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CONFERENCE PAPER

Identifying spatial characteristics to design restorative Neighbourhood Open Spaces for older adults

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ABSTRACT

As society ages, planners, designers and policymakers must consider how to (re)design neighbourhoods that support older adults' mental health. Restorative neighbourhood open spaces can reduce stress and attention fatigue, yet current knowledge is based mainly on research with younger adults. Given the changing needs of older adults, restorative environments may require different design strategies. This study explores how to design neighbourhood open spaces that promote psychological restoration for older adults, focussing on identifying spatial characteristics that promote attention restoration and reduce stress. Forty independently living older adults from the Netherlands (M_{age}=79,9) were interviewed about their preferred restorative environment. Through visual content analysis of 360-degree imagery of these environments, 64 key environmental characteristics were identified and compared with current literature. While characteristics such as water, greenery, and boundary elements aligned with previous research, unexpected characteristics emerged as particularly important for older adults, including elevated vantage points, spaces for social interaction and open views. Interestingly, many participants preferred (sub)urban environments near their homes over natural settings. These findings challenge existing literature on restorative environments and suggest additional spatial characteristics may be considered when designing restorative neighbourhood open spaces to support older adults' mental health.

Keywords: Restorative environments; Older adults; Spatial analyses; Neighbourhood Open Space design; Mental health

1. INTRODUCTION

By 2050, the global population of individuals aged 60 and over is expected to double to nearly 2.1 billion (WHO, 2022), posing a challenge for planners, designers and policymakers to (re)design neighbourhoods to support the ageing population (van Hees, 2017; van Helder et al., 2020; Yasamy et al., 2013). As individuals age, they experience changes in their physical abilities, social needs, and mental health, impacting their overall well-being (Garin et al., 2014; Hooyman & Kiyak, 2014; Ten Bruggencate et al., 2018). Older adults are more susceptible to mental fatigue due to physiological changes in cognitive structures (Jansen, 1997, 2008) and are more vulnerable to environmental stressors (Almeida et al., 2011; Evans, 2003). Therefore, it is crucial to design environments that consider these changing needs and capabilities and support older adults' mental health (Bornioli & Subiza-Pérez, 2022; Collado et al., 2017; Roe & McCay, 2021).

From earlier studies, we know that neighbourhood open spaces (NOS), such as community gardens and village squares, can positively impact the health of residents (Van Hecke et al., 2018; Weber & Trojan, 2018). This also applies to older residents, for whom NOS close to their homes can offer significant health benefits (Aspinall et al., 2010; Schmidt et al., 2019; Sugiyama et al., 2009). However, current research primarily focuses on designing NOS for older adults that promote physical and social health (Aspinall et al., 2010; Schmidt et al., 2019; Sugiyama et al., 2009), less attention is given to mental health of older adults (Garin et al., 2014; Roe & Roe, 2018; Zhu et al., 2021). To (re)design healthy neighbourhoods for older adults, age-related changes must be taken into account, prioritising mental health through thoughtful environmental design (Aneshensel et al., 2016; Moore et al., 2020; Oswald & Wahl, 2004).

Restorative environment theories – Attention Restoration Theory (ART) (Kaplan & Kaplan, 1989) and Stress Recovery Theory (SRT) (Ulrich, 1984; Ulrich et al., 1991) – offer insights into designing these mental health-promoting environments (Bornioli & Subiza-Pérez, 2022; Roe & McCay, 2021). Both theories propose that certain environmental characteristics can reduce stress and renew or recover adaptive resources, thereby promoting psychological well-being through the process of psychological restoration (Hartig, 2004; Kaplan & Kaplan, 1989; Ulrich et al., 1991). ART suggests four environmental characteristics that do so: 1) Compatibility, 2) Fascination, 3) Extent and 4) Being-away (Kaplan & Kaplan, 1989; Kaplan, 1995; Staats, 2012). SRT proposes seven different environmental characteristics for it to be stress restorative: 1) Complexity – a balance between structured and unstructured elements, 2) Structural properties, 3) Depth, 4) Ground surface, 5) Deflected vista, 6) Absence of threat, and 7) Presence of water (Ulrich, 1984; Ulrich et al., 1991). Despite their differences, both theories are often used simultaneously to examine mental health effects of restorative environments (Hartig, 2021; Staats, 2012).

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Although existing studies provide evidence that NOS can indeed offer restoration to citizens, there is a notable lack of research specifically focused on how to design restorative NOS to promote the mental health of older individuals. A recent literature review by Grave and colleagues (2024) found only three studies involving older participants (Fumagalli et al., 2020; Lu et al., 2022; Qiu et al., 2021). These studies highlight that specific spatial characteristics – such as seating, ground cover and site facilities – promote psychological restoration for the older population significantly more than for the general population (Lu et al., 2022; Qiu et al., 2021). Other factors identified by these studies are the permeability of spaces and the openness of building arrangement. The studies suggest that openness and prospect (ability to see and observe distant surroundings) are of higher importance for older people than for younger individuals (Lu et al., 2022; Qiu et al., 2021).

This study examines whether these previous findings apply to Dutch older adults and if other spatial characteristics of NOS can be identified that promote psychological restoration of older adults. With this knowledge, we want to learn how to design restorative NOS that can promote older adults' mental health by offering psychological restoration. We aim to answer the following research question: *What spatial characteristics are present in restorative neighbourhood open spaces preferred by Dutch adults aged 70 and older?* During the study, we will focus on preferred restorative environments. Existing literature demonstrates a strong link between restorative experiences and favoured places (Korpela, 2001; Korpela & Hartig, 1996; Scopelliti & Giuliani, 2004) and shows that people of all age groups are adept in describing their favourite places (Korpela, 2001; Nordh et al., 2017). This study will analyse older adults' preferred restorative NOS and identify the spatial characteristics that promote restoration, providing valuable insights to aid designers in designing restorative NOS that can promote older adults' mental health.

2. METHODS

2.1 Study design

A visual content analysis was conducted to identify the spatial characteristics of NOS that can promote restoration for older adults. Visual content analysis is a way of classifying visual elements into different groups (Hao et al., 2016; Langmann & Pick, 2017; Raaphorst et al., 2020; Rose, 2022). This categorisation helps to make sense of the significance of characteristics if they repeatedly recur in environments (Hao et al., 2016; Rose, 2022). This study follows the four steps of visual content analysis set out by Rose (2022): 1) Finding images (case study selection), 2) Devising your categories for coding, 3) Coding the images, 4) Analysing the results in order to achieve replicable and valid results.

