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Review

How Public Urban Space Enhance Restoration Benefits Through Combined Multisensory Effects: A Systematic Review

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Abstract: Rapid urbanization has heightened attention fatigue and physiological stress among urban residents. However, high-density urban construction, mainly covered by streets, squares/plazas, and buildings, in particular, poses a challenge to traditional restoration dominated by green infrasturcture. This research aims to conduct a systematic review of the available body of knowledge regarding the relationship between public urban spaces and restorativeness based on combined multisensory effects. First, a conceptual framework was proposed to connect spatial properties of public realms, sensorial mechanisms, and restoration benefits. As a result, detailed spatial elements and organization affecting multiple sensory modalities combined via additive, antagonistic, and synergistic effects were extracted, which essentially act on urban restoration, including attention, stress, and emotional recovery. Last, but not least, compared with previous research, restoration design strategies of public urban spaces accelerating multisensory integration were drawn to contribute new insights for future high-density urban development.

Keywords: public urban space; multisensory perception; combined effect; restoration benefit; spatial property; urban design

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1. Introduction

The city has become the main place of human habitation, and 68% of the population worldwide is expected to live in cities by 2050 [1,2]. Rapid urbanization has heightened attention fatigue and physiological stress among urban residents [3–7]. From the design perspective, restorative urban spaces provide appropriate spatial pathways to trigger the psychological and/or physiological recovery processes of resource-consuming individuals through particular urban settings, which thereby improves the whole well-beings but also the effective functioning of cities [8–11].

A traditional restorative environment normally indicates natural space dominated by green elements [12,13]. However, high-density urban construction captured by extensive hard surfaces and an abundance of built infrastructure poses a challenge to get close to nature or insert large-scale green spaces [14–18]. Under this circumstance, urban designers and researchers gradually paid their attention to the restoration benefits of public urban spaces with a more hardscape layout, such as streets and squares [16,19–22]. Several studies pointed out that well-designed and appealing public urban spaces might be as curative as natural environment [23,24]. For example, Lindal and Hartig found physical attributes of the urban residential street, especially the variation of building façades and building height, could significantly influence possibilities for people's restoration [25]. Zhao et al. detected that the clearness of painted traffic signs and diverse species of plants in the streetscape were capable of alleviating physical stress [22]. As for the research about squares/plazas, Subiza–Pérez et al. determined the composition and number of benches, sculptures, and

playgrounds in urban squares are important in affecting restoration qualities, which functionally offer opportunities for people to rest and socialize [26]. Though research on the restoration of these urban environments is inadequate, it is still explicit that certain urban settings could arouse environmental perception formed by multiple sensations, including sight, touch, sound, etc., and the mediation of behavioral activities and emotional responses are beneficial to increase restorative effects accordingly [27].

Previous studies in terms of restoration benefits of urban spaces mainly focus on the account of their spatial properties and the visual stimuli. However, other sensory stimuli felt by the auditory, olfactory, gustatory, and tactile systems could also make key impressions on perceived restorativeness [28–30]. In fact, due to the rich mix of built elements and human activities, people in the urban environment are more easily exposed to multisensory stimuli rather than single senses [15,19,31]. Urban surroundings, such as air pollution odors, bird sounds, and various thermal factors, have been proven to positively or negatively affect restoration effectiveness [32–35]. Nevertheless, minimal research has tried to reveal the complex mechanism between multisensory effects on urban settings and the corresponding restoration benefits. Ha and Kim investigated the combination of visual and auditory influence within a biodiverse environment, which could provide restorative effects for students' everyday life on campus [36]. Also, Jiang et al. conducted a laboratory experiment to analyse how odour affects people's satisfaction with urban landscapes by modulating their noise and visual perception simultaneously [37]. Though these studies partly verified the Gestalt principle that different sensory inputs affect environmental perception as a whole, recovery outcomes, depending on the mode, approach, and level of multisensory stimulation, are still lacking [38,39].

In summary, despite natural spaces with large green substrates, public spaces primarily constituted by hard materials, by means of their abundant physical traits and two- and three-dimensional layouts, also could conduct multiple sensory experiences and accelerate human health. Therefore, this study aimed to provide a systematic overview summarizing, analyzing, and understanding the relationship between restoration benefits and the spatial properties of public urban spaces (e.g., street and square) via combined multisensory effects. To achieve this objective, the following two questions need to be answered: (1) Which spatial character and spatial organization of public urban spaces could effectively act on restoration benefits? (2) How do these spatial properties influence recovery through different multisensory combination patterns and effects?

This paper was divided into the following sections. In Section 1, a theoretical framework was constructed to illustrate the linkage among the spatial property of public urban spaces, multisensory effects, and restoration benefits. Section 2 describes the methodology of this systematic review, which specifies the inclusion and exclusion criteria of data collection and how the body of evidence was assessed. In Section 3, the reviewed studies were grouped by which the inner relationship between various multisensory combination patterns (i.e., visual-auditory, olfactory-auditory, tactile-visual, olfactory-thermal, tacitle-olfactory, visual-olfactory, thermal-visual, and tri-sensory combinations) and main categories of restoration benefits, including attention, stress, and emotional recovery, were summarised, respectively. In Section 4, comparisons were made with previous research on the restorative effectiveness of natural spaces and single senses' efficiency, as well as a series of design strategies for future urban restoration practices.

