There are different species of trees and opportunities to study and collect various berries, sticks and leaves of different shapes, among other things. Dead wood, mosses and a pond are present in the immediate vicinity. The area provides auditory sensory experiences through birdsong and the rustling of leaves in the wind.	There is some noise from the motorway, but it is considered less problematic for the user group as it is not sudden.
Facilities:	Bulltofta Park is a spacious UGS with various facilities in other parts. It includes a dog walking area where dogs can roam freely off the lead, which could be an asset for the user group. The park also offers opportunities for picnics and play. The area has a low frequency of visitors and lacks a designated place for social interaction. The area can be accessed throughout the year via the main paths and there are ample benches and bins available. Additionally, there is a designated BBQ area.	A dog walking area where dogs are allowed off the lead, which could be a challenge for the user group. Limited access in winter since smaller paths are not cleared of snow. Limited access after dark with only main paths lit up. Lack of toilets. Signs of areas used by school but unclear if it is regular and could cause a problem with too many people at those times.

different abilities, designers and architects should expand their scope of design from 'being accessible' to 'being more inclusive' for children on the spectrum, in order to make outdoor play spaces function for all users.

A majority of people with autism experience sensory processing differently related to vestibular, proprioception, tactile, audio, visual, and olfactory senses, resulting in extreme reactions to sensory input, where hypo-sensitive persons seek it, while hyper-sensitive persons avoid it (Gaudion and McGinley, 2012; Tola et al., 2021). People with autism identify the surrounding architectural environment based on both sensory and functional zoning, rather than the conventional functional zoning alone (Mostafa, 2008; 2014; 2015). While multi-functional UGS are called for to meet the needs of a wide range of user groups (Hansen et al., 2019), multifunctional spaces should be avoided to increase sensory clarity for people with autism (Mostafa, 2008).

3.2. The nine design aspects of autism-friendly public landscape architecture

Based on the 11 articles selected for in-depth analysis, Online Supplementary Material 1 presents an overview of aspects to consider when designing autism-friendly environments. It includes studies concerning indoor environments and housing architecture (Kinnaer et al., 2016; Mostafa, 2008; 2014; 2015); the built environment (Tola et al., 2021); the walkability of a city, studied using the example of a journey from a transport hub to a UGS (McAllister et al., 2022); private garden for adults with autism (Gaudion and McGinley, 2012; Lowe et al., 2014); outdoor environments for children with autism (Sachs and Vincenta, 2011); playgrounds (Harris et al., 2024); and UGS for children with autism (Li et al., 2019). In general, the literature on autism-friendly public landscape architecture is scarce, particularly for adults with autism. As argued by Li et al. (2019), if UGS are to be accessible to all, indoor environment design principles must be extended to such spaces. In line with this, we analysed the 11 selected articles and identified nine tentative design aspects of autism-friendly public landscape architecture:

1. **Select a location that is tranquil, quiet and accessible**, taking into account the physical, social and mobility aspects (Sachs and Vincenta, 2011; Tola et al., 2021). Noise from e.g. nearby traffic can be overwhelming (Sachs and Vincenta, 2011).
2. Different sensory processing styles require thoughtful design approaches to **create spaces that work well for both hypo- and hyper-sensitive users** (Gaudion and McGinley, 2012; Lowe et al., 2014). For example, those who are hyper-sensitive to touch would benefit from plants grouped into types of texture (i.e. coarse, fine, medium) or shape (i.e. spiky, round, oval) and introduced gradually, one type at a time, and would prefer paths without long grasses that might brush against users, as light touch can be uncomfortable (Gaudion and McGinley, 2012). Those who are hypo-sensitive, on the other hand, would prefer a wild UGS with a mix of coarse, fine and medium textures, touch-reactive plants and different types of tactile surfaces such as sand, crushed gravel or stone slabs along the paths (Gaudion and McGinley, 2012). Provide a variety of sensory experiences in some areas, while offering calmer spaces elsewhere (Li et al., 2019; Mostafa, 2008; 2014; 2015; Tola et al., 2021). This might be organised as 'sensory spaces' that offer various multi-sensory experiences related to all the senses (touch, sound, sight, smell, proprioception and vestibulation) through textures, light, colours and sounds, and 'escape spaces', where the user can retreat from too demanding situations (Kinnaer et al., 2016). Sensory and escape spaces complement each other (Kinnaer et al., 2016). Provide smooth, non-glare, wide pathways and surfaces to eliminate the feeling of crowding, and for those sensitive to textures and bright light, and provide plenty of shade, with trees and shade structures, for photosensitive users (Sachs and Vincenta, 2011). Those that have a hyper-sensitive vestibular sense, being anxious about heights or lacking depth perception, prefer slopes over steps (Gaudion and McGinley, 2012; Kinnaer et al., 2016).
3. Provide **escape spaces** to allow for refuge from intense sensory environments, support emotional regulation and reduce anxiety (Gaudion and McGinley, 2012; Harris et al., 2024; Kinnaer et al., 2016; Li et al., 2019; Lowe et al., 2014; McAllister et al., 2022; Mostafa, 2008; 2014; 2015; Tola et al., 2021). In such small, quiet spaces, the user can enjoy the feeling of enclosure and re-centre when needed, or observe activities from a distance until ready to participate (Kinnaer et al., 2016; Sachs and Vincenta, 2011). Escape spaces