2.2 Case study selection of restorative neighbourhood open spaces

The first step in the visual content analysis was the selection of restorative NOS through participant interviews. Forty independently living older adults from the Netherlands (M_{age}=79,9) were asked to describe their favourite restorative environment. Images of these preferred environments were used for the visual content analysis and are the focus of this study. Older adults' descriptions of the preferred restorative environments will be reported in another study. The interviews were conducted with written consent from participants and approval from Eindhoven University of Technology ethics boards.

Figure 1 illustrates the research procedure.

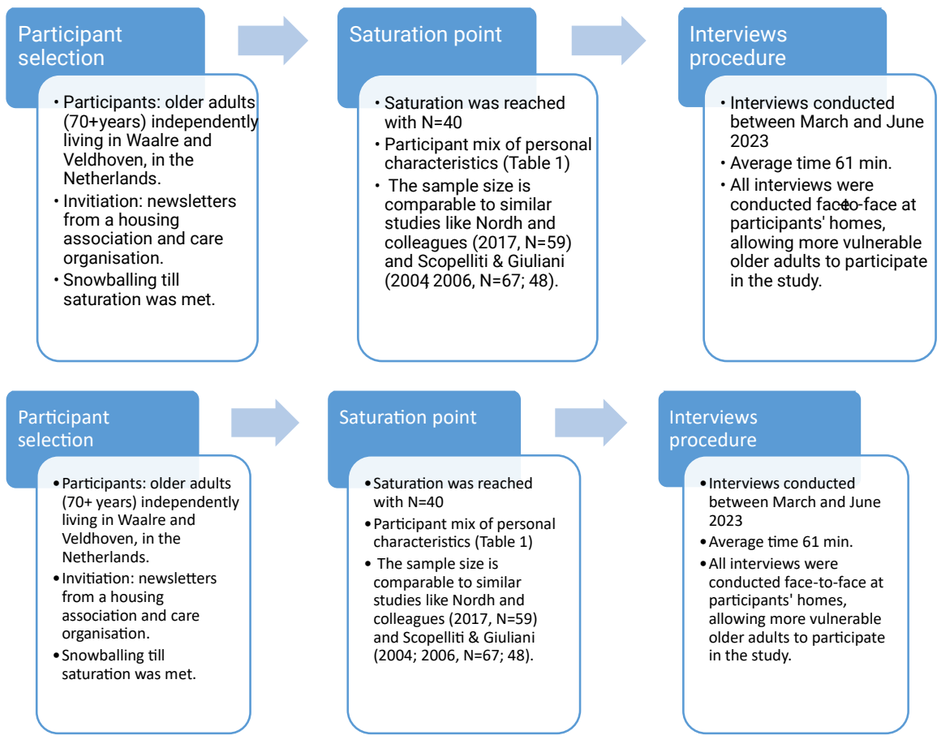

Figure 1. Research procedure to select the case study environments.

Interview questions were developed based on existing literature (e.g. Nordh et al., 2017; Subiza-Pérez, Korpela, et al., 2021; Subiza-Pérez, Pasanen, et al., 2021) and pilot interviews (N=7) conducted in the summer of 2022. The first part of the interview aimed to build rapport between the interviewer and participant and gather personal information. Thereafter, participants were asked to reminisce about a day when they were mentally depleted and stressed. Then, they were requested to indicate their most preferred actual outdoor environment where they would like to go to restore and recharge. This approach was chosen based on prior research suggesting a strong connection between restorative experiences and favoured places (Korpela, 2001; Korpela & Hartig, 1996; Purcell et al., 2001; Scopelliti & Giuliani, 2004).

Twenty of the preferred restorative NOS were located near participants' homes. For these environments, the first author visited and photographed them, in June 2023, using a 360-degree Ricoh Theta camera. For the remaining environments (N=20), 360-degree images were obtained via Google Street View. All images, captured at eye level, are accessible for virtual analysis in a 360-degree viewer (Ricoh Theta), allowing researchers to examine the environments virtually from various angles.

Table 1. Socio-demographic profile of the participants

Demographics	(N=40)	Frequency	Percentage
Sex	Female	25	62.5
	Male	15	37.5
Age (M_{age} = 79.9)	70-79 years	24	60
	80-89 years	14	35
	90+ years	2	5
Frailty score	Not frail	22	55
	Frail	18	45
Being stressed last month		21	52.5
Family composition	Living alone	15	37.5
	Living with spouse	25	62.5
Living situation	Apartment with no outdoor space	4	10
	Apartment with outdoor space	8	20
	Terraced house and/or semi-detached	17	42.5
	Free standing house	11	27.5
Socio-economic status	Low	13	32.5
	High	27	67.5
Average social activities per week	Less than 1 activity	3	7.5
	1-2 activities	4	10
	3-4 activities	14	35
	5-7 activities	13	32.5
	More than 7 activities	6	15
Experience feelings of loneliness		20	50
Urban-nature orientedness	Urban oriented	15	37.5
	Neutral	4	10
	Nature oriented	20	50
Mobility	Low mobility	14	35
	Moderate mobility	8	20
	High mobility	18	45
	Can drive car	22	55
	Can ride bike	18	45
	Can walk without support	18	45

2.3 Devising coding categories

For the content analysis, a codebook was developed based on spatial characteristics promoting psychological restoration in NOS for younger individuals, incorporating 32 characteristics identified by Grave and colleagues (2024). The codebook was expanded with spatial characteristics from the IEPRUEscale (a systematic social observation tool) (Subiza-Pérez et al., 2019), resulting in a final version of the codebook with 39 spatial characteristics known to promote restoration in NOS across diverse populations.

2.4 Coding the images and analysing the results

The visual content analysis was done by four experts in architecture, urbanism and socio-gerontology, who examined the forty visual images of older adults' preferred restorative NOS. The researchers aimed to identify common characteristics, patterns, typologies and variations in these environments (Hao et al., 2016; Raaphorst et al., 2020; Rose, 2022). Both deductive and inductive coding were employed using the codebook. Any new spatial characteristics identified during the analysis were added to the codebook. To ensure reliability, coding was first conducted independently. Finally, the researchers met to compare their findings, resolve discrepancies through discussion until a consensus was reached, and categorise the spatial characteristics, resulting in the study's findings.