2. A Framework Linking the Spatial Property of Public Urban Spaces, Multisensory Effects, and Restoration Benefits

Public urban spaces, including streets, squares/plazas, building exterior spaces, and roof spaces, etc., play an important role for people's daily use [40]. In addition to integrated green spaces, these everyday urban environments provide the residents' unnoticed existing situation and frequent embodied experience [41]. Based on Affordance Theory [42] and Environmental Perception Theory [43], an individual's cognition is significantly influenced by spatial characteristics. Environmental factors offer specific "affordances" through

various sensory inputs, which are processed through sensation and perception to influence individuals' restorative experiences [44,45]. A large number of studies of restorative urban environments have stated that contact with certain spatial features may effectively facilitate people's attention, stress, and emotional recovery, while this psychological response is immediate, spontaneous, and accompanied by a series of positive emotions [31,43,46–50]. Therefore, in order to grasp the nature of how public urban spaces influence people's restoration benefits, it is useful to start extracting spatial clues in terms of the composition and organization of urban elements and multisensory experiences incorporated [51,52]. We conducted a framework linking spatial properties of public urban spaces, multisensory effects, and restoration benefits in Figure 1.

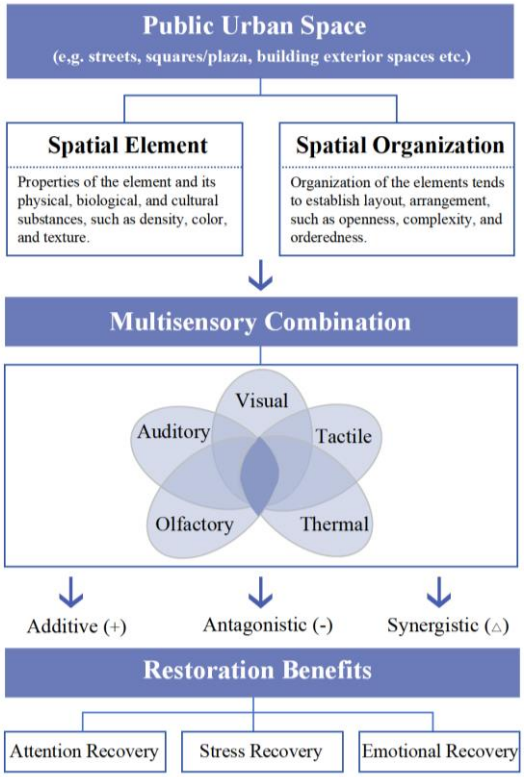


Figure 1. A framework linking spatial properties of public urban spaces, multisensory effects, and restoration benefits.

Firstly, properties of the element and its physical, biological, and cultural substances, such as density, color, and texture, could indicate straightforward recovery effects. For example, the façade design of buildings based on the selection of materials or vertical greening, and the underlying/in-house commercial facilities emanating artificial aromas of fragrance, coffee, bread, etc., could lead to different aesthetic and tactile perceptions, which provide calming and recovery effects for people who work nearby or just pass through the neighbourhood [25,53,54]. Moreover, the density of street trees has been observed to be an essential design and planning factor in the streetscape in terms of attention and stress restoration through creating green vista, while the compactness of fragrant plants that affect the odor concentration has been shown to reduce human's stress [22,55,56]. Secondly, the organization of the elements tends to establish layout, arrangement, and spatial relationships among multiple urban elements to indicate perceptual experiences, such as openness, complexity, and orderedness [57–59]. Apart from visual aesthetics, it could also induce other sensory stimuli ultimately acting on recovery benefits [59–62]. For example, people prefer to experience a feeling of openness in high-density commercial and business areas, which provoke positive responses by allowing odor dispersal and reducing noise levels [49,63,64]. Furthermore, the complexity of planting design could effectively

create a microclimate that promotes better thermal satisfaction and the attenuation of artificial odors [63,65,66]. Also, the street ratio (i.e., H/W) and tree plantings with different canopy sizes could functionally determine thermal and visual comfort and ameliorate heat stress for urban dwellers [67].

As mentioned, the spatial properties, including variations of texture, form, pattern, and colour of urban elements, initiate people to synthetically perceive the environment. However, different sensory inputs stemming from the outdoor space cannot simply be regarded as the sum of visual, olfactory, auditory, tactile, and thermal senses. All senses collaborate to grasp information through complex interactions with the surroundings and influence various emotional responses [39,68]. Based on the previous research, three key multisensory combinations acting on restorativeness can be summarized, namely additive, antagonistic, and synergistic effects [69–71].