should be small, defined, neutral in terms of sensory environment, easily accessible (Mostafa, 2008; 2014; 2015; Tola et al., 2021), peripheral to communal areas (Gaudion and McGinley, 2012; Lowe et al., 2014), have greenery and comfortable street furniture, and be free of bright, fluorescent lighting (McAllister et al., 2022). A bamboo tunnel or a low growing tree to hide beneath could create an escape space (Sachs and Vincenta, 2011). While the escape space should provide a calm sensory environment (Mostafa, 2008; 2014; 2015; Tola et al., 2021), temporary or mobile elements of sensory stimulus could be provided for those who seek additional sensory input (Mostafa, 2008; 2014; 2015).

4. Provide **transition spaces** between spaces with different sensorial experiences, level of sensory stimuli and character to support users in adjusting their senses as they move between spaces and prepare for the move to or from an area of high sensory activity (McAllister et al., 2022; Mostafa, 2008; 2014; 2015; Sachs and Vincenta, 2011; Tola et al., 2021). Transition spaces make the transition between different sensory zones more fluid (Mostafa, 2008; 2014; 2015).
5. **Compartmentalisation**: Provide a variety of spaces within the UGS (Gaudion and McGinley, 2012). Then, if one part of the UGS becomes too intense for users, they can move to a more serene area within the overall space (McAllister et al., 2022). This design creates a more comfortable experience of a large UGS for users (McAllister et al., 2022) and provides while allowing control over sensory input in each space (Kinnaer et al., 2016). With compartmentalisation of a space, users with hyper-visual and hyper-auditory processing can better focus on their chosen activities (Mostafa, 2008; 2014; 2015). It also supports people with autism who process foreground and background sounds differently (Kinnaer et al., 2016). Spaces could be organised in a series of monofunctional compartments, designed for specific activities and smaller groups of users, as this allows people to engage with optimal levels of sensory and social input for their preferred activities (Mostafa, 2008; 2014; 2015). These compartments can be delineated from each other in various ways to enhance user comfort and control, from the use of walls for full enclosure, to the placement of furniture and variations in levels for moderate enclosure, to the use of different colours, patterns or materials for a minimalist definition of each space (Harris et al., 2024; Mostafa, 2008; 2014; 2015). The sensory qualities of each space should be used to define its function and separate it from neighbouring compartments (Mostafa, 2008; 2014; 2015). For enhanced sense of control, there should be sufficient exits to leave a space, while maintaining enough enclosure to provide comfort, since controllability can feel reduced in very open areas (Kinnaer et al., 2016). That said, some people with autism prefer an open space because it affords an overview, thereby increasing predictability (Kinnaer et al., 2016). Ensuring visual connections between all components of the space offers an alternative way to maintain overview (Tola et al., 2021).
6. **Predictability and visual cues**: Provide a clear, simple and well-defined spatial structure to enhance predictability (Tola et al., 2021). Many people with autism prefer predictable environments and may find unexpected changes stressful (Sachs and Vincenta, 2011). Spaces that are visible from other areas and circulation routes increase the predictability of social interactions and provide users with choices (Gaudion and McGinley, 2012; Lowe et al., 2014). Including some elements of consistency, such as a hedge or stone wall, creates a predictable pattern in the space (Sachs and Vincenta, 2011). If the spatial and furniture arrangement in a space is always the same, the user is provided with visual cues that facilitate prediction of what activity that will take place there (Mostafa, 2008; 2014; 2015). Compartmentalisation reinforces this predictability (Mostafa, 2008; 2014; 2015). Use patterns, colours, abstractions or pictograms to create signage with clear, simple pictures to communicate the character and intended use of various spaces to help people navigate (Sachs and Vincenta, 2011; Tola et al., 2021). Similar visual supports can be used to report potentially critical situations, such as stairs or slopes (Tola et al., 2021). Use architectural elements to help orientation and navigation, e.g. noticeable junctions to create districts and visually distinctive landmarks (e.g. fountains) at the hub of each space, indicative of its