ACTA SCIENTIARUM POLONORUM Acta Sci. Pol., Administratio Locorum 24(2) 2025, 253–263.
https://czasopisma.uwm.edu.pl/index.php/aspal plISSN 1644-0749 eISSN 2450-0771 DOI: 10.31648/aspal.11060

ORIGINAL PAPER
Received: 28.01.2025 Accepted: 22.04.2025

THE CONCEPT OF MULTISENSORY LANDSCAPE ASSESSMENT IN TERMS OF AESTHETIC ATTRACTIVENESS

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ABSTRACT

Motives: A landscape is perceived through multiple senses. The notion that sight is the primary sense for aesthetic perception is indisputable. However, depending on the research objectives or practical applications of the results, this assumption should be reconsidered to account for the importance of multisensory reception.
Aim: The aim of this study is to conduct a factor analysis of the broader context of aesthetic landscape perception, considering all senses. From the perspective of spatial planning, diverse human needs, and the abundance of stimuli affecting individuals, multisensory perception becomes essential. Sight, hearing, smell, touch, and taste serve as receptors for the information conveyed by the landscape.
Results: The findings confirm the multisensory nature of landscape aesthetic perception. Decisions made in spatial planning and land management depend on multiple stimuli received by individuals. Research confirms that hearing and smell may play a greater role in decision-making processes than sight under certain conditions. This is particularly relevant to the location of residential and recreational functions near environmentally disruptive sites.

Keywords: landscape, multisensory perception, aesthetic attractiveness, perception, pairwise comparison

INTRODUCTION

Landscape is a subject of research in multiple scientific disciplines. From the perspective of spatial planning and land management, three primary approaches exist. The first two concern geographical perspectives (human geography and physical geography), while the third pertains to the ecological-landscape approach. Landscape is perceived through multiple senses (Jackson, 1984; Nassauer, 2012; Shi & Müller, 2013). The assumption that sight is the primary sense in assessing the aesthetic attractiveness of landscapes is undergoing significant changes depending on the research objectives or practical applications. Given the variety of stimuli people perceive, other senses such as hearing, smell, touch, and taste play an important role. Visual stimuli do not always dictate decision-making or the classification of evaluated objects. In recent decades, numerous reflections, theories, and studies have emerged on multisensory perception. However, this does not mean that landscape design using multiple senses is widespread. No universal methodology has been developed for applying multisensory perception, even in the most

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relevant fields: architecture, landscape architecture, urban and environmental design, tourism, and recreation (Roehr, 2022). If an environment is excessively noisy or has an unpleasant, disruptive odor, visual values become marginalised or even disregarded in decision-making processes (Brown & Brabyn, 2012; Rogowski, 2016). Furthermore, taste may be included in the set of multisensory perceptions – for example, as an association with a region or culture – as well as the "spirit of place" (*genius loci*), which characterises the intangible aspects of perceiving places that are particularly attractive due to their historical, cultural, or sacred significance (Oppido et al., 2020; Szymski, 2008). In summary, sight, hearing, smell, touch, taste, and even *genius loci* serve as receptors for all the information that landscapes transmit to individuals.

The objective of this study is to conduct a factor analysis of the broader context of landscape aesthetic attractiveness perception, taking into account all human senses. An attempt has been made to answer two research questions:

1. What is the degree of influence of each human sense on the perception of the aesthetic values of landscapes?
2. Does the purpose of the assessment highlight a specific sense that determines the results and directly influences landscape design and land use planning processes?

LITERATURE REVIEW

Transformations of landscapes are driven by current needs and developmental, technological, and civilizational possibilities. Their direction largely depends on the aesthetic values of a given area. These changes can be both planned and spontaneous processes. Decisions made by investors or stakeholders are influenced by various factors that result from the perception of space (Sahraoui et al., 2016). Similar mechanisms related to aesthetic assessment are well established in the management of biodiversity and ecosystems (Tribot et al., 2018). This perception is closely linked to the ability to evaluate aesthetic values in the planning and spatial development process. Methods and techniques of such assessment result from three dimensions: social, economic, and spatial. All these dimensions should (and usually do) take into account the multisensory nature of the landscape (Ren, 2023; Zhang et al., 2024).

Landscape design can be defined as a form of spatial organisation in which the diverse (often conflicting) demands of users and designers are balanced in a way that ensures a more or less attractive visual outcome. Research conducted in the past century indicated that visual perception plays a fundamental role in the perception of landscapes (Bell, 1994) (Table 1).

Table 1. Perception of the landscape through the observer's senses

Sense	Estimated influence on perception of stimuli [%]
sight	87
hearing	7
smell	3.5
taste	1
touch	1.5

Source: own elaboration based on (Bell, 1994).

