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To cite this article: Dan Luo, Lieve Doucé & Karin Nys (26 May 2024): Multisensory museum experience: an integrative view and future research directions, Museum Management and Curatorship, DOI: [10.1080/09647775.2024.2357071](https://doi.org/10.1080/09647775.2024.2357071)

To link to this article: <https://doi.org/10.1080/09647775.2024.2357071>



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Multisensory museum experience: an integrative view and future research directions

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ABSTRACT

In museum and aesthetic contexts, the role of multisensory experiences in boosting visitor engagement is well-recognised. Yet, the diverse disciplinary perspectives have led to a scattered and sometimes unclear literature landscape. This article undertakes a systematic review, combining systematic literature extraction and qualitative content analysis of 331 academic sources to address the following questions: What are the theoretical underpinnings for studying multisensory museum experiences? What are the general characteristics of these experiences? How can we understand the role of technology in sensory practices within museums and related sites? By focusing on visitors' perspectives, the review aims to offer a comprehensive understanding of multisensory experiences, emphasising research framework, conceptualisation, and technology in museum practices. Furthermore, it outlines future research directions in these areas, contributing to a more unified theory and providing practical insights for exhibition design. This establishes a groundwork for nuanced future research endeavours.

ARTICLE HISTORY



Received 13 December 2023
Accepted 15 May 2024


KEYWORDS

sensory museology;
multisensory museum
experience; visitor
experience; multisensory
research; visitor-exhibition
interaction

1. Introduction

In recent decades, scholars from humanities and social sciences have shifted their focus to multisensory research, challenging psychology's dominance in this domain. This shift has yielded critical insights into museum studies. Howes (2014) introduced the idea of *sensory museology*, advocating a transition from vision-centric to sensory-rich museum experiences, such as sound, smell, and touch (Fors 2013; Zhou, Zhou, and Li 2023). This emphasis on the senses has spurred calls for further research in exhibition design and understanding factors influencing visitor responses, from sensory stimuli to embodied cognition. Psychology, neuroscience, and anthropology have also contributed significantly to our understanding of the interplay between senses, body, mind, and behaviour (Badde, Navarro, and Landy 2020; Belke et al. 2010; Komarac and Ozretić Došen 2022).

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 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/09647775.2024.2357071>.

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However, despite these advances, research on multisensory interactions between visitors and exhibitions remains fragmented, necessitating consensus on conceptualisation and investigation. The definition of multisensory museum experiences varies across disciplines and contexts. Howes (2014) regarded museums as exciting places for historical, cross-cultural, and aesthetic exploration. Velasco and Obrist (2021) emphasised technology's role in evoking impressions of objects, even in their absence. Some researchers focused on specific areas, such as *servicescape* (e.g., Bitner 1992; Chui et al. 2010). Research on the implications of senses in tourism and museum atmospheres is greatly scattered. Currently, there is no comprehensive view of multisensory museum experiences that encompasses its characteristics, the crafting of multisensory experiences using technologies, and the suitable research framework and methodology to study it. Such an integrative view is necessary to understand the multisensory museum experience thoroughly and restricts further studies on its consequences. Existing literature often examined the effect of isolated sensory cues, providing detailed qualitative interpretations from a constructive sociocultural perspective (emphasising learned and social experiences; Tarlow 2012). In some cases, however, scholars employed quantitative methods to test potential mediators and moderators (e.g., Jiang 2022; Lee and Jeong 2020). Due to the complexity of multisensory processes, including cross-modal associations and synaesthesia, an integrative view is essential for profound research and theoretical advancement. This perspective will benefit researchers and museum practitioners in enhancing public services through exhibition design.

To address these challenges and develop a unified museum experience theory, this review aims to provide fundamental insights into visitors' multisensory museum experiences across three research topics: research framework, conceptualisation, and technology in museum practices. We categorise subbranches in the current literature and analyse their compatibility to form a holistic view of multisensory museum experiences and identify future research directions. Key research questions include: (1) what are the theoretical underpinnings for studying multisensory museum experiences? (2) what are the general characteristics of these experiences? (3) How can we understand the role of technology in sensory practices within museums and related sites?

We conducted a systematic literature review within these three research topics and supplemented our findings with a bibliography search for deeper insights. This comprehensive and iterative approach to literature selection ensures a comprehensive understanding of the multisensory museum experience within each research topic. Through qualitative content analysis, we aim to provide an integrative view of multisensory museum experiences. This review complements existing work, offering a comprehensive perspective on multisensory experiences in museums and relevant sites, addressing diverse topics and future research directions. This 'big picture' of multisensory museum experiences can inform sensory research in museums and related areas, with implications for exhibition design and tourism services.

2. Methodology

This review aims to develop an integrative perspective on multisensory experiences in the museum context by organising and analysing the scattered literature from both theoretical and empirical sources (Becker and Jaakkola 2020; Booth, Sutton, and Papaioannou

2016). The analysis consists of two phases: (1) a systematic literature review of the multisensory museum experience that categorises individual studies and books into three research topics, and (2) the development of an integrated view of the multisensory museum experience within these topics, along with identifying research gaps and future research directions.

2.1. Phase 1: identifying and grouping relevant multisensory experience research

To ensure comprehensive coverage, we systematically selected relevant studies based on strict guidelines (e.g., Booth, Sutton, and Papaioannou 2016). Following a five-stage search process suggested by Booth, Sutton, and Papaioannou (2016), we initially explored the 'multisensory museum experience' in the Web of Science database to identify key search terms. We then utilised adjusted search terms to retrieve academic articles from 2002 to 2023 in four databases: Web of Science, Scopus, EBSCO Host, and ScienceDirect. According to prior studies, the four databases are comprehensive and effective in studying customer or visitor issues (e.g., Becker and Jaakkola 2020; Slabbert and Du Preez 2021). Moreover, as this review focuses on the sensory museum, we included other sources from Taylor & Francis Online, such as *The Senses and Society* and *Curator*, which are essential journals in this field but are not covered by the previous four databases. Additionally, Google Scholar and ProQuest, well-known databases that provide grey literature (Booth, Sutton, and Papaioannou 2016), are included, considering they comprise issued publications that other academic databases have not yet captured.

Based on the identified records, we grouped them into three research topics through full-text assessment. To be classified into a specific research topic, a reference had to address at least one aspect of the multisensory museum experience related to the research framework, conceptualisation, or technology in museum practices. Most references were grouped under a single topic, but some overlaps existed since some studies can contribute to understanding in diverse topics. For example, several empirical studies on extended reality (XR) contributed to conceptualising multisensory experiences and provided insights into the current museum practices of technical embodiment. Some books and reviews covered multiple research topics, contributing to a comprehensive understanding of the multisensory museum experience. Overall, this classification aimed to develop a holistic view of researching the multisensory process in the museum context or relevant aesthetic sites across the three research topics.

A bibliography search was also conducted to identify supplementary studies that offered deeper insights into the three research topics (Booth, Sutton, and Papaioannou 2016). This iterative process involved reading articles, identifying research topics, categorising them, and adding additional papers from the bibliography until we reached a saturation point in understanding the multisensory museum experience within each topic. After thorough verification, we compiled a final list of 331 references, including theoretical and empirical studies. For an overview of the systematic literature review process, including key search terms, inclusion and exclusion criteria, PRISMA 2020 flow diagram (Page et al. 2021) and the selection of references, please see the documentation in Appendix 1.

