

Original Research Article

Comparative Analysis of Sensory Richness Components in Residential Environments (A Case Study of Cactus and Andisheh Complexes, Rasht)*

Sogand Rouhani Mardakhi

Department of Architecture, Faculty of Architecture and Art, University of Guilan, Rasht, Iran

Amirreza Karimi Azeri**

Department of Architecture, Faculty of Architecture and Art, University of Guilan, Rasht, Iran

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Abstract | In residential environment design, the quality of residents' perception and lived experience is closely linked to the alignment of environmental attributes with human sensory and cognitive capacities. Environmental stimuli attuned to perceptual thresholds play a key role in enhancing sensory richness and the overall quality of spatial experience. However, sensory factors are often neglected and rarely addressed in a comprehensive, multidimensional, or systematic manner in contemporary residential design practices. This study investigates the architectural components that most significantly contribute to enriching sensory experience in residential complexes. This study aims to identify and analyze the architectural and environmental components affecting sensory richness and assess their measurable impact on users' environmental perception quality in two selected residential complexes in the city of Rasht, Iran. The theoretical part is based on an extensive literature review, covering the role of the five senses in environmental perception, as well as relevant theoretical frameworks related to sensory design. Empirically, the study applies sensory walking and multisensory mapping techniques to explore users' sensory experiences across six spatial nodes in the Cactus and Andisheh residential complexes. Data were gathered through direct observation, semi-structured interviews, and supplementary questionnaires, and were analyzed using a mixed-methods approach (qualitative-quantitative), with results visualized through comparative spider diagrams. The findings reveal that the Cactus complex, characterized by climate-responsive design strategies, rich vegetation, and active, well-defined semi-public spaces, exhibited stronger performance in olfactory, tactile, and gustatory aspects, resulting in deeper levels of sensory engagement. In contrast, the Andisheh complex, despite its visual coherence and structural order, underperformed in stimulating the remaining senses. The study highlights the importance of multisensory design in improving environmental quality, enhancing user satisfaction, strengthening place attachment, and promoting psychological comfort and mental well-being. Recommendations are proposed to guide future sensory-enriched residential design and foster deeper, more meaningful human-environment interaction.

Keywords | *Sensory richness, Sensory components, Environmental perception, Multisensory experience, Residential complex.*

Introduction | The components of sensory richness in the process of human interaction with the built environment, considering the capacity of sensory receptors, play a pivotal and decisive role in enhancing users' satisfaction and the quality of spatial experience. The five senses are recognized as the primary stimuli influencing human behavior and psychological states in the environment (Mojtabavi et al., 2022). In fact, neglecting the simultaneous and balanced interaction among these senses is regarded as a fundamental shortcoming in the human environmental

experience (Ghaderi & Khatami, 2023). Nevertheless, evidence shows that urban designers have mainly focused on the physical and morphological aspects of space, while paying limited attention to the impact of sensory components on users' behavior and experience (Elrafie et al., 2023). Several studies indicate that increasing the involvement of senses in the process of spatial perception deepens experience, enhances attractiveness, strengthens memorability of space, and facilitates place attachment and self-actualization (Pallasmaa, 2005; Ghaderi & Khatami, 2023). With the growth of urbanization

**Corresponding author: +989122938113, amirreza_karimiazeri@guilan.ac.ir

and the increasing population density in residential areas, spatial limitations in housing complexes have led to a decline in sensory richness and a reduction in the quality of environmental experience (Grahm & Stigsdotter, 2010). Contemporary research emphasizes the significance of multisensory experiences in improving residents' satisfaction and psychophysiological restoration (Fan et al., 2025). However, the prevailing design of residential complexes is often vision-centered, with other senses receiving little attention. This issue not only reduces user satisfaction but also results in the exclusion and isolation of individuals with sensory or perceptual limitations (Zanganeh & Keshmiri, 2019). The rapid trend of urbanization in Iran, along with mass housing policies, particularly in the form of large-scale residential estates, has frequently been implemented without sufficient consideration for spatial quality and residents' mental health. This has contributed to the emergence of psychosocial disorders in urban life (Javani et al., 2019). Moreover, environmental perception, as the foundation of residents' spatial evaluation and preference, is directly shaped by their values, attitudes, and social expectations, all of which play a key role in generating satisfaction or dissatisfaction with space (Pakzad & Bozorg, 2012; Faraji et al., 2023).

The aim of this study is to explore the various dimensions of sensory richness in the physical and functional features of residential complexes and to analyze how sensory components influence perception and the quality of living environments. The findings from a comparative study of two residential complexes identify a set of key factors that highlight the shortcomings in prevailing architectural design patterns and provide a basis for improving quality of life and enhancing the design of residential environments in dense urban context.

Research Objectives

The main objective of this research is to identify and analyze the components affecting sensory richness in residential environments and to examine their influence on users' environmental Perception.

To achieve this objective, the study focuses on the following:

- Identifying the physical components that enhance sensory richness;
- Analyzing functional factors contributing to multisensory experiences of residents;
- Examining the relationship and interaction between physical and functional components in shaping and strengthening users' sensory experiences.

Research Questions and Hypotheses

Based on the above discussions, the research questions are as follows:

- Which physical components play a role in enhancing sensory richness in residential environments?

- What functional factors can effectively increase the sensory richness of living spaces?

- What relationship exists between physical and functional components in shaping and reinforcing sensory richness from the perspective of residents?

In response to these questions, the following hypotheses are proposed:

- Physical features such as the quality of natural lighting, desirable views, coherent spatial organization, and diversity in texture and materials play an effective role in enhancing sensory richness in residential environments.

- Functional components such as spatial flexibility, functional diversity, interactive spaces, and access to welfare services can improve sensory richness and strengthen residents' environmental perception.

- Overall, the synergy between physical and functional components can foster a multisensory residential experience, thereby enhancing sensory richness and improving residents' psychological and emotional well-being.

Literature Review

Sensory-rich experiences, as one of the key dimensions of environmental quality, have increasingly attracted scholarly attention in recent years. These experiences, generated through the simultaneous or sequential stimulation of the five senses, lead to multilayered perceptions of the environment. Numerous studies have shown that spaces with high sensory richness can contribute to improved quality of life, increased satisfaction, reduced stress, and enhanced mental health (Kyttä et al., 2013; Kang et al., 2016). In this regard, the study of Szczepanska et al. (2013) in Poznan, focusing on auditory, olfactory, and tactile senses, demonstrated that environmental perception is not limited to visual factors and that non-visual senses play a significant role in landscape experience. Similarly, Larson, Jennings & Cloutier (2016) argue that multisensory environmental qualities are directly associated with psychological well-being in urban and residential settings. Bentley et al. (1985), in their influential book "Responsive Environments: A Manual for Designers", emphasize the limited capacity of human perception, noting that perceptual elements should be designed in accordance with sensory processing abilities. For instance, grouping façade elements into clusters of 5–9 prevents perceptual overload or monotony. This point is also highlighted in "The Alphabet of Environmental Psychology for Designers" (Pakzad & Bozorg, 2012), which stresses the necessity of aligning environmental information with users' perceptual capacities. Domestic research, such as the study by Lotfi et al. (2017) in Babol, also explores the role of olfactory and auditory senses in urban design, emphasizing the significance of "invisible space" in reinforcing sense of place and perceptual quality. Their findings underscore the need to consider sensory qualities beyond the visible, both