The prevailing view in the literature, supported by numerous studies, confirms the dominant role of sight in landscape perception. Colour, shape, form, structure, and size are highly expressive elements that define a landscape and its unique style (Neale et al., 2021). However, in recent years, the role of other human senses in aesthetic landscape perception has been increasingly recognised and appreciated. Besides visual perception, research has focused on the influence of hearing, smell, touch, and taste. These senses can enhance the perception of landscape aesthetics but can also evoke negative emotions and impressions. Apart from sight, hearing receives the most attention in academic discussions. Excessive noise is harmful and causes everyday inconveniences. It can lead to health issues, social disturbances, and economic decline. Noise pollution contributes to severe sleep disturbances, significant hearing loss, reduced productivity and creativity in professional settings, and numerous dangerous, often incurable diseases. In the long term, excessive noise can even lead to premature death (Basner et al., 2014; Papi & Halleman,

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2004; Raimbault & Dubois, 2005). Many studies confirm the negative impact of this factor on the real estate market and associated investments. Noise pollution, particularly in urban environments, reduces the value of residential properties (Andersson et al., 2010; Blanco & Flindell, 2011; Gallo, 2018; Kuehnel & Moeckel, 2020). However, not all sounds are perceived negatively in terms of direct experience; some may have a positive impact on both physical health and human well-being. Natural sounds and their varied sequences (a kind of "music of nature") provide positive emotional experiences and significantly support bodily regeneration processes (Jaszczak et al., 2021).

Despite numerous studies across different scientific disciplines, the influence of other senses on the perception of aesthetic landscape values has not been thoroughly examined. Nonetheless, smell, taste, and touch also play a significant role in landscape perception. Decisions made by tourists, for example, ultimately translate into economic effects. Unpleasant or overwhelming odours or tastes in a tourist region can significantly diminish its attractiveness and lead to a decline in visitor numbers. Culinary tourism, based on regional products, is an example of how taste can shape the perception of a landscape. To a large extent, culinary tourism can be viewed through the lens of landscape evaluation, as it engages all the senses fundamental to its perception (Kim et al., 2021; Spence, 2011; Su et al., 2020). Juchacz et al. (2023) attempted to investigate the influence of non-visual landscape perception on its attractiveness. Their findings confirm the substantial impact of non-visual sensory input on the perception of the immediate environment. It has been established that individual senses are neither isolated nor independent; instead, they interact, complement each other, and merge into an integrated experience. The authors' survey research further confirmed that respondents are capable of identifying the contribution and significance of non-visual senses in multisensory landscape perception.

MATERIALS AND METHODS

The survey study, aimed at answering the first research question, was based on the assumptions of the direct comparison method. This method is widely used across various scientific disciplines, including psychology, pedagogy, and landscape studies, and has a universal character. It is based on Kendall's method for the statistical processing of collected responses (Ferguson & Takane, 2003; Kendall, 1970). The method allows for pairwise comparisons of the evaluated elements (k – number of evaluated elements), features, landscapes, photographs, possibilities, etc., and for ranking them in terms of, for example, attractiveness or suitability for a given evaluation purpose. Respondents complete the survey in a matrix format (Fig. 1). The results of each pairwise comparison are recorded graphically using arrows indicating the sense (in the case of the presented study) that is perceived as more valuable (according to the respondent)

sense	taste (X_1)	smell (X_2)	sight (X_3)	touch (X_4)	hearing (X_5)	**points**	**ranking**
taste (X_1)	x	↑	↑	↑	↑	**0 (0+0+0+0)**	**5**
smell (X_2)	←	x	←	←	↑	**2 (1+0+1+0)**	**3**
sight (X_3)	←	←	x	←	←	**4 (1+1+1+1)**	**1**
touch (X_4)	←	↑	↑	x	↑	**1 (1+0+0+0)**	**4**
hearing (X_5)	←	←	↑	←	x	**3 (1+1+0+1)**	**2**

Fig. 1. Evaluation matrix using the direct comparison method – example
Source: own elaboration.

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in terms of its significance for the aesthetic perception of the landscape. For instance, if a respondent considers element X_3 more attractive than element X_1, the notation in the template takes the form: $X_3 \leftarrow X_1$. In a single comparison, the more attractive element receives a value of 1, while the less attractive one receives a value of 0. A fully completed template for all possible pairwise comparisons serves as the basis for summing points and ultimately ranking the elements (Ferguson & Takane, 2003). Survey participants complete only the upper part above the diagonal, as the lower part is a mirror reflection and is filled in by the researcher analysing the results. At this stage, respondents' participation in the study ends. The total score for each element is calculated in the respective rows.