3. RESULTS

Before presenting the spatial characteristics frequently present in older adults' preferred restorative NOS, we will briefly describe the analysed environments using results from the visual content analyses. The forty favourite restorative environments identified by the older participants are a combination of urban and nature environments. Contrary to what was expected from the literature, no wild nature settings were selected. All natural environments selected were all with the civilised world in sight. For instance, participants preferred settings like council-owned woodlands on the village outskirts (Figure 2A) or a sea view with the harbour still in sight (Figure 2B). The (sub)urban environments selected were mainly environments like terraces and town squares, places full of life (Figure 2C & 2D).

A) Meadow on the village outskirts (p.5)

B) Viewpoint at the harbour (p.7)

C) Bench at the town square (p.2)

D) Terrace (p.1)

Figure 2. Preferred restorative environments of older participants, a selection.

When analysing the preferred restorative environments, it is noteworthy that regardless of whether participants selected natural or (sub)urban settings, the majority favoured environments with a social function where people come together, such as terraces, campsites, and beach cafes. Another remarkable fact is that most environments were within 20 kilometres of participants' homes.

Zooming in on older adults' preferred restorative NOS, 64 distinct spatial characteristics could be identified as frequently recurring and potentially promoting psychological restoration for older adults. The characteristics were classified into three categories – natural, landscape, and architectural characteristics – which will be discussed further in the following sections.

3.1 Nature characteristics

Nature characteristics are common in all analysed restorative NOS (Table 2). Vegetation in different shapes and sizes – trees, flowers, bushes and grass – is present in almost all preferred restorative environments. Water (e.g. sea or river) is another element regularly present in older adults' preferred NOS.

Table 2. Nature characteristics emerging from the analyses of older adults preferred restorative environments.

Natural characteristics	Occurance in preferred restorative environments (N=40)
Animal presence	11
Aquatic plants	6
Bushes/undergrowth	34
Flowers (wild)	21
Flowers (pot)	12
Grass	28
Trees	34
Water (total)	18
Water (sea)	8
Water (lake)	2
Water (river/stream)	5

3.2 Landscape characteristics

The content analysis identified 36 distinct spatial landscape characteristics (Table 3). Almost all the environments had walking paths to explore the surrounding environments. The predominant types of ground cover observed were grass, asphalt or smooth tiles. Interestingly, sand paths were also common in the selected environments. The reoccurrence of sand paths was unexpected from other restorative environment research, and looking at the older target group can be seen as an interesting ground cover choice.

Table 3. Landscape characteristics emerging from the analyses of older adults preferred restorative environments.

Landscape characteristics	Occurance in preferred restorative environments (N=40)	Landscape characteristics	Occurance in preferred restorative environments (N=40)
Water (easy acces)	10	Traffic (cars/bikes)	20
Groundcover (green/grass)	28	Traffic & navigation signs	21
Groundcover (sand/gravel)	16	Bike racks	11
Groundcover (smooth but with texture)	19	Powerlines	3
Spring grid	2	Seating	24
Walking paths	38	Table	12
Topography	13	Street lighting (functional)	24
Visual permeability/scope (prospect)	36	Lighting (atmosphere)	9
Fences	19	Art	6
Hedges	11	Historical object (stones)	2
Railings	6	Graffiti	3
Stairs	6	Fountain	1
Bridge	7	Advertisement signs	8
Playground	7	Trash can	14
Tent/caravan	4	Abandoned objects	7
Church	3	Sun protection (tarp/parasol)	10
Parking space	9	Windscreen	5

Furthermore, many environments had open views of meadows or water bodies on the edge of a forest or the village outskirts (Figure 2A & 2B). Participants seem to be looking for expansive views. For example, they often choose environments with a raised area like a dike, dune or lookout tower (Figure 3A & 3B).

Figure 3. Preferred restorative environment: A) lookout tower over the fens (p. 8) and B) Lookout on the dike looking over the sea (p. 32).

Further analysis of the preferred restorative NOS shows that boundary elements, such as fences, hedges or rows for trees, frequently occur (Figure 3A & 3B). Other spatial characteristics recurring in older adults' preferred restorative NOS are traffic and site facilities, including streetlights, garbage bins, information and traffic signs and seating possibilities. These are all characteristics that can be expected in (sub)urban environments. What is striking about this, however, is that the seating options are mostly situated so that people can easily come together in those places, like a terrace at the town square (Figure 4A) or a meeting place with a circular bench on a dune (Figure 4B). These findings contradict traditional restoration literature, where solitary activities are seen as most restorative.

Figure 4. Preferred restorative environment: A) Terrace on the village square (p. 22). B) Seating arrangement on a dune (p. 14).

3.3 Architectural characteristics

The visual content analysis identified 17 architectural characteristics frequently occurring in older adults' preferred restorative NOS (Table 4).

Table 4. Architectural characteristics emerging from the analyses of older adults preferred restorative environments.

Architectural characteristics	Occurance in preferred restorative environments (N=40)
Building design (diversity)	17
Building design (variation color)	17
Building arrangement (enclosure)	18
Building arrangement (openness)	29
Permeability of facade	9
Entropy (facade variation decoration windows	18
Highrise	7
Overhang	10
Peaked roofs	22
Biophilic materials/natural materials	9
Materials (diversity)	6
Barn	9
Shadow - play of light	14
Complexity of environment	15
Exploration possibilities (mystery)	26
Coherence of space	23
Calmness of space	16

From an architectural perspective, it is remarkable that most people choose places close to their homes with typical Dutch architecture. Dutch architecture consists of low-story brick houses, often with peaked roofs in rows, semi-connected or small volumes (Figure 5A & 5B). There is not much diversity in material use. However, there is quite a variety in façade entropy. Furthermore, there is a low density of buildings and openness between buildings, which are characteristics of almost all preferred restorative NOS. Moreover, you always see houses in the distance, even in the more nature-oriented preferred restorative environments.

Figure 5. Preferred restorative environment: A) Dutch neighbourhood street (p. 34) and B) Neighbourhood pocket park (p. 39).