- The additive effect refers to several sensory factors working together to promote recovery by providing a favorable perceptual experience. For example, rich plant communities with fragrant plant odours could promote restoration benefits [72]. The combination of green landscapes and birdsong has also been shown to promote a favourable perception [54].
- The synergistic effect is manifested by the fact that one sensory sensation can compensate for a certain sensory discomfort, which in turn promotes recovery. Olfactory and visual experiences in urban spaces have been shown to increase the overall perception by alleviating thermal discomfort from high temperatures, as well as easing the annoyance of traffic noise [33,37]. Comfortable sensations of olfactory and tactile could similarly promote recovery in an environment with low green visibility [72,73].
- The antagonism effect is the inhibitory effect of sensory factors on recovery, and the poor performance of one sensory factor may exert a masking effect on others. A masking effect has been shown to exist between sound and smell, where the introduction of traffic sound may reduce overall perception when the sense of smell is comfortable [74]. The tactile experience of crowdedness may also reduce the effectiveness of other sensory experiences [75].

3. Materials and Methods

3.1. Data Collection

The data collected come from the Web of Science (WOS) core collection database. WOS is the premier research platform for information in several scientific fields and the world's most reliable publisher-independent global citation database. To gain useful clues, we divided the topic into three main categories as obligatory terms ("urban public space", "multisensory", and "restoration benefit"), with each of them having a set of keywords for their related concepts. Meanwhile, we excluded search terms such as forests, villages, and suburbs, which do not meet the definition of public urban spaces in this study.

- Public urban space: TS1 = (public urban space* OR urban OR high-density city OR square OR street)
- Multisensory: TS2 = (multisensory OR multi-sensory OR multisensory OR audi* OR sound* OR acoustic OR noise OR smell OR olfactory OR fragrance* OR tactile OR touch OR haptics OR thermal)
- Restoration benefits: TS3 = (restoration benefit* OR restoration environment* OR therapeutic landscapes OR stress relief OR stress recovery OR attention recovery OR mood states OR emotional recovery)
- Non-urban space: TS4 = (forest* OR village OR outskirts OR suburb OR wilderness)

We then matched these three groups of keywords, with each as (TS1) AND (TS2) AND (TS3) NOT TS4. Data were accessed on April 2024 from the Harbin Institute of Technology Online Library.

3.2. Literature Screening

The results yielded 447 documents from the WOS. The PRISMA diagram illustrates the search process [12] (Figure 2). Literature from unrelated disciplines was removed, such as dentistry medicine and materials science, and then 119 documents were obtained for a second round of screening (n = 119). Single sensory studies and literature only related to the natural environment were excluded, as well as literature not related to spatial elements and organisation (n = 70). The titles and abstracts of the studies met the inclusion criteria and were reviewed in full text (n = 49). Then, a further 19 papers were excluded because the literature focused on environments with large green substrates or built indoor environments were not accessible. In particular, the documents with term "park" were scrutinized. Specifically, references to squares, roadside spaces, or community parks as distinct from large-scale green spaces were included in the examination. Finally, 30 articles remained as the final set of references used in this study. The table resume of the studies selected for the full-text review is displayed in Table 1.

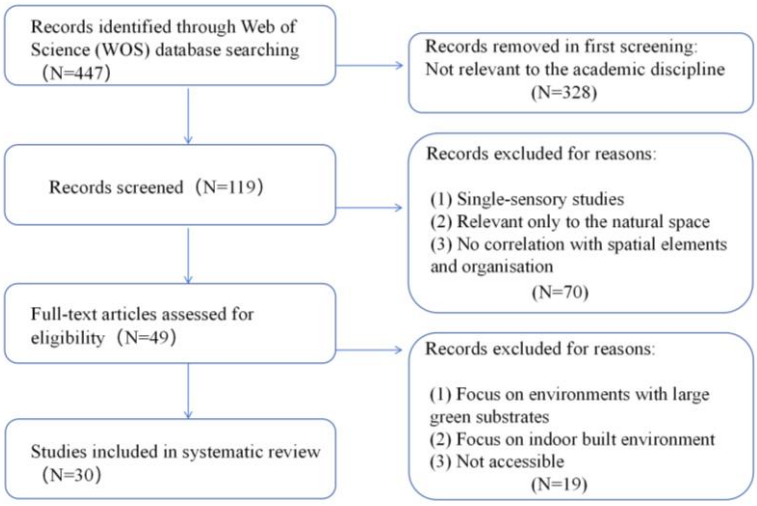


Figure 2. PRISMA flow diagram for paper screening.

Table 1. Literature review summary table.

Author, Time	Multisensory Combination	Measurement Method(s)	Study Site(s)
Jeon et al. (2021) [76]	Visual–Auditory	Narrative interviews; Questionnaire	Seoul, South Korea
Liu et al. (2022) [77]	Visual–Auditory	Short-version revised restoration scale (SRRS)	Harbin, China
Gallou et al. (2022) [78]	Visual–Olfactory–Tactile	Perceived restoration scale	England
Ha and Kim (2021) [36]	Visual–Auditory	Restorative state scale (RSS); Profile of mood states (POMS)	America
Ruotolo et al. (2024) [79]	Visual–Auditory	Emotional appraisal questionnaire; Cross-modal attention task; MAIA questionnaire	Italy
Jeon et al. (2023) [49]	Visual–Auditory	Heart rate variability (HRV) and electroencephalogram (EEG); Positive and negative affect schedule (PANAS)	South Korea
Ba and Kang (2019) [55]	Olfactory–Auditory	Questionnaire	Harbin, China
Chung et al. (2022) [80]	Visual–Auditory	Questionnaire	Hong Kong, China
Chang et al. (2023) [81]	Olfactory–Thermal	EEG measurements; Questionnaire	Xi'an, China
Pitt (2014) [82]	Tactile–Visual	Semi-structured interviews	Wales, UK
Ba et al. (2022) [83]	Olfactory–Auditory	Questionnaire	China
Schnell et al. (2016) [84]	Olfactory–Auditory–Tactile	HRV; Questionnaire	Tel Aviv, Israel
Lee et al. (2024) [73]	Tactile–Visual	Semi-structured interviews	Australia