for enriching space and for strengthening place attachment, a perspective consistent with international research such as that of Gifford (2007), who emphasizes the role of multisensory perception in fostering attachment and interaction with the environment. In the field of sensory richness and mental health, the study of Dehghan et al. (2022) reports a meaningful relationship between the quality of the built environment and the reduction of psychological disorders such as depression. Factors such as permeability, sociability, safety, and climatic comfort as subcomponents of sensory richness play an important role in improving mental health. Similar findings are observed in international studies, including those of Mazuch & Stephen (2005) and Nelson & Hummel (2022), which show that multisensory spatial design can reduce anxiety and enhance psychological well-being through positive mental stimulation. Likewise Naeimi Foroutani Nezhad et al. (2022) demonstrate that factors such as spatial arrangement, lighting quality, color, and even the physical form of blocks can significantly affect residents' stress, depression, and comfort levels. In this regard, Kaplan & Kaplan's (1989) Landscape Preference Model highlights that features such as coherence, legibility, and visual complexity influence environmental preference and perception. Shahcheraghi (2009), drawing on ecological psychology, emphasizes the importance of designing environments with high sensory affordances, spaces that stimulate multiple senses simultaneously and thus promote reflection, self-awareness, and ultimately mental health. This perspective aligns with contemporary human-centered design approaches (Pallasmaa, 2005; Golembiewski, 2016). Spence (2020), in his paper "Senses of place: Architectural design for the multisensory mind", stresses the necessity of designing architecture for the multisensory mind, arguing that residential environments provide meaningful and satisfying experiences only when all human senses (sight, hearing, smell, touch, and thermal perception) are considered in design. He points out that spatial perception extends far beyond visual input and that attention to non-visual senses is vital in the design of everyday environments, particularly housing. Malnar & Vodvarka (2004), in "Sensory Design", also underline the undeniable role of the senses in shaping environmental qualities, contending that sensory-rich spaces can meet psychological needs and enhance users' sense of calm and satisfaction. Pallasmaa (2005), in his seminal book "The Eyes of the Skin: Architecture and the Senses", critiques the dominance of vision in architecture and highlights the importance of other senses, particularly touch and smell, arguing that architectural experience is inherently multisensory and should be approached as such, especially in the design of residential environments. In the field of soundscapes, Blesser & Salter (2006) in "Spaces Speak, Are You Listening?: Experiencing Aural Architecture" demonstrate how auditory experience of space affects residents' feelings of

safety, belonging, and even cognitive performance. Similarly, Heschong (1979), in "Thermal Delight in Architecture", explores the importance of thermal experience, considering it a fundamental part of memorable and rich residential environments. Kaplan (1995) also shows that urban landscape design, when based on principles of coherence, legibility, and complexity, enhances environmental perception and ultimately improves users' psychological well-being. Despite the growth of research on sensory aspects of the environment, studies that systematically and interdisciplinarily examine the relationship between multisensory design, sensory richness, and mental health in residential complexes remain limited. In particular, there is a notable lack of integrative analyses capable of linking environmental design components (such as form, color, texture, sound, light, and smell) with psychological indicators, and of proposing novel conceptual frameworks for enhancing environmental perception and residents' mental health in housing complexes.

Theoretical Foundations

This study is based on the assumption that favorable sensory stimuli at the onset of perception can create a rich and profound experience of being in the living environment. As soon as individuals are situated in a space, through the interaction of spatial, personal, and social factors and by engaging their senses, the connection between human and environment is established, and the process of sensory reception begins (Mojtabavi et al., 2022). According to Gibson's theory of affordances, the environmental affordances of any phenomenon are those physical characteristics that allow it to be utilized by a particular organism. In other words, an object or a place possesses qualities that render its functions meaningful in fulfilling human needs (Tabatabaian & Tamannaee, 2014). Within this perspective, it appears that employing sensory richness components can both directly and indirectly enhance the qualities of residential environments and reinforce their sustainability (Dehghan et al., 2022). Accordingly, the conceptual framework of this study is structured around the process of sensory perception and the multilayered interaction between humans and their environment.

• Perception and sensation

Perception is an active process of acquiring, interpreting, and organizing information from the surrounding environment, positioned at the intersection of cognition and reality (Lang, 1987). While sensation refers to raw and primary sensory inputs, perception is a more complex, purposeful, and integrated process through which sensory data are analyzed and interpreted to create a meaningful understanding of the environment (Goldstein, 2002). Human beings typically experience multiple senses simultaneously and, often unconsciously, combine them; therefore, perception goes beyond the mere sum of individual

sensations (Lashley, 1951). Perception involves organizing and interpreting sensory data to construct a coherent and unified image of the environment (Palmer, 1999). In everyday life, individuals rely simultaneously on vision, hearing, touch, and other senses, and their experience of space emerges from this multisensory perception rather than from isolated sensory inputs (Lawson, 2001). This view aligns with the concept of integrated processing, which emphasizes the interaction between sensory inputs and prior knowledge in shaping perception (Clark, 1996). Accordingly, environmental perception can be considered an integrative process that transmits to the mind a holistic and contextualized image rather than fragmented sensory details (Purves et al., 2007). Perception is not merely a passive reflection of sensory inputs but an active mental construct through which individuals interpret environmental cues within the framework of their experiences, memory, and prior knowledge (Rock, 1983; Palmer, 2002). This perspective highlights the essential role of perception in shaping human reactions to, and interactions with, architectural spaces and designed environments (Pakzad & Bozorg, 2012).

• Sensory richness

Human environmental perception is inherently multisensory and integrated, formed through the simultaneous engagement of the five senses with the environment and influenced by mental, emotional, and physical experiences. In recent years, a holistic approach to sensory experience in residential design has gained attention, emphasizing the role of non-visual components such as sound, smell, texture, and temperature (Spence, 2020). Within this context, the concept of sensory richness, referring to the degree of positive, diverse, and meaningful sensory stimulation, has been identified in environmental psychology as a crucial indicator of spatial quality and aesthetics (Levent & Pascual-Leone, 2014). Research demonstrates that sensory-rich environments enhance psychological well-being, strengthen place attachment, improve cognitive performance, reduce stress, and promote mental health (Evans et al., 2003). Such environments, shaped through tangible and intangible elements such as natural light, material diversity, calming sounds, natural scents, and soothing colors, offer meaningful perceptions and positive sensory experiences (Henshaw, 2014; Spence, 2020). Environmental theories further highlight the role of sensory richness in improving spatial legibility, supporting wayfinding, and generating meaning through sensory memory (Lynch, 1960; Nasar, 1992). Based on the sensory balance theory, alignment between environmental stimuli and users' perceptual preferences produces a more harmonious and pleasant experience (Sternberg, 2009). In this framework, Table 1 categorizes the factors influencing environmental perception, focusing on the five senses and drawing upon theoretical and empirical studies.

• Sensory richness in residential complexes

Within residential environments, sensory richness is

regarded as a key factor in enhancing spatial perception and the lived experience of residents. Spaces that stimulate the five senses in a coordinated manner can foster feelings of satisfaction, security, and belonging (Malnar & Vodvarka, 2004; Pallasmaa, 2005). This sensory experience extends beyond visual elements such as light, color, and greenery to include factors like sound, smell, airflow, and surface qualities (Gifford, 2007). Effective residential design should aim to stimulate multiple sensory systems simultaneously and coherently, as such an approach is associated with improved mental health, reduced anxiety, and greater life satisfaction (Zardini, 2005; Howes & Classen, 2013). Semi-public spaces such as courtyards, circulation paths, and shared lounges also play a significant role in strengthening sensory perception and fostering social interaction (Kaplan & Kaplan, 1989). Thus, sensory richness is not merely a physical construct but also an experiential, emotional, and social dimension that influences quality of life and place attachment (Zimring & Reizenstein, 1980; Diaconu et al., 2011). Adopting an interdisciplinary perspective, this study draws upon theories from environmental psychology and urban design to identify and categorize the factors shaping residents' sensory experiences in residential complexes. Table 2 outlines the key components that contribute to spatial aesthetics, mental well-being, social interaction, and overall quality of life.

Theoretical Framework

The theoretical framework of this research is built upon Gifford's (2007) environmental perception model, which, due to its comprehensiveness and alignment with the concept of sensory richness, analyzes the environment through three main dimensions: cognitive, affective, and sensory. Gifford argues that environmental perception is a complex process that goes beyond the mere reception of visual stimuli, incorporating psychological, emotional, and sensory factors that simultaneously shape the environmental experience. Accordingly, this model is particularly well-suited for understanding the perceptual and emotional dimensions of environmental experience. Moreover, Kaplan & Kaplan's (1989) landscape preference model emphasizes the importance of aligning environmental features with human perceptual and psychological needs, particularly highlighting coherence, legibility, and visual complexity as decisive factors influencing perceptual quality. This approach is especially useful in analyzing landscape preferences and responding to the psychological needs of users. Likewise, Pallasmaa's (2005) perspective, which stresses the necessity of multisensory design and the engagement of all five senses in architectural experience, further strengthens this framework. His approach underlines the significance of environmental factors beyond visual input alone, particularly in residential contexts, thereby

Table 1. The influence of sensory systems on spatial experience and perception based on theorists' perspectives. Source: Authors.