3.4 Comparison of spatial characteristics preferences: older adults vs. other age groups

The visual content analysis identified 64 spatial characteristics frequently occurring in older adults' preferred restorative NOS and may promote restoration for older adults. When comparing these results with previous research conducted with younger individuals (Grave et al., 2024; Subiza-Pérez et al., 2019), several similarities and differences emerge (Table 5). Notably, 24 spatial characteristics were identified that had not been highlighted in earlier literature but seem to be relevant for older adults (e.g. playground, animals, sunshades). Additionally, one characteristic – market stalls – was included in the codebook based on previous research but did not appear in the preferred restorative environments. Table 5 outlines the characteristics identified in the current study and earlier research.

Table 5. Spatial characteristics of the preferred restorative environments compared with current literature using a review of Grave and colleagues (2024) and the IEPRUE-scale (Subiza-Pérez et al., 2019).

Characteristics	Spatial analysis	Literature review *(Grave et al. 2023)*	IEPRUE scale *(Subiza-Pérez et al., 2019)*
Natural characteristics			
Animal presence	x		
Aquatic plants	x		
Bushes/undergrowth	x	x	x
Flowers (wild)	x	x	x
Flowers (pot)	x		x
Grass	x	x	x
Trees	x	x	x
Water (total)	x	x	x
Water (sea)	x	x	x
Water (lake)	x	x	x
Water (river/stream)	x	x	x
Architectural characteristics			
Building design (diversity)	x		x
Building design (variation colour)	x	x	x
Building arrangement (enclosure)	x		
Building arrangement (openness)	x	x	
Permeability of facade	x		
Entropy (facade variation)	x	x	x
Highrise	x	x (negative)	
Overhang	x		
Peaked roofs	x	x	
Biophilic materials/natural materials	x		
Materials (diversity)	x		x
Barn	x		
Shadow - play of light	x		
Complexity of environment	x	x	x
Exploration possibilities	x		x
Coherence of space	x		x
Calmness of space	x		x

Characteristics	Spatial analysis	Literature review *(Grave et al. 2023)*	IEPRUE scale *(Subiza-Pérez et al., 2019)*
Landscape characteristics			
Water (easy access)	x	x	
Groundcover (green/grass)	x	x	x
Groundcover (sand/gravel)	x		
Groundcover (smooth but with texture)	x	x	
Spring grid	x		
Walking paths	x	x	
Topography	x	x	x
Visual permeability	x		x
Fences	x		
Hedges	x		
Railings	x		
Stairs	x		
Bridge	x		
Playground	x		
Market stall		x	
Tent/caravan	x		
Church	x		
Parking space	x		
Traffic (cars/bikes)	x	x (negative)	
Traffic & navigation signs	x	x	x
Bike racks	x		x
Powerlines	x	x (negative)	
Seating	x	x	x
Table	x	x (negative)	
Street lighting (functional)	x	x	x
Lighting (atmosphere)	x		
Art	x	x	x
Historical object (stones)	x		
Graffiti	x		x (negative)
Fountain	x		x
Advertisement signs	x		
Trash can	x		x
Abandoned objects	x		x (negative)
Sun protection (tarp/parasol)	x		
Windscreen	x		

4. DISCUSSION

4.1 Restorative spatial characteristics similar for older and younger individuals

Natural characteristics

The visual content analysis reveals that natural characteristics such as vegetation, grass and trees are prominent spatial characteristics in older adults' preferred restorative NOS (Figure 6). These findings align with previous studies, which have demonstrated the significant role of natural characteristics in promoting psychological restoration for diverse population groups (Grave et al., 2024; Hartig et al., 2014). Furthermore, it is consistent with the theoretical framework, as both ART and SRT emphasise the importance of nature characteristics for the restoration process (Kaplan, 1995; Ulrich et al., 1991). The results suggest that this also holds true for older adults, indicating that natural characteristics can effectively promote restoration for this demographic. A similar trend is observed for the presence of water. Water is known to promote psychological restoration for diverse population groups (Andreucci et al., 2019; Finlay et al., 2015). The findings of this study suggest that this is also the case for older individuals.

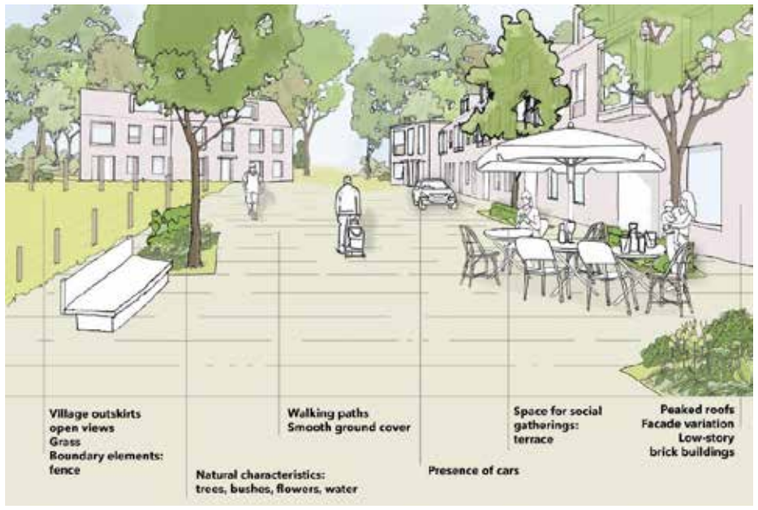

Figure 6. Example of a restorative neighbourhood open space containing characteristics that may promote restoration for older adults.

Walking paths & ground cover

Other characteristics in accordance with previous research are the presence of walking paths and ground cover. Both grass and smooth pavements are frequently observed in older adults' preferred restorative NOS and are proven to be restorative for other age groups (Gu et al., 2021; Lai et al., 2020; Olszewska-Guizzo et al., 2022). As Lu and colleagues (2022) and Qiu and colleagues (2021) noted, these elements are also considered important for older individuals. The findings in this study confirm this. However, another type of ground cover frequently occurs: sand paths. This type of ground cover would not typically be expected to be a favourite for this demographic group. Whether sand paths can promote psychological restoration for older adults or whether there is another reason behind their frequent occurrence needs to be further studied.

Boundary elements

Furthermore, boundary elements such as rows of trees, fences and hedges were commonly found in the preferred restorative environments of older adults (Figure 6). Literature suggests that boundary elements can create spaces of refuge by providing a sense of privacy, safety and enclosure, all of which can promote psychological restoration for other age groups (e.g. Akpınar, 2021; Barros et al., 2021; Xie et al., 2022). As a frequently occurring feature in the analysed environments, these boundary elements appear to offer similar benefits for older adults when incorporated into NOS.