2.2. Phase 2: developing an integrative view of the multisensory museum experience within three distinct research topics

To achieve an integrated perspective on the multisensory museum experience, we departed from the traditional approach of studying the senses separately. Instead, we emphasised the interconnectedness of multiple senses. Drawing upon prior research of scholars like David Howes and the critique of Aristotle’s five-sense model, we recognised the limitations of the traditional ‘one sense at a time’ approach in fully capturing the complexity of visitor sensory experiences (Skeates and Day 2019). Research in the field of sensory studies, including interoceptive senses and synaesthesia (i.e., one sensory stimulus causes different sensory-physical experiences), suggests that sensory experiences are often multimodal and interconnected (Damasio 2003; Merter 2017). Empirical studies in the context of museums and experiential environments have also shown that sensory experiences are rarely isolated; instead, they overlap and influence each other, creating a more immersive and profound experience for visitors. This interconnectedness is particularly relevant in museum settings, where exhibitions are designed to engage multiple senses simultaneously. Additionally, from a practical standpoint, understanding how different senses interact and contribute to the overall museum experience is crucial for museum professionals and exhibition designers. This knowledge allows for the creation of more engaging, inclusive, and memorable experiences that cater to the diverse sensory preferences and needs of visitors.

By studying the senses in conjunction paired with inductive content analysis, we sought to identify the main components of the multisensory experience, reconcile any contradictions, and consolidate them within the three research topics. Our qualitative analysis approach allowed for an in-depth exploration of complex interplay between exhibitions and visitors. Integrating the multisensory museum experience will result in a comprehensive and holistic understanding of visitors’ sensory experiences, enriched with valuable insights for future research and practices (see Figure 1).

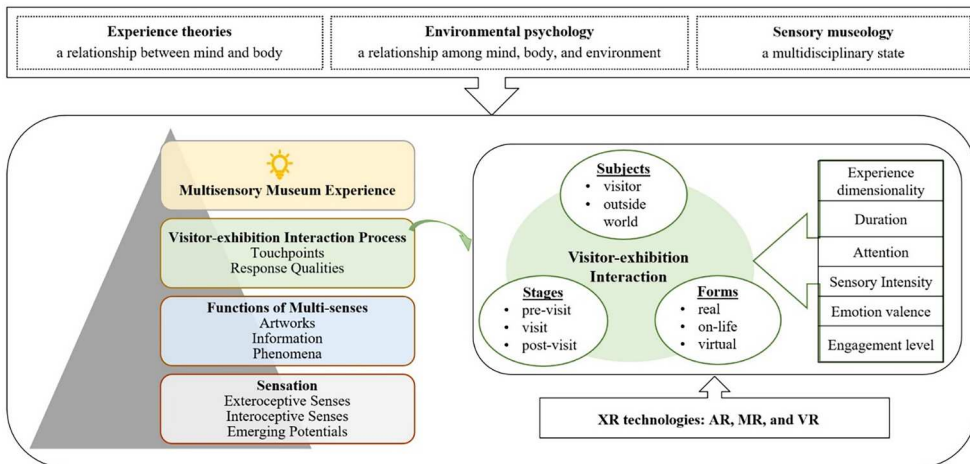


Figure 1. A Conceptual framework for understanding the phenomenon of multisensory museum experience advocate for its use in future systematic reviews.

This review employs systematic literature extraction and qualitative content analysis to explore the interdisciplinary nature of multisensory museum experiences. To ensure inter-rater reliability, the screening and data extraction performed by one author underwent strict scrutiny by two other authors. This involved a detailed examination of literature selection, extraction methodology, and synthesis of results, maintaining methodological precision. This collaborative oversight notably improved the review's accuracy and uniformity. Additionally, this review was initiated at an early stage without protocol registration, due to its qualitative, interdisciplinary approach to multisensory museum experiences, a departure from typical quantitative studies that usually require online protocol registration. Understanding the importance of protocol registration for research credibility, we advocate for its use in future systematic reviews.

3. Research framework

This section establishes the theoretical and methodological groundwork for examining multisensory museum experiences. It integrates diverse theories and methods to address the question of the theoretical underpinnings essential for studying multisensory experiences in museums.

Early theories, originating from ancient Greece, offer ontological insights into sense perception, exploring the intricate connection between mind and body, as well as physiological phenomena like emotion, dreams, and fatigue (Baltussen 2019). Debates on the relationship between external senses and the inner mind (which can also be described as arguments in objectivity versus subjectivity) have been presented since the time of Plato, Aristotle, Theophrastus and Strato. Phenomenological traditions have subsequently emerged as effective approaches for illustrating and interpreting the interrelationship between mind and body. Fors (2013) indicated that 'Heidegger's and Merleau-Ponty's ideas about the interrelationships between bodies, learning, and technologies challenge the Cartesian idea of perception and experience as transferring information to the brain in the process of knowledge production'. Thus, sense perception is understood as an extension of the body into the world, with technologies playing an essential role in facilitating this extension between individuals and their external environment. The concept of embodiment (i.e., behaviour patterns enabled by bodily experiences; Strathern and Stewart 2011) helps us understand the world and our surroundings. Dewey's (1934) *Art as Experience* provides a practical and revisionary way of questioning how to make life more meaningful for people in terms of aesthetic learning rather than replacing old metaphysical certainties with new ones. In *Progressive Museum Practice: John Dewey and Democracy*, Hein (2012) systematically described Dewey's educational ideas in the progressive era, emphasising the belief in social and political intervention to improve society regarding greater social justice and equitable distribution of benefits derived from science and technological advancements. The *experience economy*, introduced by Pine and Gilmore (1999), introduced four experience realms (i.e., aesthetic, entertainment, education, and escapism) based on active or passive participation and absorption or immersion in the experience, positioning visitors as cultural consumers. This framework emphasises the importance of creating unique customer experiences to differentiate from competitors and leave a lasting impression. Pine and Gilmore's model has been widely used to analyse visitor experiences in tourism (e.g., Radder and Han 2015).

Furthermore, environmental psychology explores the relationship between mind, body, and environment. Atmospheric theories stress the role of both internal and external environments in visitors' affective, cognitive, and behavioural responses, which can be shaped by design cues. Atmospheric refers to environmental elements that can either facilitate or inhibit sensory experiences. Kotler (1973) defined this term as 'the conscious designing of space to create certain effects in buyers'. Drawing from Turley and Bolton's (1999) *servicescape* variables in a retail context, Forrest (2013) gave an analogous characterisation of the museum servicescape, which categorised atmospheric stimuli into five groups: external variables, general interior variables, layout, and design, point of purchase and decoration, and human variables. Additionally, the Stimulus–Organism–Response (S-O-R) model (Mehrabian and Russell 1974) further explained that atmospheric variables, acting as stimulus (S), can elicit either approach or avoid behaviours (R) via the individual organism's emotional states (O; empirical studies: Jiang 2022; Zhou, Zhou, and Li 2023). The SOR model is extensively used in tourism research, serving as a framework for examining the mediators and moderators shaping the influence of sensory inputs (e.g., Liu et al. 2023). As technological advancements continue, scholars are expanding the scope of the SOR model by integrating it with presence theory. For instance Zhu et al. (2024) demonstrated that object-based and existential authenticity affect the formation of visitors' presence and further influence their travel intentions in a context of augmented reality. Furthermore, the contextual learning model structurally demonstrates situational factors influencing the visitor-exhibition interaction process from overlapping physical, sociocultural, and personal contexts (Falk and Dierking 2018). Notably, sociocultural background has played a more and more critical role in developing international tourism (e.g., Holder et al. 2023; Yin, Qu, and Ni 2023). Figure 2 presents a holistic overview based on this model, depicting detailed subcategories of key factors within each context, incorporating Falk and Dierking's original arguments as well as valuable insights from other scholars (e.g., Harada et al. 2018; Leder and Nadal 2014; Mastandrea, Smith, and Tinio 2021; Pelowski et al. 2017).