Each comparison (matrix cell) is assigned a value of 1, meaning the total value of the matrix remains constant and equals the total number of possible comparisons (Equation 1). For a set consisting of five elements, the total score of a single survey is 10. This scheme is commonly used, for example, in league-based sports competitions, where "everyone plays against everyone". The result columns present the score of a given element (sense) obtained from comparisons with all others, as well as its assigned ranking. The highest rank – 1 – is assigned to the element with the highest score (in this case, 4). The lowest rank – 5 – is assigned to the element with the lowest score (in this case, 0).

$$\frac{k(k-1)}{2} \tag{1}$$

where:

k – number of evaluated elements (senses).

Additionally, the direct comparison method allows for the application of statistical coefficients to eliminate improperly completed surveys. The first of these is Kendall's consistency coefficient (K), which determines the accuracy level of responses provided by each respondent. The second is Kendall's concordance coefficient (W), which assesses the overall agreement within the respondent group. These two statistical tools help eliminate the influence of erroneous responses from participants who made inconsistent or random choices. Furthermore, they can be used to standardise the group in terms of statistical agreement. The detailed procedure has been described in numerous academic sources across various, often unrelated, scientific fields (Brzeziński, 2010; Cieślak et al., 2008; Ferguson & Takane, 2003; Góralski, 1987; Kendall, 1970; Senetra, 2016).

The second survey study, aimed at answering the second research question, involved assessing the acceptance of discomfort factors present in the landscape, perceived by different senses. It was assumed

Table 2. Survey on acceptable inconveniences when choosing a building plot

Smell	Sight	Hearing
What inconveniences are you willing to accept in the vicinity?	What inconveniences are you willing to accept in the vicinity?	What inconveniences are you willing to accept in the vicinity?
1. Periodic odours related to agricultural activities (fertilisers, harvests, etc.).	1. View of multi-family residential estates.	1. Road noise from motorways.
2. Periodic odours from animal farming, poultry farms, etc.	2. View of rural settlements with farm buildings.	2. Road noise from local residential traffic.
3. Periodic odour nuisances from landfills and waste disposal sites.	3. View of industrial facilities, warehouses, etc.	3. Aircraft noise from airports.
4. Low-intensity exhaust fumes from nearby roads.	4. View of technical infrastructure elements (power lines, streets, masts, chimneys, bridges, viaducts, culverts, etc.).	4. Railway noise.
5. Odour associated with proximity to wetlands, swamps, and peat bogs.	5. View of commercial and service buildings.	5. Industrial noise.
6. Odour from industrial or production areas.	6. View of wetlands, swamps, and peat bogs.	6. Seasonal noise from agricultural activities – cultivated fields.
		7. Noise from animal farming facilities and infrastructure.
		8. Residential area noise associated with everyday activities.

Source: own elaboration.

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that respondents would answer questions regarding the possibility of purchasing a building plot for residential purposes under various conditions involving potential inconveniences affecting liveability. The focus was on three key senses relevant to the local real estate market – smell, hearing, and sight. Questions related to taste and touch were omitted, as these are more relevant in studies of, for example, tourism or in decisions regarding relocation to different regions, countries, or continents. The questions and proposed response options are presented in Table 2. Respondents could select any number of answers.

The survey matrix design did not allow for the addition of respondents' own observations due to the potential for varied interpretations of landscape phenomena and ambiguities in their terminology. This could also lead to incorrect interpretation and grouping of responses by the researcher analysing the results. Furthermore, a relatively high level of generalisation of these inconveniences was assumed, as the primary objective was to understand preferences and general patterns used by individuals in the multisensory perception of landscapes.

RESULTS AND DISCUSSION

To achieve the study's objectives and answer the research questions, a survey was conducted. It took place in February 2025 with a random group of 106 respondents. Participation in the survey was voluntary. It was assumed that respondents would not be selected from expert groups specialising in landscape research, nor would they be professionals from related fields (e.g., spatial planning, architecture, sociology). This approach was chosen to ensure results from individuals who are not professionally engaged in the subject but are instead landscape observers and potential or actual participants in the local real estate market. Among the surveyed group, there were 56 men and 50 women. The respondent structure is illustrated in Figure 2.

For the surveys conducted using the direct comparison method, Kendall's coefficient of choice consistency (K) (Kendall, 1970) was calculated for all completed questionnaires. As expected, given the small set of five evaluated senses in the multisensory perception of landscapes, all surveys were completed correctly. Consequently, no results were excluded. Furthermore, the ranking consistency for the entire group of respondents and within specific age groups, expressed by Kendall's W coefficient, is presented in Table 3. According to Kendall's methodology (Kendall, 1970), this coefficient ranges from zero (indicating complete disagreement among respondents) to one (indicating total agreement). Both Kendall's K and W coefficients were statistically evaluated using the chi-squared χ^2 distribution (Brzeziński, 2010; Ferguson & Takane, 2003; Kendall, 1970).