Dutch architecture

Older adults predominantly choose urban environments instead of the expected more nature-oriented environments. Participants also mark their preference for environments featuring typical Dutch architecture (Figure 5A & 5B). On the one hand, this preference can be explained by the presence of restorative building characteristics. Lindal and Hartig (2013; 2015) found that buildings with specific design features – such as one-story structures, façade details, and peaked roofs – scored highly in terms of their restorative potential (Lindal & Hartig, 2013, 2015). These spatial characteristics align with the Dutch architecture style, particularly the buildings in many residential suburban areas. It is possible that design elements such as building height, density, and façade variation, like for other age groups, positively influence the restoration process for older adults.

On the other hand, cultural factors and familiarity may also influence older adults' preferences for Dutch architecture. Research indicates that familiarity significantly shapes preferences for restorative environments (Hartig & Staats, 2006; Korpela & Hartig, 1996; Lorenzo et al., 2016). However, further research is needed to identify the factors (e.g. familiarity, building design, cultural factors) that most effectively promote psychological restoration for older adults.

4.2 Restorative spatial characteristics specifically important for older adults

While characteristics such as water, greenery, and boundary elements aligned with previous research regarding other age groups, other spatial characteristics emerged that seem to be specifically important for older adults' restorative processes, including elevated vantage points & open views, spaces for social gatherings and the presence of cars. These factors are discussed below:

Elevated vantage point & open views

The preference for elevated vantage points, such as dikes, dunes and view towers (Figures 3A & 3B), is notable in older adults' preferred restorative NOS. This preference is striking, as it does not align with existing literature. It appears that older adults have a stronger need for views over landscapes such as meadows or the sea (Figures 2A & 2B). Visual permeability or 'prospect' are spatial characteristics frequently found in restorative environment literature, although no significant evidence is found that prospect offers restoration in NOS (Grave et al., 2024). The findings in this study show that the prospect is important for older adults when choosing restorative NOS. This preference could be explained by the fact that open views provide opportunities for exploration, offering fascination and extent, two of the characteristics of ART (Liu et al., 2022; Qiu et al., 2021; J. Zhao et al., 2018). Another explanation may be that open views promote feelings of safety and compatibility – other characteristics of ART and SRT – which are important factors in older adults' restoration process (Scopelliti & Giuliani, 2004, 2006). As older adults' capabilities change, their sense of safety may be altered; greater visibility of the surrounding environment can offer a sense of security, thereby promoting restoration. This is important to consider when designing restorative NOS for older adults.

Spaces for social gatherings

The older participants often chose environments on the outskirts of cities with wide open views. Interestingly, many of these preferred environments also feature a social function. The spatial characteristics present in these environments often facilitated social gatherings. For instance, seating areas with benches, streetlights, sunshades and trashcans were common. Notably, terraces appeared to be particularly favoured by older participants. This is surprising as the inclusion of tables in these spaces might typically have a negative impact on restorative outcomes for other age groups (Peschardt et al., 2014). Tables are often points for people to gather around, while in literature, restoration is considered a solitary activity (Korpela & Staats, 2021). Solitude can provide opportunities for reflection, mental clarity, and a break from social demands, all of which contribute to psychological restoration (Korpela & Staats, 2021; Wohlwill, 1983). However, it seems that for older adults, the presence of others and the opportunity for social interaction, such as gathering on a terrace, has a positive effect on the choice of restorative NOS. This preference may be linked to feelings of safety and compatibility

(Scopelliti & Giuliani, 2004, 2006; Staats & Hartig, 2004), suggesting that certain spatial characteristics of NOS, such as spaces for social gatherings, may promote restoration for older adults. Future research is needed to explore the mechanisms behind these findings.

Presence of cars

An element that is traditionally viewed as having a negative effect on psychological restoration is car traffic. The presence of cars often has an adverse effect on restoration for other age groups (Bornioli et al., 2018; Nordh & Østby, 2013), primarily attributed to noise pollution. Car sounds can interrupt a sense of escape, diminishing the feeling of being away, which is essential for psychological restoration (Zhang et al., 2019). Furthermore, the presence of cars can undermine feelings of safety, thereby reducing the restorative potential of NOS (J. Zhao et al., 2020). However, older adults often select environments with frequent presence of various traffic-related spatial characteristics in their preferred restorative NOS, such as cars, bike racks, streetlights and traffic signs. Whether these elements promote restoration for older adults and why needs to be further studied. For example, the role of the presence of cars in influencing feelings of social control and the preference for urban settings can be examined as factors contributing to this preference for cars.

4.3 Study limitations and future research

The findings of this study suggest that certain spatial characteristics of NOS may promote restoration for older adults. However, it is important to note that this study focused on visual content analysis. We found spatial characteristics frequently occurring in preferred restorative environments, indicating that they likely play a role in older adults' restoration process. The extent of their importance, however, remains unclear. The frequency of occurrence does not necessarily equate to significance (Rose, 2022). This study did not measure actual restoration, so we cannot confirm whether these frequently occurring spatial characteristics significantly offer restoration. Future research should employ alternative methods, such as in-situ measures of actual restoration or choice experiments, to assess their impact on the restorative process of older adults.

Additionally, the occurrence of spatial characteristics does not address their quality. For example, a tree or lookout point may vary in design across environments but is still counted as a single occurrence in the visual content analysis. Supplementing the visual content analysis with textual content analysis of the in-depth interview data on older adults' preferred environment can provide further insights into how these characteristics should be designed and integrated into restorative NOS.

Furthermore, it is important to acknowledge that these spatial characteristics do not exist in isolation but form a coherent environment. The visual content analysis does not account for potential interactions

between these characteristics. When designers utilise the proposed characteristics to promote restoration in NOS for older adults, they must consider such interactions.

The final limitation is the use of image representations instead of analysing real environments. Due to the wide geographic range of participants' locations (as they could choose any place in the world), virtual representations of the environments were used. While this approach provided valuable insights, we acknowledge that virtual representations can differ from real-life dynamic experiences (Ellard, 2017; J. Zhao et al., 2020). We tried to partly overcome this by creating 360-degree images and analysing those. However, we are aware that in future research, other senses like sound and smell should also be studied (Ratcliffe, 2015; W. Zhao et al., 2020). Also, this study was conducted during the spring months (March-June), which resulted in images predominantly depicting sunny weather and blue skies. We selected this time period based on the assumption that older individuals are more likely to spend time outdoors and engage with their environment during favourable weather, whereas they may remain indoors on rainy days. However, this assumption may have led to a more positively biased representation of the preferred restorative environments, potentially overlooking qualities of the environments as experienced under overcast, rainy or otherwise less 'picturesque' conditions (Paddle & Gilliland, 2016). Future research should consider a broader range of weather conditions to provide a more comprehensive understanding of environmental experiences.

