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From soundscapes and smellscapes to visualscapes: circumplex models of indoor environmental perception

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Abstract

Understanding how built environments influence their occupants is essential for improving building design and, consequently, human well-being and everyday activities. While observational studies and qualitative methods provide rich insight into building–occupant relationships, Post-Occupancy Evaluation (POE) surveys remain the most widely used tool due to their practicality. Existing surveys focus largely on satisfaction, often overlooking the emotional and multidimensional nature of human–environment interactions. Recent soundscape and smellscape research demonstrates the value of circumplex models, originally developed in environmental psychology, which map occupants' responses within two-dimensional perceptual spaces and have been incorporated into international standards. These models allow designers to visualise perceptual responses, define design targets, and assess the impact of interventions. Building on these advances, this paper examines the potential of extending the circumplex model for the assessment of visual perception of indoor environments. Through a literature search, we identify key attributes and factors characterising indoor visualscapes and outline the steps toward developing a circumplex model of indoor visual perception. Such a framework could enrich POE practice, support perceptual-based design, and contribute to multisensory approaches to evaluating and shaping built environments through a harmonisation of POE procedures across sensory domains.

Keywords: Visualscape, Soundscape, Smellscape, Circumplex, Architectural engineering

1. Introduction

Collecting information on how the built environment influences occupants is essential for assessing the impact of buildings on occupants and their ability to perform everyday tasks (e.g., concentrating, listening, relaxing, sleeping), as well as for identifying actions for improvement. Observational studies, for instance, offer high ecological validity because they do not interfere with ongoing activities but rather observe and record human behaviours over time. However, interviews and focus groups can provide deeper insight into the underlying drivers of these behaviours by engaging directly with occupants. That said, such methods are largely confined to research contexts, as they tend to be both labour- and time-intensive. In practice, the most widely adopted approach is to conduct Post Occupancy Evaluation (POE) surveys to collect insights from occupants. These surveys consist of structured questionnaires designed to assess occupants' satisfaction and self-reported productivity across various types of buildings. Among the most influential survey protocols is the one developed in 1999 by the Centre for the Built Environment (CBE) at the University of California, Berkeley. Over its first 20 years of application, it collected and analysed responses from more than 90,000 individuals across approximately 900 buildings [1]. This large-scale effort has also revealed the limitations of existing survey tools and identified potential directions for improvement. If POEs are intended to evaluate a building's success, it is important to recognise that the very criteria defining such success have evolved in recent decades. Thus, the instruments used to measure it must evolve as well. Historically, the goal was to design buildings that minimised dissatisfaction with environmental conditions and improved productivity. Today, however, the focus has shifted toward creating buildings that foster well-being and pleasantness [2, 3]. As highlighted by Graham et al. [4], POEs should move beyond measuring satisfaction alone to include information on the emotions experienced by occupants within a given environment, as these can help explain the underlying reasons for satisfaction, behaviour and productivity levels [5]. In some cases -particularly within laboratory settings- this has been achieved by collecting emotional response data from participants, next to more conventional data about comfort, perception and acceptability [6]. For instance, Kim and Mansfield [7] and Zhang et al. [8] investigated the impact of lighting conditions on emotional responses employing established models to describe human affective responses.

A useful theoretical framework in this regard is Russell's circumplex model of affect [9], which posits that all affective states arise from two fundamental neurophysiological dimensions: valence (a pleasure–displeasure continuum) and arousal (alertness). Each emotion can therefore be represented as a linear combination of these two dimensions, or as varying degrees of both. A 45° rotation of the valence and arousal axes yields two bipolar dimensions: excitement–depression and distress–contentment. Nevertheless, what if, instead of collecting overall emotional responses, we focused on occupants' emotional reactions to specific environmental components, for example, to the visual, olfactory, or auditory environment? Indeed, data on valence-related aspects (e.g., pleasantness or comfort) are commonly gathered [10], yet environmental psychology shows that perceptual response is multidimensional and can be mapped within a two-dimensional space.

In the field of soundscape research, defined as the acoustic environment as perceived by people within a context [11], Axelsson et al. developed a soundscape circumplex describing perceptual responses to outdoor soundscapes as a combination of two dimensions: "pleasantness" and an orthogonal dimension, "eventfulness" [12]. This model was later adapted for indoor environments such as homes [13] and offices [14], and ongoing studies are extending it to other contexts, including schools [15]. The soundscape circumplex, which will be discussed further below, has been incorporated into the international ISO standard and technical specifications 12913 series on soundscape [11, 16, 17]. It guides the measurement of perceptual responses to soundscapes by defining relevant perceptual attributes and enabling the visualisation of responses within a circumplex space [18]. This visualisation is particularly valuable for design purposes, as it allows architects and engineers to set perceptual design targets and, after interventions, assess whether those targets have been achieved by comparing desired and reported perceptual outcomes.

Interestingly, this approach, originating in soundscape research and policy, has subsequently influenced other domains, including smellscape research. The concept of the indoor smellscape has recently been introduced as a framework for studying "the olfactory environment perceived and understood by a person in an indoor context, also considering social, cultural, and historical aspects" [19]. This represents a shift beyond the traditional indoor air quality perspective focused solely on pollutant concentrations and olfactory neutrality. Building on soundscape research, a circumplex model for indoor smellscapes has been proposed, where occupants' perceptions are described as a combination of two main dimensions: "pleasantness" and "presence" [20].

Drawing from these advances in soundscape and smellscape research, this paper aims to explore the broader applicability of circumplex models in evaluating the built environment and their potential extension to new domains such as the visual environment. Specifically, based on the methodologies that led to the development of the circumplex models of soundscapes (Section 2.1) and smellscapes (Section 2.2), this contribution represents a preliminary step toward developing a circumplex model for indoor visual perception, or "visualscape" (Section 3). This process involves a review of the literature to identify a foundational set of attributes that describe visualscapes and the core factors defining visual environments. These insights will serve as the basis for constructing a visualscape model, as outlined in the following sections.

Ultimately, the goal is to discuss the relevance of circumplex models as a means of enhancing POE practice, with implications for design decision-making, building standards, and, ultimately, the way people experience and inhabit built spaces.