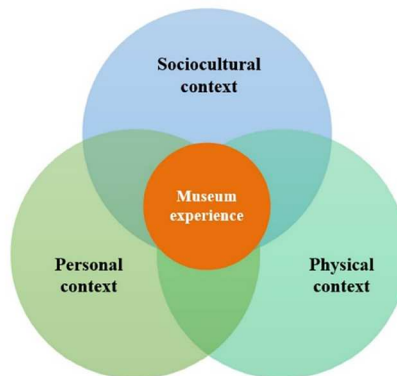
Based on those above, the existing body of knowledge regarding the multisensory museum experience has been accumulated through relevant experience theories and

Sociocultural context

- Group size
- Within-group sociocultural mediation (collaborative learning in social groups)
- Facilitated mediation by others (e.g., museum staffs, docents)
- Cultural background (e.g., customary ways of behaving, codes, patterns of social relations, collective memory)

Personal context

- Basic demographic and socioeconomic characteristics (e.g., social status)
- Motivation and expectations
- Prior knowledge, interests, and believes (e.g., art expertise and novice, memory, self-identity)
- Choice and control (free-choice learning settings)
- Mood



Physical context

- Orientation and advance organizers
- Architecture design
- Artwork's features (e.g., art style, texture, physical presence, physical remnants of the artist's touch and effort, perceived authenticity, seeing reproduction as art, size, symmetry, content)
- Design of exhibits (e.g., display, frame, lighting, labels, decoration)
- Reinforcing events and experiences outside the museum
- Other situational variables (e.g., visitor flow, fatigue)

Figure 2. Situational factors for visitor-exhibition interaction. Source: adapted from Falk and Dierking (2018).

environmental psychology, covering the relationship between mind and body and the effect of atmospherics on human behaviours. Overall, the extant literature in these fields indicates a multidisciplinary state of research in multisensory museum experiences. In line with the Sensory Studies School (led by Howes and Classen from Concordia University) and with a focus on multi-senses, this review highlights the following features of sensory museology:

- Adoption of a social-cultural construction view: This perspective highlights that the multisensory museum experience is learned and social, shaped by sociocultural contexts (Tarlow 2012). Previous research suggests that individuals, as receptors of the multisensory world, can actively engage with their senses rather than adopting a passive role. Moreover, the senses can shape an individual's perceptions and experiences within social and cultural dimensions. For instance, Putkinen et al. (2024) demonstrated that music-induced emotions can transcend cultural boundaries between Western and East Asian due to cross-culturally shared links between musical features, bodily sensations and emotions. Taking into account cultural and social perspectives, Agapito, Mendes, and Valle (2013) argued that learned behaviours beyond the physical impacts of place and time influence individual perception. Additionally, personal, physical, and sociocultural situational factors are recognised.
- Embracing dynamism in visitor-exhibition interaction: This indicates that the research in sensory museology should reject Cartesian dualism, which posits a separation between mind and body, subject and object, and nature and culture. The current literature suggests a broader research scope, encompassing exploring the senses themselves (e.g., introducing non-visual cues or redefining specific senses, Ohlberg 2020) and diverse contexts (e.g., expanding sensory studies into non-Western cultures, Classen 2007).

4. Conceptualisation of the multisensory museum experience

Building upon the *research framework* of essential theoretical underpinnings, this section elucidates the distinct aspects of multisensory experiences within museum settings. It involves classifying human sensations, delineating the roles of sensory cues, and exploring visitor-exhibition dynamics, thereby clarifying the essence of multisensory interactions and responding to the query regarding the general characteristics of these experiences (see Figure 1). An inductive analysis is employed to provide insight into the interaction between visitors and exhibitions. This analytical approach entails thoroughly investigating the touchpoints and the inherent qualities of responses in this interaction.

4.1. Sensation

Originally based on Aristotle's five-sense model, the traditional sensation classification is currently being extended to encompass the potential for multi-sensorial experiences. In addition to the five senses (sight, sound, smell, taste, and touch), which provide information from the external environment (exteroceptive senses), there exist senses that originate from within the body, contributing to body awareness (interoceptive senses,

Agapito, Mendes, and Valle 2013). The interoceptive system includes (1) the sense of internal milieu (which encompasses perceptions such as pain and temperature), (2) the proprioceptive sense (which involves perceiving gesture movement via kinaesthesia), (3) the vestibular sense (responsible for balance and spatial orientation), (4) the viscera sense (which involves sensations like a racing pulse via splanchnesthesia; Agapito, Mendes, and Valle 2013; Damasio 2003). Additionally, some scholars have proposed the existence of additional senses, such as synaesthesia (wherein a single sensory stimulus elicits multiple sensory experiences; Merter 2017) and presence (the sensation of being present within a particular environment; Chrysanthakopoulou, Kalatzis, and Moustakas 2021), though there are ongoing debates surrounding their inclusion. Parker, Spennemann, and Bond (2023) concluded in their review that visual and auditory cues are the most prominent, followed by smell and touch, while other sensory cues are often overlooked. They recommended reevaluating current heritage assessment processes and reconsidering the limitations of visually centric heritage documentation and management practices.

4.2. Functions of multi-senses

The functions of multi-senses within the context of the museum experience can be understood in several ways. Firstly, senses can be considered as artworks, either comprising a single sense (e.g., the lighting as an exhibit) or playing a supplementary role in the formation of exhibits. Recently, museums and galleries have increasingly emphasised the importance of visitors' bodily experiences, incorporating music, lighting, scent, and hands-on activities as integral parts of the exhibition (Levent, Pascual-Leone, and Lacey 2014). This approach extends beyond experimental exhibitions in contemporary museums and revitalises historical objects at heritage sites. Scholars in these fields are also actively developing databases to catalogue sensory exhibits for preparing the intended exhibitions (e.g., Bembibre and Strlič 2017).

Secondly, senses function as sources of information. In response to the evolving understanding of sense perception over the centuries, modern museums are exploring the potential of multisensory solutions to improve sensory, cognitive, and social information processing. Touch, for example, can trigger a feeling of authenticity and ownership of artworks; smell plays a crucial role in influencing visitors' emotions and memories; taste encompasses the integration of multiple senses and kinaesthetic feelings; and synaesthesia, as both a cross-modal phenomenon and a design strategy, enriches visitor experiences in an exhibition (e.g., Christidou and Pierroux 2019).

Thirdly, senses also perform as phenomena. Phenomena draw upon phenomenological perspectives, which refer to how individuals experience the world. According to post-intentional phenomenology, phenomena capture our day-to-day engagement with the world, while post-phenomenology seeks to provide descriptive and interpretive meanings and structures of specific first-hand experiences (Mask 2020; Vagle 2018). In the museum context, phenomena encompass contextualised lived experiences, where the body and senses are embedded in these experiences, shaping embodied cognition – a cognitive process influenced by bodily experiences (Melvin, Crossley, and Cromby 2021; Merter 2017). Visitors can swiftly immerse themselves in a multisensory world through their bodies and sensory perceptions. Consequently,

concepts such as multisensory immersion and flow theory have emerged to explore how to approach and engage with these contextualised lived experiences (Kirchberg and Tröndle 2012).