Despite these limitations, visual content analysis is a valuable method for mapping spatial characteristics in older adults' preferred restorative NOS. Spatial characteristics that are likely to play a role in promoting restoration for this population were identified. These findings serve as a starting point for designers to gain a deeper understanding of how to design restorative NOS for older adults. Future research is needed to obtain more detailed information on the effects of different characteristics, how these characteristics are interrelated, and which characteristics are most important for promoting restoration of older adults in Neighbourhood Open Spaces.

5. CONCLUSION

In conclusion, this study highlights different spatial characteristics which can be used to design restorative NOS for older adults. Some spatial characteristics, such as water, greenery, boundary elements, and Dutch building characteristics, were similar to what could be expected from previous research with other age groups. Other factors like elevated vantage points and open views, spaces for social gatherings and the presence of cars should be specifically considered when designing restorative NOS to promote older adults' mental health. Despite several limitations and paths for future research, this study can aid designers in designing restorative Neighbourhood Open Spaces to promote mental health of older adults.

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REFERENCES

Akpınar, A. (2021). How perceived sensory dimensions of urban green spaces are associated with teenagers' perceived restoration, stress, and mental health? Landscape and Urban Planning, 214(July), 104185. https://doi.org/10.1016/j.landurbplan.2021.104185

Almeida, D. M., Piazza, J. R., Stawski, R. S., & Klein, L. C. (2011). The Speedometer of Life: Stress, Health and Aging. In Handbook of the psychology of aging (7th ed.). Academic Press.

Andreucci, M. B., Russo, A., & Olszewska-Guizzo, A. (2019). Designing urban green blue infrastructure for mental health and elderly wellbeing. Sustainability (Switzerland), 11(22). https://doi.org/10.3390/su11226425

Aneshensel, C. S., Harig, F., & Wight, R. G. (2016). Aging, Neighborhoods, and the Built Environment. In Handbook of Aging and the Social Sciences: Eighth Edition. Elsevier Inc. https://doi.org/10.1016/B978-0-12417235-7.00015-9

Aspinall, P. A., Thompson, C. W., Alves, S., Sugiyama, T., Brice, R., & Vickers, A. (2010). Preference and relative importance for environmental attributes of neighbourhood open space in older people. Environment and Planning B: Planning and Design, 37(6), 1022–1039. https://doi.org/10.1068/b36024

Barros, P., Mehta, V., Brindley, P., & Zandieh, R. (2021). The restorative potential of commercial streets. Landscape Research, 46(7), 1017–1037. https://doi.org/10.1080/01426397.2021.1938983

Bornioli, A., Parkhurst, G., & Morgan, P. L. (2018). Psychological Wellbeing Benefits of Simulated Exposure to Five Urban Settings: An Experimental Study from the Pedestrian's Perspective. Journal of Transport and Health, 9(March), 105–116. https://doi.org/10.1016/j.jth.2018.02.003

Bornioli, A., & Subiza-Pérez, M. (2022). Restorative urban environments for healthy cities: a theoretical model for the study of restorative experiences in urban built settings. Landscape Research, 0(0), 1–12. https://doi.org/10.1080/01426397.2022.2124962

Collado, S., Staats, H., J., A. C., & Hartig, T. (2017). Restorative environments and health. In G. F. Enric & P. Oscar (Eds.), Handbook of Environmental Psychology and Quality of Life Research (p. 574). Springer.

Ellard, C. (2017). A New Agenda for Urban Psychology: Out of the Laboratory and Onto the Streets. Journal of Urban Design and Mental Health, 2(3). http://www.urbandesignmentalhealth.com/journal2-ellard.html

Evans, G. W. (2003). The Built Environment and Mental Health. Journal of Urban Health: Bulletin of the New York Academy of Medicine, 80(4).

Finlay, J., Franke, T., McKay, H., & Sims-Gould, J. (2015). Therapeutic landscapes and wellbeing in later life: Impacts of blue and green spaces for older adults. Health & Place, 34, 97–106. https://doi.org/10.1016/j.healthplace.2015.05.001

Fumagalli, N., Fermani, E., Senes, G., Boffi, M., Pola, L., & Inghilleri, P. (2020). Sustainable co-design with older people: The case of a public restorative garden in Milan (Italy). Sustainability (Switzerland), 12(8), 3166. https://doi.org/10.3390/SU12083166

Garin, N., Olaya, B., Miret, M., Ayuso-Mateos, J. L., Power, M., Bucciarelli, P., & Haro, J. M. (2014). Built Environment and Elderly Population Health: A Comprehensive Literature Review. Clinical Practice & Epidemiology in Mental Health, 10(1), 103–115. https://doi.org/10.2174/1745017901410010103

Grave, A. J. J., Neven, L., & Mohammadi, M. (2024). The design of neighbourhood open spaces to improve mental health: a critical review of restorative spatial characteristics and their applicability in design practice. Cities and Health, 8(4), 784–799. https://doi.org/10.1080/23748834.2024.2359759

Gu, L., Batistatou, A., Delevoye-Turrell, Y. N., Roe, J., & Knöll, M. (2021). Using artificial ground color to promote a restorative sidewalk experience: an experimental study based on manipulated street view images. AIC 14th Congress.

Hao, X., Wu, B., Morrison, A. M., & Wang, F. (2016). Worth thousands of words? Visual content analysis and photo interpretation of an outdoor tourism spectacular performance in Yangshuo-Guilin, China. Anatolia, 27(2), 201–213. https://doi.org/10.1080/13032917.2015.1082921

Hartig, T. (2004). Restorative environments. In C. Spielberger (Ed.), Encyclopaedia of applied psychology (pp. 273–279). Academic Press.

