

Interactive window display design in physical store environments: A systematic review of current research and future directions

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ARTICLE INFO	ABSTRACT
<i>Article history:</i> Received March 31, 2026 Received in revised form April 20, 2026 Accepted August 15, 2026 Available online September 01, 2026 <i>Keywords:</i> Environmental psychology Interactive window display Physical retail environment Storefront design Systematic review *Corresponding author: Mohd Jaki Bin Mamat School of Housing, Building & Planning, Universiti Sains Malaysia, Penang, Malaysia Gelugor, Penang, 11800, Malaysia Email: mohdjaki@usm.my ORCID: https://orcid.org/0000-0002-1358-8208	<i>This systematic review examines the current state of research on interactive window display design in physical retail environments. Following PRISMA guidelines, a comprehensive search of Web of Science and Scopus databases (2006-2025) identified 186 records, with 141 unique articles after deduplication. Through title and abstract screening, 105 articles were excluded, resulting in 36 articles for full-text review. The final synthesis includes 17 core empirical studies, supplemented by 3 partially relevant articles and 6 foundational theoretical works identified through snowball sampling. The reviewed literature reveals four major research themes: consumer behavior and experiential responses, interaction technologies and interface design, design strategies and spatial integration, and technical implementation and system architecture. Key findings indicate that interactive window displays influence consumer approach behaviors through emotional mediation, with pleasure as the primary driver and arousal serving as an amplifier in pleasant environments. Interaction modalities significantly affect user experience, with multi-modal feedback and social elements enhancing engagement. Design strategies must integrate lighting, interface, and spatial elements to create seamless transitions between physical and digital realms. However, significant research gaps persist, particularly regarding design processes and tools, cross-cultural comparisons, longitudinal effects, and sustainability considerations. This review proposes an integrated four-layer design framework—context, experience, interaction, and interface to guide future research and practice. Future directions include multi-sensory integration, adaptive spatial design, human-AI collaboration, sustainable interface design, cross-cultural studies, longitudinal impact assessment, and design tool development. This synthesis contributes to advancing both academic understanding and practical application of interactive window display design.</i>

Introduction

The digitization of retail environments has significantly transformed the relationship between consumers and commercial spaces (Pantano 2016). While e-commerce has reshaped retail operations, physical stores remain essential environments for brand engagement and

experiential consumption (Blázquez 2014). Within this context, the storefront window has evolved from a passive merchandising surface into a critical spatial interface between the public street and the interior retail environment (Carrai 2022). Increasingly, retailers integrate interactive technologies into window displays to create dynamic content, responsive interactions, and

personalized engagement with passersby. These interactive window displays represent a convergence of architectural design, digital technology, and user experience, functioning as transitional interfaces that mediate between urban public space and the private commercial interior (Nepomuceno, Moura, and Oliveira 2023).

Over the past two decades, the retail landscape has been reshaped by rapid technological development and changing consumer expectations (Pantano 2016). Although online commerce has altered traditional retail functions, physical stores continue to serve as important touchpoints where consumers encounter brands and experience products (Blázquez 2014). Within the architectural composition of retail environments, window displays occupy a unique role. Historically associated with static visual merchandising, storefront windows have gradually developed into interactive communication platforms capable of influencing consumer attention and store entry decisions (Carrai 2022). This transformation reflects broader shifts in retail strategy from transaction-oriented approaches to experience-driven models that emphasize engagement and emotional connection (Puccinelli et al. 2009).

The integration of interactive technologies into storefront design represents a significant departure from conventional retail display practices. Technologies such as augmented reality, mixed reality, smart glass, and phygital environments enable window displays to become responsive systems that sense, react to, and engage pedestrians (Kessels, van Loenen, and Lashina 2009; Perry et al. 2010). Through modalities such as gesture recognition, touch-sensitive surfaces, and proximity-based interaction, interactive displays encourage passersby to participate in the retail experience rather than simply observe it (Gerritsen et al. 2014). In this way, the shop window becomes an active communicative interface that can transform casual pedestrians into potential customers by creating moments of curiosity, engagement, and experiential immersion (Reitberger et al. 2009).

Despite increasing technological adoption and commercial interest, academic research on interactive window displays remains fragmented across disciplinary boundaries. Marketing and consumer behavior studies have primarily examined their influence on approach behavior, store entry, and purchase intention (Pantano 2016; Lecointre-Erickson, Daucé, and Legohérel 2018).

Research in human-computer interaction has focused on evaluating interaction modalities and user experience characteristics such as usability and engagement (Kessels, van Loenen, and Lashina 2009; De Carolis and Palestra 2017). Meanwhile, retail technology studies have explored system implementation and technological integration in retail environments (van Doorn, de Vries, and Aarts 2008; Osadchiy et al. 2025). However, a spatial and architectural interpretation of interactive window displays remains largely underdeveloped.