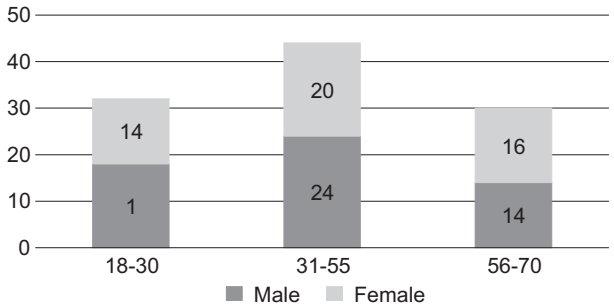

Fig. 2. Age structure of respondents
Source: own elaboration.

Table 3. Kendall's W coefficient of ranking consistency

Group	Kendall's W coefficient
18–30 years old	0.972
31–55 years old	0.960
56–70 years old	0.933
entire group	0.961

Source: own elaboration.

The analysis of Table 3 reveals a very high level of agreement among the entire surveyed group, although the oldest group of respondents shows slightly less agreement compared to the other two groups. However, there is no doubt that the entire sample demonstrates a remarkable level of consistency, which is rarely observed in this type of procedure. The small size of the evaluated set likely contributed positively to the high level of engagement. Furthermore, the topic was correctly understood and interpreted by all respondents, as it pertains to various

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aspects of human life and everyday interactions with space (Brzeziński, 2010).

As a result of calculating the point values for each of the evaluated senses, their hierarchy in the multisensory perception of the aesthetic qualities of the landscape was determined. To achieve this, ranks were assigned to each sense (Table 4). The highest rank (1) was given to vision (424 points). While this result is not surprising, the fact that all respondents were unanimous in assigning this element the maximum possible score (106 surveys, each awarding 4 points) is a strong indication that aligns with previous research findings (Brabyn, 2009; Cassatella, 2011; Gan et al., 2014). Another significant finding is the identification of the two next most important senses in the multisensory perception of landscape aesthetics. Hearing received rank 2 (285 points), while smell was ranked third (245 points). Across all analysed surveys, these two senses were consistently ranked in second or third place, with a predominance of responses favouring hearing. Besides visual perception, soundscapes have been a focal point in previous studies, as both positive and negative aspects of landscape-related sounds are widely recognised (Bernat, 2013; Bernat & Adamczyk, 2024; Halonen et al., 2015; Seidman & Standring, 2010; Zhu et al., 2023).

The remaining senses – touch (92 points, rank 4) and taste (14 points, rank 5) – were not ranked among the top three in any of the surveys. This suggests that these senses are relatively more difficult to identify in the everyday experience of a multisensory landscape. They tend to play a more significant role in specific contexts, such as tourism. The most important conclusion from this part of the study is that the multisensory perception of landscapes primarily relies on three senses. Compared to findings from the literature (Bell, 1994; Rogowski, 2018), the present study did not show a pronounced dominance of hearing over smell (7% vs. 3.5%, respectively). The difference in scoring is not as pronounced as in the cited studies. However, a clear distinction is observed between the two remaining senses, with respondents overwhelmingly ranking touch higher than taste. These differences compared to previous studies may stem from varying perceptions of landscape aesthetics in everyday life.

It is also worth noting that the significance of the sense of hearing increases with age. This may be related to a greater need for silence among older individuals, despite the potential decline in auditory perception. At the same time, it can be confirmed that younger groups exhibit greater tolerance to noise and its harmful impact on everyday comfort (Dor et al., 2024; Edworthy, 1997). Younger respondents are able to accept an environment with a higher noise level while demonstrating a lower tolerance for more or less unpleasant odors.

Table 4. Kendall's *W* coefficient of ranking consistency

Group	Taste Σ of points (M/F) [%]	Smell Σ of points (M/F) [%]	Sight Σ of points (M/F) [%]	Touch Σ of points (M/F) [%])	Hearing Σ of points (M/F) [%]
18–30 years old	5 (2/3)	79 (44/35)	128 (72/56)	27 (16/11)	81 (46/35)
	11/21	44/50	100/100	89/79	56/50
31–55 years old	6 (4/2)	100 (55/45)	176 (96/80)	38 (20/18)	120 (65/55)
	17/10	29/25	100/100	83/90	71/75
56–70 years old	3 (2/1)	66 (30/36)	120 (56/64)	27 (12/15)	84 (40/44)
	14/6	14/25	100/100	86/94	86/75
entire group	14 (8/6)	245 (129/116)	424 (224/200)	92 (48/44)	285 (151//134)
rank	5	3	1	4	2

The percentage share represents the agreement of the rank assigned by respondents (distinguished by gender) with the ranking obtained in the overall study.
M – male
F – female
Source: own elaboration.

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The answer to the second research question was obtained during the second stage of the survey, which allowed respondents to select any number of proposed answers (Table 2). In accordance with the adopted methodology, supported by results obtained from the direct comparison method, an assessment was made of the three most important senses – sight, hearing, and smell. These senses are the most comprehensible to respondents and have the greatest influence on the process of perception and evaluation, as confirmed by the obtained and discussed results. Detailed results are presented in Table 5.