Hartig, T. (2021). Restoration in Nature: Beyond the Conventional Narrative. In A. R. Schutte, J. C. Torquati, & J. R. Stevens (Eds.), Nature and Psychology. Nebraska Symposium on Motivation (Vol. 67, pp. 89–151). Springer. https://doi.org/10.1007/978-3-030-69020-5_5

Hartig, T., Mitchell, R., De Vries, S., & Frumkin, H. (2014). Nature and health. Annual Review of Public Health, 35, 207–228. https://doi.org/10.1146/annurev-publhealth-032013-182443

Hartig, T., & Staats, H. (2006). Linking preference for environments with their restorative quality. In B. Tress, G. Tress, G. Fry, & P. Opdam (Eds.), From Landscape Research to Landscape Planning. Springer.

Hooyman, N. R., & Kiyak, H. A. (2014). Social gerontology: a multidisciplinary perspective. Pearson.

Jansen, D. A. (1997). Attentional demands and restorative activities: do they influence directed attention among the elderly [PhD dissertation]. University of Wisconsin - Madison.

Jansen, D. A. (2008). Mentally Restorative Activities and Daily Functioning Among Community-Dwelling Elders. Activities, Adaptation & Aging, 32(3), 181–197. https://doi.org/10.1080/01924780802339919

Kaplan, R., & Kaplan, S. (1989). The experience of nature: a psychological perspective. Cambridge University Press.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. Journal of Environmental Psychology, 15(3), 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Korpela, K. M. (2001). Restorative experience and self-regulation in favorite places. Environment and behavior, 33(4), 572–589.

Korpela, K. M., & Hartig, T. (1996). Restorative qualities of favorite places. Journal of Environmental Psychology, 16, 221–233.

Korpela, K. M., & Staats, H. (2021). Solitary and social aspects of restoration in nature. In R. J. Coplan, J. Bowker, & N. L.J. (Eds.), The handbook of solitude (pp. 325–339). John Wiley & Sons.

Lai, K. Y., Sarkar, C., Sun, Z., & Scott, I. (2020). Are greenspace attributes associated with perceived restorativeness? A comparative study of urban cemeteries and parks in Edinburgh, Scotland. Urban Forestry and Urban Greening, 53(October 2019), 126720. https://doi.org/10.1016/j.ufug.2020.126720

Langmann, S., & Pick, D. (2017). Photography as a social research method. In Photography as a Social Research Method. Springer Singapore. https://doi.org/10.1007/978-981-10-7279-6

Lindal, P. J., & Hartig, T. (2013). Architectural variation, building height, and the restorative quality of urban residential streetscapes. Journal of Environmental Psychology, 33, 26–36. https://doi.org/10.1016/j.jenvp.2012.09.003

Lindal, P. J., & Hartig, T. (2015). Effects of urban street vegetation on judgments of restoration likelihood. Urban Forestry & Urban Greening, 14(2), 200–209. https://doi.org/10.1016/J.UFUG.2015.02.001

Liu, L., Qu, H., Ma, Y., Wang, K., & Qu, H. (2022). Restorative benefits of urban green space: Physiological, psychological restoration and eye movement analysis. Journal of Environmental Management, 301(25), 113930. https://doi.org/10.1016/j.jenvman.2021.113930

Lorenzo, E., Corraliza, J. A., Collado, S., & Sevillano, V. (2016). Preference, restorativeness and perceived environmental quality of small urban spaces. Psyecology, 7(2), 152–177. https://doi.org/10.1080/21711976.2016.1149985

Lu, S., Oh, W., Ooka, R., & Wang, L. (2022). Effects of Environmental Features in Small Public Urban Green Spaces on Older Adults' Mental Restoration: Evidence from Tokyo. International Journal of Environmental Research and Public Health, 19(9), 5477. https://doi.org/10.3390/ijerph19095477

Moore, R. C., Straus, E., & Campbell, L. M. (2020). Stress, mental health, and aging. In N. Hantke, A. Etkin, & R. O'Hara (Eds.), Handbook of Mental Health and Aging (pp. 37–58). Academic Press. https://doi.org/10.1016/B978-0-12-800136-3.00004-1

Nordh, H., Evensen, K. H., & Skår, M. (2017). A peaceful place in the city—A qualitative study of restorative components of the cemetery. Landscape and Urban Planning, 167(May), 108–117. https://doi.org/10.1016/j.landurbplan.2017.06.004

Nordh, H., & Østby, K. (2013). Pocket parks for people - A study of park design and use. Urban Forestry and Urban Greening, 12(1), 12–17. https://doi.org/10.1016/j.ufug.2012.11.003

Olszewska-Guizzo, A., Sia, A., Fogel, A., & Ho, R. (2022). Features of urban green spaces associated with positive emotions, mindfulness and relaxation. Scientific Reports, 12(1), 1–13. https://doi.org/10.1038/s41598-02224637-0

Oswald, F., & Wahl, H. W. (2004). Housing and health in later life. Reviews on Environmental Health, 19(3–4), 223–252. https://doi.org/10.1515/reveh-2004-19-3-405

Paddle, E., & Gilliland, J. (2016). Orange is the new green: Exploring the restorative capacity of seasonal foliage in schoolyard trees. International Journal of Environmental Research and Public Health, 13(5). https://doi.org/10.3390/ijerph13050497

Peschardt, K. K., Stigsdotter, U. K., & Schipperrijn, J. (2014). Identifying Features of Pocket Parks that May Be Related to Health Promoting Use. Landscape Research, 41(1), 79–94. https://doi.org/10.1080/01426397.2014.894006

Purcell, T., Peron, E., & Berto, R. (2001). Why do Preferences Differ between Scene Types? Environment and Behavior, 33(1), 93–106. https://doi.org/10.1177/00139160121972882

Qiu, L., Chen, Q., & Gao, T. (2021). The Effects of Urban Natural Environments on Preference and Self-Reported Psychological Restoration of the Elderly. Environmental Research and Public Health, 18(509), 1–14. https://doi.org/10.3390/ijerph18020509

Raaphorst, K., Roeleveld, G., Duchhart, I., Van der Knaap, W., & Van den Brink, A. (2020). Reading landscape design representations as an interplay of validity, readability and interactivity: a framework for visual content analysis. Visual Communication, 19(2), 163–197. https://doi.org/10.1177/1470357218779103

Ratcliffe, E. (2015). Restorative perceptions and outcomes associated with listening to birds. [PhD dissertation], University of Surrey, Surrey, England.

Roe, J., & McCay, L. (2021). Restorative cities. Urban design for mental health and wellbeing. Bloomsbury.