4.3. Visitor-exhibition interaction process

In the field of customer studies, scholars have provided comprehensive definitions of 'customer experience', as evidenced in works by Becker and Jaakkola (2020) and De Keyser et al. (2020). These studies offer valuable insights for structuring the general characteristics of visitor-exhibition interaction, which are incorporated in the present review. To provide an overview of this visitor-exhibition interaction, we propose three interaction touchpoints (i.e., subject, stage, and form) and six response qualities (i.e., experience dimensionality, duration, attention, sensory intensity, emotion valence, and engagement level). The interaction touchpoints reflect critical components in forming multisensory museum experiences when visitors interact (or 'touch') with atmospheric stimuli in an exhibition. The response qualities indicate distinctive properties or dimensions that reflect visitor responses to these stimuli.

4.3.1. Interaction touchpoints

Interaction subjects of the interactive process between visitors and exhibitions involve the control and influence exerted by visitors and the external world. Visitors can spontaneously respond to external stimuli while attempting to understand the exhibited objects. This process can be understood through the bottom-up and the top-down pathways (Talsma et al. 2010). The bottom-up pathway involves the flow of sensory information from the external world to the individual, leading to automatic and non-deliberate responses. In contrast, the top-down pathway emphasises internal factors and the deliberate consideration of the meaning and significance of experiential elements. Additionally, there is a secondary reassessment within the top-down pathway that reflects different levels of individual awareness during the deliberate cognitive process, considering the discrepancies between initial connections and the surrounding environment (Pelowski et al. 2017). For example, visitors' reflections on their daily lives and long-term memories of the exhibition represent this secondary cognition, indicating that its impact extends beyond its conclusion (e.g., Barclay 2020).

Interaction stages within the whole multisensory museum journey can be identified as three specific phases: the pre-visit stage, the visit stage, and the post-visit stage. The pre-visit stage encompasses various factors influencing the decision-making process before the visit. These factors include the museum's narratives, image, exhibition advertising, visitor characteristics, and sociocultural background, such as collective memory of sensory experiences (Pelowski and Specker 2020). Visitors gather information and make decisions based on these factors. The visit stage focuses on the interactive process during the visit itself. It encompasses a wide range of experiences, including sensory perception, communication, learning, and emotional changes, highlighting the multidimensional nature of the visitor experience. Lastly, the post-visit stage involves the consequences and benefits after the interactive multisensory visit. A range of possibilities and research directions emerge in this stage, including but not limited to knowledge acquisition, visitor satisfaction, and the impact on psychological well-being.

Interaction forms refer to the different approaches to interaction throughout the multi-sensory journey. They can be identified as real, virtual, and a combination of both, known as on-life with Mixed Reality ([MR], Chang et al. 2014; Simone, Cerquetti, and La Sala 2021). The real form involves visitors entering a physical environment to experience actual elements. The virtual form entails experiences generated through technological means, such as Virtual Reality (VR). The on-life form combines aspects of both the real and virtual approaches, creating MR experiences for visitors. The real form of interaction has been the traditional way visitors engage with exhibitions. Visitors go to museums for ‘real things’, seeking a feeling of authenticity in museums (Gilmore and Pine 2007). However, with technological advancements, museums have increasingly embraced digital platforms to provide informational resources, employed VR (i.e., the virtual form) to reconstruct heritage sites, and explored the potential of MR in exhibition design (the on-life form; Hammady et al. 2020). The on-life form of interaction broadens the scope of the museum space, eliminating barriers and enabling effective dialogues between visitors and museums, reshaping the museum’s Info-Sphere (Simone, Cerquetti, and La Sala 2021). Driven notably by the contactless dynamics of the COVID era, an increasing number of museums are exploring hybrid communication formats – integrating both physical and virtual realms – facilitated by metaverse technologies (Sánchez-Amboage et al. 2023). Technologies along the reality-virtuality continuum facilitate the design of multisensory exhibitions, offering diverse sensory experiences during museum visits. This phenomenon, often called ‘experimental museology’, leverages technology to provide memorable and immersive experiences. Emerging technologies such as MR, VR, AR, mobile applications, 3D techniques and Chatbots have introduced new narratives to the museum field, combining education and entertainment in what is often referred to as ‘edutainment’ experiences (e.g., Fischer-Dárdai and Dezso 2015; Suzuki and Tubuku 2021).

4.3.2. Response qualities

The dimensionality of the visitor experience is derived from diverse responses that arise from the interaction between visitors and exhibitions. Scholars from various disciplines enriched the classification of visitor experiences, resulting in a continuum of experiences ranging from unidimensional to multidimensional, depending on the research objectives and disciplinary perspectives adopted (typical examples: Csikszentmihalyi and Robinson 1990; Packer and Bond 2010; Pekarik, Doering, and Karns 1999; Pekarik et al. 2014; Pine and Gilmore 1999; Kim, Ritchie, and McCormick 2012). For example, Pekarik, Doering, and Karns (1999) classified visitor experiences into four dimensions regarding overall satisfaction towards exhibitions, including objective, cognitive, introspective, and social experiences. Considering visitors’ psychological well-being, Packer and Bond (2010) added a fifth dimension of restorative experience based on Pekarik, Doering, and Karns’ four experience spectrum. In addition, Csikszentmihalyi and Robinson’s (1990) flow theory and Pine and Gilmore’s experience economy (1999) have also provided valuable insights into classifying visitor experiences. Based on a network analysis of subjective bodily experiences, Kühnapfel, Fingerhut, and Pelowski (2023) identified four communities of significant determinants in art appreciation: interoception (e.g., sweat), presence (e.g., weightless), disturbance (i.e., awkward) and proprioception (e.g., body).

Attention and duration are two inherent qualities of the multisensory experience. Attention refers to the level of visitor concentration during the experience, while duration relates to the time a visitor spends in the museum (Bitgood 2016). According to Bitgood's attention-value model, learning is a by-product of attention, and value is a critical motivational factor in determining where visitors direct their attention. The value ratio, which considers the benefits (e.g., visitors' interest, motivation, and expectations) and costs (e.g., time, workload, and effort), influences visitors' choices. It also suggests that visitors adopt a cost-minimising approach, expending the minimum amount of energy during their visit (Pelowski et al. 2017). Thus, time duration becomes critical in measuring visitors' perceived value. However, it is essential to note that longer duration does not always equate to higher costs. Sometimes, visitors may spend more time due to their affinity for particular objects or willingness to pay closer attention (e.g., Li 2022). The duration of the interaction only partially predicts the quality of the visit, especially in the case of fixed-time digital exhibitions.

Sensory intensity refers to the intensity or amplitude of sensory stimuli that visitors can feel or perceive in a museum experience (Matthews, Stewart, and Wearden 2011), ranging from low to high sensory perception. Individual differences such as age, gender, and sensory preferences (Balea and Nelson 2020; Jilani, Peplies, and Buchecker 2019), as well as the nature of the senses themselves (e.g., sensory modality, number of senses involved), can influence sensory intensity (Jones and Dawkins 2018). It is also essential to consider that excessive sensory stimuli in the environment can lead to satiation or overload, resulting in 'museum fatigue' and decreased attention during the visit (Bitgood 2010).