The results presented in Table 5 show the level of acceptance of inconveniences resulting from the multisensory perception of the landscape through individual senses. This serves as an introduction to a detailed analysis of how these senses influence the choice of places such as residential locations. Despite the very dangerous and burdensome effects of noise, respondents rated its impact as the most acceptable (51%). Other studies indicate that, over time, civilization has become increasingly accustomed to rising noise levels, with health effects not appearing immediately upon exposure but often manifesting after years (Mac Domhnaill et al., 2021). The youngest group of respondents shows a significantly higher level of noise acceptance than other age groups. At the same time, certain types of noise and sounds may be associated with unattractive views or unpleasant odors, making it difficult to separate such associations definitively during surveys. The oldest group is the least tolerant of even everyday neighborhood noise, which is entirely acceptable to the youngest group.

Inconveniences related to the perception of landscape qualities through sight and smell are significantly less acceptable. This confirms that visual perception is the most important element in landscape assessment. The average level of acceptance, at approximately 45%, is relatively low. The influence of infrastructure, industry, and engineering structures is particularly noteworthy. Visual perception has the greatest impact on the oldest group, where acceptance levels are the lowest. Younger individuals are more willing to accept urban landscapes with industrial elements, whereas older individuals prefer rural landscapes with agricultural and farm buildings.

Unpleasant odors, on the other hand, are experienced in real time and often trigger immediate reactions. This contributes to the lowest level of acceptance of their impact on the perception of landscape aesthetics. Odors from livestock farms and landfills are unacceptable to all respondents, who were

Table 5. Results of acceptance of inconveniences perceived by the studied senses when selecting a building plot (descriptions correspond to numbering in Table 2)

Smell	Indications by groups (number/ %) 18–30[1]; 31–55[2]; 56–70[3]; **sum**[4]	Sight	Indications by groups (number/ %) 18–30[1]; 31–55[2]; 56–70[3]; **sum**[4]	Hearing	Indications by groups (number/ %) 18–30[1]; 31–55[2]; 56–70[3]; **sum**[4]
1.	18/56; 35/80; 28/93; **81/76**	1.	28/88; 31/70; 12/40; **71/67**	1.	24/75; 21/48; 6/20; **51/48**
2.	0/0; 0/0; 0/0; **0/0**	2.	19/59; 35/80; 25/83; **79/75**	2.	30/94; 38/86; 18/60; **86/81**
3.	0/0; 0/0; 0/0; **0/0**	3.	2/6; 2/5; 1/3; **5/5**	3.	8/25; 7/16; 4/13; **19/18**
4.	24/75; 30/68; 16/53; **70/66**	4.	11/34; 15/34; 6/20; **32/30**	4.	20/62; 25/57; 21/70; **66/62**
5.	25/78; 29/66; 21/70; **75/71**	5.	24/75; 21/48; 12/40; **57/54**	5.	2/6; 1/2; 0/0; **3/3**
6.	10/31; 12/27; 9/30; **31/29**	6.	9/28; 16/36; 17/57; **42/39**	6.	24/75; 29/66; 23/77; **76/72**
				7.	7/22; 11/25; 16/53; **34/32**
				8.	32/100; 41/93; 24/80; **97/92**
			average values for particular senses		
smell	77/40; 106/40; 74/41; **257/40**	sight	93/48; 120/45; 73/41; **286/45**	hearing	147/57; 173/49; 112/47; **432/51**

[1] – age group 18–30
[2] – age group 31–55
[3] – age group 56–70
[4] – all age groups combined
Source: own elaboration.

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exceptionally unanimous on this issue. In no survey was there any acceptance of these elements in the observed landscape. Younger respondents are more likely to tolerate, for example, inconveniences related to exhaust fumes from daily vehicle use. This result reflects civilizational changes similar to the increasing acceptance (or habituation) of noise sources. In contrast, the oldest group does not perceive odors from agricultural work, which cause temporary inconveniences, as problematic. For the youngest group, however, this is a more pronounced issue.

In light of the obtained results, it should be stated that it is possible to assess the impact of individual sensory receptors on the perceived aesthetic value of the landscape. However, it should be remembered that as civilization develops, we become accustomed to certain inconveniences, lifestyle changes, and trends. It is expected that future research will continue to evolve, providing insights into ever-higher levels of acceptance of environmental nuisances. New facts, technologies, and reasons for changes in the multisensory perception of landscapes will emerge. However, it is important to emphasise that certain conditions of perception and differentiation between the senses remain constant (Wu, 2024). In the pairwise comparison method, respondents clearly established a hierarchy of senses that are most important in multisensory perception. Another highly significant issue is the difficulty in clearly defining the influence of a specific sense. For example, when looking at a motorway, one is aware of both the intrusive road noise it generates and the significant amount of toxic fumes with an unpleasant odor. Similarly, wetlands may be associated with an unpleasant smell or an unattractive view. However, this is not always the case, as they may also be visually appealing, free from unpleasant odors or noise. On the contrary, they may produce nature sounds that are pleasant to humans and provide ecological value, benefiting the protection and shaping of landscapes. In every case, the assessment may be ambiguous, and different senses may influence the final perception.