Table 1. *Cont.*

Author, Time	Multisensory Combination	Measurement Method(s)	Study Site(s)
Jiang et al. (2021) [31]	Visual–Auditory	Multi-dimensional mood questionnaire (MDMQ)	Illinois, UK and Hong Kong, China
Lyu et al. (2022) [85]	Visual–Auditory–Thermal	Cognitive performance tests; Skin conductance level (SCL); Questionnaire	Sydney, Australia
Lyu et al. (2023) [50]	Thermal–Visual	Cognitive performance tests; Questionnaire	Sydney, Australia
Masullo et al. (2021) [86]	Visual–Auditory	Questionnaire	Hong Kong, China and Aversa, Italy
Wang and Zhao (2020) [87]	Thermal–Visual	Questionnaire	Nanjing, China
Elsadek et al. (2019) [33]	Thermal–Visual	Questionnaire	Shanghai, China
Ho and Au (2021) [88]	Visual–Auditory	Questionnaire	Hong Kong, China
Zhou et al. (2023) [89]	Visual–Auditory	Semi-structured interviews	Beijing and Huainan, China
Henshaw (2011) [90]	Olfactory–Visual	Semi-structured interviews	Britain
Zhang et al. (2023) [75]	Tactile–Visual	Galvanic skin response (GSR)	Salzburg, Austria
Zhou et al. (2023) [72]	Olfactory–Visual	HR; EEG; Cognitive performance tests; Questionnaire	Hangzhou, China
Cui et al. (2023) [91]	Olfactory–Auditory	EEG; HR; Blood pressure(BP); Questionnaire	Hangzhou, China
Osborne (2022) [34]	Tactile–Olfactory	Video elicitation interviews; Biosensing	Birmingham, UK
Xu et al. (2024) [19]	Visual–Auditory	Questionnaire	Hong Kong, China
Zhang et al. (2021) [92]	Thermal–Visual	Questionnaire	Xi'an, China
Karmanov and Hamel (2008) [23]	Visual–Auditory	Profile of mood states (POMS)	Sporenburg, Netherlands
Chan et al. (2021) [53]	Visual–Auditory	ECG; Questionnaire	Singapore

4. Results

The number of publications reviewed in this study is shown in Figure 3. The first relevant literature was published in 2008, surpassing the original nature versus urban dichotomy, which conducted studies in terms of visual-auditory perception of human health issues. The increasing trend of articles during the first decade was slow (four articles). However, the number of papers grew rapidly after 2018, with 87% of the total studies published in the last 5 years. The patterns and distribution of multisensory combinations are displayed in Figure 3. Studies with two and three types of combinations were included, with the former having the highest number. Among these studies, visual–auditory studies accounted for the largest share, followed by visual–thermal, olfactory–auditory, and tactile–visual studies. In addition, sight and smell are sensory factors that combine most frequently with other senses.

In the screened literature, minimal research was conducted in China (14 publications, 47%), followed by Britain, Australia (3 publications, 10%), and Italy, South Korea, and the Netherlands (2 publications, 7%), with some studies from the United States, Singapore, and Denmark (1 publication, 3%). It can be seen that studies are mainly concentrated in countries with a high degree of urbanization and high-density cities. Additionally, this research was related to multi-disciplinary subjects, especially including landscape design, public health, and environmental psychology. In the following sections, a comprehensive overview of how spatial elements and organization in public urban spaces influence restorative benefits was provided based on the classification of sensory types and the number of sensory combinations.