The emotion valence of a museum experience indicates the nature of the emotional response elicited by the interaction with exhibits, ranging from negative to positive emotion. Since there is still controversy and ambiguity in the definition of emotions in the literature, specific emotions, such as pleasure, anger, and sadness, are widely recognised, while others, like empathy or hope, require further clarification (Savenije and de Bruijn 2017; Tarlow 2012; Varutti 2023). In addition to negative and positive emotions, neutral emotions also exist, representing a state of indifference or a lack of emotional response towards the exhibits. Alelis, Bobrowicz, and Ang (2013) found that self-reported neutral or indifferent emotion can be induced by repetitive displays of the same type of objects or prior experiences with similar items in other exhibitions. This raises the question of whether creating new experiences or surprises during the visit is necessary. Moreover, it is also possible for visitors to perceive several emotions at the same time, like feeling awe, fear, and sublime emotions when seeing a bloody religious painting. In addition, some negative emotions can sometimes leave a more lasting and memorable impression than neutral emotions (e.g., Adelman and Estes 2013). In a recent study by Nummenmaa and Hari (2023) exploring the link between bodily sensations and aesthetic responses to art, aesthetic emotions such as balance, beauty, and elegance were predominant, followed by positive emotions (e.g., liking) and empathy. Feelings associated with surprise and effort were moderately prevalent, while negative emotions were infrequent, despite the inclusion of paintings depicting unpleasant themes such as death and grief in their research. Hartmann, Lenggenhager, and Stocker (2023) showed that positive emotions evoke a sense of lightness, whereas negative emotions evoke a feeling of heaviness. Additionally, participants found it easier to recognise their emotions using a

combined method that incorporates both activity- and valence-related bodily sensation mapping.

The engagement level of a museum experience reflects how visitors respond actively or passively when encountering an exhibition. The sensory shift in a museum context encouraged visitors to engage with displays in bodily, sensorial, emotional, and immersive ways, aligning with broader concepts such as ‘access and inclusion’ and conceptualisations of visitors as ‘active and engaged’ participants (Chen et al. 2021). According to the extant academic understanding, engagement is generally divided into three dimensions: cognitive engagement (e.g., self-regulated learning), emotional engagement (e.g., enthusiasm, inspiration), and behavioural engagement (e.g., two-way interaction between visitors and art objects, social communication with other people; Uhrmacher 2009; Islam, Rahman, and Hollebeek 2018; Siu, Zhang, and Kwan 2022). Cognitive and emotional engagement significantly predict overall satisfaction and subsequent behavioural intentions in the museum context (Siu, Zhang, and Kwan 2022). Based on the stimulus-organism-response (S-O-R) model, Ponsignon et al. (2024) demonstrated that epistemic (learning) and hedonic (having fun) values are the underlying mechanisms for the impact of experience design characteristics on visitor satisfaction in the context of wine museum. Prior researchers also distinguished differences between ordinary and extraordinary experiences, suggesting that exhibitions designed to provide novelty, surprise, or immersion have the potential to create more engaging and memorable experiences compared to traditional exhibition formats in museums (Crouch and Damjanov 2021; Robaina-Calderín, Martín-Santana, and Muñoz-Leiva 2023). Tosun, Uslu, and Erul (2024) demonstrated that emotional digital storytelling by chatbots is perceived more positively, leading to a higher level of place attachment and ultimately enhancing participants’ engagement in value co-creation.

5. Technology in museum practices

5.1. Technical embodiment

The embodiment theory suggests that individuals’ behaviour patterns are reflected in their bodies and enacted through bodily forms (Strathern and Stewart 2011). *Technical embodiment* refers to a set of behaviour patterns related to bodily experience shaped by technologies. In museum experiences, significant attention has been given to multi-sensory extended reality (XR) and its impact. XR encompasses computer technology and wearable devices that blend virtual and real environments, enabling human-computer interactions (HCI; Santoso, Wang, and Windasari 2022). XR includes virtual reality (VR), mixed reality (MR) and augmented reality (AR), depending on the balance of virtual and real elements within the experience. This virtuality-reality continuum in XR allows museums to design exhibitions that offer diverse sensory experiences, transcending limitations of time and space (see Figure 3). The sense-motor system plays a core position to trigger proprioceptive-kinaesthetic movements, such as gesture, voice, and full-body tracking (e.g., Hsu and Lin 2014). In virtual reality, sense-motor technology, such as virtual locomotion, enables users to move in ways that are impossible in the real world. On the other hand, in reality, sense-motor technology also allows physical movement, like walking and running (Chrysanthakopoulou, Kalatzis, and Moustakas 2021).

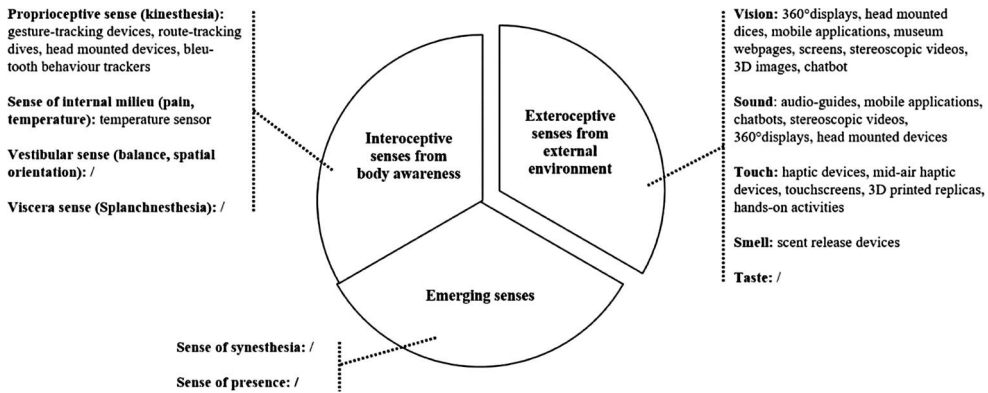


Figure 3. Extant technologies and devices for multisensory representation in museums or relevant aesthetic sites, categorised by human sensation.

However, computer engineers still face many challenges in triggering sensations due to technological limitations, physical space constraints, personal factors, and other unpredictable contingencies.

In the pre-visit stage, there are three main application domains: archive, information promotion, and intention to visit (e.g., Bruce et al. 2014; Bird et al. 2023). Documentations or archives of art collections attract growing attention in the museum context. On the one hand, museums regard documentation as a primary conservation strategy for time-based media and sensory artworks (like sounds as artworks; Brost 2021). On the other hand, museums try to build a holistic large-scale dataset of art collections (Shehade and Stylianou-Lambert 2021). These archival efforts serve as the foundation for virtual tours, site reconstructions, and digital live performances (Wang et al. 2023). Technology also provides visitors with information about the museum or the exhibition, shaping their expectations, motivations, and first impressions before making a visit decision. In the pre-visit period, the museum can predominantly improve visitors' cognitive and affective evaluations of the potential destination through visual stimuli, such as VR and AR. For example, some museums provide virtual tours of a specific exhibition on their official website, allowing visitors to preview the displays. Additionally, exhibition advertisements are ubiquitous, whether on the streets, on the web, or in brochures preceding the commencement of an exhibition. These advertisements can employ a range of sensory stimuli, eliciting diverse cognitive responses from individuals, which, in turn, stimulate the formation of mental imagery (Elder and Krishna 2022). Consequently, this interplay of stimuli and cognitive processes shapes the visitors' expectations and perceptions of the museum or exhibition (i.e., the destination image).