CONCLUSIONS

The methodology applied in the study and the results obtained indicate that it is possible to determine the hierarchy of senses through which the aesthetic values of the landscape are perceived. The interest in the surveys and the very high consistency of individual surveys, as well as the agreement of the entire group of respondents, indicate a high awareness and recognition of this important research issue for both science and practice. The study did not involve experts in landscape research, but only individuals who are typical recipients and participants in the processes occurring in the space, which further emphasizes the value of the results obtained in the context of statistical correctness.

Previous findings regarding certain mechanisms of multisensory perception of landscape aesthetics have been confirmed. Sight is the dominant receptor in this complex process. However, not all previous scientific findings can be considered permanent and indisputable in light of the results obtained. With the development of modern technologies and the increase in the human population, there is a clear trend towards perceiving noise as one of the most important elements of the process. At the same time, it can be stated that people easily adapt to and become accustomed to noise, which is a destructive factor for health and quality of life in the long term. The perception of unpleasant and harmful odors in the landscape is also strongly emphasized. They play a significant role due to their direct impact and causing immediate inconveniences. Despite often lower harmfulness, the acceptability of the negative impact of odors is often the least acceptable element of the perception of landscape aesthetics.

The other two senses, touch and taste, occupy the lowest place in the hierarchy of senses perceiving the landscape. Respondents are aware of their impact but do not place them on par with the others, especially when it comes to aspects of daily life. The results clearly indicate that it is impossible to use individual senses completely separately. They constitute, in a sense, a system of interconnected vessels.

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The perception of the landscape by one sense is related to the associated features perceived by other senses, as confirmed by the responses obtained in the second part of the survey. In light of the study's objective and the answers to the research questions, it should be stated that the study of multisensory perception of landscape aesthetics is an important and unresolved issue. Further analyses, in the context of changing environmental and civilizational conditions, may be indicative of directions for planning and spatial development. The result of such an approach is the necessity to consider the needs and developmental threats characteristic of many fields related to the organization of human living space and the functioning of natural systems.

Author contributions: The author has approved the final version of the article. The author have contributed to this work as follows: A.S. developed the concept and designed the study, A.S. collected the data, A.S. analysed and interpreted the data, A.S. drafted the article, A.S. revised the article critically for important intellectual content.

REFERENCES

Andersson, H., Jonsson, L., & Ögren, M. (2010). Property Prices and Exposure to Multiple Noise Sources: Hedonic Regression with Road and Railway Noise. *Environmental and Resource Economics*, *45*(1), 73–89. https://doi.org/10.1007/s10640-009-9306-4

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *The Lancet*, *383*(9925), 1325–1332. https://doi.org/10.1016/S0140-6736(13)61613-X

Bell, S. (1994). *Visual Landscape Design Training Manual*. Forest Recreation. Recreation Branch Publication. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/visual-resource-mgmt/training-vrm/vrm_visual_landscape_design_training_manual_complete.pdf

Bernat, S. (2013). Awareness of Noise Hazards and the Value of Soundscapes in Polish National Parks. *Archives of Acoustics*, *38*(4), 479–487. https://doi.org/10.2478/aoa-2013-0057

Bernat, S., & Adamczyk, P. (2024). Protection of the quiet and nocturnal landscape. *Acta Scientiarum Polonorum. Administratio Locorum*, *23*(3), 349–364. https://doi.org/10.31648/aspal.9780

Blanco, J. C., & Flindell, I. (2011). Property prices in urban areas affected by road traffic noise. *Applied Acoustics*, *72*(4), 133–141. https://doi.org/10.1016/j.apacoust.2010.11.004

Brabyn, L. (2009). Classifying Landscape Character. *Landscape Research*, *34*(3), 299–321. https://doi.org/10.1080/01426390802371202

Brown, G., & Brabyn, L. (2012). An analysis of the relationships between multiple values and physical landscapes at a regional scale using public participation GIS and landscape character classification. *Landscape and Urban Planning*, *107*(3), 317–331. https://doi.org/10.1016/j.landurbplan.2012.06.007

Brzeziński, J. (2010). *Metodologia badań psychologicznych* [*Methodology of psychological research*]. Wydawnictwo Naukowe PWN [Polish Scientific Publishers PWN].