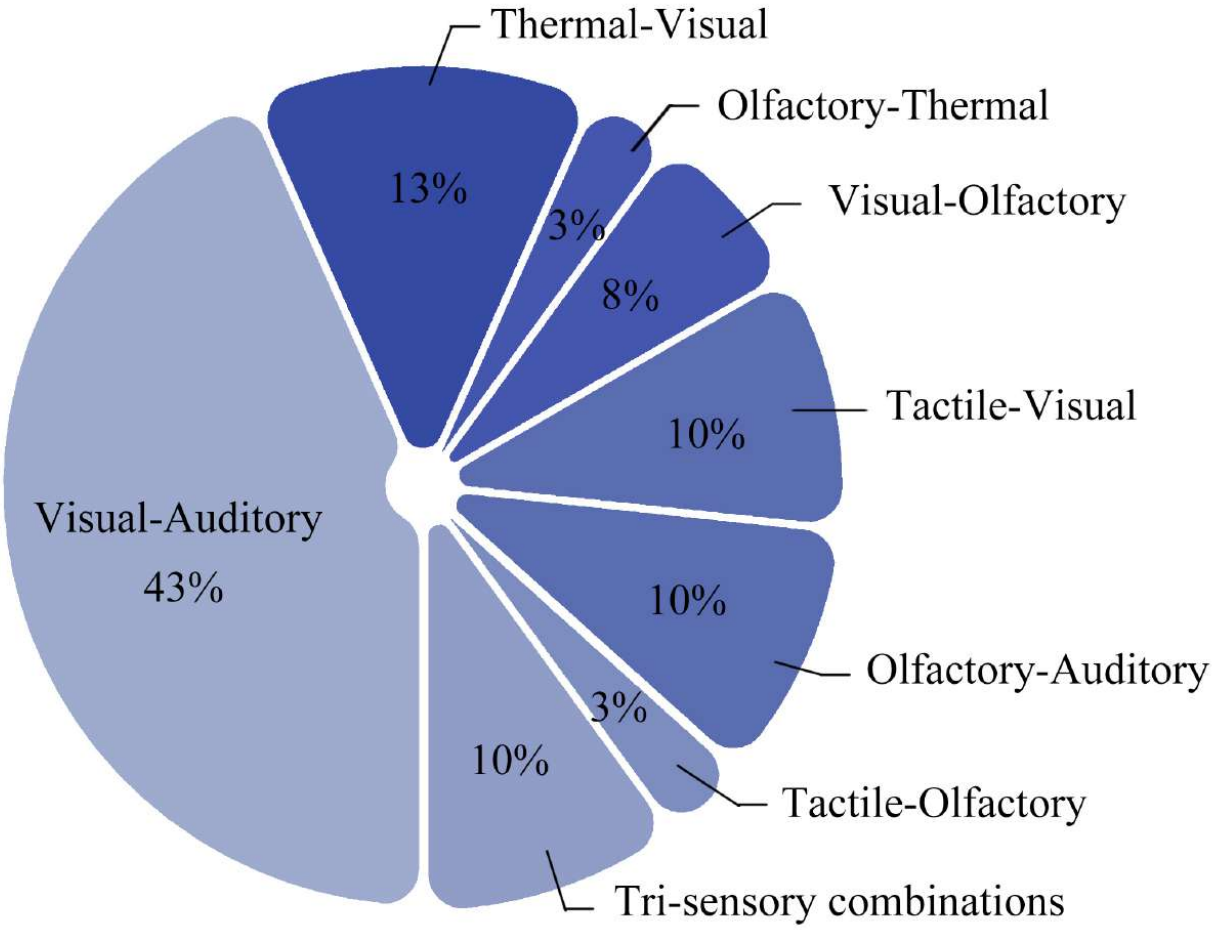


Figure 3. Patterns and distribution of multisensory combinations.

4.1. Auditory–Visual Perception

Studies in terms of auditory–visual perception accounted for the largest proportion of the literature screened (n = 13). Compared with previous research on the single auditory sense, which mainly pointed to the positive effect of sound types on recovery (e.g., bird calls and the sound of running water) and negative effects on mental health, (e.g., traffic noises might cause increased stress levels), auditory–visual perception research examined how to visually compensate for an existing urban background sound to promote restoration benefits [93–95]. More attention is paid to the coordination of different senses and the impact of everyday life scenarios.

Chung et al. conducted audio–visual stimuli via immersive virtual reality (IVR) combined with physiological devices, by which they found well-maintained building facades and how the coverage of vertical greening could provide urbanites stress relief under the exposure of noise levels from 55 to 65 dBA [80]. Meanwhile, Chan et al. also emphasized the role of vertical greening in buffering stress and promoting recovery under the background of a high-density noisy downtown area through a virtual cityscape environment facilitating the user's visual senses and body movement [53]. Ruotolo et al. revealed the use of colored architectural elements (e.g., colourful bridges) in open spaces had a positive impact on the well-being of the elderly, even in the presence of traffic sounds [79]. In addition to the vertical architectonic attributes, Chung et al. explored horizontal spatial organization, such as separation distance [80]. The presence of building spacing in the neighbourhood would significantly affect human perception of oppressiveness and decrease noise annoyance as well. A VR study combining narrative interviews with questionnaires found that open views strengthen the psychological effect of reducing perceived loudness [76].

Much research has identified that natural elements in urban surroundings notably help to achieve audio–visual coherence. The importance of vegetation for providing a green environment and its natural sounds (e.g., bird song, rustle of leaves) is well known [19,31,36,79]. Furthermore, as one of the most basic spatial elements, water stimulates different sensory effects and plays an important role in encouraging restoration benefits. For example, Masullo et al. pointed out that installations with water sound could effectively help people achieve attentional recovery from road traffic noises, while from the visual perspective, the enveloping shape and transparency of the water elements also influenced restoration [86]. Also, Jeon et al. have proved the proper design of audio-visual design elements could improve restoration response [49]. They realized that physical parameters like grey ratio (grey/urban element in a scene) were crucial to reinforcing acoustically calm and tranquil soundscapes. However, visual and auditory senses need to be properly coordinated to achieve satisfied perception. One study found that reducing plant diversity enhances the restoration of hydroacoustic sound in highly urbanised coastal areas, which may relate to the fact that landscape complexity reduces other perceptual stimuli [77].