However, most existing literature on multisensory practices in museums focuses on implementing technologies to enhance the visiting experience, especially the educational experience, which is considered the museum's core service from a visitor-centred perspective. During the visit stage, visitors interact with different stakeholders, such as exhibits, other people, and the external and internal environments, triggering multisensory experiences, mainly through visual, auditory, and haptic-kinaesthetic stimuli (Santoso, Wang, and Windasari 2022). Special exhibitions, such as perfume exhibitions (e.g., Shiner 2015), gustatory displays (e.g., Everett 2019), and thermal perception displays

(e.g., Feltrin et al. 2020), incorporate additional sensory cues which are less explored in the field of museum study. Visitors can immerse themselves in exhibitions through VR, AR, and MR technologies, enhancing their sense of presence and possibly confirming the destination image formed during the pre-visit stage (Akgun et al. 2020).

Finally, in the post-visit stage of the museum experience, visitors evaluate and recall the exhibition they experienced, and their loyalty toward the museum is reflected in their willingness to revisit and provide word-of-mouth recommendations. However, current technology still needs to be improved in realising the full potential of multisensory experiences, especially in facilitating the passive human-exhibition interaction after visitors conclude their visit. In most situations, technologies like VR and AR, mainly through visual stimuli, are more feasible and effective in enhancing memory recognition and eliciting positive emotional responses (Santoso, Wang, and Windasari 2022). Thus, virtual tours, images of site reconstruction and digital live performances are accessible through some mobile applications or online websites, allowing visitors to re-experience the exhibition from the comfort of their home after their visit (e.g., Callaway, Stock, and Dekoven 2014; Qian et al. 2021).

In the post-COVID era, an increasing number of scholars and museum professionals are focusing on immersive exhibitions, leveraging metaverse technologies to enhance visitor engagement or to provide better public education about the arts. For instance, Zhang and Peng (2024) introduced an innovative approach to immersive virtual exhibitions showcasing Australian aboriginal art, emphasising its potential to attract visitors from diverse communities and cultures. While digital technologies are recognised for their potential to make museums more inclusive and accessible, the effectiveness of immersive formats in art appreciation remains debated in academia. Kuo et al. (2023) demonstrated that full-immersive painting experiences through VR can negatively impact students' performance in object recognition and interpretation. Several factors, such as the sense of presence, interaction level, vividness, and perceived authenticity, significantly influence the impact of metaverse technologies on visitors (Cheng, Chi, and Han 2023; Jiang, Deng, and Zheng 2023). A growing number of reviews aim to elucidate the features of various VR/AR technologies for context-specific sensory implications (e.g., Jiang, Deng, and Zheng 2023; Marto et al. 2022). Nonetheless, the integration of new technologies in museums and related sites remains a potent tool to enhance visitor experiences and support sustainable development in the future (e.g., Marto et al. 2022).

5.2. Children in new era

In the rapidly evolving landscape of technology, children have emerged as a focal group of interest within the museum context. While prior research underscores the importance of bodily experiences in facilitating children's learning due to their tender age, museums encounter significant challenges in crafting exhibitions tailored to their needs. Amidst this scenario, the strategic utilisation of sensory cues and technical embodiment of sensory representations emerges as a paramount concern in contemporary discourse.

Elwick et al. (2020) in their review denoted that must explore innovative avenues to leverage music and sound as tools for engaging children in unexpected yet generative ways. Simultaneously, there exists a pressing need for a reconceptualisation of young children's role within museum spaces. Fletcher, Blake, and Shelffo (2018) also emphasised the

pivotal role of museums in providing educational experiences and fostering family interactions, particularly considering the rising prevalence of autism and sensory processing disorders among children. However, to ensure inclusive access, museums must actively foster cognitive engagement, encourage observation, promote dialogue, and create immersive environments featuring diverse sensory stimuli. Drawing from a video-based exploration of an immersive mathematics exhibition, Kelton et al. (2018) indicated the significance of embodied movement and social interaction in enhancing children's engagement levels. Moreover, Kucirkova and Gausel (2023) demonstrated the value of olfactory experiences in enriching children's museum visits, where aesthetics, art, and entertainment converge to stimulate their imaginations. Additionally, scholars advocate for empowering children to play active roles in exhibition design. Dardanou (2019) demonstrated how children's visual lines of movement can serve as digital pathways for innovative storytelling, while De Franco et al. (2019) assert that young children can act as curators, infusing exhibitions with their perspectives. Notably, interactive techniques can enhance child motivation and provide pertinent routes for them. In recognising museums as 'restorative environments' – providing break from the routine of daily life, Annechini et al. (2020) revealed that fostering a high level of fascination can prompt children to engage in learning tasks with effortless attention.

6. Conclusion

The present review contributes to the academic understanding of the visitors' sensory experiences in museums or relevant aesthetic sites, as detailed in Table 1, which presents key findings and identifies research gaps. We have developed a comprehensive multisensory experience theory through content analysis. The following section addresses future research directions, theoretical and practical implications, and limitations.

6.1. Future research directions

The existing body of research in the field of multisensory experiences, supported by experience theories and environmental psychology, has significantly contributed to our understanding of sensory museology. Nevertheless, noteworthy research gaps exist that necessitate further investigation. These gaps primarily pertain to the selection of pertinent theories for elucidating visitor sensory experiences and identifying pivotal determinants shaping these experiences. While prior studies have furnished invaluable insights in these domains, a re-evaluation and contextual analysis are imperative. For instance, past research has illustrated the applicability of Pine and Gilmore's (1999) four categories of customer experiences (i.e., aesthetic, entertainment, educational, and escapism experiences) to expound visitors' encounters within the tourism sector. Nonetheless, it is essential to recontextualise this framework in diverse exhibition settings, comprehending how the distinct experiential dimensions within this framework affect visitor reactions and satisfaction. Further research should prioritise refining our understanding of the diverse dimensions within theoretical frameworks derived from various traditions, as well as identifying mediating and moderating variables involved in this process. Furthermore, there is a multitude of factors that could influence the overall museum experience. Nevertheless, which factors significantly influence visitor-exhibition interactions and their ensuing



Table 1. Key findings of the multisensory museum experience and research gaps: an integrative framework

Areas	Key findings	Guidelines of the findings	Potential new research topics
Research Framework	<p>Experience theories and environmental psychology have contributed to our understanding of visitor experiences.</p> <p>Key factors of visitor-exhibition interaction vary from personal, physical, and sociocultural contexts.</p>	<ul style="list-style-type: none"> Different theoretical traditions can interpret one particular museum experience. Researchers should consider the specific contexts and research objectives before choosing the proper interpretive theories. Studies should account for factors influencing the visitor-exhibition interaction and the corresponding evaluative outcomes. The museum experience is subjective and context-specific, and the stimuli depend on personal, physical, and sociocultural contingencies. 	<ul style="list-style-type: none"> How do we re-explain the multisensory museum experience through different theoretical traditions? How can specific museum atmospheres be crafted to trigger intended visitor experiences? Which factors are essential in influencing visitor-exhibition interaction and its consequences to visitors' reactions? How do we employ the learned guidelines in exhibition design?
Conceptualisation of the Multisensory Museum Experience	<p>There is a multidisciplinary state in researching the multisensory museum experience.</p> <p>A multi-sensorial possibility of sensation is being extended.</p> <p>The senses serve three primary functions: experiencing artworks, accessing information, and perceiving phenomena.</p>	<ul style="list-style-type: none"> It is better to take a multidisciplinary approach to understand the complexity of the relationship between senses and individual experiences within internal and external environments. It embraces dynamism in visitor-exhibition interaction, refusing Cartesian dualism of separations between mind and body, subject and object, and nature and culture. Individual sensation comes from (1) exteroceptive senses, (2) interoceptive senses, and (3) other emerging senses. Crafting multisensory exhibitions can be done through (1) creating artworks, (2) transforming sensory information, and (3) supporting contextualised lived experiences through the immersive environment. 	<ul style="list-style-type: none"> How does a multidisciplinary approach, drawing on insights from various disciplines, deepen our understanding of the impacts of different senses on visitor experiences? What are the impacts of different sensory modalities? Is it possible to configure new terminology in describing the emerging sensory phenomenon (e.g., cross-modal associations, multisensory integration)? What design strategy should we take in exhibition design, and in which specific situation or context?