Cassatella, C. (2011). Assessing Visual and Social Perceptions of Landscape. In *Landscape Indicators* (pp. 105–140). Springer Netherlands. https://doi.org/10.1007/978-94-007-0366-7_6

Cieślak, M., Dittmann, P., Krupowicz, J., Kuropka, I., Kwiatkowska-Ciotucha, D., Radzikowska, B., Szanduła, J., & Załuska, U. (2008). *Prognozowanie gospodarcze: metody i zastosowania* [*Economic forecasting: methods and applications*]. Wydawnictwo Naukowe PWN [Polish Scientific Publishers PWN].

Dor, Y. I., Algom, D., Shakuf, V., & Ben-David, B. M. (2024). Age-related differences in processing of emotions in speech disappear with babble noise in the background. *Cognition and Emotion*, 1–10. https://doi.org/10.1080/02699931.2024.2351960

Edworthy, J. (1997). Noise and its effects on people: an overview. *International Journal of Environmental Studies*, *51*(4), 335–344. https://doi.org/10.1080/00207239708711091

Ferguson, G. A., & Takane, Y. (2003). *Analiza statystyczna w psychologii i pedagogice* [*Statistical analysis in psychology and pedagogy*]. Wydawnictwo Naukowe PWN [Polish Scientific Publishers PWN].

Gallo, M. (2018). The Impact of Urban Transit Systems on Property Values: A Model and Some Evidences from the City of Naples. *Journal of Advanced Transportation*, *2018*, 1–22. https://doi.org/10.1155/2018/1767149

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Gan, Y., Luo, T., Breitung, W., Kang, J., & Zhang, T. (2014). Multi-sensory landscape assessment: The contribution of acoustic perception to landscape evaluation. *The Journal of the Acoustical Society of America*, *136*(6), 3200–3210. https://doi.org/10.1121/1.4898424

Góralski, A. (1987). *Metody opisu i wnioskowania statystycznego w psychologii i pedagogice* [*Methods of description and statistical inference in psychology and pedagogy*]. Wydawnictwo Naukowe PWN [Polish Scientific Publishers PWN].

Halonen, J. I., Hansell, A. L., Gulliver, J., Morley, D., Blangiardo, M., Fecht, D., Toledano, M. B., Beevers, S. D., Anderson, H. R., Kelly, F. J., & Tonne, C. (2015). Road traffic noise is associated with increased cardiovascular morbidity and mortality and all-cause mortality in London. *European Heart Journal*, *36*(39), 2653–2661. https://doi.org/10.1093/eurheartj/ehv216

Jackson, J. B. (1984). *Discovering the vernacular landscape*. Yale University Press.

Jaszczak, A., Małkowska, N., Kristianova, K., Bernat, S., & Pochodyła, E. (2021). Evaluation of soundscapes in urban parks in Olsztyn (Poland) for improvement of landscape design and management. *Land*, *10*(1), 66. https://doi.org/10.3390/land10010066

Juchacz, O., Czerwiński, P., & Wilkaniec, A. (2023). Pozawzrokowe postrzeganie krajobrazu przez zróżnicowane grupy użytkowników na przykładzie Bydgoszczy [Non-visual perception of landscape by diverse user groups on the example of Bydgoszcz]. *Rozwój Regionalny i Polityka Regionalna* [*Regional Development and Policy*], *64*, 117–133. https://doi.org/10.14746/rrpr.2023.64.08

Kendall, M. G. (1970). *Rank correlation methods*. Charles Griffin and Co.

Kim, S., Park, E., Fu, Y., & Jiang, F. (2021). The cognitive development of food taste perception in a food tourism destination: A gastrophysics approach. *Appetite*, *165*, 105310. https://doi.org/10.1016/j.appet.2021.105310

Kuehnel, N., & Moeckel, R. (2020). Impact of simulation-based traffic noise on rent prices. *Transportation Research Part D: Transport and Environment*, *78*, 102191. https://doi.org/10.1016/j.trd.2019.11.020

Mac Domhnaill, C., Douglas, O., Lyons, S., Murphy, E., & Nolan, A. (2021). Road traffic noise and cognitive function in older adults: a cross-sectional investigation of The Irish Longitudinal Study on Ageing. *BMC Public Health*, *21*(1), 1814. https://doi.org/10.1186/s12889-021-11853-y

Nassauer, J. I. (2012). Landscape as medium and method for synthesis in urban ecological design. *Landscape and Urban Planning*, *106*(3), 221–229. https://doi.org/10.1016/j.landurbplan.2012.03.014

Neale, C., Griffiths, A., Chalmin-Pui, L. S., Mendu, S., Boukhechba, M., & Roe, J. (2021). Color aesthetics: A transatlantic comparison of psychological and physiological impacts of warm and cool colors in garden landscapes. *Wellbeing, Space and Society*, *2*, 100038. https://doi.org/10.1016/j.wss.2021.100038

Oppido, S., Ragozino, S., De Vita, G.E. (2020). Exploring Territorial Imbalances: A Systematic Literature Review of Meanings and Terms. In C. Bevilacqua, F. Calabrò, & L. Della Spina (Eds.), *New Metropolitan Perspectives. NMP 2020. Smart Innovation, Systems and Technologies* (vol. 177). Springer, Cham. https://doi.org/10.1007/978-3-030-52869-0_8

Papi, J., & Halleman, B. (2004). *Road traffic noise the road sector's perspective*. The European Union Road Federation.