2. Examples of circumplex models for the indoor built environment

Building on Russell's circumplex model, several frameworks have been developed to identify the key dimensions underlying perceptual responses to different sensory built environments (e.g., soundscapes, smellscapes). These dimensions form the basis for assessing human perceptions and evaluating the effectiveness of design interventions. Such models were typically derived using Semantic Differential or Visual Analogue Scales, where participants rated stimuli across multiple perceptual attributes. Principal Component Analysis (PCA) or factor analysis was then used to reduce these attributes to a smaller set of principal dimensions. These dimensions explained most of the variance in the data and were interpreted according to the attributes with which they were most strongly associated.

The following sections outline some of the circumplex models that have become established in both research and policy within the field of built environment assessment, together with the experimental designs that supported their development. These examples provide a reference point for discussing the development of a future circumplex model of visualscape perception.

2.1. Circumplex model of soundscape perception

2.1.1. Circumplex models for outdoor soundscapes

One of the soundscape perception models that has become established in both research and practice is the one derived from Axelsson and colleagues through a laboratory listening test designed to investigate how individuals perceive and evaluate everyday urban soundscapes [12]. Fifty 30-second binaural recordings were selected from a database of outdoor environments in London and Stockholm. To qualify as a soundscape excerpt, each recording needed to include both a continuous background ambience and multiple foreground sound events. This distinction ensured that the excerpts captured the complex acoustic context typical of real-world environments, rather than isolated sound events such as a passing vehicle or a single voice. A set of 116 unidirectional perceptual attribute scales was developed to characterise listeners' responses. These attributes were chosen to capture affective reactions to soundscapes (such as "pleasant", "calm", or "vibrant") rather than purely physical or descriptive terms like "loud" or "sharp", which are more suitable for isolated sounds. The initial pool of 189 adjectives, adapted from an earlier study on the aesthetic appraisal of photographs [21], was expanded through synonym and antonym searches and refined through pilot testing with 30 participants experienced in soundscape evaluation. This process yielded a final set of 116 adjectives deemed most applicable to soundscape perception. Each attribute was presented to participants with a 100-mm visual analogue scale (VAS), anchored from no match at all (0%) to perfect match (100%). One hundred listeners individually rated 5 of the 50 soundscape excerpts, marking the point that best represented the extent to which each attribute described their perceptual experience. The collected data were analysed using PCA. Three principal components were extracted, accounting for approximately 50%, 18%, and 6% of the total variance in participants' responses. The first two dimensions, explaining most of the variance, were interpreted as "pleasantness" and "eventfulness", based on the attributes most strongly loading on each component. Pleasantness captures the affective valence of the soundscape (from unpleasant to pleasant), while eventfulness represents the degree of sensory stimulation or activity (from uneventful to eventful). These two orthogonal dimensions form a circumplex model of soundscape perception, where emotional responses can be represented as a "mix" of pleasantness and eventfulness within a two-dimensional space. A 45° rotation of the axes yields alternative descriptors, labelled according to the adjectives loading approximately equally on both dimensions: "calmness" (the opposite of chaos) and "excitement" (the opposite of monotony), as shown in Fig. 1. Accordingly:

- Vibrant soundscapes are perceived as both pleasant and eventful
- Chaotic soundscapes are eventful but unpleasant
- Monotonous soundscapes are uneventful and unpleasant
- Calm soundscapes are both pleasant and uneventful.

A further dimension, "familiarity", can be considered orthogonal to this two-dimensional space, reflecting how unusual or familiar the soundscape is to the listener. It should be noted that other studies have led to the derivation of dimensions labelled differently, but as discussed by Fiebig [22], these can be traced back in most cases to the pleasantness and arousal/eventfulness structure described by Russell and Axelsson.

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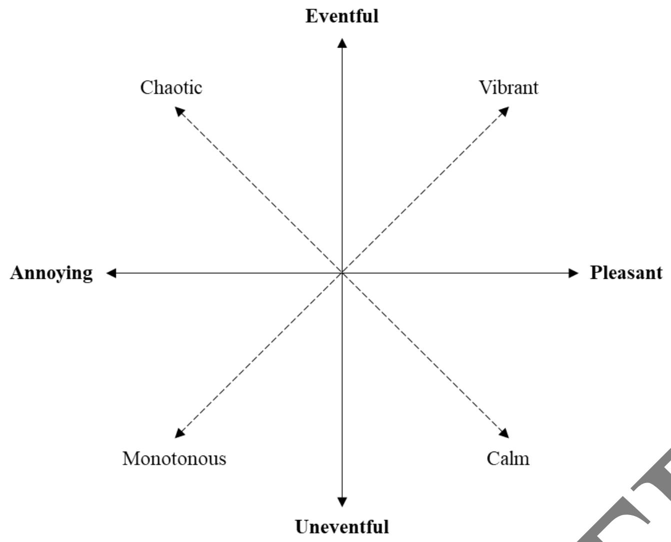

Figure 1 – Circumplex model of soundscape perception as assessed according to the ISO/TS 12913-2

This circumplex framework has then informed international standardisation efforts, most notably the ISO 12913 series on soundscape evaluation [11, 16, 17]. Among the methods included in ISO/TS 12913-2 [16], the most widely used is Method A [23], which employs eight perceptual attributes (i.e., "pleasant", "vibrant", "eventful", "chaotic", "annoying", "monotonous", "uneventful", and "calm") rated on five-point Likert scales to quantify affective, or more accurately, perceptual responses. Indeed, from a terminological standpoint, while Axelsson and Russell describe the dimensions of valence and arousal (or eventfulness) as affective dimensions, later discussions have led to identifying arousal as pertaining to the cognitive rather than affective domain [24, 25]. For this reason, in the 2025 revision of ISO/TS 12913-3 [17], the term "perceptual" is adopted rather than the more restrictive term "affective", thereby encompassing both affective and cognitive dimensions and their related attributes. Therefore, in what follows, these models will be referred to as models of perceptual response evaluation rather than affective response.

Through trigonometric transformation, responses can be reduced to two coordinates representing pleasantness and eventfulness, as described in ISO/TS 12913-3. These coordinates can be plotted within the circumplex space to visualise perceptual soundscape responses. Statistical or probabilistic representations, such as 50th percentile contours, allow comparison of perceptual distributions across locations or acoustic conditions, following approaches proposed by Mitchell et al [18]. Furthermore, distance metrics can be used to express how close a given (real or simulated) soundscape is to a target soundscape, taking into account its distributional features (see the concept of Soundscape Perception Indices, SPIs [26]).