(Continued)

Table 1. Continued.

Areas	Key findings	Guidelines of the findings	Potential new research topics
<p>The multisensory experience journey consists of several touchpoints from interaction subject to stage to form.</p>	<ul style="list-style-type: none"> • Three specific phases are involved in the whole multisensory experience journey: (1) the pre-visit stage, (2) the visit stage, and (3) the post-visit stage. • Two responsible subjects are for the interactive process: (1) the visitor and (2) the outside world. • Three interaction forms that visits are engaged in an exhibition: (1) real, (2) virtual, and (3) on-life fashion. 	<ul style="list-style-type: none"> • Does the proposed model of the visitor-exhibition interaction with touchpoints and response qualities need to be adapted? • How do we understand the connectivity among different touchpoints and response qualities? • Which interaction touchpoints are better to prompt the response qualities? 	
<p>Six response qualities reflect the nature of the visitor-exhibition interaction process.</p>	<ul style="list-style-type: none"> • Response qualities include: (1) experience dimensionality, (2) duration, (3) attention, (4) sensory intensity, (5) emotion valence, and (6) engagement level. • It is still unclear to what extent each quality is potentially (un)important for visitor-exhibition interaction. 	<ul style="list-style-type: none"> • To what extent does each quality create value and contribution to the visitor-exhibition process? In what way(s)? • What qualities are important aspects influencing the interactive process? At which interaction touchpoints? 	
<p>Technology In Museum Practices</p>	<p>Extended Reality (XR) has provided potential for museums to develop memorable and engaging encounters.</p>	<ul style="list-style-type: none"> • Extended reality includes virtual, augmented, and mixed reality based on the balance of virtual and real elements. • The current XR technologies are still limited to triggering all sensations, mainly derived from applying the sense-motor system. 	<ul style="list-style-type: none"> • How can we maximise the use of multi-senses in exhibition design with the support of technology? • To what extent do technologies change our sensory perceptions and evaluations?
<p>Technologies can be used in all stages of the multisensory experience journey, though main objectives differ from specific stages.</p>	<ul style="list-style-type: none"> • Technologies are mainly employed in the visit stage to enhance the visiting experiences like learning. • In the pre-visit stage, there are three main application domains: archive, information promotion, and intention to visit. • In the post-visit stage, memory enhancement and loyalty building are the primary purposes. 	<ul style="list-style-type: none"> • What specific expectations do the visitors seek across different visit stages? 	
<p>Children have emerged as a focal group of interest within the museum context.</p>	<ul style="list-style-type: none"> • A strategic utilisation of both sensory cues and technical embodiment of sensory representations is important in exhibition design tailored for children. 	<ul style="list-style-type: none"> • In comparison to adults, what exhibition design strategies should museums adopt for Children? 	

consequences still need to be clarified. Subsequent research should encompass various subjective and context-specific factors relevant to exhibition design. An interdisciplinary approach would prove advantageous in unravelling the intricacies of the interplay between the senses and individual experiences within both internal and external environments.

There is also a pressing need for further research to enhance our understanding of the influence of various sensory modalities within museum settings. This includes both external sensory experiences (exteroceptive) and internal sensory perceptions (interoceptive). Additionally, we recommend exploring novel terminology to describe emerging sensory phenomena, such as cross-modal associations and sensory integration. Another critical avenue for future research involves gaining a deeper insight into the multi-senses' role in the design of museum exhibitions. Our review highlights that the senses serve diverse functions in the context of museums, including the appreciation of artworks, the communication of information, and engagement with various phenomena. Consequently, when museums plan specific exhibition events, they have various approaches at their disposal to create multisensory experiences: (1) crafting artworks, (2) transforming information delivery, and (3) fostering immersive environments that facilitate embodied cognition for context-specific and lived experiences.

Future research should delve into the complexities of curating purposeful exhibitions to advance the field further. This entails investigating how to optimise multisensory cues, determining the most effective design strategies, and understanding the situations or contexts in which specific approaches yield the most significant impact. By addressing these questions, museums can refine the design of multisensory exhibitions, delivering more captivating and engaging experiences for their visitors. Moreover, our proposed framework, comprising three touchpoints and six response qualities, lays a foundation for comprehending the interactive dynamics between visitors and exhibitions. However, future research should focus on exploring the interplay and connections among different touchpoints, discerning which specific interaction points are most effective in eliciting desired visitor responses. Furthermore, as the existing literature suggests, it remains determined to what extent each response quality holds significance in the visitor-exhibition interaction. Subsequent research should delve into each quality's specific values and contributions and elucidate how they align with the achievement of desired objectives. Comparative analyses of these response qualities and their relationships with various touchpoints should be explored across the journey of the multisensory experience. It is vital to clarify which qualities exert a more pronounced impact on the interactive process and at which interaction touchpoints hold particular significance.

Moreover, extended reality (XR), encompassing augmented reality (AR), virtual reality (VR), and mixed reality (MR), plays a pivotal role in driving innovation within museums, particularly concerning the sensory-motor system. Scholars continue their investigations into the effects of technological applications on cognitive embodiment, emotional connections, and associated behavioural changes (e.g., McCarthy and Wright 2004). Nevertheless, prior research has indicated that current technologies and devices for creating multisensory experiences in museums and aesthetic settings remain somewhat constrained, particularly in eliciting sensations like smell and taste (see Figure 3). Forthcoming research should focus on optimising the integration of multi-senses in exhibition design, harnessing technology, and exploring how these technologies reshape our assessments

and behaviours throughout the journey of the multisensory museum experience. Such research endeavours will enrich our insights into developing more inclusive museums by fusing multi-senses and technology, enabling comparisons across various exhibition types. Moreover, considering the diverse technological applications throughout different stages of the multisensory museum experience, future research should delve into visitors' assessments and acceptance of emerging technologies. Understanding their specific expectations at various points during a museum visit is essential to align technological innovations with museumgoers' evolving needs and preferences. Furthermore, in light of the unique characteristics of children as visitors, museums are compelled to finely tune their utilisation of sensory inputs and emerging technologies to enhance the children's museum experience, particularly their educational journey.

6.2. Theoretical implications

Theoretical underpinnings. This review highlights several essential theories of museum experience and atmospherics, deepening our understanding of *sensory museology*. It assists researchers in positioning their research within a suitable theoretical framework. Moreover, this review triggers enquiries on re-explaining multisensory experiences from different theoretical traditions. It encourages delving into the intricate nuances of the impact of different dimensions of each theoretical framework derived from these traditions. The importance of bodily experience was emphasised from different perspectives, including early theories of sense perception, phenomenology, the pragmatism of art education, and the experience economy. The bodily experience is recognised as individual, multi-layered, dynamic, and complex. Personal, physical, and sociocultural factors influence visitors' reactions towards these stimuli during the interactive process between visitors and atmospherics. Future research should consider these key factors in investigating this interactive process (see [Figure 1](#)). The review demonstrates the multidisciplinary nature of researching the multisensory museum experience, highlighting the importance of adopting a multidisciplinary approach to understanding sensory museology.