The storefront window is fundamentally an architectural threshold that shapes the perceptual transition between exterior urban space and interior retail environments (Carrai 2022). Yet existing studies rarely address how interactive technologies influence spatial perception, approach behavior, or the experiential continuity between street and store. Questions regarding how interactive displays reshape the spatial relationship between pedestrians and retail interiors, and how such technologies should be integrated into storefront architecture, remain insufficiently explored. Furthermore, although previous reviews have examined related topics such as store atmospherics (Turley and Milliman 2000), customer experience (Puccinelli et al. 2009), and in-store technology adoption (Blázquez 2014), none has systematically synthesized research specifically focused on interactive window displays within physical store environments.

Therefore, this systematic review aims to synthesize existing research on interactive window display design in physical retail environments and to identify future research directions. Adopting an interdisciplinary perspective that integrates marketing, human-computer interaction, design, and architectural theory, this study addresses four research questions: (1) What design elements characterize interactive window displays in physical store environments? (2) What technological and interaction strategies are most commonly adopted? (3) Which theoretical frameworks explain spatial and behavioral engagement? and (4) What future design and research concerns emerge in this field?

Table 1. Conceptual framework of interactive window display within the physical store environment

Urban context	Window display interface	Interior store environment
Pedestrian flow	Interactive façade	Store layout
Street visibility	Digital interface	Product arrangement
Public engagement	Threshold mediation	Consumer movement

Methods

Review design

This study employs a systematic literature review to synthesize existing research on interactive window display design in physical retail environments. Systematic review methods are suitable for interdisciplinary topics spanning marketing, human–computer interaction, design studies, and environmental psychology (Petticrew and Roberts 2006). The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency and replicability in the search, screening, and reporting processes (Page et al. 2021). While PRISMA was originally developed for health sciences, its structured approach has been widely adopted in social science and design research (Xing 2019). The study applies a design-oriented interpretive synthesis to integrate diverse evidence including experiments, case studies, and conceptual work and to identify patterns, themes, and research gaps in interactive retail environments. The review covers studies published between 2006 and 2025, capturing the development of interactive storefront technologies from early smart windows to contemporary phygital retail systems (van Doorn, de Vries, and Aarts 2008; Nordh and Nordh 2012; Blázquez 2014).

Search strategy

A comprehensive literature search was conducted in February 2026 using two major academic databases: Web of Science Core Collection and Scopus. These databases were selected for their extensive coverage of peer-reviewed literature across the social sciences, technology, design, and business disciplines, ensuring broad capture of relevant studies from multiple fields contributing to interactive window display research.

The search strategy employed a Boolean combination of terms capturing three core concepts: (1) the interactive or digital nature of the display, (2) the window or storefront as the physical locus, and (3) the retail context. The full search string was constructed as follows:

"interactive" OR "digital" OR "smart" OR "augmented reality" OR "AR" OR "mixed reality" OR "phygital" AND "window display*" OR "storefront*" OR "shop window*" AND "retail*" OR "store*" OR "shopping*".

The search was limited to English-language publications. No restrictions were applied regarding publication type (journal articles, conference proceedings, book chapters) to ensure comprehensive coverage of design-oriented research, which is frequently disseminated through conference venues and edited collections.

The initial search yielded 186 records across the two databases:

Web of Science: 63 records

Scopus: 123 records

Total before deduplication: 186 records

Following the removal of duplicate records (n = 45), a total of 141 unique records proceeded to the screening phase.

Screening and eligibility criteria

The screening process was conducted in two stages: title and abstract screening, followed by full-text eligibility assessment. At each stage, records were evaluated against predefined inclusion and exclusion criteria developed to ensure relevance to the review's focus on interactive window display design in physical retail environments.

Inclusion criteria:

Physical retail setting: The study must be situated within, or directly relevant to, physical retail environments. Studies focusing exclusively on online retail, virtual stores, or non-retail contexts (museums, exhibitions, public installations without retail function) were excluded.

Interactive or digital window component: The study must address window displays, storefronts, or shop windows incorporating interactive or digital elements. This includes touch-sensitive surfaces, gesture-controlled interfaces, gaze-activated displays, augmented reality overlays, projection mapping, smart glass technologies, and other forms of responsive or dynamic storefront systems. Studies of traditional static window

displays without interactive components were excluded.

Discussion of spatial, experiential, or behavioral effects: The study must engage with the spatial, experiential, or behavioral dimensions of interactive window displays. This includes effects on pedestrian attention and approach behavior, spatial experience of the store threshold, consumer emotional responses, entry decisions, in-store engagement, or broader implications for retail space design. Purely technical papers focusing exclusively on system implementation without consideration of user experience or spatial effects were excluded.