2.1.2. Circumplex models for indoor soundscapes

While the model developed by Axelsson et al., later incorporated into the ISO 12913 framework, was originally designed to assess outdoor soundscapes, recent research has questioned the validity of applying such circumplex structures to indoor acoustic environments. Indoor soundscapes differ fundamentally from outdoor ones due to several factors, such as the coexistence of sounds from both external and internal sources; the presence of a reverberant sound field characteristic of enclosed spaces; the greater diversity of activities and tasks typically performed indoors, beyond passive or transitory behaviours such as relaxation or walking; longer exposure durations, as individuals generally spend more time indoors; and a reduced degree of personal control over the acoustic environment (e.g., limited ability to relocate) [13]. Given these differences, the direct transferability of outdoor soundscape models to indoor settings has been called into question. To address this issue, Torresin et al. conducted a laboratory listening test—adapting the experimental framework proposed by Axelsson et al.—to develop a conceptual model for indoor residential soundscapes [13]. The experiment was carried out in a mock-up living room with a window view, where 35 participants evaluated 20 distinct acoustic scenarios. Each scenario was generated by combining four indoor sound sources with five outdoor urban environments, the latter transmitted through an ajar window to simulate realistic acoustic interactions. Participants assessed the scenarios using 97 perceptual attribute

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scales, previously derived to describe the subjective acoustic perception of residential indoor settings. PCA identified three principal perceptual dimensions ("comfort", "content", and "familiarity"), which accounted for 58%, 25%, and 7% of the total variance, respectively. The first two dimensions, comfort and content, reflected the classical two-dimensional structure observed in prior circumplex models. Notably, however, within this orthogonal perceptual space, secondary axes rotated by 45° could meaningfully interpret "Private and under control" versus "Intrusive and uncontrolled", and "Engaging" versus "Detached" environments (see Fig. 2).

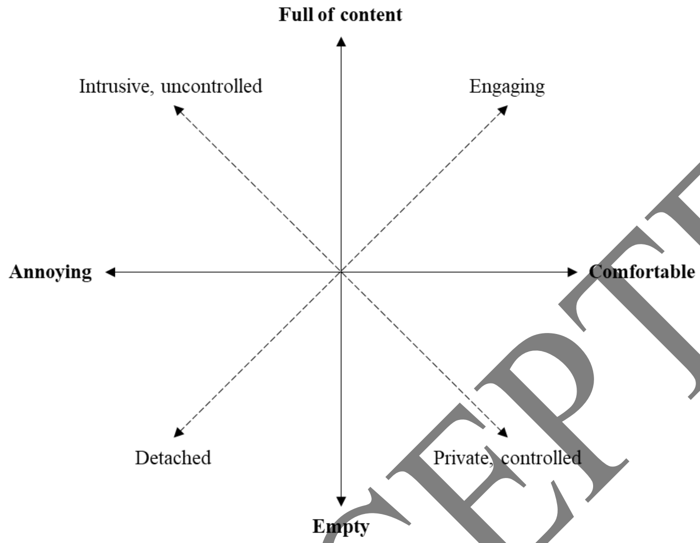

Figure 2 – Circumplex model of indoor soundscape perception in residential spaces according to Torresin et al. [13]

Such dimensions appear particularly relevant to residential indoor contexts, where notions of privacy, control, and personal engagement play a central role in shaping acoustic perception. Conversely, these dimensions are less likely to emerge in public or occupational environments. Indeed, the dimension of privacy and perceived control is notably absent from the model developed by West et al. for office soundscapes [14], which aligns with the Axelsson model adopted in the ISO 12913 standard series.

2.2. Circumplex model of smellscape perception

The circumplex modelling approach has been recently extended to the indoor smellscape domain. Torriani et al. developed a circumplex model of indoor smellscape through a controlled laboratory sensory test involving 42 participants [20]. Twenty-two distinct olfactory scenarios were selected among those most frequently reported in offices, as identified by 200 respondents to a UK-based questionnaire. These scenarios comprised 14 individual odours (coffee, caramel biscuit, rotten food, cleaning product, cedarwood, mint candy, talcum deodorant, orange, air freshener lavender, human sweat/vinegar, rose, whiteboard marker, flatulence, and plant), seven of their most frequently co-occurring combinations, and an odourless condition. The odours were chemically reproduced, stored in sanitised glass jars containing cotton pads (100 mL jars, Uline, Pleasant Prairie, WI, USA), and delivered using a computer-controlled olfactometer (Sniff-0, CyNexo, Udine, Italy, https://www.cynexo.com/portfolio/sniff-0-olfactometer/).

Subjective assessment was conducted using a set of 80 unidirectional descriptor scales to capture the human perceptual response to the indoor smellscape. Initially, 118 descriptors were compiled from existing lists developed for indoor soundscape assessment (n = 97) [13] and outdoor smellscape (n = 21) [27, 28]. The extended list was evaluated for applicability to indoor smellscape by ten experts in indoor air quality (IAQ) and olfactory perception. Subsequently, an online questionnaire was distributed via the SurveyMonkey platform to 200 English-speaking participants (gender balanced). Participants completed the questionnaire in their office environment, describing their olfactory experience by providing both emotional attributes and lists of perceived odour sources. The 191 attributes collected from both researchers and laypersons were merged, and semantically similar terms were clustered into 80 groups using natural language processing (NLP)

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techniques implemented in Python. During the experimental phase, each descriptor was rated using visual analogue scales representing the descriptor–smellscape match, following the approach by Axelsson et al. [12] and Torresin et al. [13].