Raimbault, M., & Dubois, D. (2005). Urban soundscapes: Experiences and knowledge. *Cities*, *22*(5), 339–350. https://doi.org/10.1016/j.cities.2005.05.003

Ren, X. (2023). Combined effects of dominant sounds, conversational speech and multisensory perception on visitors' acoustic comfort in urban open spaces. *Landscape and Urban Planning*, *232*, 104674. https://doi.org/10.1016/j.landurbplan.2022.104674

Roehr, D. (2022). *Multisensory Landscape Design*. Routledge. https://doi.org/10.4324/9780429504389

Rogowski, M. (2016). The Multi-sensory landscape as an inspiration in the creation of a tourism product. *Turyzm/Tourism*, *26*(2), 23–32. https://doi.org/10.1515/tour-2016-0010

Rogowski, M. (2018). Multisensoryczność krajobrazu w przestrzeni turystycznej – kontekst badawczy [The landscape multi-sensory of tourism space – research context]. *Prace i Studia Geograficzne* [*Geographical Works and Studies*], *63*(2), 117–130.

Sahraoui, Y., Clauzel, C., & Foltête, J.-C. (2016). Spatial modelling of landscape aesthetic potential in urban-rural fringes. *Journal of Environmental Management*, *181*, 623–636. https://doi.org/10.1016/j.jenvman.2016.06.031

Seidman, M. D., & Standring, R. T. (2010). Noise and Quality of Life. *International Journal of Environmen-*

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tal Research and Public Health, *7*(10), 3730–3738. https://doi.org/10.3390/ijerph7103730

Senetra, A. (2016). Badania ankietowe jako element konstrukcji metody bonitacyjnej oceny wartości estetyczno-widokowych krajobrazów na przykładzie wiejskich obszarów pojeziernych [Questionnaire surveys as an element of the construction of point valuation method for the aesthetic-view value on the example of rural lake districts landscapes]. *Acta Scientiarum Polonorum. Administratio Locorum*, *15*(4), 111–121. https://doi.org/10.31648/aspal.662

Shi, Z., & Müller, H. J. (2013). Multisensory perception and action: development, decision-making, and neural mechanisms. *Frontiers in Integrative Neuroscience*, *7*. https://doi.org/10.3389/fnint.2013.00081

Spence, C. (2011). Mouth-watering: the influence of environmental and cognitive factors on salivation and gustatory/flavor perception. *Journal of Texture Studies*, *42*(2), 157–171. https://doi.org/10.1111/j.1745-4603.2011.00299.x

Su, D. N., Johnson, L. W., & O'Mahony, B. (2020). Analysis of push and pull factors in food travel motivation. *Current Issues in Tourism*, *23*(5), 572–586. https://doi.org/10.1080/13683500.2018.1553152

Szymski, A. M. (2008). Genius loci – czyli o odkrywaniu i na nowo definiowaniu znaczeń w istniejącej przestrzeni miejskiej (trzy przykłady) [Genius loci – about discovery and new definitione of implications in existing urban space (three examples)]. *Czasopismo Techniczne. Architektura* [*Technical Journal. Architecture*], *105*, 162–166.

Tribot, A.-S., Deter, J., & Mouquet, N. (2018). Integrating the aesthetic value of landscapes and biological diversity. *Proceedings of the Royal Society B: Biological Sciences*, *285*(1886), 20180971. https://doi.org/10.1098/rspb.2018.0971

Wu, S. (2024). Construction of Multisensory Landscape and Integration of Soundscape, Smellscape and Lightscape in Traditional Chinese Gardens. *Journal of South Architecture*, *1*(2). https://doi.org/10.33142/jsa.v1i2.12575

Zhang, J., Shi, Y., Zhao, L., Cai, C., & Furuya, K. (2024). *Perception of Landscape and Cultural Landscape Sustainability–Evidence from Multisensory Descriptions in Online Reviews Using Deep Learning Methods*. https://doi.org/10.21203/rs.3.rs-4776972/v1

Zhu, Y., Huang, N., Weng, Y., Tong, H., Wang, X., Chen, J., Liu, J., Chen, Z., Dong, J., & Wang, M. (2023). Does Soundscape Perception Affect Health Benefits, as Mediated by Restorative Perception? *Forests*, *14*(9), 1798. https://doi.org/10.3390/f14091798

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