Peer-reviewed academic publication: The study must be published in a peer-reviewed journal, conference proceeding, or as an academic book chapter. Trade publications, industry reports, and non-academic sources were excluded.

English language: The study must be published in English.

Screening process:

Title and abstract screening: The 141 unique records were screened based on their titles and abstracts against the inclusion criteria. Records clearly not meeting the criteria for example, studies of in-store digital signage not involving windows, research on online retail interfaces, or technical papers lacking user or spatial dimensions were excluded. This phase resulted in the exclusion of 105 records, with 36 records proceeding to full-text review.

Full-text eligibility assessment: The full text of each of the 36 remaining records was obtained

and assessed against the inclusion criteria. At this stage, studies were evaluated in greater depth to confirm their relevance to the review's focus. Following full-text assessment, 15 studies were identified as meeting all inclusion criteria and were designated as the core analytical corpus from the database search.

Snowball sampling: To ensure comprehensive coverage of foundational theoretical work and to identify studies that might have been missed by the database search, snowball sampling was conducted. This involved examining the reference lists of the 15 core studies and consulting with domain experts to identify additional relevant publications. Through this process, six foundational theoretical works were identified (Mehrabian and Russell 1974; Donovan and Rossiter 1982; Bitner 1992; Turley and Milliman 2000; Puccinelli et al. 2009; Blázquez 2014). Additionally, two further core empirical studies were identified (Pantano and Naccarato 2010; De Carolis and Palestra 2017), and three partially relevant articles were included for contextual reference (Cazzato et al. 2014; Qu and Ren 2015; Osadchiy et al. 2025).

Final corpus:

Core empirical studies from database search: 15

Additional core studies from snowball sampling: +2

Total core analytical corpus: 17 studies

Foundational theoretical works: 6

Partially relevant contextual studies: 3

Total references informing the review: 26 publications.

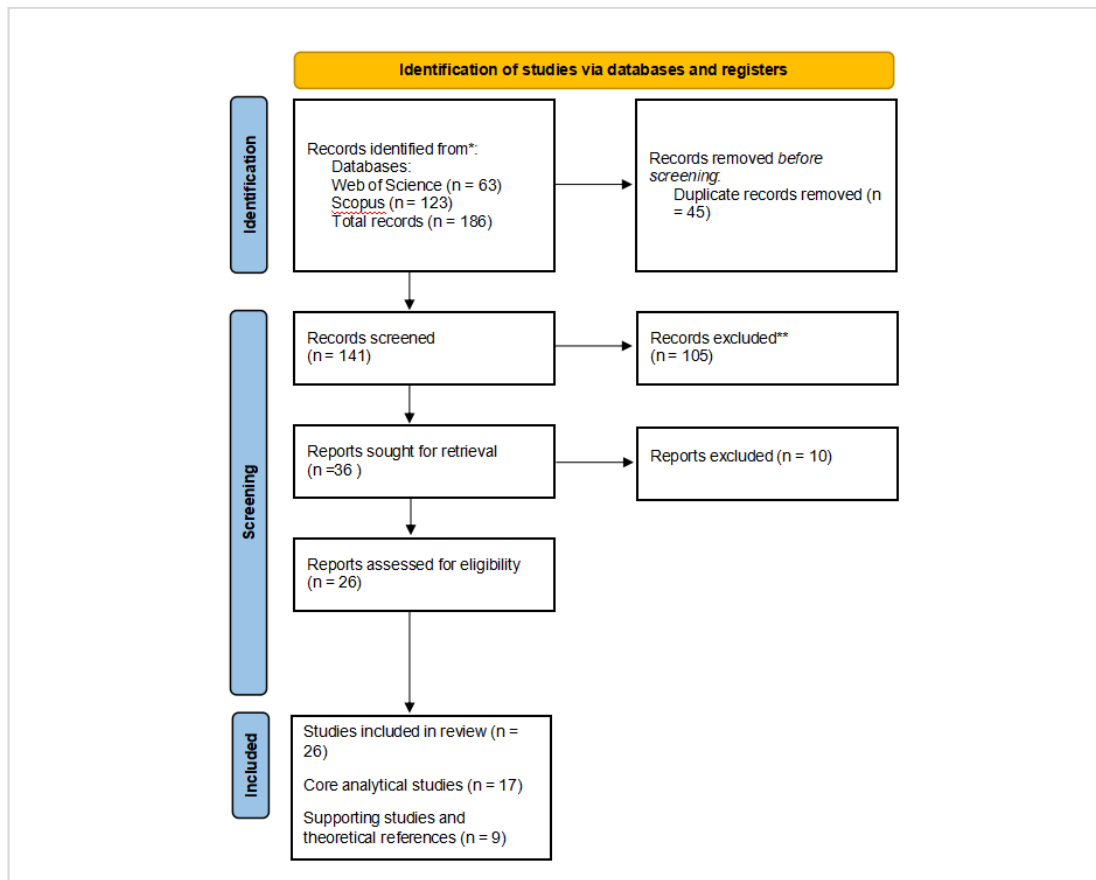


Figure 1. PRISMA flow diagram
Source: Adapted from Page et al. (2021)