Three principal components were extracted, explaining approximately 65%, 14%, and 7% of the total variance, respectively. The first two dimensions, accounting for the majority of variance, were interpreted as "pleasantness" and "presence", based on the descriptors with the highest factor loadings, and were used to construct a two-dimensional circumplex model (see Fig. 3), while the third dimension was related to the "naturalness" of the smellscape. The pleasantness dimension ordered the smellscape excerpts along a pleasant–unpleasant continuum. This component aligned with prior research on visual atmosphere [29], emotions [9], and soundscape [12, 13], which identified cosiness, valence, or pleasantness as fundamental dimensions underlying affective responses. The presence dimension organised the smellscape excerpts along a present–absent continuum, reflecting the degree of environmental saturation. Presence can be associated with eventfulness (eventful–uneventful) [12] and content (full of content–empty) [13] in the soundscape framework. A 45° rotation of the axes yields two alternative dimensions: engagement and power (see Fig. 3). Consequently:

- Engaging smellscapes are perceived as pleasant and present.
- Overpowering smellscapes are present and unpleasant.
- Detached smellscapes are absent (or less present) and unpleasant.
- Light smellscapes are pleasant and absent (or less present).

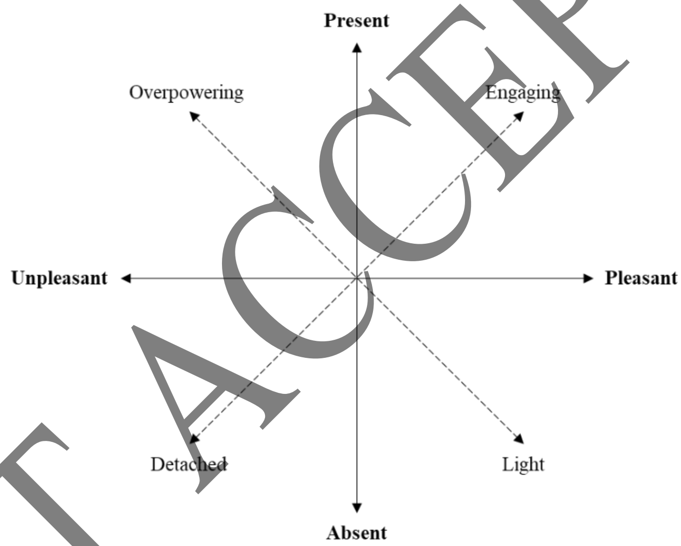

Figure 3 – Circumplex model of indoor smellscape perception in office spaces according to Torriani et al. [20]

A method for indoor smellscape evaluation was proposed, analogous to the soundscape questionnaire introduced in ISO/TS 12913–2 [16]. The developed questionnaire employs eight perceptual attributes—pleasant, unpleasant, present, absent, engaging, detached, light, and overpowering—evaluated using five-point Likert scales to quantify perceptual responses. The Likert responses are coded from 1 (strongly disagree) to 5 (strongly agree). Through a trigonometric transformation, the responses can be reduced to two coordinates representing pleasantness and presence [20], which can be plotted in the circumplex space to visualise perceptual responses to indoor smellscapes using statistical or probabilistic representations.

3. Towards a circumplex model of visualscape perception

3.1. Previous studies on the assessment of visual perception

Based on an assessment of the aesthetic appeal of photographs, the study by Axelsson identified three key dimensions relevant to visual appraisal: "hedonic tone–familiarity", "absence of colour", and "expressiveness–dynamics" [21]. Although derived from photographic material, these dimensions may also hold relevance for

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understanding the aesthetic evaluation of real-world environments. Circumplex models have been proposed in the literature for the evaluation of places, generally assuming a visual representation. Compared to Osgood's dimensions of evaluation, activity, and potency [30], Russell retained a two-dimensional structure as the basis of the affective quality attributed to places, with dominance explaining only a trivial proportion of the variance [31]. The model, illustrated in Fig. 4, reflects the previously introduced valence–arousal framework, with two secondary axes related to excitement and relaxation.

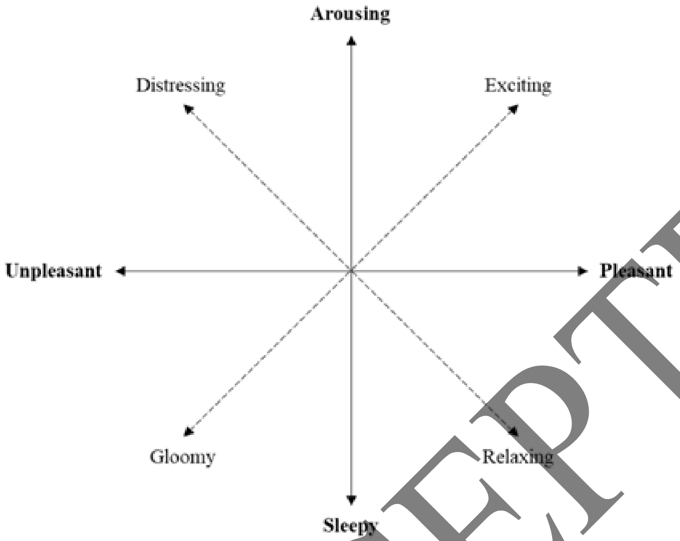

Figure 4 – Circumplex model of affective quality of places according to Russell & Pratt [31]

Russell and Pratt argued that, beyond these two main dimensions, additional ones account for smaller proportions of variance (e.g., locus of control) and are more cognitive than emotional in nature. However, as previously discussed, even arousal itself was later interpreted as a cognitive dimension. In Russell's work, the focus was on describing the emotional quality of environments, regardless of their type (e.g., natural or urban, private or public, indoor or outdoor, etc).

One of the most influential frameworks for quantifying the experience of built environments was introduced by Vogels [32], who developed an empirical tool to measure perceived atmosphere. In contrast to affective-state assessments, this approach conceptualises atmosphere as the subjective experience of one's surroundings through external perception and internal sensation. To operationalise this construct, a semantic differential questionnaire was created based on a lexicon of 38 descriptive terms derived from 184 atmosphere-related adjectives. Participants evaluated various real and simulated indoor environments. Each term was rated on a 5-point scale from "not applicable at all" to "very applicable". The resulting data were analysed through PCA. Two dominant and reliable factors emerged – "cosiness" and "liveliness" - accounting for the major portion of variance in participants' responses (30% and 19%, respectively). Cosiness describes the affective appraisal of environmental comfort and pleasantness, whereas liveliness describes the perceived level of sensory stimulation and activity. These dimensions align with the evaluation of affect (positive/negative) and activity (arousal/non-arousal) dimensions found in many other studies.