	The Influence of the Five Senses on Spatial Perception	Theorists
Visual System	More than two-thirds of the neural input to the central nervous system is received through the eyes; therefore, vision plays a dominant role in environmental perception. In the complex interaction between the eye and the brain, the experience of space is primarily shaped through visual perception.	Gregory (1966), Lawson (2001)
	The human brain responds only to selected visual features, which leads to a filtering of perception when encountering environmental stimuli.	Gregory (1966)
	The artificial visual environment, depending on the quality of its interaction with the visual system, can be categorized as homogeneous, comforting, or aggressive. Comforting environments, with pleasing elements and favorable structures, positively influence the quality of spatial perception.	Filin (1998)
	In conditions of very low light, the structural details of space are eliminated from visual perception, reducing the ability to comprehend form and spatial organization.	Gibson (1969)
Auditory System	The quality and intensity of sound are key factors influencing spatial perception. The auditory system, in addition to identifying sounds, plays a role in orientation, recognizing surface materials and coverings, distinguishing whether spaces are full or empty, and even estimating the approximate dimensions of space.	Pakzad & Bozorg (2012)
	In noisy residential environments, social interactions decrease, and individuals are less inclined to support or communicate with one another.	Krause (2015)
	Sounds differ in meaning and value across cultures and societies, with each community being identified by its unique auditory patterns; these auditory cues reflect the culture and identity of the environment.	Schafer (1993), Truax (2001), Krause (2015)
	In work environments, music can enhance productivity, reduce turnover, and improve employee morale, whereas white or unwanted noise leads to increased stress and decreased supportive behaviors.	Valentin & Gamez (2010/2017), Mathews & Canon (1975)
Olfactory System	The sense of smell is vital in evoking spatial memories. Specific scents associated with objects or places can trigger recollections of the past and strengthen a sense of place attachment.	Sarmadi et al. (2020)
	Odors serve as markers within space and, in early modern cities, acted as distinguishing elements for social groups and residential boundaries.	Classen et al. (1994)
	Olfactory information is stored in long-term memory and has strong connections with emotional memories.	Porteous (1985)
	Although olfaction and taste are distinct senses, they often function in combination. A complete gustatory experience depends on the simultaneous interaction of these two senses.	Goldstein (2002)
Gustatory System	Taste has the capacity to convey meaning through gustatory stimuli and, in many cases, can evoke memories and mental images of other places within a particular spatial setting.	Spence (2020)
	Although taste does not play a direct role in perception in residential spaces, it holds cultural and social significance and, in interaction with smell, shapes a multisensory experience.	Sutton (2010)
	Spaces such as restaurants and cafés within the urban fabric reflect the material, social, and spiritual culture of society.	Zukin (1995)
Tactile System	The sense of touch allows for skin-based experiences, including pressure, temperature, and pain, and through either direct contact or visual-tactile perception, completes the understanding of the environment.	Atkinson et al. (1953/2002)
	The richness of tactile perception can arise from direct contact with objects or the visual observation of textures (indirect visual-tactile contact).	Sedaghat (2017)
	The presence and function of touch make it possible to modify and manipulate space for all age groups and abilities. This sense is especially crucial for specific groups such as children, the elderly, and individuals with sensory impairments, as it plays a key role in their environmental experience.	Hall (1966), Rodaway (1994), Howes (2005)

deepening the understanding of multisensory experience and sensory richness. In addition, Gibson's (1979) theory of affordances contributes to a better understanding of person-environment interactions, illustrating how different environmental features provide opportunities for action (affordances). These opportunities, by stimulating multiple

senses, reinforce multisensory experience and enhance the psychological quality of the environment. This perspective complements the other models by explaining why integrated multisensory perception and sensory convergence can foster a stronger sense of belonging, security, and environmental pleasure among users. Accordingly, this study integrates these

Table 2. Components influencing the enhancement of sensory enrichment in residential environments. Source: Authors.

Factors Influencing the Enhancement of Sensory Enrichment in Residential Environments		Main References
<ul style="list-style-type: none"> - Wallscape quality - Design components (landmarks, patterns, building density) - Absence of stressors - Propensity to linger in the environment - Inclusivity - Type and quality of vegetation - Spatial expectations - Attractive visual features (texture, materials, ornamentation) - Recreational and sports facilities - Absence of nuisance-generating neighbors - Cultural and social vitality - Liveliness - Flexibility (adaptability) - Opportunities for natural surveillance and stewardship - Contextual harmony with the surrounding fabric - Climatic comfort (shade, waiting areas) - Legibility and view corridors - Distinctive paving - Variety in color and form - Attention to the needs of all resident groups - Pleasant fragrance - Psychological calm 	<ul style="list-style-type: none"> - Enhancing user satisfaction - Security enhancement (crime reduction; CPTED-compliant spatial design) - Adequate accessibility - Intra-neighborhood participation (human-scale dimensions) - Landscape quality - Natural elements and materials - Green spaces - Cleanliness and overall environmental quality - Clear delineation of spatial territories (territoriality) - Place attachment - Sense of memorability - Access to amenities - Social interactions - Access to natural light - Absence of noise pollution - Appropriate siting of amenities - Absence of overcrowding - Effective solid-waste management - Signature scents and soundscapes - Authenticity, meaning, and identity 	<ul style="list-style-type: none"> - Desirable visual access to landmarks - Provision of suitable microclimates - Human-scale proportions - Lighting design and adequate night-time illumination - Absence of visual blight (vandalism, graffiti, dereliction) - Use of blue (calming) and yellow (mood-enhancing) hues - An optimal level of spatial complexity - Responsiveness to functional needs - Uninterrupted pedestrian routes - Creation of diverse routes and their proper connectivity - Reduction of crime-prone spots - Avoidance of visual clutter - Individual preferences - Articulation of diverse spatial sequences - Varied and pleasant soundscapes - Presence of fruit trees accessible to residents - Articulation of diverse spatial sequences

Jacobs & Appleyard (1987), Hall (1966), Loffi & Zamani (2015), Zanganeh & Keshmiri (2019), Maroofi & Ansari (2014), Abroon et al. (2019), Shaykh Baygloo (2017), Faraji et al. (2023), Dehghan et al. (2022), Karimi Azeri et al. (2016), Naeimi Foroutani Nezhad et al. (2022)

Hansmann et al. (2007), Ory et al. (2021), Evans et al. (2003), Dannenberg et al. (2011), Lynch (1960), Bowler et al. (2010), Gifford & Lacombe (2006), Tibbalds (1992), Francis et al. (2012), Bruce et al. (2015), Jackson & Kochitzky (2000), Nasar (1992), Bentley et al. (1985), Kaplan & Kaplan (1989), Gifford (2007), Jacobs (1961), Manzo (2005), Fried (2000), Relph (1976), Henshaw (2014), Gehl (2010)

models to define sensory richness as a multidimensional and multisensory experience resulting from the dynamic interaction between environmental and individual factors within the cognitive, affective, and sensory domains. Within this framework, individual factors not only play a direct role in shaping sensory experience but also act as moderators of environmental influences. In other words, psychological traits, lived experiences, and personal preferences can alter the strength or quality of environmental impacts on sensory perception. To validate and refine these components, a directed content analysis approach was employed (Hsieh & Shannon, 2005). Data were collected through semi-structured interviews and open-ended questionnaires with five purposively selected experts (three architects and two environmental psychologists). The selection criteria for experts included relevant research background, practical experience in residential design, and familiarity with the concepts of sensory richness (Patton, 2015). The identified components were refined using theoretical analysis and inter-rater validation and were categorized into two groups: environmental and individual factors representing independent and moderating variables in the proposed conceptual model (Lincoln & Guba, 1985). The final conceptual framework illustrates the relationship between environmental and individual factors, sensory experience, and the enhancement of perceptual quality in a clear and

structured manner. Individual factors act as moderators of environmental influences, while sensory experience functions as a mediating variable that improves environmental perception quality (the dependent variable). The main dependent variable is “environmental perception quality,” while “psychological well-being/mental health” serves as a secondary expected outcome discussed in the study (Fig. 1). For the selection of 10 key components out of the 32 initially extracted from the conceptual framework, a systematic two-step process was implemented to ensure scientific rigor, validity, and neutrality. In the first stage, the 32 components were virtually distributed and assessed by a panel of nine experts specializing in architecture, environmental psychology, and mental health. Their evaluation was based on three key criteria: “theoretical necessity,” “practical relevance to the research context,” and “feasibility of empirical measurement.” These criteria were chosen to ensure that the selected components were theoretically sound and practically applicable. Specifically, “theoretical necessity” ensured scientific grounding, “practical relevance” confirmed applicability in real-world contexts, and “empirical feasibility” enabled objective evaluation and reliable data collection (Lynn, 1986). Experts rated each component on a 1–4 scale across these criteria and provided open-ended feedback for merging, eliminating, or redefining items. In the second stage, to strengthen content validity, reduce bias,