Analytical coding framework

To enable systematic analysis and synthesis of the included studies, a coding framework was developed prior to data extraction. The framework was informed by the review's research

questions and by preliminary reading of the literature, and was refined iteratively during the coding process. Each core study was coded according to the following dimensions:

Table 2. Coding scheme for systematic review

Category	Variables
Store Context	Shopping mall / High Street / Flagship store / Department store / Pop-up / Not specified
Technology Type	AR / Projection / Smart glass / Media façade / Touch screen / Gaze tracking / Sensor-based / AI-driven
Interaction Mode	Touch / Gesture / Gaze / Proximity / Mobile-triggered / Social media integration / Multi-modal
Spatial Position	Façade / Threshold / Window as interface / Interior extension / Standalone
Store Context	Shopping mall / High Street / Flagship store / Department store / Pop-up / Not specified
Technology Type	AR / Projection / Smart glass / Media façade / Touch screen / Gaze tracking / Sensor-based / AI-driven
Interaction Mode	Touch / Gesture / Gaze / Proximity / Mobile-triggered / Social media integration / Multi-modal
Spatial Position	Façade / Threshold / Window as interface / Interior extension / Standalone

Data extraction was conducted by the lead author using a standardized form that recorded bibliographic information, study characteristics,

key findings, and design implications for each core study. The extracted data were then synthesized thematically, identifying patterns and

themes across the literature. The interpretive synthesis paid particular attention to spatial and design dimensions, seeking to integrate findings from diverse disciplinary perspectives into a coherent understanding of interactive window display design.

The coding framework enabled systematic comparison across studies and facilitated the identification of dominant themes, methodological approaches, and theoretical frameworks in the literature. The results of this analysis are presented in Section 4, organized according to the major themes that emerged from the synthesis.

Current research status

This section presents a structured analysis of the seventeen core studies identified through the systematic review process. The analysis is organized around three thematic dimensions that emerged from the coding framework: technological approaches in interactive window display design, interaction and engagement mechanisms, and the influence of store environment context. Each dimension is examined through the lens of the core literature, with attention to key findings, methodological approaches, and design implications.

Technological approaches in interactive window display design

The technological foundations of interactive window displays have evolved considerably over the past two decades, progressing from experimental prototypes to commercially viable installations. The reviewed literature reveals four distinct technological approaches that characterize the current research landscape: augmented reality storefronts, projection-based digital windows, sensor-responsive interfaces, and smart glass with dynamic façades.

Augmented reality storefronts represent one of the most actively investigated technological approaches. [Xing \(2019\)](#) conducted simulation experiments comparing traditional, multimedia, and interactive window displays, finding that interactive displays incorporating augmented reality elements significantly enhanced consumer purchasing intentions. The study demonstrated that attractiveness cues in augmented reality displays influenced pleasure and arousal, which in turn increased consumer satisfaction and approach behavior. Similarly, [Hu, Mamat, and Aziz \(2024\)](#) employed qualitative interviews to

explore consumer engagement with interactive technology in window displays, revealing that augmented reality features create immersive experiences that transform traditional window shopping into dynamic consumer-brand interactions.

Projection-based digital windows have been explored as a means of creating flexible, updatable display surfaces without requiring permanent structural modifications. [Reitberger et al. \(2009\)](#) developed and evaluated a persuasive interactive mannequin (PIM) using projection onto a large LCD screen situated in a shop window. The prototype responded to customer presence by changing body posture and looking in their direction, demonstrating how projection technologies can animate traditional retail elements. The three-day field study in a shopping mall revealed that 75.2 percent of participants reported staying longer in front of the interactive window compared to conventional displays.

Sensor-responsive interfaces utilizing depth cameras and motion tracking have been extensively investigated. [Kessels, van Loenen, and Lashina \(2009\)](#) developed the Intelligent Shop Window (ISW) at Philips Research, combining transparent displays with physical products. Their evaluation of touch and gaze interaction with large displays in shopping environments revealed that while touch interaction offered greater efficiency and control, gaze interaction provided novelty and hedonic value. The "polite products" concept where products on turntables rotated toward selected users was rated significantly higher than light-based feedback mechanisms. [Cazzato et al. \(2014\)](#) extended this work by developing a free gaze estimation system using RGB-D sensors to analyze focus of attention in shop window contexts. Their system operated without initial calibration, demonstrating the feasibility of tracking completely unaware persons moving in unconstrained environments.