character (Kinnaer et al., 2016; Mostafa, 2008; 2014; 2015). Paths and visual markers such as signposts and visual orientation maps that illustrate the layout of the UGS let users know where they are and what to expect next, thereby enhancing predictability (Gaudion and McGinley, 2012; Lowe et al., 2014). Use a similar visual concept for signage throughout the space to allow people with autism a sense of orientation and ability to navigate through it independently (Mostafa, 2008; 2014; 2015). In addition to visual support, diverse and clear sensory cues that address smell, sound and touch can help users interpret and understand the spaces they are in and their intended function (Gaudion and McGinley, 2012; Harris et al., 2024; Lowe et al., 2014).
7. **Sensory hierarchy of spaces**: The built environment is typically organised by function, but when designing inclusively for people with autism, spaces should be organised by both function and sensory level (Mostafa, 2015; 2014; 2008). Provide a hierarchy of spaces (Tola et al., 2021) to let users themselves choose the type and level of social interaction and sensory stimulation (Gaudion and McGinley, 2012; Kinnaer et al., 2016; Lowe et al., 2014). Desirable areas should be easily accessible, while less desirable areas, such as unsafe places, should be made more difficult to encounter by chance (Gaudion and McGinley, 2012). Sequence activities and functions and arrange them to follow a 'one-way', or at least clear, circulation pattern (Mostafa, 2008; 2014; 2015; Sachs and Vincenta, 2011). Use sensory zoning, i.e. group spaces with similar levels of sensory stimulation together, into high, moderate and low stimulation spaces with transition spaces between these zones (Mostafa, 2008; 2014; 2015). Design spaces with clear, defined functions rather than universal or multifunctional spaces, to support predictability and sensory clarity (Mostafa, 2008; 2014; 2015).
8. **Familiarity, something to hold on to**: Familiarity, e.g. a type of object that reoccurs in different environments, including those that are new to the person, could create continuity in the environment for people with autism (Kinnaer et al., 2016). This familiarity facilitates social interaction, as the individual does not have to survey the entire room and can instead concentrate on interacting with people (Kinnaer et al., 2016). While, for example, the implementation of clear and consistent signage could create predictability (aspect 6) within a UGS, familiarity is not achieved unless this signage is replicated across other UGS. This gives UGS managers a key role in creating conditions for familiarity in UGS. In some situations, people with autism may experience differences in proprioceptive awareness – how their body relates to the surrounding space (Kinnaer et al., 2016). Then something to literally hold on to, such as a fence, can both offer a way of positioning oneself in space and act as a reference point, supporting navigation of unexpected events that may arise in daily life (Kinnaer et al., 2016).
9. **Safety**: Environments and materials should be safe, durable, flexible in their use, and easy to maintain, while still being aesthetically pleasing and comfortable (Kinnaer et al., 2016; Mostafa, 2008; 2014; 2015). Designing safe spaces and managing access to potentially hazardous areas is important, especially considering that some people with autism have strong sensory seeking needs or may process risk information differently (Gaudion and McGinley, 2012; Harris et al., 2024; Lowe et al., 2014; Mostafa, 2008; 2014; 2015; Tola et al., 2021). Provide smooth paving to prevent falls and support safe navigation for people with autism who have coordination differences (Li et al., 2019; Sachs and Vincenta, 2011). Some people with autism may process spatial information such as distances or vehicle speed differently, which can affect navigation decisions when crossing the street (Kinnaer et al., 2016). To enhance road safety, add signs with

easily understandable images at road crossings (McAllister et al., 2022).

3.3. Exploring the relevance of the nine design aspects to practice

To explore the practical relevance of the nine design aspects identified in the literature, we assessed whether these aspects were aligned with those employed by practitioners with expertise in autism and UGS management who sought to create a more autism-friendly UGS in the Malmö case. High consistency could suggest that the nine design aspects can be implemented in a UGS in practice, indicating their potential usefulness and applicability for autism-friendly redesign of existing UGS.