General Characteristics of the Multisensory Museum Experience. One crucial aspect involves broadening the scope of sensory classification beyond Aristotle's traditional five-sense model. This expansion allows for a more comprehensive exploration of multisensory possibilities and has even given rise to new sensory terminology, for instance, the concept of 'sense of presence'. The functions of the senses in a museum context can be distilled into three primary roles: facilitating the experience of artworks, providing access to information, and enabling the perception of phenomena. Sensory cues, however, transcend the confines of merely triggering immediate reactions from visitors. They are pivotal in shaping the museum's information transformation process and establishing a meaningful connection between visitors and the sensory environment, grounded in lived experiences. These findings underscore the significance of multisensory cues in museums, offering valuable guidance for researchers in understanding the role of the senses in shaping visitor experiences and exhibition design. Furthermore, through an inductive analysis, this review identifies three key interaction touchpoints in the visitor-exhibition dynamic: subject, stage, and form. This proposed model encourages scholars to re-evaluate the concept of the multisensory museum experience, prompting

contemplation on the individuals who may drive the interactive journey, the specific phases within the overall experience, and the various forms that facilitate visitors' sensory engagement. Additionally, the review highlights six distinct response qualities that reflect the nature of the interactive process between visitors and exhibitions. Understanding these interaction touchpoints and response qualities is essential for comprehending the intricate dynamics of multisensory experiences.

The Role of Technology. The evolution of technology has spurred considerable scholarly interest in the concept of technical embodiment and its significance in various phases of the museum visit. This review underscores the pivotal role of technology throughout the multisensory museum journey, emphasising the vital role of extended reality (XR) technologies, encompassing augmented reality (AR), virtual reality (VR), and mixed reality (MR), in creating immersive and multisensory encounters. Incorporating the sense-motor system has proven effective in generating proprioceptive and kinaesthetic movements, contributing to the richness of XR experiences. Additionally, this review sheds light on how technology shapes visitors' responses to sensory cues, providing valuable insights into the intricate dynamics of the visitor-exhibition interaction. At the pre-visit stage, technology plays a critical role in archival efforts, information dissemination, and the formation of visitors' intentions to explore the museum. Conversely, during the post-visit stage, technology primarily supports activities related to memory enhancement and building visitor loyalty. Significantly, technology serves as a cornerstone in enhancing and enriching visitor experiences during the actual visit, particularly in the context of learning. Diverse technological tools are harnessed throughout the multisensory museum journey to capture visitors' attention, elevate engagement, and create enduring memories (see [Figure 3](#)). While current technologies may not yet fully replicate full-body sensations, there remains ample opportunity for further exploration and development in technology's role in understanding multisensory museum experiences. Furthermore, children have emerged as a distinct visitor demographic in museums. Beyond optimising sensory inputs and technological embodiments of sensory representations, it is imperative for museums to foster children's active involvement in creative exhibition design.

6.3. Managerial implications

Set Clear Criteria to Evaluate the Exhibition Design. The six response qualities that reflect visitors' interactions and responses to stimuli in an exhibition can act as valuable criteria for evaluating the effectiveness of exhibition design. These criteria can help assess whether visitors are obtaining multidimensional experiences, exhibiting high levels of attention, experiencing strong sensory intensity, expressing positive emotions, and demonstrating high levels of engagement. By defining the desired visitor experience based on these criteria, museums can then map out the multisensory journey, identifying the stimuli that are likely to influence visitor responses, the appropriate forms of interaction to employ, and the specific stages at which the use of new technologies (such as XR technologies) can optimise sensory representation.

Consider Situational Factors from Personal, Physical, and Sociocultural Contexts. When designing multisensory exhibitions, it is crucial to recognise that visitor experiences are influenced by personal, physical, and sociocultural contingencies. Museums should, therefore, identify key factors that might impact visitors' responses to stimuli. This process

involves connecting visitor characteristics, contextual settings, and desired outcomes. The findings from empirical studies investigating these connections can provide valuable guidelines for triggering the intended experiences in future exhibitions. While museums should strive to maximise control over the elements they can manage, they should also allow visitor participation in areas beyond their control. By providing platforms for interaction, museums can act as facilitators, empowering visitors to engage with the exhibits.

Manage What Museums Can Control: The Bottom-Up and The Top-Down Pathways. The multisensory interactive process is influenced by visitors themselves and the outside world, in which visitors may spontaneously respond to external stimuli while making sense of exhibits. Embodied cognition (i.e., a cognitive process shaped by bodily experience) occurs through both the bottom-up pathway involving the sensory information from the external world to the individual and the top-down pathway emphasising the deliberate thinking of sensory elements from the individual to the external world. Thus, instead of attempting to control every aspect of the interactive process, museums should define the desired visitor experience with nuanced considerations. This involves determining the extent to which they need to guide the interactive process in the exhibition and how much space they need to allow for visitors' initiative. Museums must determine which visitor experiences and responses they hope to trigger and combine them with proper measures to capture visitors' attention and evaluations. Museum atmospherics contain various factors influencing visitor responses embedded in personal, physical, and sociocultural contexts. While museums can control certain external stimuli, such as exhibition design, navigation pathways, and ambient environments, many other factors lie outside their control, including sociocultural backgrounds, visitor characteristics, and situational variables.

6.4. Limitations

The results of this systematic review should be understood in the context of certain limitations. First, the scope of this review is exclusively centred on the sensory experiences of visitors in museums or related aesthetic settings, with the primary goal of gaining insights into the multisensory museum experience. As a result, studies addressing sensory aspects in museums using varying terminology or those failing to explicitly connect sensory processes with visitor or aesthetic experiences may not have been included in this review. For example, although there exist studies in fields like customer experience and neuroscience that delve into sensory research, they may not specifically address the influence of sensory cues within the context of museums or related aesthetic experiences. Nevertheless, the iterative and systematic approach, along with comprehensive bibliography research, was designed to mitigate the risk of overlooking influential studies pertaining to the multisensory museum experience. Second, this literature review adhered to stringent inclusion criteria (see in Appendix 1), which could potentially limit the scope of the results. For instance, empirical studies exclusively focused on technology or non-academic articles, such as commentaries and news articles, were excluded. While this method enabled the analysis of 331 references, it is acknowledged that the results may have differed if we had considered different research objectives (e.g., examining other key stakeholders like employees). Lastly, like many systematic reviews, this review

primarily analysed English-language literature in its qualitative content analysis. This focus was not a result of an initial exclusion criterion but emerged because non-English articles did not meet our inclusion criteria upon detailed review. The dominance of English in academic research also influenced this choice. Future research should consider incorporating non-English literature to enrich the understanding of visitors' multisensory experiences, providing a more global and diverse perspective on museum studies. Despite these limitations, this review combined systematic literature extraction with qualitative content analysis to lay the groundwork for understanding visitors' multisensory experiences in museums. By delving into three key areas – research framework, conceptualisation, and technology integration – it sets the stage for targeted future investigations.

7. Appendices: supplementary data

Supplementary data related to this article can be seen in the attached file, including Appendix 1.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research work was supported by the China Scholarship Council (CSC-VUB scholarship programme).

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