In a subsequent experiment, Vogels [29] investigated how variations in artificial light influence the visual impression of interior spaces. The study was conducted in a full-scale simulated retail environment under four lighting conditions differing in intensity, distribution, and colour temperature. Using the same 38-item semantic differential scale developed in the first study, participants evaluated each lighting scenario in terms of experienced atmosphere. PCA confirmed the stability of two principal dimensions: cosiness and liveliness. Cosiness encompassed perceptions of warmth, intimacy, and comfort, whereas liveliness reflected brightness, clarity, and visual stimulation. Warm and diffuse light scenes were rated as more cosy and pleasant, while cool and directional light increased liveliness and perceived activity.

Building on Vogels' preliminary work, Stokkermans et al. [33] extended the atmospheric framework by examining the perceptual attributes of light in human affective experience. Their study confirmed that atmosphere can be represented through four perceptual attributes to describe the subjective impression of a space in response to variations in light properties such as brightness and uniformity.

- Cosiness, describes impressions of intimacy and pleasantness,
- Liveliness, describes the visual stimulation and activity,
- Tenseness, describes the sense of pressure or unease,
- Detachment, reflects emotional distance, or the lack of engagement with the space.

Within the light domain, Castilla et al. examined the affective vocabulary employed by students to describe the luminous atmosphere of university classrooms [34]. From an initial pool of 178 spontaneous descriptors, a refined list of 37 adjectives was established to capture both perceptual and emotional qualities of light, including bright, uniform, cosy, and stimulating. Each term was rated on a five-point Likert scale across 29 real classrooms exhibiting diverse lighting conditions defined by illuminance, distribution, and colour temperature. PCA revealed six orthogonal semantic dimensions: "surprising–amazing", "clear–efficient", "cheerful–colourful", "uniform", "intense–brilliant", and "warm–cosy", which together accounted for the principal structure of affective responses. The clear–efficient factor showed the strongest correlation with measured vertical and horizontal illuminance levels, indicating that well-lit and evenly illuminated spaces were perceived as more comfortable and visually adequate. In contrast, the warm–cozy factor increased under lower colour temperatures, while surprising–amazing was amplified by directional and contrast-rich light effects, linking subjective impressions to measurable photometric conditions.

If the literature has already investigated the visual perception of indoor built environments, the derivation of a circumplex model—similar to those developed in the soundscape and smellscape domains—for indoor built environments is currently lacking. While the overall structure is plausibly linked to the valence–arousal pattern (or cosiness and liveliness), previous research in soundscape and smellscape has shown that these models can be meaningfully interpreted across different environmental domains, particularly through the secondary 45-degree dimensions. The availability of such a perceptual model—that is, models encompassing both affective and cognitive aspects of light and indoor visual conditions more broadly—would, compared with visual analogue scales, allow for collecting and representing data across multiple sensory domains in a coherent manner, which is particularly relevant for multisensory studies.

The following section examines the attributes that can be used to describe the perception of indoor visualscapes and the potential factors underlying such perception, based on an analysis of previous literature. This knowledge will be instrumental in designing a future experiment aimed at developing a model of indoor visualscape perception, derived through the dimensional reduction of these attributes, as described in Sections 2.1 and 2.2.

3.2. Attributes

A set of attributes describing human perception of the visual environment was compiled through a non-systematic literature search of studies employing questionnaires to assess occupants' perceptual responses. Sources included foundational work on place perception [31, 35], studies focusing on landscape and urban outdoor settings [36–47] or photographs and pictures evaluation [21, 48–50], and research specifically addressing indoor built environments [51–61], examining aesthetic, cognitive, and affective responses to the visual experience. Additional material was drawn from the literature on lighting conditions [6–8, 29, 33, 34, 62–70] and colour perception [71–74]. This initial phase yielded 630 attributes, many of which recurred across multiple publications. While acknowledging the limitations inherent in the non-systematic approach adopted, including the potential for selection bias in source identification and the absence of formal reproducibility procedures, it is important to note that the screening process reached a point of conceptual saturation. Additional articles did not introduce further distinct attributes beyond those already identified. This suggests that the resulting attribute set can be considered sufficiently robust for the purposes of the study. Its suitability for describing indoor visualscapes was then independently evaluated by the six authors. Attributes were retained if they reached a consensus score of at least 5 out of 6, based on a three-level coding scheme (1 pt: "adequate", 0 pts: "not adequate", or 0.5 pts: "uncertain"), resulting in a refined set of 519 attributes. Duplicate items were removed, and semantically similar attributes were clustered using artificial intelligence (OpenAI). The AI model was provided with the list of 519 attributes and instructed through structured prompts to: i) identify semantically overlapping or conceptually redundant terms; ii) suggest potential clusters based on shared perceptual meaning rather than purely lexical similarity; iii) explicitly justify proposed groupings by describing the underlying conceptual commonality; iv) flag ambiguous terms that might belong to more than one semantic group. Proposed clusters were evaluated according to the following criteria: i) conceptual equivalence (i.e., attributes referring to the same underlying perceptual construct); ii) theoretical coherence (i.e., attributes aligning with the established constructs in environmental perception literature); iii) functional distinctiveness (i.e., terms were kept separate if they implied different psychological mechanisms (e.g., "stimulating" vs "pleasant", even if positively valenced)). During this initial AI-assisted clustering process, some additional attributes were automatically generated, while others were added based on the authors' expert judgment. Through iterative discussion and consensus-building, this process produced a final set of 137 unique attributes or attribute clusters, which are presented in Table 1. Consistent with established methodologies in soundscape and smellscape research, this attribute set can be used in perceptual experiments in which participants evaluate different environmental conditions (in this case, indoor visualscapes). Dimensionality-reduction techniques (e.g., PCA) may then be applied to derive a fundamental set of perceptual dimensions from this larger pool. As the related literature notes, people comprehend more words than they actively use [75]. Offering a predefined list of descriptors, therefore, enables participants to report experiences that exceed their active vocabulary, yet are accessible within their passive vocabulary [76]. Similarly, using clusters of semantically related terms can help reduce individual variability in interpretation, as the overlapping meaning shared across terms more precisely delineates the concept under study [76].