The nine aspects found in the literature could all be identified in the design of the Peaceful Path, with the exception of *transition spaces*. Fig. 4 shows which part of the Peaceful Path design could be said to correspond to each of the remaining eight design aspects. The UGS is located on the outskirts of the city, has a low visitor frequency relative to its size, and is easily accessible on foot, by bicycle, by public transport or from the adjacent car park, i.e. it is *1) A location that is tranquil, quiet and accessible*. The path and its closest surroundings are low on sensory stimuli, thereby accommodating *2) Hyper-sensitivity*. An early proposal to alter the vegetation management and create a meadow with mown paths was not implemented due to concerns that it would attract insects and change in appearance throughout the year, which could distress hyper-sensitive users. A QR code placed on some of the bollards along the path links to a website with a brief description of the Peaceful Path. *2) Hypo-sensitivity*, could possibly be accommodated by providing suggestions here for activities that engage different senses. In two places along the path, *3) Escape spaces* are provided, or more precisely escape routes, for users who experience intense sensory environments when following the path.

City of Malmö did not design any element along the Peaceful Path that could be interpreted as *transition spaces* (Aspect 4). In Bulltofta Park, *5) Compartmentalisation* was achieved by creating a variety of spaces within the overall UGS with varying levels of sensory stimuli between spaces: the path along a delimiting row of Swedish whitebeam trees, two other parts of the path somewhat more frequently visited by the public, and the barbecue area in the northern part (the most socially intense area when used by a group). An important part of *6) Predictability* is not visible in the physical environment, but pictures or written material about the UGS can enable people with autism to prepare themselves in advance of a visit. Supporting the user group in preparing themselves for the UGS visit and enhancing cognitive accessibility were two of the themes identified during the co-design workshop. These needs were partly addressed through the creation of a homepage offering