Apart from the above-mentioned natural sounds, soundscapes derived from human daily life also exert an impact on recovery. Ho and Au marked the facilitating effect of street music performances on people's attention recovery, especially while walking along the street or pausing in the square [88]. Then, the behavioral responses of the audience and crowd size were also critical in enhancing the atmosphere [96]. Another study found that daily exercise routines with music like Tai Chi and dances for older people had an effect on the restoration of various groups, either ones who participated or stood by [89].

4.2. Olfactory–Visual, –Auditory and –Thermal Perception

Mutisensory studies related to the sense of smell accounted for 23% of the total screened literature, which mainly explains how restoration benefits are facilitated by exploiting compensatory or additive effects between olfaction and other senses.

Firstly, as for the olfactory–visual approach, Zhou et al. measured the effects of smelling materials, including gardenia, cedarwood, and no-fragrance vegetation on attention, stress, and emotional recovery processes at different levels of visible green [72]. The results showed that, in under 10–35% of greenery, only the fragrance of gardenia could significantly reduce human stress, while both fragrances of gardenia and cedar leaf produced stress-reduction effects in under 35–60% of visible greenery. In addition, cedar was more effective in attention recovery, and gardenias improved negative moods to a large extent. Henshaw pointed out that even small-scale plant landscapes could trigger a restorative effect after experiencing poorly perceived odors through positive alliesthesia [90]. The additive effect of sight and smell on recovery studies was also mentioned. For instance, rich plant communities combined with aromas could create a good restorative environment [72].

Secondly, interactive sensory stimulations between olfactory and thermals also have been proven to influence the perception of restoration. Chang et al. revealed that increasing scent comfort can alleviate the discomfort from summer heat, which results in stress relief and improved mood states [81]. They examined fragrance stimulation in different temperature stages, by which odour affected attentional recovery within an environment of 30.80 °C $\leq$ PET (physiological equivalent temperature), <44.53 °C rather than 44.53 °C $\leq$ PET < 58.27 °C, while emotional recovery is always present under different PETs.

Third, appropriate odors in public spaces can improve people's assessment of background noise. Cui et al. used physiological equipment and the profile of mood-state (POMS) scales to find that the odor stimulus of gardenia had a stress and emotional restorative effect under the sounds of everyday life and machinery at the sound pressure level of 55 db [91]. Ba and Kang conducted a questionnaire survey on-site to detect that the natural aroma of plants can reduce noise annoyance, while a double row of fragrant trees has a stronger effect on restoration benefits than single-row streets from the visual perspective [55]. Furthermore, food odors on both sides of the pedestrianized streets were shown to have the same effects [83].

4.3. Thermal–Visual Perception

Previous research about microclimate or thermal comfort of urban environments has pointed out that air temperature, heat-stress index, and wind speed are linked with physiological stress in humans. Searching multisensory approaches related to thermal perception, most of the existing studies focused on the thermal–visual synergistic effects, which explained how spatial characters and organizations modify the experience of visual and thermal environments and determine recovery. For example, Lyn et al. conducted a multisensory virtual reality to simulate dynamic environmental conditions, which noted that different shading patterns through different structures of space could facilitate restoration by providing landscape characters and optional thermal adaptation opportunities [50]. Another field study along urban roads by Elsadek et al. found that cherry trees had a relatively large sky view factor (SVF), but their aesthetic and symbolic significance still provided an equally powerful recovery experience like highly shaded roadside trees [33]. However, the inconsistency of the thermal–visual environment through seasons might influence the level of stress recovery [92]. Wang and Zhao found that the effect of deciduous trees on perceived recovery differed in spring and winter because of the visual penetration and sunlight exposure for the changes in permeability [87]. However, the inconsistency of the visual–thermal environment may reduce stress recovery when exposed to cold environments in images with high green visibility [92], though the presence of verdant vegetation may increase thermal comfort and overall perceptual effects by enhancing visual comfort [97,98].

4.4. Tactile–Visual and –Olfactory Perception

Multisensory studies related to the sense of tactile accounted for 13% of the total literature. Compared with the single-sense procedures focusing on the therapeutic function of different materials, such as sand, leaves, and water [99], the existing multisensory research has paid more attention to the mechanism between tactile and other sensory experiences, which were simultaneously stimulated by spatial properties of urban environments. Lee et al. explored dynamic visual features of green roofs (e.g., traditional lawn, biodiverse meadow, colourful succulent, and structural roof) and encouraged virtual visits to facilitate appropriate multisensory experiences in cities [73]. As for the results, they found that the significance of haptic experience arises when the space lacks complex and interesting landscape features. In addition, tactile also works with other sensations through additive or antagonistic effects on recovery. For example, Pitt demonstrated that, in community gardens, skin contact with a variety of plant textures and the whole-body tactility of horticultural activities like weeding and digging could contribute to an immersive experience with attention and stress recovery [82]. Zhang et al. conducted an outdoor experiment with wearable sensors and noted that the installation of roadside sitting facilities in a busy pedestrianized area or a narrow street might lead to increased levels of physiological stress owing to the close contact with people [75]. In addition to direct physical contact, our bodies also react to other atmospheric measures, such as air pollution. Osborne suggested that some microspatial features, such as wider pavement sidewalks, could avoid close proximity to polluted and turbulent air, while strategic vegetation was also useful to buffer pollutant flows [34].