To elicit the widest possible range of perceptual responses, it is essential to determine which stimulus factors should be manipulated when selecting the visual environments presented to participants. This issue is addressed in the following section.

Table 1. An alphabetically ordered list of descriptive attributes of indoor visualscape perception, along with the references from which they were sourced. Attributes without listed references were introduced by the authors or during the AI-assisted clustering process.

ID	Attribute	Reference
1	Accessible, Easy to reach	[32, 45]
2	Active, Dynamic, Full of action	[21, 31, 34, 37]
3	Aesthetic, Beautiful, Graceful, Lovely, Pretty	[21, 31, 34, 40, 44, 46, 51, 52, 70]
4	Agreeable, Appealing, Liked, Nice, Pleasant, Pleasing	[21, 31–36, 46, 51, 52, 70–74]
5	Alive, Living	[21, 31, 60]
6	Amazing, Awesome, Impressive	[34, 45]
7	Annoying, Distressing, Stressful	[35–37, 46, 47, 55]
8	Anti-hygienic, Dirty, Musty	[32, 36, 55]
9	Arousing, Exciting, Exhilarating, Making me feel wide awake, Stimulating	[31–37, 46, 48, 51, 52, 60, 70–74]
10	Arranged, Ordered, Orderly, Organised, Planned, Thought out	[21, 34, 36, 38, 55, 59, 70]
11	Artificial, Unnatural, Unrealistic	[21, 36, 40, 61, 64, 70, 77]
12	Authentic, Genuine, Original	[34, 40, 44, 45]
13	Balanced	[34]
14	Banal, Common, Commonplace, Generic, Normal, Ordinary	[21, 36, 40, 52]
15	Boring, Dreary, Dull, Monotonous, Uninteresting, Unstimulating, Vapid	[35, 40, 46, 48, 49, 70–74]
16	Bright, Brilliant, Light, Radiant, Too much light	[32, 34, 37, 52, 55, 62, 68, 70–74]
17	Broad, Large, Open, Roomy, Spacious	[37, 51, 52, 55, 59, 70]
18	Business-like, Commercial	[21, 32, 33]
19	Calm, Calming, Peaceful, Quiet, Relaxing, Restful, Serene, Tranquil	[21, 31, 32, 34–37, 44, 46, 48–52, 55, 70–74]
20	Captivating, Engaging, Interesting	[21, 31, 32, 34, 37, 38, 46, 51, 52, 70]
21	Casual, Informal	[70]
22	Chaotic, Cluttered; Hectic, Disordered, Messy	[31, 36, 38, 55, 59, 70]
23	Characteristic, Familiar, Identitary, Recognisable, Typical, Unmistakable	[37, 38, 40, 45, 47]
24	Cheerful, Happy, Joyful	[21, 32, 34, 49, 70–74]
25	Clean, Hygienic, Pure	[21, 36, 37, 55]
26	Clear, Distinct, Noticeable	[32, 34, 36, 40, 45, 70]
27	Coherent	[37, 45]
28	Cold, Cool	[32, 46, 55, 68, 70]
29	Colourful, Vivid	[32, 34, 59, 62, 70]
30	Colourless	[32, 62, 70]
31	Comfortable, Cosy, Snug	[32–34, 40, 44, 54, 70]
32	Comforting	
33	Complex, Complicated, Elaborate, Labyrinthine	[32, 36, 37, 40, 45, 55, 70]

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34	Confined, Cramped, Enclosed, Narrow, Small	[51, 52, 55, 70]
35	Confusing, Unclear, Vague	[36, 45, 70]
36	Contented	[48]
37	Contrasted, High-contrast	[70]
38	Convenient, Efficient, Functional	[34]
39	Creating movement, Curvilinear	[38]
40	Creating right mood	[60]
41	Crowded	[46, 55]
42	Cute	[21]
43	Dangerous	[36, 45]
44	Dark, Dim	[32, 34, 52, 55, 68, 70]
45	Decorative, Ornate	[36]
46	Defamiliarised, Mysterious, Strange, Unfamiliar, Unusual	[32, 36–38, 40, 52]
47	Depressing, Gloomy, Melancholic, Sad, Somber	[35, 40, 46, 48, 49, 70–74]
48	Despairing	[48]
49	Detached, Impersonal	[32]
50	Detailed	
51	Different, Differentiated, Diversified, Non-uniform, Varied, Variform	[21, 32, 38, 40, 68, 70]
52	Difficult to concentrate	[51]
53	Difficult to interact with colleagues	[51]
54	Diffuse	[32, 70]
55	Disagreeable, Disliked, Displeasing, Grotesque, Loathsome, Repellent, Repelling, Repulsive, Ugly, Unappealing, Unpleasant	[21, 31, 35, 36, 40, 46, 51, 52, 70]
56	Disharmonious, Dissonant, Inconsistent	[21, 40, 45]
57	Dissatisfying, Unsatisfying	[31, 48, 70]
58	Dominant	[38, 71–74]
59	Dramatic, Emotional, Expressive, Full of feeling	[21, 32, 70]
60	Easy to concentrate	[51]
61	Easy to interact with colleagues	[51]
62	Elegant, Tasteful	[21]
63	Empowering, Enabling	[34, 71–74]
64	Energetic, Forceful	[31, 60, 71–74]
65	Enhancing belonging, Generating sense of place	[47]
66	Enhancing connection	[54]
67	Enhancing productivity	[54]
68	Enhancing room/building image	[60]
69	Excessive, Overdone	[45]
70	Expansive	
71	Fearful, Frightening, Gruesome, Hostile, Terrifying, Threatening	[21, 32, 33, 36, 37]
72	Formal, Serious	[21, 32, 33, 70]
73	Frenzied, Jittery, Tense	[31, 33, 48]
74	Friendly, Hospitable, Inviting	[32, 34, 36]
75	Generating attention, Generating attraction	[60]
76	Generating personal fulfilment	[47]
77	Glaring	[32, 34, 70]
78	Harmonious	[21, 36]
79	Hazy, Murky	[32, 70]
80	Helping to experience myself	[44]
81	Historical	[45]
82	Homogeneous, Uniform, Unvaried	[32, 34, 37, 68, 70]
83	Inaccessible	
84	Inactive, Sleepy, Stagnant, Unaroused	[31, 46, 48]
85	Inciting	[21]
86	Insignificant, Meaningless	[21, 71–74]
87	Inspiring, Suggestive, Thought-provoking	[21, 32, 34]
88	Insufficient light, Too dark	[62]
89	Intact, Undamaged, Unspoilt, Well-maintained	[40, 44, 45]
90	Intense	[31, 34, 38]
91	Intimate, Personal	[21, 32, 33, 70]
92	Intolerable	[68]
93	Kitch	
94	Legible, Understandable	[36–38, 78]