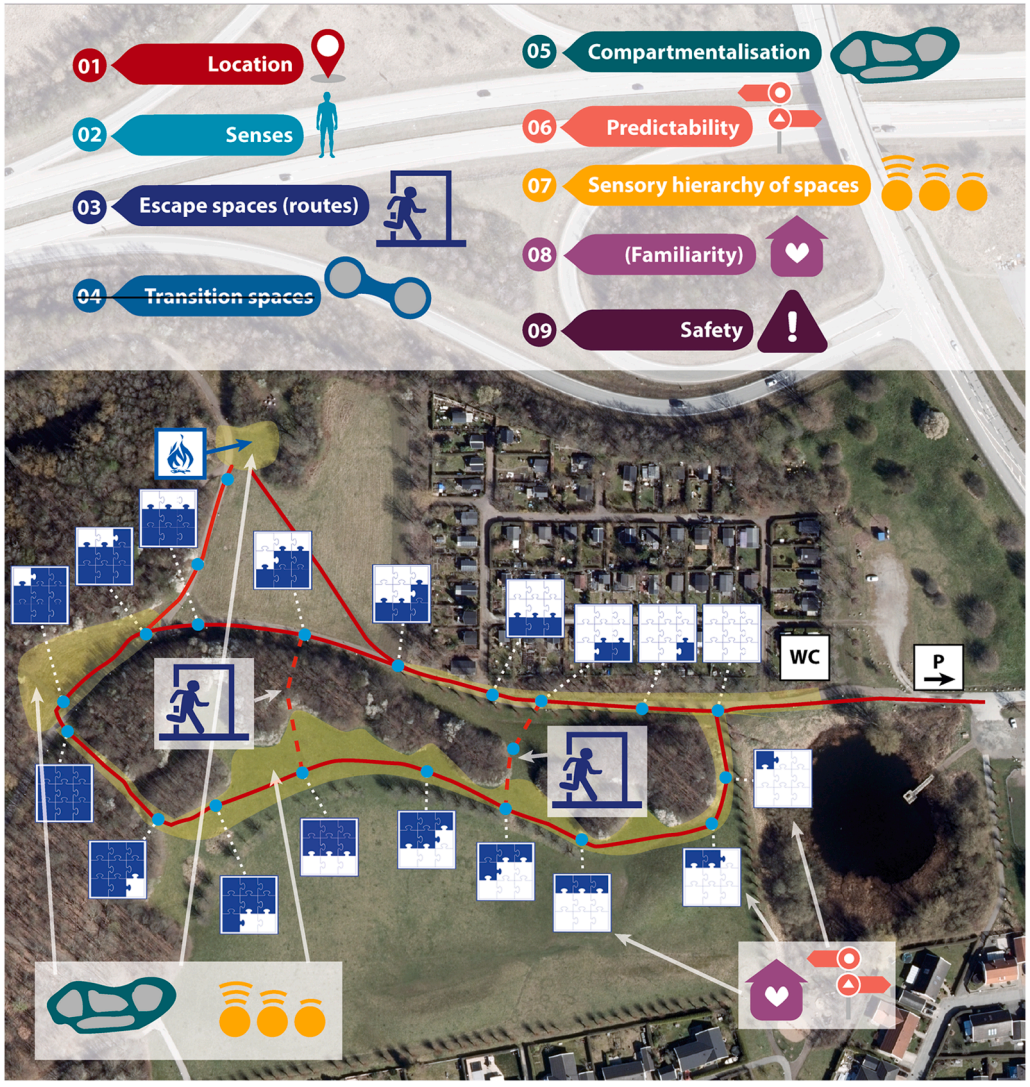


Fig. 4. Plan of the Peaceful Path in Bulltofta Park, showing which part of the design could be said to correspond to which of the nine aspects of autism-friendly public landscape architecture identified in the literature. Aspect 4 (transition spaces) could not be identified in the design.

preparatory material, including descriptions of the Peaceful Path and the site and what sensory experiences to expect there, as well as activity suggestions. The predictability around the Peaceful Path is further enhanced by *6) Visual cues* in the form of bollards with a sign showing a nine-piece jigsaw puzzle to guide the user along the path, with each bollard passed adding another piece to the puzzle, until both the puzzle and the walk are complete. The jigsaw puzzle piece is one of the symbols commonly associated with autism. It is a controversial symbol as it is associated with mystery by some, while others see it as outdated and stigmatising. For this reason, the idea of using it was initially rejected when it was first discussed within the municipality. However, later in the process it was rediscovered and all involved stakeholders agreed to use the puzzle piece to make a jigsaw puzzle, as this created a simple and clear activity to be carried out during the walk.

Aspect *7) Sensory hierarchy of spaces* is closely related to compartmentalisation. Through the signage on bollards, the functions along the Peaceful Path are arranged to follow a clear circulation pattern. The barbecue area is likely the space with the greatest sensory stimuli (when occupied), while the path between the vegetation and the allotment garden area has a medium sensory level and the path along the row of trees has the lowest level. The location of the barbecue area, off to the side of the main part of the Peaceful Path, increases predictability for the user and reduces the risk of encountering this area by accident. If the City of Malmö decides to reuse the bollards with the nine-piece puzzle sign in other UGS in the future, the signage could become the necessary object that recurs in different environments, creating *8) Familiarity* and continuity in the environment for a person with autism. Ensuring that environments and materials are safe, durable, tolerant of unintended use, and easy to maintain, while still being aesthetic and comfortable, is an inherent part of planning, design and management of UGS. Thus, aspect *9) Safety* for the Peaceful Path is addressed in the choice of benches along the path and the design of the barbecue area. Further, there are no evident hazards in the area, such as hills with steep verges or heavy traffic close by. Part of the Peaceful Path has smooth paving, while part of it runs over a lawn.

4. Discussion

4.1. Autism-friendly vs. general public landscape architecture

There is an increasing demand for multifunctional UGS (Hansen et al., 2019), which may sound difficult to combine with the fact that some people with autism need monofunctional spaces to increase sensory clarity (Mostafa, 2008). Social multifunctionality, where different user groups use the same UGS, has been found to be more easily achieved in non-programmed spaces (e.g. an open lawn, a shrubbery), whereas programmed elements that have a predefined intended use (e.g. a playground, a bridge, a fence) make the target user group feel welcome, while other groups may feel excluded from the space (Sundevall and Jansson, 2020). While a private therapeutic garden for people with autism is a programmed space, a UGS should meet the needs of a wide range of user groups and therefore needs to be unprogrammed to a greater extent. Therefore, as the Peaceful Path was created in an existing UGS, a conscious decision was made to create an autism-friendly but non-programmed space so as not to stigmatise the group and make it only for people with autism. Thus, the area around the Peaceful Path is still a multifunctional space. Here, design aspect *1) Select a location that is tranquil, quiet and accessible* is crucial in order to make the space autism-friendly. While a multifunctional, heavily visited UGS in the city centre is not autism-friendly, a person with autism might be able to visit a multifunctional UGS on the outskirts of a city that is unprogrammed and has low visitor numbers.