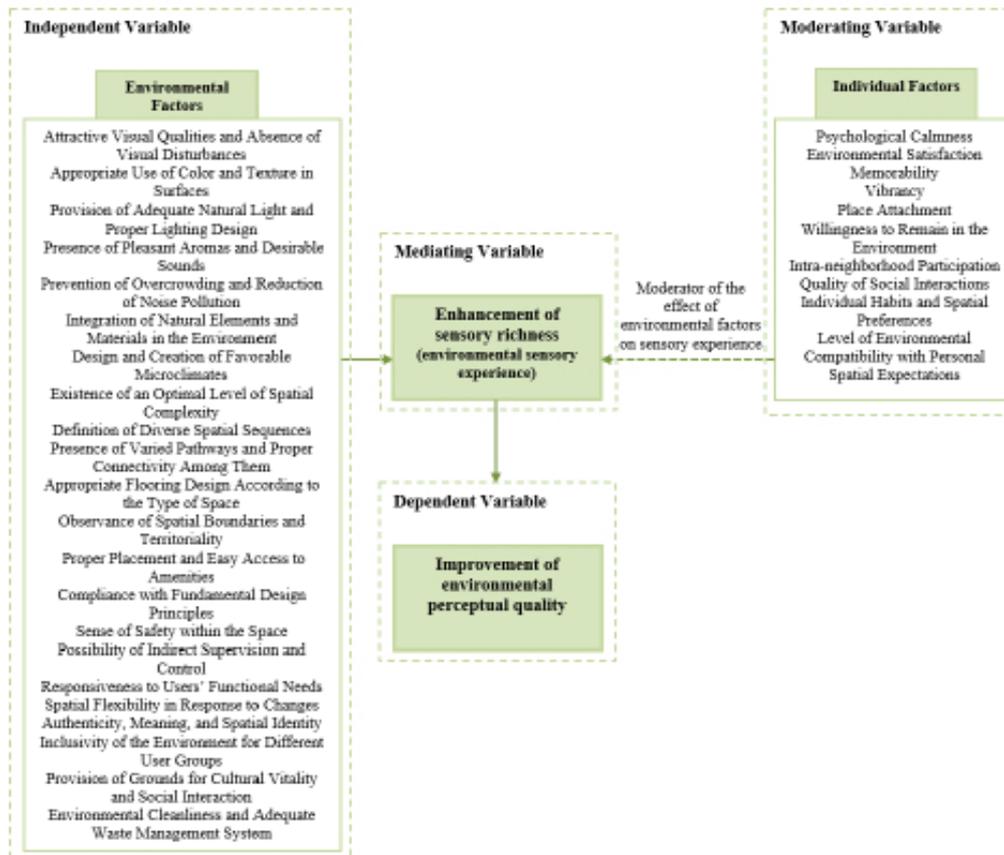


Fig. 1. Conceptual model of variable relationships, their interactions, and effects (the role of environmental and individual factors and sensory experience in enhancing the quality of perception). Source: Authors.

and enhance scientific credibility, the preliminary list of selected components was reviewed using the Delphi method by an independent group of five specialists (including expert environmental psychologists and architects). Through two to three iterative rounds of structured feedback and revision, consensus was achieved on the final 10 key components (Hsu & Sandford, 2007). Consensus was defined as at least 70% agreement among participants, consistent with methodological recommendations in Delphi studies within the social sciences (ibid.). This two-stage approach not only streamlined the measurement tool and reduced analytical complexity but also ensured that the final list of components comprehensively represented the dimensions of the conceptual framework, selected with methodological rigor, validity, and impartiality (Table 3). The three expert groups were independent with no overlap in membership, a strategy designed to reduce bias and guarantee the novelty of feedback.

Research Method

The research methodology of this study is mixed in nature and follows a descriptive-analytical approach. In the first stage, through library research and the analysis of authoritative sources, the research background, theoretical framework, determinants of sensory richness, research variables, and their interrelations were identified. In the

Table 3. Selected components based on thematic categorization. Source: Authors.

Physical Environmental Factors	Individual Factors
Cultural and Social Vitality	Psychological Calmness
Definition of Diverse Spatial Sequences and Microclimates	Satisfaction
Safety and Security	Social Interactions
Compliance with Design Principles	Spatial Expectations
Attractive Visual Qualities and Absence of Visual Disturbances	Sense of Memorability

field study, two qualitative techniques, sensory walking and multisensory mapping, were employed for data collection. These methods provide a systematic means of recording and analyzing users' multisensory experiences of space (Lucas & Romice, 2008). The empirical investigation focused on two residential complexes in Rasht, Guilan Province: Cactus and Andisheh. These cases were selected based on their spatial and social differences, density, population, number of housing units, and socio-economic characteristics. Located in Districts 1 and 4 of Rasht Municipality, respectively, the complexes differ considerably in terms of internal facilities, green spaces, accessibility, and amenities. Such diversity created a suitable context for a more comprehensive exploration of how sensory richness operates across varied urban conditions (Sedaghat, 2017). Although

one of the sites is formally called Andisheh Residential Town, its scale, design form, organization of shared spaces, and integration into the surrounding fabric led it to be considered as a residential complex within this study.

In the first step, sensory walking was used to identify the key sensory hotspots within each complex. This method allows both comparison across different sensory stimuli and the detailed analysis of a single sensory modality across locations (Sarmadi et al., 2020). Initially introduced in the 1960s for evaluating spatial and cognitive aspects of the built environment, sensory walking is rooted in approaches that analyze everyday human responses to space (Mojtabavi et al., 2022). For this study, predetermined routes were mapped in each complex after preliminary assessments. A group of six participants (three women and three men), all master's students in architecture, conducted the walks to identify areas of highest sensory engagement. The outcome

was the identification of sensory hotspots in each complex (Figs. 2 & 3). The number of participants was determined based on established qualitative research practices, where small groups enable deeper interaction, more detailed discussion, and the collection of richer data (Schultz, 2014). Previous studies have demonstrated that, in multisensory environmental research, smaller groups can yield more precise results and allow better data management. For example, Schultz (ibid.) conducted sensory walking with a small cohort in Hamburg, generating in-depth and reliable findings. Likewise, Kusenbach (2003) showed that small group sizes in field methods such as the go-along technique facilitate closer engagement and deeper data collection. Using master's students was advantageous due to their familiarity with architectural concepts, spatial perception, and research processes, which enhanced the accuracy and reliability of the data (Creswell & Poth, 2017). Participants, aged 28–35, were



Fig. 2. Landmark Points and sensory walking path in Cactus residential complex. Source: Authors.



Fig. 3. Landmark Points and sensory walking path in Andisheh residential complex. Source: Authors.

gender-balanced to reduce bias. Although some studies have included larger groups (e.g., Schultz's 7-person sample in Hamburg), the analysis here revealed that no new codes emerged beyond the fifth participant, with data saturation reached at the sixth (Guest et al., 2006). Given the focused aim and relative homogeneity of the sample, six participants were deemed sufficient (Malterud et al., 2016). None of the participants resided in the selected complexes or had prior in-depth familiarity with them, thereby minimizing bias from pre-existing knowledge (Patton, 2015). In the next step, multisensory mapping was applied as a more precise method for analyzing sensory engagement. First introduced by Lucas & Romice (2008), this method has become a valuable tool in qualitative environmental and architectural research for capturing and analyzing multisensory user experiences (Silverman & Patterson, 2021). Field observations were documented through detailed descriptive notes, recording sensory behaviors and subjective impressions of participants along the designated routes. To strengthen validity, observations were independently coded by two researchers, reducing the risk of researcher bias (Patton, 2015). In addition, participants completed sensory charts, providing structured visual documentation of their experiences. Semi-structured interviews were also conducted to capture deeper reflections on environmental elements and their influence on multisensory perception. These complementary methods allowed for a more nuanced analysis of sensory experiences and behavioral patterns. The results derived from observations, interviews, and sensory charts (Spider/Radar diagrams) were synthesized for each hotspot, examining dimensions such as sensory diversity, dominant modalities, duration of perception, and cross-sensory interactions. The radar charts, structured around the five primary senses, aggregated participant scores to illustrate sensory engagement at each location and enabled cross-case comparison between the two complexes. Due to their clarity and ability to visually represent intensity and diversity simultaneously, radar charts are widely recognized as a valid method for analyzing multisensory environments (Gifford, 2007; Sedaghat, 2017). In these diagrams, the shaded green area represented the degree of sensory involvement, with larger areas indicating higher levels of sensory richness. For each case study, a table was prepared including the radar diagram and data on the five senses at the identified hotspots (Tables 4 & 5). In the final stage, the charts for each complex were overlaid, allowing comparative analysis of the intensity and diversity of sensory richness across the residential environments (Pallasmaa, 2005). Additionally, a questionnaire with 20 items was administered, designed on a five-point Likert scale (1 = minimum, 5 = maximum) to assess the multisensory experience (vision, hearing, smell, touch, taste) in the selected spaces. A midpoint score of 3 was set as the reference for comparison against mean sensory indices. To enhance