4.5. Tri-Sensory Combinations

One study pointed to the role of the multisensory qualities (e.g., smells, sights, sounds, or textures) of historic buildings in restoration [78]. Their fractal patterns from building structures to decorative elements could add visual coherence and textured feeling, and the unique odor of urban history can trigger collective memories, which thus provoke recollections, emotional attachments, and associations [99–101]. The symbolic narrative of multisensory environments creates a sense of "moving to a bigger world" and leads urban dwellers to a feeling of being away from their stressful lives. What is more, two studies investigated the weight of the sensory contribution to restorative effects. To be specific, a

representative study conducted in Singapore with individual sensory pleasantness votes and physiological measurements indicated thermal and visual pleasures were correlated to physiological recovery. However, the effect of auditory was not that significant [85]. In contrast, Schnell et al. did an outdoor experiment in the city center of Tel Aviv, Israel, and used portable measuring equipment to calculate in situ climatic and environmental variables [84]. They found that noise and crowding from the presence of people are more of a stressor than thermal load and carbonic oxide. It can be seen that different seasonal conditions and sensory combinations lead to different conclusions.

5. Discussion

5.1. Multisensory Effects of Restoration Benefits Between Public Urban Spaces and Natural Green Spaces

As for the restorative spatial property, the proportion of green elements is always positively correlated with restoration effects [77]. However, in high-density urban spaces, the presence of greenery is more effective for recovery than its area and density from time to time. To be specific, a modest amount of greenery is enough to ensure restoration effects through the critical role of auditory, olfactory, and/or thermal sensations [33,53,90]. Moreover, some architectural elements also show significant correlations with restorativeness in urban spaces than in naturalized environments. For instance, fountains have been proven to have a more pronounced restoration effect within urban surroundings enclosed by buildings [77]. Moreover, compared with the preference for high shelter spaces in natural restorative environments, people tend to demand more openness in compact public urban spaces. This might be because the open sky provides "soft glamour" [61], and open views have restoration benefits by reducing the perception of loudness and crowding, which could effectively facilitate urban background stressors [49,64,75]. Last but not least, "serene" is an important restorative quality of natural space [102,103]. However, everyday activities conducted in high-density urban spaces, such as streetscapes or squares, based on amenities people can sit in and stay in, and acoustic comfort from human-related sounds in plazas, can shape familiar and reassuring social atmospheres through multiple senses [88,89,104,105].

Regarding the multisensory mechanisms, relevant research in nature usually focuses on the additive effects in terms of spatial properties, since those restorative sources are mostly positive healing elements like water and vegetation [36]. Meanwhile, contexts in cities with more artificial and diverse urban elements, as well as interactions among multisenses, are relatively antagonistic and synergistic for recovery.

5.2. Comparison with the Previous Single-Sensory Studies

Compared with existing studies focused on the effects of individual senses on restorativeness, multisensory research provides a more comprehensive understanding of the complex mechanisms of sensory experience in a more realistic and applicable way.

(1) Compared to single-sensory studies, multisensory research can further clarify the effective stages of restoration. Previous single-sensory studies have often reported positive correlations between restoration benefits and factors such as plant cover and aroma concentration [77,106]. However, our study suggests that when a certain sensory input reaches a threshold, it may overshadow the positive effects of other senses [74,75]. For example, while single-sensory studies may highlight the benefits of increased plant coverage for psychological restoration, they overlook how excessive olfactory or auditory stimuli can diminish this effect when combined.

(2) Adjusting only one sensory input is not always sufficient to enhance recovery outcomes, as a significant restorative effect may emerge only through multisensory approaches. Furthermore, the limitations of single-sensory studies become more evident in contexts with conflicting sensory inputs. Prior studies have shown that the link between urban biodiversity and restoration is often weak [107,108]. However, the addition of natural sounds has been found to significantly enhance the

restorative experience [36]. In addition, while previous single-sensory studies emphasize the value of benches in promoting restorativeness by providing opportunities to pause [109,110], seating areas located near busy roads or crowded commercial zones are observed to lead to perceptions of overcrowding and increased stress in the multisensory research [75].

(3) Focusing on sensory coherence rather than single-sensory inputs is essential for promoting restoration [19,36,92]. While previous single-sensory studies have highlighted the significant role of plant aromas in recovery [56,111], they may become ineffective if they clash with the surrounding environment, even in areas with high green visibility [72].

5.3. Application of Combined Multisensory Experience on Restoration in Urban Design

Implementing restorative design strategy in urban practices involves integrating principles and techniques that promote the physical and mental well-being of city dwellers. In the past, this approach normally emphasizes utilizing certain sensory factors to mask the same sensory discomfort in urban environments [112–114]. However, it has been discovered that sounds like water and birdsong in noisy traffic environments are limited for noise masking and stress recovery [115,116]. Our research suggested that since recovery can be achieved through the synergic effect of multiple senses, restorative design needs to consider how spatial elements and their properties can effectively stimulate multisensory experiences and make good use of their interactions. By integrating sensory elements such as sight, sound, touch, and smell, designers can create more attractive and comfortable environments. This not only helps to enhance the psychological and physiological health of users but also promotes deeper emotional connections and community interactions.