The nine design aspects of autism-friendly public landscape architecture identified in this study partly build on studies of interior architecture. It is plausible that differences exist between indoor and outdoor environments in how functions and spaces are experienced. UGS have been found to have restorative properties and can have significant positive effects on public health when they are easily accessible and free from demands and stress (Grahn and Stigsdotter, 2003), while indoor environments do not automatically provide such benefits. Here, people with autism may find multifunctionality less of a problem outdoors than indoors. While 'open-plan' classrooms should be avoided in an autism-friendly school to increase sensory clarity (Mostafa, 2008), available functions are not as visible in a non-programmed multifunctional UGS and are thus less confusing. Instead, each user only sees the functions that the UGS offers them (e.g. a shading tree) and is not necessarily disturbed by functions offered to other user groups (e.g. a tree for climbing). That said, compartmentalisation and sensory hierarchy of spaces are important to increase predictability and sensory clarity in an autism-friendly UGS.

Several of the design aspects of autism-friendly landscape architecture are likely to benefit all user groups, for example *5) Compartmentalisation* of a large UGS and enhancement of *6) Predictability*. Working with a public space, landscape architects already need to address *9) Safety*, choosing plants and materials that are safe, durable and tolerant of unintended use, as well as providing smooth paving. Other aspects, such as *7) Sensory hierarchy of spaces* or *8) Familiarity*, could likely be integrated in UGS design without jeopardising qualities important to other user groups. It is important to design *3) Escape spaces* surrounded by vegetation in a way that does not negatively affect perceived safety in the UGS.

According to Fors et al. (2018), there are four central aspects of UGS quality from a general user perspective: *maintenance*, where the level should relate to the desired function and character of the area; *accessibility* to and within the UGS; *nature*, both to support biodiversity and to enable people to experience nature; and *facilities* such as paths, toilets, benches. While these aspects are important for users with autism as well, they do not cover specific needs of people with autism. In order to make UGS accessible to all, including traditionally marginalised groups, a UGS sometimes requires redesigning and adaptations. User participation can be a valuable tool for identifying adaptations to UGS that meet the needs of the user group (Fors et al., 2021). The nine aspects are well-founded in the literature, but as Kinnaer et al. (2016) emphasised, design guidelines may still require local interpretation and adaptation through user involvement. Fig. 5 provides a concise overview of the nine design aspects of autism-friendly public landscape architecture. This can be used to facilitate discussion and guide a diverse group of actors in a co-design process aiming to adapt the aspects to the local context and needs of the individuals who are to use the UGS at hand.

When managing UGS for people with autism, it is crucial to consider their sensitivity to change and make major changes cautiously. This sensitivity also limits opportunities to return and adjust changes made to the UGS. It is therefore essential to ensure careful implementation in the physical UGS to get things right the first time.

4.2. Study limitations

Our analysis showed that the nine aspects of autism-friendly public landscape architecture were to a large extent aligned with those employed by the practitioners in the Malmö UGS redesign; all aspects but transition spaces could be identified in the design of the Peaceful Path. This indicates the potential usefulness and applicability of the nine design aspects for autism-friendly redesign of existing UGS. However, further studies are still needed of how to operationalise the nine design aspects to make UGS more autism-friendly and to explore how cultural and geographic factors, as well as local context, may influence implementation. In the Malmö intervention, the LSS accommodation staff were consulted, as involvement of people with autism in a design process requires collaboration between the person with autism, support staff and the designer (Gaudion et al., 2015), combining place-specific and user group-specific needs. However, it was not possible to involve people with autism themselves, partly because the design intervention