content validity, the questionnaire underwent two rounds of Delphi review. In the first round, 11 experts and stakeholders reviewed the initial version in a group session, where feedback was collected and coded. In the second round, the revised version was distributed virtually to nine experts (architecture and environmental psychology professors specializing in perception and mental health). Their feedback, collected within one week, guided final modifications (Dalkey & Helmer, 1963). Experts were selected based on criteria including academic publications in environmental perception and health, at least five years of professional experience, and relevant research or design background. Consensus was defined as $\geq 70\%$ agreement and documented accordingly. Written feedback was coded, and revisions (rewording items, clarifying phrasing, removing overlaps) were incorporated into the final version. Internal consistency was measured through Cronbach's alpha, which was 0.77, indicating adequate reliability and coherence of the instrument (DeVellis, 2016). In addition, neuroscience studies demonstrate that multisensory processing in the brain requires precise and valid instruments to assess sensory experiences; the present questionnaire, with its structured design, provides the capacity to record and accurately measure these dimensions (Stein & Stanford, 2008). The Delphi process was applied solely for the content validity of the instrument and was independent of the field data collection stage. The questionnaire was completed by two distinct groups: the first group consisted of six master's students in architecture who had previously participated in the sensory walking and multisensory mapping exercises and had provided qualitative data; the second group included four university professors specializing in architecture and environmental psychology, each with research experience in environmental perception and mental health, who responded to the questionnaire to enhance its disciplinary and psychological validity. The questionnaires were completed in person and on paper at the designated sensory hotspots. This diversity of participants contributed to deepening the understanding of sensory experiences and strengthened the validity of the quantitative findings. Recording responses at each point took approximately 5–7 minutes. The questionnaires were completed within a fixed daily time frame (10:00 a.m. –1:00 p.m.) under similar contextual conditions. For each of the six selected hotspots in each residential complex, ten questionnaires were completed. Subsequently, the mean scores for each sensory modality at each point were calculated, and by aggregating the means of the six points, the final score for each sense within each complex was obtained. This approach enabled both intra-complex and inter-complex comparative analysis of sensory richness. Moreover, to test the statistical significance of differences in mean sensory scores between the two case studies, an independent-samples t-test was conducted. The

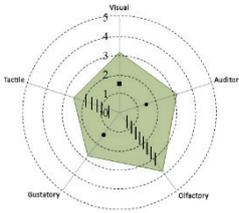
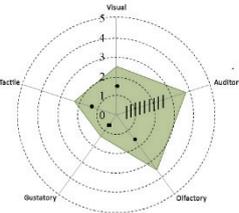
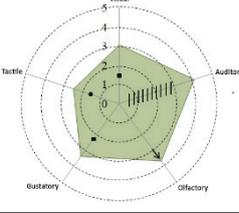
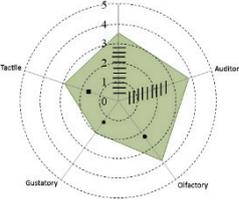
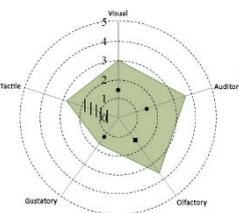
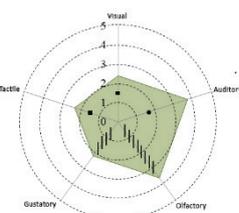
Table 4. Different Dimensions of Sensory Richness in the Cactus Residential Complex. Source: Authors.

Points	Visual Sensory Richness	Auditory Sensory Richness	Olfactory Sensory Richness	Gustatory Sensory Richness	Tactile Sensory Richness	Sensory Diagram
1	Visual identity (cactus), spatial order, worn façade covered by trees, appropriate light and color, plant diversity	Pleasant sound of children, absence of disturbing traffic, sense of psychological security	Natural fragrance, positive perception of food aromas, and absence of unpleasant odors	Limited evocation of gustatory experience	Balanced temperature and relative thermal comfort, surfaces and materials with a sense of safety and comfort	
2	Weak visual attractiveness, trees with varying heights, and evocation of livability	Reduced echo due to vegetation cover, the presence of people's voices, and children playing	Mild and pleasant scents of flowering plants, proper ventilation, and a sense of tranquility	Weak gustatory perception, influenced by olfactory sense, and limited multisensory experience	Children's play equipment, relative thermal comfort, spatial separation (edges) through vegetation	
3	Favorable shading, color diversity, respect for spatial territories, presence of some visual clutter	Noise reduction through foliage density, auditory calm due to block spacing, positive natural sounds	Pleasant smell of plants, proper ventilation, absence of unpleasant odors	Presence of food aromas (linking gustatory and olfactory senses), enhanced multisensory perception	Acceptable thermal comfort, shading by trees, desirable airflow from block arrangement	
4	Visual clutter and lack of spatial diversity, concentration of plants at edges	Relative quiet accompanied by natural sounds such as birds, dominance over artificial noises	Mild and pleasant scent of flowering plants and grass	Overlap of olfactory and gustatory perception, limited experience	Tree shade, thermal comfort, presence of blossoms on the ground, and tactile perception of soft textures	
5	Lack of visual diversity, orderly integration of architecture with greenery, and the presence of fruit trees	Lively and dynamic human sounds enhanced the auditory quality of space	High quality of natural scents, evoking freshness and tranquility	Limited gustatory experience	Presence of greenery, enriched tactile contact with nature, and desirable surface coverage	
6	Order in linear perspective, organized and logical arrangement of building blocks, enhanced sense of orientation and spatial legibility, spatial separation through vegetation, effective lighting of open spaces and pathways	Joyful natural sounds such as wind and birdsong	Excellent ventilation, sense of freshness, and environmental vitality	Gustatory perception interrelated with other senses, compared to other key points of the complex	Adequate physical comfort, balanced temperature, and favorable tactile conditions	

unit of quantitative analysis was defined as “spatial units”: each complex included six selected points (n = 6 per group). For each point, the mean scores of ten questionnaires were

calculated, and then the point averages of each complex were compared through the independent-samples t-test. Given the nature of the Likert scale and common analytical

Table 5. Different Dimensions of Sensory Richness in the Andisheh Residential Complex. Source: Authors.

Points	Visual Sensory Richness	Auditory Sensory Richness	Olfactory Sensory Richness	Gustatory Sensory Richness	Tactile Sensory Richness	Sensory Diagram
1	Presence of urban elements, diverse vegetation cover, central plaza, outdoor fitness equipment, views of the playground, spatial order, and variety and detail in form, color, and structure	Unpleasant noise from traffic and adjacency to sidewalks and the main road	Pleasant natural aroma due to flowerbeds and vegetation	Limited gustatory experience	Restricted tactile contact with surfaces and stimulating elements, varied paving, and inconsistent thermal comfort	
2	Lack of distinctive visual features and spatial legibility, façade disorder, and the presence of garbage bins along walkways	Auditory stillness with natural sounds (wind, birds)	Weak and scattered greenery	No activation of gustatory sense	Absence of diverse tactile elements, limited paving variety	
3	Presence of green space, playground equipment, and tree shading; views toward greenery, parks, and the playground	Positive natural sounds (birds), children playing, and family interactions	Pleasant scent of native plants and absence of unpleasant odors	Presence of a snack kiosk and benches	Insufficient shading; tactile contact with play equipment and grass-covered areas	
4	Varied visual elements, defined pathways, diverse vegetation, color variety in architectural details (e.g., blue accents), and coordinated façade appearance	Relatively positive and natural environmental sounds	Flowerbeds and aromatic shrubs	Lack of environmental factors contributing to gustatory experience	Presence of tactile surfaces and appropriate separation of pedestrian and vehicular paths, with adequate width of passages	
5	Spatial order but monotonous, lacking visual creativity	Dominance of bird sounds and other natural sounds	High-quality scents, freshness conveyed by aromatic vegetation	No stimulation of gustatory sense in the environment	Presence of flowering plants and greenery; paving with tangible and perceptible textures	
6	Lack of visual appeal, scorched vegetation, and poorly maintained building façades with exposed waterproofing	Overall silence in the environment	Presence of native plants and flowers	No perceptible gustatory components	Lack of thermal comfort and insufficient tactile variety in surfaces and textures	