Smart glass and dynamic façades represent an emerging technological approach that integrates interactivity directly into architectural elements. [Zielinska-Dabkowska and Xavia \(2019\)](#) conducted field measurements of twenty-eight non-static, self-luminous LED shop window displays along Zurich's Bahnhofstrasse, revealing that luminance levels exceeded recommended limits by factors of twelve to eighteen times. Their study highlighted the environmental and health implications of dynamic display technologies

while proposing practical recommendations for sustainable implementation. [van Doorn, de Vries, and Aarts \(2008\)](#) developed an end-user software engineering approach for intelligent shop

windows, enabling retail designers to create, simulate, deploy, and maintain interactive immersive retail spaces through ambient narrative concepts.

Table 3. Typology of interactive window display technologies

Interactive window display technologies				
Augmented Reality Storefronts	Projection-Based Digital Windows	Sensor-Responsive Interfaces	Smart Glass Dynamic Glassdynamic	Mobile-Mediated
Xing (2019) Hu, Mamat, and Aziz (2024)	Reitberger et al. (2009) Perry et al. (2010)	Kessels, van Loenen, and Lashina (2009) Cazzato et al. (2014) De Carolis and Palestra (2017)	Zielinska-Dabkowska and Xavia (2019) van Doorn, de Vries, and Aarts (2008)	Nordh and Nordh (2012) Aguirre Reid and Lackes (2023) Gerritsen et al. (2014)
Virtual overlays on physical products	Non-invasive surfaceprojection	Depth sensing, gaze & gesturetracking	Luminance management, energy efficiency, light pollution control	Wi-Fi/Bluetooth connection, mobile apps, QR codes

Interaction and engagement mechanisms

The mechanisms through which users interact with and engage through interactive window displays constitute a second major theme in the reviewed literature. Four distinct interaction paradigms emerge: gesture-based interaction, mobile-mediated participation, passive digital attraction, and hybrid physical-digital engagement.

Gesture-based interaction has been extensively investigated as a means of enabling intuitive, touchless engagement. [Perry et al. \(2010\)](#) developed and evaluated WaveWindow, an interactive see-through display allowing users to interact with digital content overlaying physical items behind a semi-transparent screen. Their two-day field study in a public retail setting recorded 455 distinct users and revealed important insights into performative gestural interaction. The visibility of gestures discouraged some potential users due to social inhibition, yet simultaneously transformed interaction into public performance that built curiosity and enabled collaborative sequential interactions. [De Carolis and Palestra \(2017\)](#) compared gesture-based and gaze-based interaction modalities for accessing product information through shop windows, finding that gaze-based approaches were preferred by users despite gesture-based interaction offering greater control.

Mobile-mediated participation has emerged as a significant research direction, leveraging ubiquitous smartphone ownership to enable personalized interaction. [Nordh and Nordh \(2012\)](#) developed a comprehensive mobile-mediated interactive shopping window system using Wi-Fi connection between a public display and Android

devices. Their iterative design process, incorporating multiple user tests and company feedback, demonstrated the feasibility of allowing users to browse categories, save viewable information, and access webpages through personal devices. [Aguirre Reid and Lackes \(2023\)](#) extended this approach through their "Digital Store Window" concept, which generated a digital twin of the storefront accessible via QR codes. Survey data from 434 respondents revealed that perceived usefulness and affinity for technology interaction significantly influenced customers' intention to use the system, particularly for accessing product information outside opening hours.

Passive digital attraction refers to systems that engage users through ambient responsiveness without requiring explicit interaction. [Reitberger et al. \(2009\)](#) demonstrated that subtle reactive behaviors such as a virtual mannequin turning its head and body toward approaching customers could significantly increase the perceived duration of stay in front of shop windows. Their field study revealed that 75.2 percent of participants reported staying longer than normal in front of the interactive window, despite the system employing only implicit interaction based on presence detection. [Cremonesi et al. \(2016\)](#) compared static, dynamic, and interactive lighting configurations in fashion store windows, finding that interactive lighting increased stopping time by 15 percent during daylight hours and 22 percent during dark hours, even without explicit user awareness of interactivity.