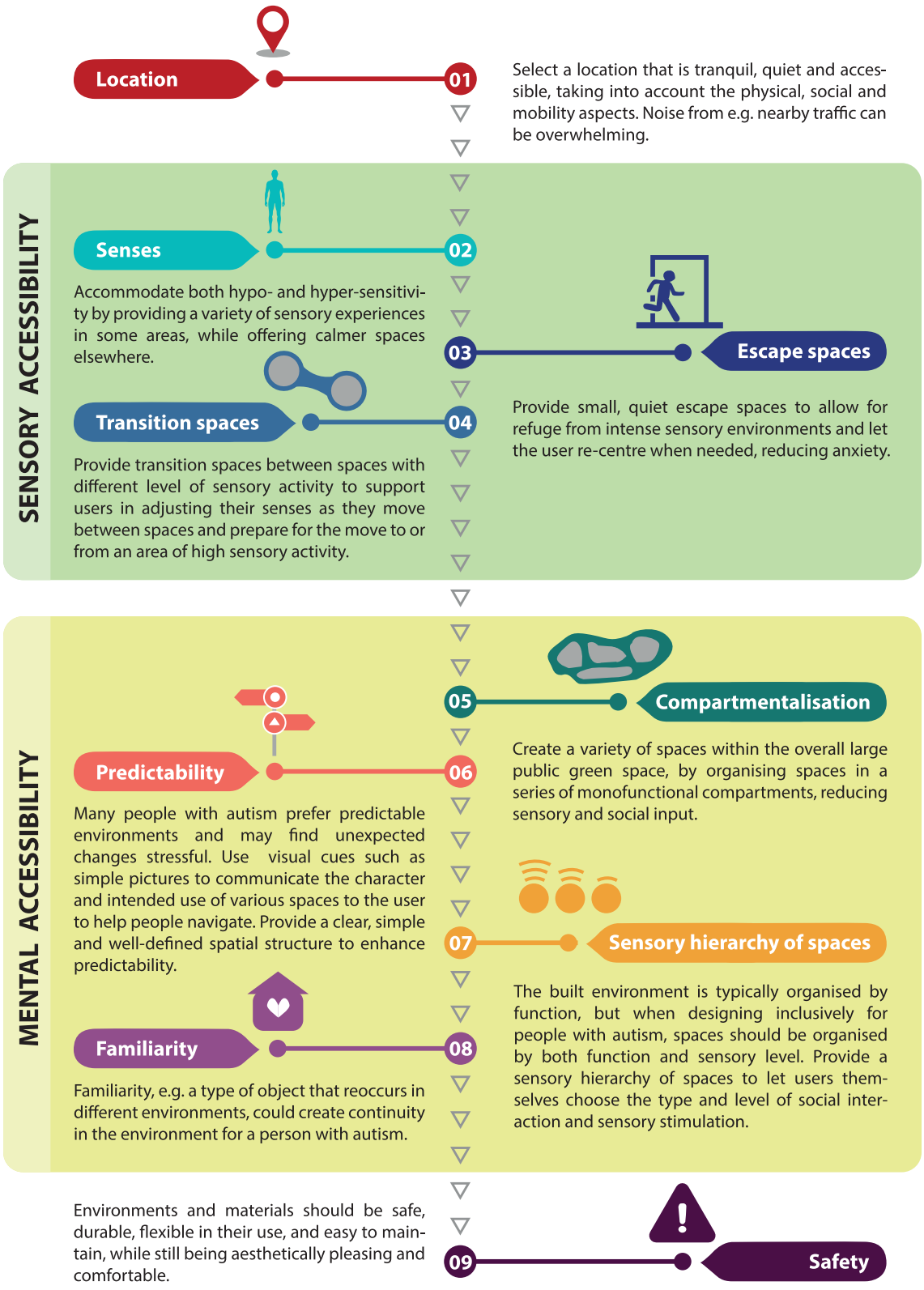


Fig. 5. A condensed overview of the nine design aspects of autism-friendly public landscape architecture. This description aims to provide guidance to practitioners who wish to redesign a UGS for it to become more autism-friendly. When used by a diverse group of stakeholders with joint knowledge on the local needs of people with autism, UGS design and management and other relevant topics, this description of the nine design aspects could serve as an outset for discussions in the group to ensure that all key aspects of autism-friendly public landscape architecture are considered in the co-redesign of the UGS. These discussions could help the group develop a shared understanding of the possibilities and challenges involved in redesigning the UGS in question.

was carried out during the Covid-19 pandemic. Participatory processes that include the lived experience of design and architecture by people with autism have to date been limited, with the rare exception of studies by Gaudion et al. (2015) and Kinnaer et al. (2016). Had the user group been directly involved, the design of the Peaceful Path might have been different. To fully validate the nine aspects would require undertaking a redesign of a UGS guided by the nine aspects, followed by a post-occupancy evaluation together with site users with autism, but neither was done as part of the current study.