Specifically based on the review, through sophisticated spatial design, odors could productively help to promote recovery in high-temperature, noisy, or low-green-visibility conditions in urban spaces [55,72,81]. Combining fragrant plants or the aroma of food with rich visual elements can enhance olfactory–visual perception and accelerate restoration. For example, London's Southbank Centre creates an immersive restorative experience by combining the aroma of coffee and bread from food stalls with visual elements such as murals and sculptures. In addition, combining essential oils from aromatic plants with landscape spray is an effective approach to integrating auditory, visual, and tactile experiences. Last but not least, using spatial organization thoughts, urban wind corridors based on the consideration of building spacing and spatial configuration can also help evacuate car exhaust fumes, reduce noise, and shape a comfortable thermal environment at the same time.

In highly urbanized areas, water installations can create dynamic, flowing landscapes that enrich multisensory experiences, thereby alleviating the annoyance and stress caused by urban noise [72,80,86]. For example, the forecourt of Sheffield Railway Station in the UK uses various water features to mask traffic noise, complemented by stainless-steel sculptures to create a restorative space. What is more, complex textures could be used to create different flow states, such as flips, drops, and bubbles, which provide rich visual, auditory, and tactile experiences.

It is also worth mentioning that urban outdoor space is a non-homeostatic environment, where an appropriate level of stimulation from other senses, even if it is a small change, is considered to be immediate and effective after discomfort is experienced [117]. This compensatory approach is based on the theory of "alliesthesia" [85,117,118]. Practically, when people pass through areas with car exhaust fumes or high solar radiation, small adjustments can help enhance restorative benefits, such as adding adjustable shading structures, using ground paving with varied textures, or placing small clusters of aromatic plants.

Future research and practice could further explore how to effectively integrate multisensory restorative design strategies into urban policies and planning regulations, such as "Green Building Standards" and "Healthy City Planning". These frameworks provide

evaluation standards for health design. However, they often lack comprehensive consideration of multisensory experiences, addressing only limited sensory factors such as sound and air quality in certain indicators. Specifically, public spaces could gain additional points in green certification by incorporating multisensory elements, such as natural sounds, aromatic plants, or diverse tactile materials. Additionally, urban management should consider broader sensory needs when formulating policies under Healthy City initiatives. For example, historic buildings should be paid attention to and maintained to preserve the distinctive odor of cities that triggers collective memories. The cultural information about historic buildings could also be conveyed through added voice-over narration, which has been shown to achieve better restorative effects by combining visual and auditory elements [23].

6. Conclusions

Due to the limited accessibility to nature and over-exposure to urban environments, spatial design towards the psychological and physiological recovery of urban inhabitants becomes problematic. This research provides a comprehensive overview that tends to summarize, analyse, and understand the relationship among the spatial property of public urban spaces, multisensory effects, and restoration benefits from the perspective of urban planning and design. First, a conceptual framework was conducted to assist in organizing the available evidence, specifying key categories, and identifying the linkage between urban settings and restorativeness. Then, based on different sensory combinations via additive, antagonistic, and synergistic effects, detailed spatial elements and organizations acting on urban restoration were extracted. The results demonstrated that restorative urban design requires the integration of various environmental factors, including, but not limited to, environmental aesthetics, the nature of ambient acoustics, the presence of specific odors, thermo-environmental factors like solar radiation and wind speed, etc. This research helps practitioners both from academia and industry to draw a better understanding of the current state of research and provide empirical guidance for incorporating health benefits into the design process of public urban spaces.

However, it still has some limitations. The data of this paper were derived from the Web of Science (WoS), and a further combination of literature from multiple databases based on disciplinary distribution is necessary. In addition, the review predominantly includes studies from highly urbanized countries, which may lead to certain cultural and environmental biases. Nevertheless, our study synthesizes the relationships between the spatial properties, sensorial mechanisms, and restoration benefits, providing a novel perspective on how to create urban restorative environments through spatial elements and organization. Furthermore, the multisensory design strategies proposed in this study have broad applicability, offering valuable insights for other cities on how to promote residents' health in the context of increased heat exposure, noise pollution, and a range of urbanization challenges. In the end, potential directions for the future development of relevant research are outlined: (1) Since variables in urban outdoor spaces are inconsistent, such as thermal climate, noise, and air pollution, restoration studies through time could also be further kept in focus. (2) Comparative studies on restorative experiences based on multisensory influences across different types of cities and cultural groups could be conducted. (3) As a product of a multidisciplinary intersection, most of the research only investigates the presence of certain spatial elements on restorative effectiveness and lacks attention to the compound spatial organization (i.e., how spatial elements are constituted together). Meanwhile, current multisensory research has fewer studies on the mechanism of three or more sensory interactions evoked by urban compositions and configurations. With the development of VR, AR, and advanced perceptual sensors, it is recommended to model multisensory experiences determined by practical spatial compositions in order to develop more applicable interventions, which could be implemented into real design and planning practices.

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