practices, data were treated at the interval scale level in the group analysis. In addition, ten respondents per point were deemed sufficient to produce a reliable standard error of the

mean and to allow for valid t-test analyses. Increasing the number of respondents per point would have had only a marginal effect on reducing the standard error of the mean

while disproportionately increasing fieldwork costs (Cohen, 1988; Field, 2013). In the qualitative analysis, the data obtained from field observations and phenomenological notes were examined and coded using Thematic Analysis in order to identify the main patterns and themes related to users' multisensory experiences (Braun & Clarke, 2006). For data integration, a Convergent Parallel Design approach was employed. In this approach, quantitative and qualitative data were analyzed independently and in parallel, and subsequently compared and aligned within an integrated matrix. This process allowed for the identification of points of convergence (similar findings) and divergence (differing findings). In cases of divergence, the conflict resolution strategy involved re-examining field notes and photographs, checking contextual variables (time of data collection, wind/temperature conditions, presence of temporary events), and conducting cross-sectional recoding to preserve the "chain of evidence." Convergence was established when the "direction of effect" in the quantitative data (↑/↓ relative to the opposite complex) aligned with "the dominance of corresponding qualitative themes" in at least two field-based pieces of evidence for the same point/component. Divergence was defined as either inconsistency in effect direction or the absence of sufficient qualitative evidence. Equal weight was assigned to both streams of data; in the final interpretation, convergence served as the basis for confirmation, whereas explained divergence served as the foundation for generating alternative explanations. Subsequently, qualitative data, through contextual evidence and concrete examples, contributed to the interpretation and deepening of quantitative findings, while quantitative data played the role of confirming or refining the qualitative results. This method of integration enhanced the validity and comprehensiveness of the research findings (Creswell & Plano Clark, 2017).

Discussion

Based on the theoretical foundations and previous research, this section presents an analysis of the sensory richness of each area, relying on integrated data obtained from sensory-mapping questionnaires, field observations, and phenomenological analyses. In the quantitative analysis, the mean scores of sensory indices in each complex were compared with the median value of the Likert scale (number 3), and an independent t-test was conducted to examine significant differences in the level of sensory richness between the two case studies. Moreover, findings were synthesized through

an integrative matrix. For example, the significant sensory differences in olfactory and tactile components between the two complexes were explained by analyzing material quality, vegetation, daylight access, and odor-generating elements in the qualitative data. Furthermore, the overlap of senses and the effect of their interaction on environmental experience were confirmed by comparing observations and sensory diagrams with quantitative results. This approach not only enhanced the validity of the findings but also enabled a deeper understanding of the multidimensional relationships between environmental stimuli and users' sensory experiences, thereby providing a more comprehensive explanation of the impact of the environment on mental health and quality of life in residential complexes. Limited cases of divergence (e.g., temporary declines in auditory quality at specific hours) were interpreted by referring to temporal conditions of data collection and transient events. Accordingly, the discussion focuses on the reasons behind convergent patterns rather than reiterating statistical tests.

According to the results presented in Table 6, visual perception in the "Andisheh" complex (mean = 2.95) was reported to be higher than in the "Cactus" complex (2.73). This difference may be attributed to more coherent design, greater façade color variety, and better daylighting. According to the studies of Nasar (1992) and Lynch (1960), such features enhance visual legibility and foster a sense of security among users. However, despite its lower numerical score, the visual quality in the "Cactus" complex was evaluated as being more profound and better integrated with the natural environment; characteristics that align with Pallasmaa's (2005) notion of "silent aesthetics," which promote long-term calming perceptions of space. In the auditory component, both complexes received relatively high scores (3.69 in Cactus and 3.71 in Andisheh), indicating effective control of intrusive sound sources, the presence of natural sounds, and semi-active sound design (Henshaw, 2014). The absence of a statistically significant difference reflects relatively equal conditions in auditory experience. The greatest sensory difference between the two complexes was observed in the olfactory component, where the "Cactus" complex achieved the highest score among all indices (mean = 3.92). The presence of fragrant plants, natural air circulation, and extensive green spaces contributed to this outcome. According to Spence (2020), pleasant scents can play an important role in strengthening emotional bonds with space and in forming spatial memory. In the tactile component, "Cactus" also showed a significant advantage

Table 6. Comparative evaluation of users' sensory experience in the two selected residential complexes. Source: Authors.

Case study	Five senses					Mean
	Visual	Auditory	Olfactory	Gustatory	Tactile	
Cactus Residential Complex	2.73	3.69	3.92	2.74	3.09	3.23
Andisheh Residential Complex	2.95	3.71	3.25	2.26	2.57	2.95

(mean = 3.09) compared to “Andisheh” (2.57). Higher material quality, diversity of tactile textures, and more favorable thermal comfort conditions were effective in enhancing tactile satisfaction. Moreover, environmental safety was considered an important factor in improving tactile experiences and psychological comfort. This finding corresponds with Sternberg’s (2009) theory of “sensory balance,” which emphasizes the role of pleasant physical contact in promoting psychological well-being. Given that Rasht is part of UNESCO’s Creative Cities Network in the field of gastronomy, taste was considered in this research not merely as a physiological experience but as one of the dimensions of environmental and cultural experiences. This sense can reinforce place identity through the smell and flavor of foods, the diversity of local cuisines, and spaces associated with food preparation and consumption (Pallasmaa, 2005; UNESCO, 2015). The higher average score of this index in the “Cactus” complex (2.74 vs. 2.26) indicates a richer gustatory experience and its close interaction with olfactory perception. It is worth noting that taste and smell continuously operate in a complementary manner, and their reciprocal effects were incorporated into the environmental experience (Stein & Stanford, 2008; Small, 2012).

Despite the availability of facilities such as sports grounds, parks, benches, children’s play equipment, and exercise equipment for adults in “Andisheh,” the absence of suitable climatic elements such as canopies, shade trees, and temperature-moderating features reduced the usability of these spaces across different seasons. Specifically, during hot seasons, the overheating of metal surfaces, and during cold seasons, persistent humidity and rainfall, lowered climatic comfort and consequently diminished the quality of multisensory experiences (Givoni, 1998). In tactile experiences, in addition to material and texture quality, safety factors such as the design of edges, the use of appropriate seating materials, and thermal comfort across seasons played a crucial role in improving user satisfaction and psychological comfort (Sternberg, 2009). These factors directly influenced the effectiveness of open spaces and ultimately affected residents’ social experiences and mental health. The above findings confirm the importance of “sensory richness” as a multidimensional factor in residential experience. Overall results show that the “Cactus” complex had relative superiority in three major sensory components (olfactory, tactile, and gustatory), while “Andisheh” performed better in the visual component. This demonstrates that high-quality spatial experience is not merely the result of stimulating a single sense but rather the outcome of a balanced integration of multiple senses (Levent & Pascual-Leone, 2014). These findings are not only consistent with the main theoretical framework of the study (Kaplan & Kaplan, 1989; Pallasmaa, 2005; Gifford, 2007; Gibson, 1979) but also align with the results of other studies in the field of multisensory perception and environmental psychology (Evans et al., 2003).