Roe, J., & Roe, A. (2018). Restorative Environments and Promoting Physical Activity Among Older People. In S. R. Nyman, A. Barker, T. Haines, K. Horton, C. Musselwhite, G. Peeters, C. R. Victor, & J. K. Wolff (Eds.), The Palgrave Handbook of Ageing and Physical Activity Promotion (pp. 467–483). Palgrave Mcmillan. https://doi.org/10.1007/978-3-319-71291-8_23

Rose, G. (2022). Visual Methodologies (5th ed.). Sage Publications LTD.

Schmidt, T., Kerr, J., & Schipperijn, J. (2019). Associations between neighborhood open space features and walking and social interaction in older adults-a mixed methods study. Geriatrics (Switzerland), 4(3). https://doi.org/10.3390/geriatrics4030041

Scopelliti, M., & Giuliani, V. (2004). Choosing restorative environments across the lifespan: A matter of place experience. Journal of Environmental Psychology, 24(4), 423–437. https://doi.org/10.1016/j.jenvp.2004.11.002

Scopelliti, M., & Giuliani, M. V. (2006). Restorative environments in later life: An approach to well-being from the perspective of environmental psychology. Journal of Housing for the Elderly, 19(3–4), 203–226. https://doi.org/10.4324/9780203820193

Staats, H. (2012). Restorative Environments. In S. D. Clayton (Ed.), The oxford handbook of environmental and conservation psychology. Oxford University Press.

Staats, H., & Hartig, T. (2004). Alone or with a friend: A social context for psychological restoration and environmental preferences. Journal of Environmental Psychology, 24(2), 199–211. https://doi.org/10.1016/j.jenvp.2003.12.005

Subiza-Pérez, M., Korpela, K. M., & Pasanen, T. (2021). Still not that bad for the grey city: A field study on the restorative effects of built open urban places. Cities, 111(July 2020). https://doi.org/10.1016/j.cities.2020.103081

Subiza-Pérez, M., Pasanen, T., Ratcliffe, E., Lee, K., Bornioli, A., de Bloom, J., & Korpela, K. M. (2021). Exploring psychological restoration in favorite indoor and outdoor urban places using a top-down

perspective. Journal of Environmental Psychology, 78(January). https://doi.org/10.1016/j.jenvp.2021.101706

Subiza-Pérez, M., Vozmediano, L., & San Juan, C. (2019). A systematic social observation tool to measure the restorative potential of urban settings. Psyecology, 10(2), 257–286. https://doi.org/10.1080/21711976.2019.1579472

Sugiyama, T., Ward Thompson, C., & Alves, S. (2009). Associations between neighborhood open space attributes and quality of life for older people in Britain. Environment and Behavior, 41(1), 3–21. https://doi.org/10.1177/0013916507311688

Ten Bruggencate, T., Luijkx, K. G., & Strum, J. (2018). Social needs of older people: a systematic literature review. Ageing and Society, 38(9), 1745–1770. https://doi.org/10.1017/S0144686X17000150

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. Science, 224(4647), 420–421. https://doi.org/10.1126/science.6143402

Ulrich, R. S., Simonst, R. F., Lositot, B. D., Fioritot, E., Milest, M. A., & Zelsont, M. (1991). Stress recovery during exposure to natural and urban environments. Journal of Environmental Psychology, 11, 201–230.

Van Hecke, L., Ghekiere, A., Veitch, J., Van Dyck, D., Van Cauwenberg, J., Clarys, P., & Deforche, B. (2018). Public open space characteristics influencing adolescents' use and physical activity: A systematic literature review of qualitative and quantitative studies. Health & Place, 51, 158–173. https://doi.org/10.1016/J.HEALTHPLACE.2018.03.008 van Hees, S. (2017). The making of ageing-in-place Perspectives on a Dutch social policy [PhD Dissertation]. University of Maastricht.

van Helder, L., Bos, W., Bleijenberg, N., van Eijck, J., de Jager, H., Klomp, M., de Langen, M., Minkman, M., Pieterse, T., van Rixtel, M., van Roozendaal, M., Vos, P., & de Vries, J. (2020). Oud en zelfstandig in 2030 - Een reisadvies.

Weber, A. M., & Trojan, J. (2018). The Restorative Value of the Urban Environment: A Systematic Review of the Existing Literature. Environmental Health Insights, 12, 1178630218812805–1178630218812805. https://doi.org/10.1177/1178630218812805

WHO. (2022). Ageing and health. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

Wohlwill, J. F. (1983). The concept of nature: A psychologist's view. Human Behavior & Environment: Advances in Theory & Research, 6, 5–37.

Xie, J., Luo, S., Furuya, K., Kagawa, T., & Yang, M. (2022). A Preferred Road to Mental Restoration in the Chinese Classical Garden. Sustainability (Switzerland), 14(8), 1–16. https://doi.org/10.3390/su14084422

Yasamy, M. T., Dua, T., Harper, M., & Saxena, S. (2013). Mental health of older adults, addressing a growing concern. In Mental Health of Older Adults. Addressing.

Zhang, S., Zhao, X., Zeng, Z., & Qiu, X. (2019). The influence of audio-visual interactions on psychological responses of young people in urban green areas: A case study in two parks in China. International Journal of Environmental Research and Public Health, 16(10). https://doi.org/10.3390/ijerph16101845

Zhao, J., Wu, J., & Wang, H. (2020). Characteristics of urban streets in relation to perceived restorativeness. Journal of Exposure Science and Environmental Epidemiology, 30(2), 309–319. https://doi.org/10.1038/s41370019-0188-4

Zhao, J., Xu, W., & Ye, L. (2018). Effects of auditory-visual combinations on perceived restorative potential of urban green space. Applied Acoustics, 141(July), 169–177. https://doi.org/10.1016/j.apacoust.2018.07.001

Zhao, W., Li, H., Zhu, X., & Ge, T. (2020). Effect of birdsong soundscape on perceived restorativeness in an Urban Park. International Journal of Environmental Research and Public Health, 17(16), 1–15. https://doi.org/10.3390/ijerph17165659

Zhu, W., Wang, J., & Qin, B. (2021). Quantity or quality? Exploring the association between public open space and mental health in urban China. Landscape and Urban Planning, 213(October 2020), 104–128. https://doi.org/10.1016/j.landurbplan.2021.104128