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95	Lively	[32–34, 46]
96	Low visual privacy, Public	[51, 70]
97	Low-contrast	[70]
98	Luxurious, Rich, Sumptuous	[32, 70]
99	Maintained, Tidy, Uncluttered	[36, 70]
100	Meaningful	
101	Minimal	
102	Modern	
103	Natural	[21, 34, 36, 37, 40, 45, 61, 64, 77]
104	Naturalistic, Rural	[36]
105	Neglected	[36]
106	Neutral	[21]
107	Not glaring	[32, 70]
108	Not properly thought out, Unplanned	[21]
109	Old	[21]
110	Oppressive	[32, 53]
111	Peculiar, Unique, Unmistakable	[36, 40]
112	Plain	[36, 70]
113	Private	[70]
114	Real	[21, 70]
115	Refreshing	[60]
116	Relaxed	[36]
117	Romantic	[32]
118	Safe	[32, 36, 45]
119	Satisfying	[48, 70]
120	Sensational	[31]
121	Sharp	[34]
122	Simple	[32, 36, 70]
123	Sparse	[46]
124	Spatial	[32]
125	Subtle	[34]
126	Surprising	[34]
127	Symmetric	[59]
128	Uncomfortable	[31, 32, 70]
129	Untamed, Wild	[40]
130	Urban	[36]
131	Warm, Warming	[21, 32, 34, 55, 68, 70]
132	With a coherent layout	
133	With consistency between materials and objects	[38]
134	With continuance of edges or surfaces	[38]
135	With quality	[34]
136	With rhythmic intervals repeated	[38]
137	With visual privacy	[51]

3.3. Factors influencing visualscape perception

A narrative review was conducted to identify the main factors that influence visualscape perception. Being exploratory, in support of the design of a future experimental activity, a non-systematic approach was deemed methodologically appropriate and proportionate to the objectives of the study. The factors emerging from studies investigating the drivers of human experience and perception of the visual environment were grouped into six key categories: geometry and spatial configuration; materials and texture; window views; spatial organisation; lighting; and colour design (Table 2). Each of these factors is discussed in more detail in the following sections.

Table 2. Categorisation of visual stimuli affecting subjective experience in indoor environments.

Category	**Factors**
Geometry and spatial configuration	Ceiling geometry [79], Room shape [80], Ceiling height and size [81–85]
Materials and texture	Wall pattern [86–88], Materiality [79, 89], Reflectivity [66, 88], Facade patterns

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	[90]
Window views	View access [61, 64, 79, 91, 92], View content [61, 64, 79, 91, 93, 94], Natural/non-natural view [61, 64, 91, 93], Number of layers [64, 93]
Spatial organisation	Biophilia [95, 96], Tidiness [97, 98], Crowdedness [99, 100], Design promoting social cohesion [100], Personal decorations and personalisation [100], Layout [101]
Lighting	Light intensity (bright/dark) [63, 66, 69], Uniformity (uniform/varied) [63, 66], Glare [63, 66, 69, 102], light colour (warm/cool) [63, 66, 67], shadows (soft/sharp) [69], reflections (smooth/hard) [69], Directionality (direct vs. diffuse) [66], Dynamics (temporality) [66], Flickering [66, 103], Sense of control [66, 67], Source (natural/artificial) [61, 64, 65, 91], Daylight penetration [61, 64, 66], Luminous intensity distribution of luminaires [66], Light distribution (natural/artificial) [64, 66]
Colour design	Colour definition [52, 53, 99], Colour combination [104], Colour dominance [52, 53, 105], Colour distribution [52, 53, 58, 88, 104]

3.4. Geometry and spatial configuration

The ceiling geometry, the room configuration, and the dimensions of the space all exert an influence on the emotional experience of the occupant. As demonstrated by Cha et al. [83] and Franz et al. [52], the effects of ceiling height and type on the affective response, room appraisal, sense of presence, and cognitive response through immersive virtual environments have been demonstrated. Rooms with higher ceilings appear to activate parietal and frontal structures in the dorsal stream, thereby supporting attention [84]. Furthermore, the study conducted by Zhang et al. [81] found that altering ceiling heights resulted in a more favourable cognitive response compared to modifying the dimensions of the classroom. Similarly, the formal properties of the spatial envelope also shape the perceptual experience and, according to Llorens-Gámez et al. [106], curvilinear interior geometries are consistently associated with higher levels of satisfaction, interest, and emotional arousal, while rectilinear configurations tend to be related to more moderate affective responses.

3.4.1. Materials and texture

Material parameters have an effect on the perception depending on their thermal properties and colour [88, 89, 99]. These effects can vary according to the sense used for the evaluation, with the visual experience being the dominant one in the wall design [89]. The significance of materiality on the perceived spaciousness of indoor environments depends on the methodology of inquiry and pattern density, and orientation [58, 79, 86]. However, Zejnilovic et al. [88] concluded that the wall colour has a predominant role in perception. The textures of the surrounding materials also have an influence. Chamilothori et al. [90] showed that the geometry of the façade and the spatial distribution of the projected sunlight patterns directly influence the perceptual experience, strengthening feelings of pleasure, interest, and excitement when the patterns have an irregular composition.

3.4.2. Window views

The quality of the view out is a fundamental descriptor of a visual environment, due to its strong impact on overall well-being, including emotion, satisfaction, performance, and stress recovery [91]: factors such as the presence of natural elements or the number of layers (e.g., sky, other building façade, ground) are key characteristics of the visual experience and the overall well-being [61]. Studies show that having a view of the outside can positively influence emotions and multi-domain comfort, an effect linked to psychological well-being [6, 92]. For example, exposure to natural environments was ascertained to support the emotional dimension, supporting recovery from physiological stress and affective state [95], and positively impacting mood and sleep. This effect seems to be related to the sensory experience as a whole and can be achieved through viewing natural elements (e.g., plants, wooden material) [96].