In the “Cactus” complex, Point 6, with the highest scores

in hearing (4.25), smell (4.08), touch (3.50), and even taste (3.18), was identified as the richest sensory point. Features such as diverse vegetation, orderly block arrangement, calming sounds, spatial separation through vegetation, and coordinated lighting were the main reasons for this sensory richness. Additionally, the use of materials with varied textures, children’s play in safe and supervised areas, and the presence of natural shading effectively stimulated the sense of touch and improved thermal comfort. The relatively high score for taste perception at this point was also likely due to stronger overlap with other senses. In contrast, Point 4 offered the weakest sensory experience. Inefficient design, visual clutter caused by deteriorated façades, lack of spatial attractiveness despite the presence of native vegetation and fruit trees, and diminished psychological security were among the main reasons for this condition. Furthermore, the lack of motivation for verbal and social interactions in this space indicated its weaker perceptual quality compared to other points in the complex. Social interactions, as an independent component of spatial experience, were examined in a separate part of the analysis and were not included in the sensory experience questionnaire. In this study, taste was limited to experiences related to food, aromas, and local culinary identity. Moreover, the research emphasized the psychological and behavioral consequences of residential life, such as reduced social interactions an issue highlighted in previous studies as an influential factor on mental health and quality of life (Cacioppo & Hawkey, 2009; Gehl, 2011). In the “Andisheh” complex, Point 4 recorded the highest scores in vision (3.55), hearing (3.83), and smell (3.83), and was thus considered the richest sensory point. Proper maintenance, spatial diversity, favorable sound quality, the presence of natural or artificial odor-producing elements, and sufficient daylight were the main factors contributing to this positive performance. Furthermore, given the relative age of the complex, this point demonstrated higher quality in terms of maintenance, diversity of paving, cleanliness, and the acceptable condition of façades. The appropriate width of pathways, well-designed edges, and diversity of vegetation also contributed to a sense of calmness and psychological security in this space. In contrast, Point 2, with the lowest scores in taste (1.38) and touch (2.28), provided the weakest sensory conditions. The absence of vegetation, visual disturbances caused by the poor appearance of certain buildings, the low number of residents, and the lack of taste and tactile stimulation were factors explaining this condition. Moreover, the lack of environmental attractiveness reduced people’s willingness to linger or interact in this area and instead increased users’ tendency to pass through quickly or directly enter residential units. Ultimately, the comparative results of shaded-area analysis and qualitative evaluations also confirmed the relative superiority of “Cactus” in perceptual aspects and multisensory experience (Figs. 4 & 5). These results were consistent with qualitative analyses and affirmed

that overall, sensory richness in the Cactus complex was higher than in Andisheh (Table 6). These analyses emphasize that the design of residential environments should enable positive and balanced stimulation of various senses in order to enhance residents' mental health and quality of life.

In line with the study's approach, which was based on analyzing spatial experience and sensory richness at the environmental scale, "spatial points" within residential complexes were selected as the units of analysis. For each sense, the mean scores from 10 questionnaires per point were calculated, and an independent t-test was then applied to compare the two complexes. This method, instead of focusing solely on respondents' individual perceptions, allowed for a more qualitative and place-based analysis of sensory perception across different spaces. Similar approaches have also been employed in environmental design research; for instance, in some studies, data analysis was conducted not at the individual level but at the level of "spatial units" or "perceptual nodes" (Nasar, 1997; Golicnik & Thompson, 2010). According to the results of the independent t-test (Table 7), the mean sensory perceptions in the Cactus and Andisheh residential complexes were compared. Findings showed that in the olfactory component ($p = 0.021$, $d = 1.58$) and tactile component ($p = 0.004$, $d = 2.18$), there were statistically significant differences in favor of the Cactus complex. In other senses, although effect sizes were moderate in some cases, the differences were not statistically significant ($p > 0.05$). Despite the fact that some variables (olfactory and tactile)

did not follow a normal distribution, given the small sample size and supporting evidence from similar studies, the use of the independent t-test was considered valid and standard (Cohen, 1988; Field, 2013; Gravetter & Wallnau, 2017). However, the effect size of the taste component fell within the medium range, suggesting potential differences that warrant further investigation in future research.

The explanation for the observed pattern can be traced to several key factors. First, the perceptual dominance of visual and auditory stimuli in human cognitive processes (visual dominance / sensory weighting) leads designers and users to initially evaluate spatial structure, orientation, and legibility through vision/hearing; this tendency is reinforced in urban applications where visibility and orientation hold practical importance (Colavita, 1974; Spence, 2020). Second, professional and practical constraints and priorities such as concerns regarding maintenance, durability, material safety, and related regulations encourage designers to use hard, uniform, low-maintenance surfaces, which reduces tactile experience; hence, touch is less frequently targeted in design (Pallasmaa, 2005; Gehl, 2011). Third, local context and land use play a role: in the "Cactus" complex, climatic conditions, the presence of aromatic vegetation, and the semi-private structure of spaces facilitated stronger olfactory and gustatory stimuli, while the open geometry and wide views in "Andisheh" reinforced visual stimuli. Our qualitative evidence (field notes and participants' comments) explicitly confirmed these patterns: for instance, participants in Cactus frequently

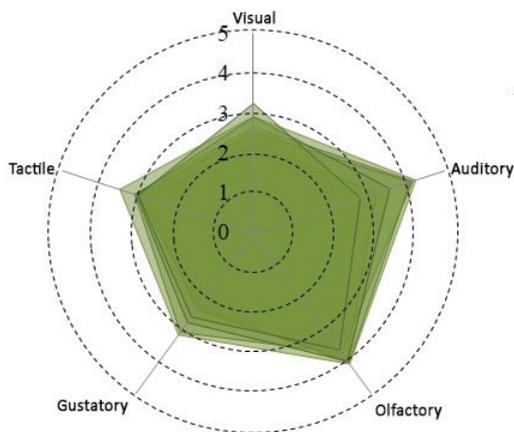


Fig. 4. Sensory richness in the Cactus residential complex. Source: Authors.

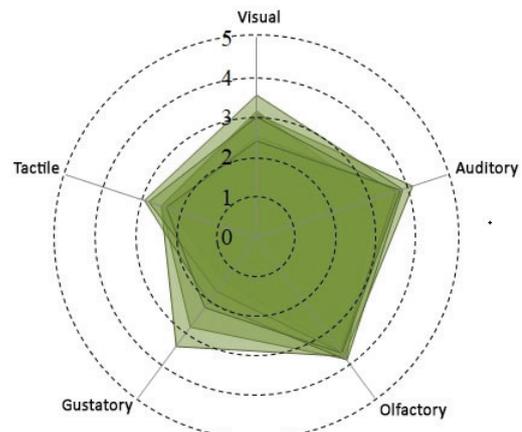


Fig. 5. Sensory richness in the Andisheh residential complex. Source: Authors.

Table 7. Results of the independent t-test comparing the mean scores of sensory perception in the two selected residential complexes. Source: Authors.

Sense	Mean-Cactus	Standard Deviation-Cactus	Mean-Andisheh	Standard Deviation-Andisheh	Independent t-test Result	df1	p-value2	Effect Size (Cohen's d)
Visual	2.73	0.36	2.95	0.43	-0.93	10	0.373	-0.54
Auditory	3.69	0.59	3.71	0.32	-0.07	10	0.948	-0.04
Olfactory	3.92	0.18	3.68	0.12	2.74	10	0.021*	1.58
Gustatory	2.74	0.35	2.26	0.74	1.44	10	0.081	0.83
Tactile	3.10	0.22	2.56	0.27	3.78	10	0.004*	2.18

mentioned the “calming smell of plants” and the “pleasant feel of materials,” whereas in Andisheh they emphasized visual legibility and clarity of routes. Therefore, what was observed was not merely a statistical difference but rather a reflection of the combined influence of physical structure, design choices, and users’ perceptual profiles. This analysis indicates that enhancing sensory richness in residential design requires aligning policies, maintenance, and design education with sensory-oriented goals, so that touch and smell, as fundamental elements of quality of life, are systematically incorporated (Malnar & Vodvarka, 2004; Gifford, 2007).

Conclusion

The reported results were obtained through the independent integration of quantitative and qualitative analyses into a combined matrix, where the convergence of direction and evidence across both data sources formed the basis for the final interpretation. The integrated output at six selected points revealed that the Cactus complex showed a significant advantage in smell, touch, and taste, while Andisheh excelled in vision and hearing, consistent with contextual evidence. According to existing studies, the order of influence of the senses on environmental experience varies in terms of subjective perception; vision and hearing often play the primary role in environmental structure and legibility, whereas smell, touch, and taste act as complementary factors, adding depth and richness to sensory experience (Levent & Pascual-Leone, 2014). This sensory hierarchy was also taken into account in the interpretation of the results. The findings of this research align with the hierarchical model of sensory influence. The visual/auditory priority reflects both “perceptual dominance” and professional prioritization in the design and management of public space. In contrast, olfactory/tactile and gustatory richness become prominent when local design and land use (vegetation, semi-private spaces, food-related activities) provide the necessary conditions. Qualitative evidence (interviews and field notes) confirmed that these differences stemmed from environmental and functional factors.