Hybrid physical-digital engagement combines physical products with digital augmentation to create seamless blended experiences. [Kessels, van](#)

Loenen, and Lashina (2009) pioneered this approach through the "polite products" concept, where physical products on turntables physically rotated toward users upon selection via touch or gaze. This hybrid mechanism was rated significantly higher on hedonic dimensions than purely digital feedback methods such as light tiles. Gerritsen et al. (2014) developed a comprehensive cyber-physical system for shopping malls, integrating mall websites, mobile applications, and interactive storefronts containing Facebook processes. Their prototype demonstrated how physical storefronts could be augmented with real-time social feedback from online friends, creating hybrid engagement that bridged digital social networks and physical retail spaces.

Influence of store environment context

The third thematic dimension emerging from the reviewed literature concerns the influence of store environment context on interactive window display design and effectiveness. The studies reveal significant variations based on retail location, market positioning, and architectural configuration.

High-street versus shopping mall contexts present distinct opportunities and constraints for interactive window implementation. Pantano (2016) conducted focus groups investigating consumer preferences for storefront windows in Italian retail contexts, revealing that while consumers appreciated innovative window designs, they were largely unaware of interactive technologies due to their limited and temporary deployment in cities such as Milan. The study highlighted the importance of location context, with high-street locations offering greater pedestrian flow but also increased competition for visual attention. Gerritsen et al. (2014) focused specifically on shopping mall contexts, developing an integrated system that leveraged mall-wide infrastructure to create coherent cross-channel experiences. Their work demonstrated that malls could function as integrative platforms, enabling collective retailer strategies that individual high-street stores cannot achieve independently.

Luxury versus mass-market retail positioning significantly influences the appropriateness and reception of interactive window displays. Carrai (2022) traced the historical evolution of shop windows from early modern displays through IKEA's maximized exhibitions, arguing that

luxury retailers have traditionally favored more restrained, aesthetically focused displays that convey exclusivity through material presence rather than technological novelty. This historical analysis suggests that interactive technologies may be more readily accepted in mass-market and experiential retail contexts where playfulness and engagement align with brand positioning. Nepomuceno, Moura, and Oliveira (2023) examined post-pandemic reinvention strategies among luxury brands, finding that while digital integration has become essential, luxury retailers prioritize maintaining physical experience quality while adapting this experience to digital media. Their analysis of luxury brand strategies across different countries revealed that monumental architecture and visually impactful facades remain central to luxury retail identity, with interactive elements serving as complementary rather than primary attractions.

Architectural scale and façade configuration profoundly influence interactive window display design possibilities. Zielinska-Dabkowska and Xavia (2019) conducted detailed field measurements of LED shop window displays along Bahnhofstrasse in Zurich, revealing that display size ranged from 1.75 square meters to approximately 50 square meters. Their analysis demonstrated that larger displays, particularly those extending over multiple building stories, generated significant light trespass into residential windows and created glare issues for adjacent traffic systems. The study emphasized that architectural integration including display positioning, viewing angles, and relationships to building façades must be carefully considered in interactive window design. van Doorn, de Vries, and Aarts (2008) developed their intelligent shop window concept within a controlled laboratory environment (ShopLab) that simulated real retail conditions, enabling systematic investigation of how architectural variables influence user experience. Their end-user software engineering approach allowed retail designers to create and simulate ambient narratives within accurate spatial representations, bridging the gap between architectural context and interactive design.

Cremonesi et al. (2016) explicitly addressed architectural scale in their study of smart lighting for fashion store windows, installing their system in three shop windows of a high-end men's clothing store in Milan. The study divided proxemic space into distinct zones proximity (0-2.3 meters), far (2.3-3 meters), and faraway

(beyond 3 meters) demonstrating how architectural context shapes interaction possibilities. Their findings revealed that interactive lighting effects were most effective in the proximity zone, where users could perceive

and respond to subtle lighting changes, highlighting the importance of designing for specific spatial relationships between window, sidewalk, and street.

Table 4. Comparison of store contexts and design strategies

Context dimension	Characteristics	Representative studies	Design implications
High-Street Retail	High pedestrian flow, competitive visual environment, diverse audience	Pantano (2016) ; Pantano, Priporas, and Foroudi (2019) ; Xing (2019)	Must capture attention within seconds; balance novelty with brand consistency; design for diverse user groups
Shopping mall	Controlled environment, multi-store integration, longer dwell times	Gerritsen et al. (2014) ; Reitberger et al. (2009)	Enable cross-store navigation; leverage mall infrastructure; support collective retail strategies
Luxury Retail	Exclusivity, restrained aesthetics, material focus	Carrai (2022) ; Nepomuceno, Moura, and Oliveira (2023)	Prioritize quality of physical experience; use technology as subtle enhancement; maintain brand heritage
Mass-Market Retail	Playful engagement, brand activation, younger demographics	Hu, Mamat, and Aziz (2024) ; Perry et al. (2010)	Embrace visible interactivity; encourage performative engagement; leverage social media integration
Flagship Store	Brand statement, experimental design, tourist destination	Zielinska-Dabkowska and Xavia (2019) ; van Doorn, de Vries, and Aarts (2008)	Push technological boundaries; create memorable experiences; integrate with architectural identity
Small-Format Retail	Limited space, local audience, practical constraints	Aguirre Reid and Lackes (2023) ; Qu and Ren (2015)	Focus on functional benefits (e.g., after-hours access); minimize implementation complexity; leverage mobile devices