4.3. Future development of autism-friendly public landscape architecture

The term 'autism-friendly' is used in various contexts, such as health care and public transport, to describe situations rather than physical environments (Dirix et al., 2022; Jones et al., 2021; Kind et al., 2016; O'Hagan et al., 2023; Parmar et al., 2022). This is also the case for autism-friendly public landscape architecture, where the study showed that enabling visitors with autism to prepare mentally for the UGS visit is just as important as the visit itself and crucial for it to be autism-friendly. While it must be recognised that the needs of people with other neurodivergent conditions may be very different from those of people with autism, the nine aspects could potentially be further developed to better attend to the multiplicity of neurodiversity more broadly, taking into account the needs of people with other neurodivergent conditions as well, such as ADHD, SPD and dyspraxia, as advocated by Kenna (2022).

While there were escape routes along the Peaceful Path, a further improvement could be to add escape spaces within the UGS, allowing users to go into seclusion and recalibrate their senses before returning to the space, instead of having to leave the UGS totally. The development of well-functioning escape spaces in UGS that do not negatively affect other user groups is yet to be achieved.

Accommodating hyper- and hypo-sensitivity is an aspect that the City of Malmö dealt with to some extent. The Malmö intervention was designed to work within existing management and budgetary constraints by making small changes to an existing UGS and developing the existing vegetation through maintenance. Therefore, no additional vegetation was planted along the Peaceful Path. The choice of materials and plants depends on several factors, such as the available budget for UGS development, the conflicting needs of different UGS user groups, and the importance of plant selection in supporting climate adaptation and biodiversity. For example, a particular choice may support a particular user group, but result in reduced climate adaptation. In the future development of autism-friendly public landscape architecture, the selection of suitable plant species and materials could be further explored with these different perspectives in mind. With its guidance on how to accommodate hyper- and hypo-sensitivity related to different senses when choosing materials and plants for a private sensory garden for adults with autism, Gaudion and McGinley (2012) is one of several documents that could be used to guide such discussions.

Of the nine design aspects, *transition spaces* was the only one that could not be identified in the Malmö UGS redesign. In indoor environments, there may be large differences in sensory stimuli between different rooms, e.g. between a classroom for music practice and a library in a school for people with autism. The need for transition spaces between such areas is evident. That gardens have been suggested as suitable transition spaces (Mostafa, 2014) raises the question of whether transition spaces are more important in indoor environments than outdoors. Further studies are needed of how the level of sensory stimuli varies within UGS and to what extent transition spaces are needed in outdoor environments for people with autism to help users adjust their senses as they move between different parts of the UGS.

5. Conclusions

In this article, we have identified nine tentative design aspects of autism-friendly public landscape architecture in the scientific literature. These are 1) Select a location that is tranquil, quiet and accessible; 2) Accommodate both hypo- and hyper-sensitivity; 3) Provide escape spaces; 4) Provide transition spaces; 5) Compartmentalisation; 6) Predictability and visual cues; 7) Sensory hierarchy of spaces; 8) Familiarity, something to hold on to; and 9) Safety.

Further, we explored the practical relevance of the nine design aspects identified in the literature by evaluating their alignment with the design of an autism-friendly path in a UGS in Malmö, Sweden, created by practitioners. Our analysis showed that the nine aspects of autism-friendly public landscape architecture were largely consistent with those employed by practitioners in the Malmö UGS redesign. This suggests that the nine design aspects can be implemented in a UGS in practice, which indicates their potential usefulness and applicability in redesign of existing UGS for increased autism-friendliness. Further studies of these aspects are necessary to explore how autism-friendly UGS differ from private gardens and the more extensively studied indoor environments. Additionally, more knowledge is needed on how to operationalise the nine identified aspects to make UGS more autism-friendly, and how this implementation is affected by cultural, geographical and local contextual factors.

CRediT authorship contribution statement

Hanna Fors: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Åsa Ode Sang:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Petra Bengtsson:** Writing – review & editing, Resources, Investigation. **Jessica Svännel:** Writing – review & editing, Investigation. **Randrup Thomas B:** Writing – review & editing, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Given his role as a member of the editorial board of the journal of Urban Forestry & Urban Greening, Thomas B. Randrup had no involvement in the peer review of this article and had no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to another journal editor. The other 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.

Acknowledgement

This research has been funded by Sweden's innovation agency Vinnova, project 2018–04141 *Tools for inclusion and accessibility to urban green spaces*. The authors would like to thank the involved persons from the City of Malmö and Living Cities and Communities, who all contributed to this study.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2025.129181.

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