Field surveys and sensory data analysis indicated that each of the two complexes exhibited particular strengths and weaknesses in creating a multisensory experience for residents. In the Cactus complex, the design of spaces allowed for deeper sensory experiences: diverse vegetation, effective tree shading, pleasant scents, the tactile quality of materials, thermal comfort, and the potential for interaction in semi-public spaces actively stimulated the senses of smell, touch, and taste. Visual quality was also enhanced through lively colors, appropriate natural lighting, and human-scale forms, producing high levels of satisfaction in the visual dimension. However, weaknesses in noise control and poor sound directionality reduced auditory quality in some areas. Thus, incorporating sound-absorbing vegetation and

acoustic insulation could significantly improve auditory performance. By contrast, the Andisheh complex, despite visual coherence and geometric order in some areas, underperformed in other sensory components due to poor climatic design and a lack of social bonding in shared spaces. This suggests that visual perception alone cannot guarantee improvements in residents’ quality of life or mental health. The absence of climate-appropriate vegetation, insufficient seating, and monotonous materials reduced stimulation of smell and touch. Tactile experience is not limited to texture and materiality; physical safety and comfort are integral to it. Removing sharp edges, using slip-resistant and “hand-friendly” materials, and controlling surface temperature across seasons (to avoid uncomfortably hot/cold seating and surfaces) enhance tactile experience and are directly tied to mental comfort (Heschong, 1979; Givoni, 1998; Sternberg, 2009). Similarly, auditory quality was only acceptable at certain times of day; at other times, excessive auditory silence diminished the vibrancy of space. In the case of taste, closely tied to smell, environmental aromas, climatic comfort, and the provision of amenities for food consumption such as seating platforms, pergolas, or group benches in open spaces played a determining role. Even without direct social interaction, this sense can affect psychological well-being through individual experiences (Classen et al., 1994; Spence, 2020). Considering Rasht’s designation as a UNESCO Creative City of Gastronomy, strengthening open and semi-private spaces for food-related activities (e.g., local markets and food courts) provides a native capacity for enhancing gustatory experience and place identity. Social interaction is interpreted as an outcome of spatial design that encourages pause and everyday encounters; the quality of seating, interactive edges, and legible accessways can enhance sense of belonging and vitality, independently of taste experience (Gehl, 2011). Findings show that integrated multisensory perception plays a key role in enhancing environmental quality and residents’ mental health (Malnar & Vodvarka, 2004; Pallasmaa, 2005). From the perspective of environmental psychology, these results can be explained through theories such as Kaplan’s Preference Model (Kaplan & Kaplan, 1989) and Gibson’s Theory of Affordances (Gibson, 1979). Natural elements, tactile surfaces, and olfactory stimuli facilitate deeper sensory engagement, fostering a sense of belonging and environmental security (Gifford, 2007). The role of taste, often overlooked in environmental design, also proves significant, as opportunities for collective experiences of eating or drinking in open spaces can foster empathy, participation, and psychological relaxation (Classen et al., 1994). This feature was more evident in the Cactus complex due to semi-private courtyards and segregated green spaces. Based on the findings of this study, it can be concluded that effective residential design for improving mental health requires a holistic, experience-oriented, and

multisensory approach in which touch, smell, hearing, and taste, alongside vision, are considered as equivalent and synergistic dimensions in the design process. Achieving this requires the use of natural elements, tactile materials, human-scaled architectural details, and interactive spaces that enable everyday sensory and social encounters (Gehl, 2011). Therefore, adopting a multisensory approach in the design of residential complexes not only enhances livability and spatial quality but also serves as an effective strategy in environmental design policies aimed at improving residents' mental health.

This study also demonstrated that physical factors such as adequate natural light, favorable accessibility, legibility and continuity of spatial sequences, quality of views, and materials stimulating the senses are significantly associated with improved satisfaction, tranquility, vitality, and spatial identity. In terms of functional factors, diversity of uses, service infrastructure, and interactive spaces played an important role in enriching residents' multisensory experiences. In the Andisheh complex, service infrastructure and open-space functional diversity enhanced perceptions of liveliness, calm, and vitality, whereas in the Cactus complex, limited amenities restricted the full emergence of these dimensions. On the other hand, interactive and culturally embedded border spaces effectively strengthened place attachment and spatial identity, underscoring the importance of synergy between physical and functional factors in sensory richness and environmental perception. In other words, appropriate

physical elements have the greatest impact on sensory richness and environmental perception when supported by complementary functional factors. These results are consistent with the study's theoretical framework and all three research hypotheses (Fig. 6). Based on the analyses, the following strategies are proposed for enhancing sensory richness in residential complexes with the aim of improving residents' mental health:

- Planting aromatic vegetation in open and semi-private spaces, employing fragrant green walls, and eliminating unpleasant odor sources to strengthen the olfactory component.
- Designing collective spaces centered on eating and drinking activities (dining platforms, local markets, open-air cafés) as focal points of social interaction;
- Utilizing controlled natural sounds and managing noise through proper placement of equipment and infrastructure;
- Creating visual balance through emphasis on human scale, natural colors, and spatial legibility;
- Designing interactive edges that allow pausing, conversation, or play as dynamic boundaries between public and private spaces;
- Increasing indirect exposure to nature through green views, natural lighting, and natural materials may improve mental health, enhance mood, and reduce anxiety.

Declaration of No Conflict of Interest

The authors declare that they have no conflict of interest in conducting this research.

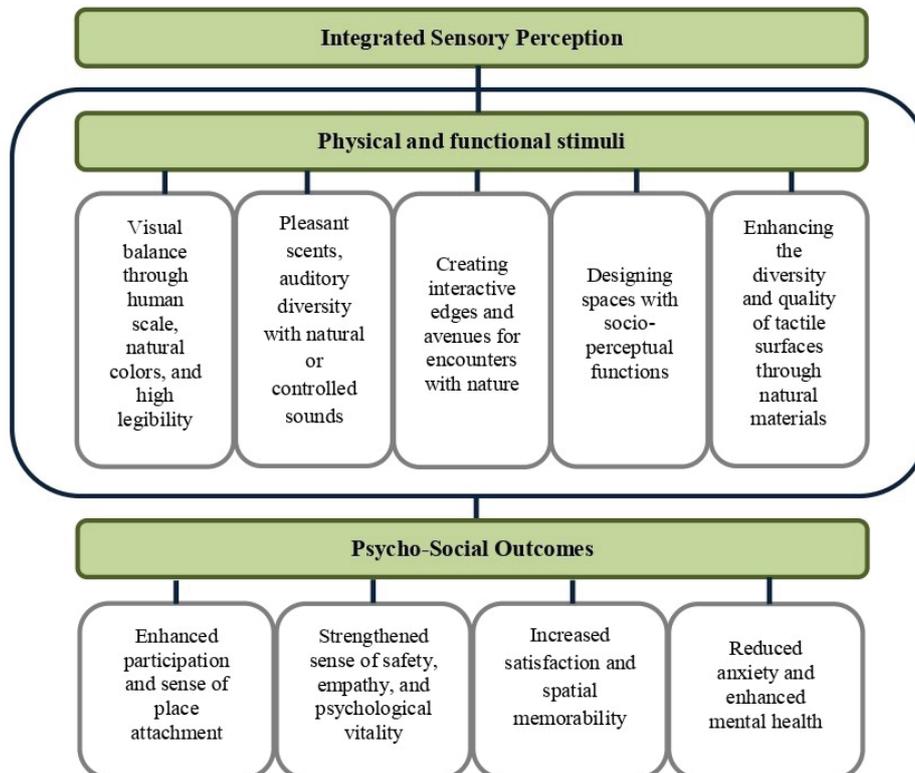


Fig. 6. Relationship between spatial sensory quality and psychosocial outcomes in residential complexes. Source: Authors.

Endnotes

* This article extracted from Master's thesis of "Sogand Rouhani Mardakhi" entitled "Designing a Residential Complex with an Emphasis on Components of Sensory Richness with the Approach of Promoting Mental Health in the City of Rasht" that under supervision of Dr. "Amirreza Karimi Azeri" which

has been done at University of Guilan, Faculty of Architecture and Art, Rasht, Iran in 2025.

1. degrees of freedom
2. p-value (Values marked with an asterisk (*) are significant at the 0.05 level)

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