Theoretical foundations

This section presents the theoretical frameworks that underpin research on interactive window display design. The reviewed literature draws upon three foundational theoretical perspectives: The Stimulus–Organism–Response (S–O–R) paradigm, Servicescape theory, and experiential retail frameworks. These theories provide complementary lenses for understanding how interactive window displays function as environmental stimuli, how they mediate psychological responses, and how they contribute to integrated physical–digital retail experiences.

Stimulus–Organism–Response (S–O–R) Paradigm

The Stimulus–Organism–Response (S–O–R) paradigm, originating in environmental psychology, provides the most frequently employed theoretical framework in interactive window display research. Developed by [Mehrabian and Russell \(1974\)](#), the paradigm

posits that environmental stimuli (S) evoke internal emotional and cognitive states (O) within individuals, which in turn drive behavioral responses (R) of approach or avoidance.

In the context of interactive window displays, the display itself functions as the environmental stimulus a designed intervention in the retail landscape intended to capture attention and influence behavior. [Donovan and Rossiter \(1982\)](#) first applied this framework to retail settings, demonstrating that store atmosphere influences shopping behaviors through emotional mediation. Their seminal work established that pleasure serves as the primary driver of approach behaviors, while arousal amplifies this effect in pleasant environments a finding subsequently validated and extended in interactive window display contexts.

Stimulus dimension. Interactive window displays constitute complex environmental stimuli incorporating visual, auditory, and interactive elements. [Pantano \(2016\)](#) identified

that storefront windows function as the first contact point between consumers and retailers, creating visual impact, differentiating retailers from competitors, and anticipating exceptional in-store experiences. [Xing \(2019\)](#) further demonstrated that both aesthetics and attractiveness of window display function as environmental cues that significantly affect consumer attitudes. The interactive dimension introduces additional stimulus complexity, as [Kessels, van Loenen, and Lashina \(2009\)](#) demonstrated through their comparison of gaze and touch interaction modalities.

Organism dimension. The organism component encompasses the internal psychological processes both cognitive and affective that mediate between environmental stimuli and behavioral responses. [Lecointre-Erickson, Daucé, and Legohérel \(2018\)](#) provided the first experimental test of interactive storefront displays, finding that interactive technology significantly influences arousal, which in turn affects expected shopping experience. Their study revealed that affective responses to interactive window displays shape consumers' expectations of subsequent in-store experiences, extending the S-O-R framework beyond immediate behavioral outcomes to include anticipatory effects.

[Pantano, Priporas, and Foroudi \(2019\)](#) incorporated consumer innovativeness as a moderating variable within the S-O-R framework, demonstrating that personal characteristics influence how consumers respond to storefront windows enriched with innovative technologies. Their quantitative study of 341 consumers revealed that when consumers sense innovative interactive technologies in storefront windows, they demonstrate greater willingness to enter stores and generate positive word-of-mouth communication, with consumer innovativeness strengthening both relationships.

Response dimension. Behavioral responses to interactive window displays encompass a range of approach behaviors including store entry, exploration, and purchase intention. [Hu, Mamat, and Aziz \(2024\)](#) employed qualitative methods to explore how interactive technology in window displays influences consumer behavior, finding that interactive features significantly affect consumers' willingness to enter stores. Their study revealed that the relationship between interactive technology and store entry is mediated by engagement with the window display and perceived store atmosphere, while consumer

technology experience moderates this relationship.

Servicescape theory

Servicescape theory, developed by [Bitner \(1992\)](#), provides a complementary framework for understanding how physical surroundings influence both customers and employees in service organizations. The theory identifies three composite dimensions of the physical environment: ambient conditions, spatial layout and functionality, and signs, symbols, and artifacts. These dimensions collectively shape perceptions and influence behavioral responses.

Window display as atmospheric extension. Within servicescape theory, window displays function as a critical atmospheric extension of the retail environment the threshold between exterior public space and interior service setting. [Carrai \(2022\)](#) traced the historical evolution of shop windows from early modern displays to contemporary digital installations, arguing that windows have always functioned as liminal interfaces mediating between interior and exterior, public and private, physical and digital realms. This historical analysis positions window displays as fundamental architectural elements that shape spatial transition and experiential continuity.