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3.4.3. Spatial organisation

Besides how the indoor environment is designed, the organisation and maintenance of the space seem to have an effect on the experience as well. Indeed, the level of tidiness can have an affective, evaluative, and behavioural effect [97] and on human accuracy [98]. In addition, tidiness and order can have a positive impact on responding to stressors and improving well-being. Salutogenic resources are also promoted by the possibility of managing and personalising the space [100].

3.4.4. Lighting

Light uniformity, direction, dynamism, and control have been linked to visual comfort and well-being [66]. Kim and Mansfield identified how the different lighting parameters influenced the targeted emotional states [7]. For example, liveliness was linked to higher illuminance and cooler colour temperatures, while relaxation was associated with warmer tones and moderate brightness. Tension was evoked by dim, cooler lighting, and gloom was associated with low brightness and low colour temperatures. Overall, the study supports the notion that emotional design in lighting can be an effective tool for creating supportive and adaptable work environments. Zhang et al. confirmed that lighting design can influence emotional states [8]. Their study revealed that relaxed and pleasant emotional responses were associated with warm light at both medium and bright levels. Similar responses were also observed under cool light at a medium level. In contrast, cool and bright light created a more exciting and tense emotional atmosphere, while low light levels under both CCTs made participants feel tired and frustrated. Light quality factors such as uniformity, directionality (direct vs diffuse), dynamics (temporality), flickering, and sense of control are cited as factors that strongly affect visual comfort and indoor well-being [66, 67, 103].

3.4.5. Colour design

How colour design is perceived depends on the definition of the dominant colour, colour combinations, and its spatial distribution [104]. Valdez & Mehrabian highlighted how positive and negative feelings, as well as other psychological states such as arousal, dominance, or aggression, can be triggered by different hues [74]. Elliot and Maier demonstrate that colour can affect cognition and behaviour [71]. Although their impact depends on the context, red generally carries the meaning of dominance or sexual attraction, blue and green promote calmness, openness, and creativity, yellow suggests caution, black implies aggression, and white suggests purity or neutrality. Research also indicates that cool colours (yellowish green to purple) support attention and memory, while warm colours reduce attentional performance, and high-contrast colour combinations enhance visual salience [106]. Jonauskaite & Mohr conducted a systematic review of 132 studies over 128 years, involving over 42,000 participants from 64 countries, to examine how people associate colours with emotions [72]. They found similar patterns linking colour categories and dimensions (hue, lightness, saturation) to perceptual qualities like valence, arousal, and power, suggesting that colours reliably evoke emotional experiences. Nevertheless, aspects such as cultural factors might play an important role in colour perception [107].

4. Discussion and final remarks

This study lays the groundwork for the future development of a circumplex model of visualscape perception for indoor built environments. Such a model could be applied in POEs, in laboratory-based visual perception research, or to guide perceptually-based design processes in architecture and engineering. Similar to those used in soundscape research (e.g., Soundscape Perception Index, SPI [26]), distance metrics can be employed to quantify how close a given (real or simulated) visualscape is to a target condition within the circumplex space. This would thus enable the evaluation of the perceptual effectiveness of design interventions.

Developing a model with a structure analogous to that already established in soundscape research and incorporated into international standards, and more recently adopted in smellscape studies, offers an important advantage: it allows perceptual responses across different environmental domains (acoustic, olfactory, visual, etc.) to be collected in a harmonised manner. This helps overcome current disciplinary boundaries, in which separate normative references—rooted in siloed research traditions—lead to

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inconsistent use of scales and attributes. A cross-domain circumplex structure is therefore aligned with the emerging body of multi-domain environmental research [108], which examines the complex experience of building occupants, acknowledging human multisensory processing [109, 110] and the need to characterise cross-modal and combined effects across environmental domains.

What comes next for visualscape research? Following methodologies already employed in soundscape and smellscape studies, laboratory experiments can be developed in which participants rate their experience of various visual stimuli, presented as images or immersive virtual reality scenes, representing a wide variety of indoor built environments. Each stimulus can be evaluated using the 137 attributes (or attribute groups) derived in Section 3.2, while the visual stimuli themselves can be selected—within reasonable temporal limits of the experiment—to systematically manipulate the factors described in Section 3.3. The presence of a large number of attributes to be rated, but comparable to what was observed in the experimental phases that led to the development of soundscape and smellscape models, and/or the inclusion of multiple visual conditions, can be addressed through different experimental design strategies in order to reduce the effort required from participants. For instance, the experiment could be divided into multiple sessions or structured as a between-subjects design, so that not all participants evaluate all visual conditions. Alternatively, assessments could be conducted using semantic differential scales [111], reorganising the list of attributes into pairs of opposite meanings. This approach would substantially reduce the number of individual items and, consequently, the time associated with each session. To elicit the widest possible range of perceptual responses, visual scenes should differ in geometry and spatial configuration, materials, type of outdoor view, spatial organisation, lighting conditions, and colour schemes.

The collected ratings may then be used to perform dimensionality reduction (e.g., Principal Component Analysis). This would allow identification of the underlying dimensions shaping the circumplex structure of visualscape perception. In other words, the analysis will reveal the primary and secondary dimensions whose combinations account for affective and cognitive responses to indoor visual environments. While existing literature on light and spatial perception already hints at a structure consistent with classical environmental psychology, typically organised around valence and arousal dimensions (e.g., cosiness and liveliness), future work should aim to more precisely characterise the eight attributes underlying the circumplex structure when visual stimuli target specific indoor typologies, such as offices or residential spaces. This will constitute an important step forward on the research horizon of characterising and designing human-centred built environments.

5. Authors Contributions

ST: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing; GT: Formal analysis, Investigation, Methodology, Writing – original draft; AC: Formal analysis, Investigation, Writing – review & editing; CP: Formal analysis, Investigation, Writing – review & editing; NGV: Formal analysis, Investigation, Writing – review & editing; LZ: Formal analysis, Investigation, Writing – review & editing.

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