[Nepomuceno, Moura, and Oliveira \(2023\)](#) examined how luxury brands reinvent themselves through facades, visual merchandising, and storytelling in the post-pandemic era. Their analysis revealed that monumental architecture with strong focus on facades marks a new phase of fashion retail, where physical environments are designed with strong appeal to shopping experience while simultaneously being propagated digitally through social networks. This dual focus on physical and digital presence extends servicescape theory by recognizing that atmospheric cues now operate across both material and virtual domains.

Façade as environmental communication element. [Zielinska-Dabkowska and Xavia \(2019\)](#) applied servicescape concepts to analyze media architecture and non-static LED displays in mixed-use urban developments. Their field measurements along Zurich's Bahnhofstrasse revealed that shop window displays function as environmental communication elements that significantly impact urban nighttime environments. The study's recommendations for reducing light pollution while maintaining display

effectiveness demonstrate how servicescape principles can guide sustainable implementation of interactive technologies.

van Doorn, de Vries, and Aarts (2008) developed an end-user software engineering approach for intelligent shop windows that explicitly engaged with servicescape concepts. Their workshops with retail designers, consultants, and retailers revealed that stakeholders view ambient effects and interactive media as integral components of overall retail concepts that must be considered from the initial design phase. The ambient narrative concept they developed enables designers to represent dynamic open ambient intelligence environments, extending servicescape theory to accommodate interactive and responsive environmental elements.

Experiential retail and phygital environments

The emergence of experiential retail paradigms and phygital (physical–digital) environments represents a third theoretical foundation informing interactive window display research. This perspective emphasizes the creation of immersive retail experiences that integrate digital and physical elements to engage consumers beyond transactional interactions.

Immersive retail experience. Reitberger et al. (2009) positioned their persuasive interactive mannequin within ambient intelligence frameworks, arguing that shopping contexts offer unique opportunities for persuasive approaches that influence customer behavior. Their field study demonstrated that interactive mannequins could increase perceived duration of stay in front of shop windows, contributing to micro-suasory effects that incrementally influence shopping behavior. The study's focus on engagement rather than immediate purchase reflects the experiential retail emphasis on creating memorable interactions that build brand relationships over time.

Cremonesi et al. (2016) explicitly investigated how smart lighting technologies could enhance the shopping experience in front of fashion store windows. Their extensive field study, involving automatic data collection from over 300,000 passersby, live observation of approximately 600 individuals, and questionnaires from 62 respondents, provided empirical evidence that interactive smart lights increase the attractiveness of shopping windows and foster engagement. The study revealed that interactive lighting

configurations increased stopping time by 15 percent during daylight hours and 22 percent during dark hours, demonstrating measurable experiential effects.

Digital–physical integration. Gerritsen et al. (2014) developed a comprehensive cyber-physical system concept for shopping malls that integrated mall websites, mobile applications, and interactive storefronts containing Facebook processes. Their prototype demonstrated how physical retail environments could be augmented with real-time social feedback from online friends, creating hybrid experiences that bridge digital social networks and physical shopping spaces. The concept of "u-retail" (ubiquitous retail) they proposed positions interactive storefronts as nodes within integrated cross-channel systems that support seamless customer journeys.

Aguirre Reid and Lackes (2023) developed a digital store window concept that generated digital twins of physical storefronts accessible via QR codes. Their Technology Acceptance Model-based evaluation of 434 respondents revealed that perceived usefulness and affinity for technology interaction significantly influenced customers' intention to use the system, particularly for accessing product information outside opening hours. This approach exemplifies digital–physical integration by extending store presence beyond physical operating hours while maintaining connection to the physical storefront location.

Engagement beyond transaction. Perry et al. (2010) investigated public, performative gestural interaction with see-through displays, revealing that interactive shop windows generate forms of engagement that extend beyond individual transactions. Their field study of WaveWindow documented collaborative interactions, sequential turn-taking among group members, and proxy interactions where children facilitated adult engagement. These findings demonstrate that interactive window displays create social experiences that contribute to retail environments in ways not captured by transaction-focused metrics.

Qu and Ren (2015) proposed combining Wi-Fi technology with dynamic window displays to create new brand promotion methods that stimulate passerby interest and attract store entry. Their conceptual work, combining literature review, interviews, and questionnaires, envisioned interactive displays that would reward free Wi-Fi access with brief advertisement

viewing, creating engagement loops that benefit both consumers and retailers. While preliminary, this work illustrates the expanding conception of

interactive window displays as platforms for ongoing consumer–brand engagement rather than merely point-of-purchase communication.

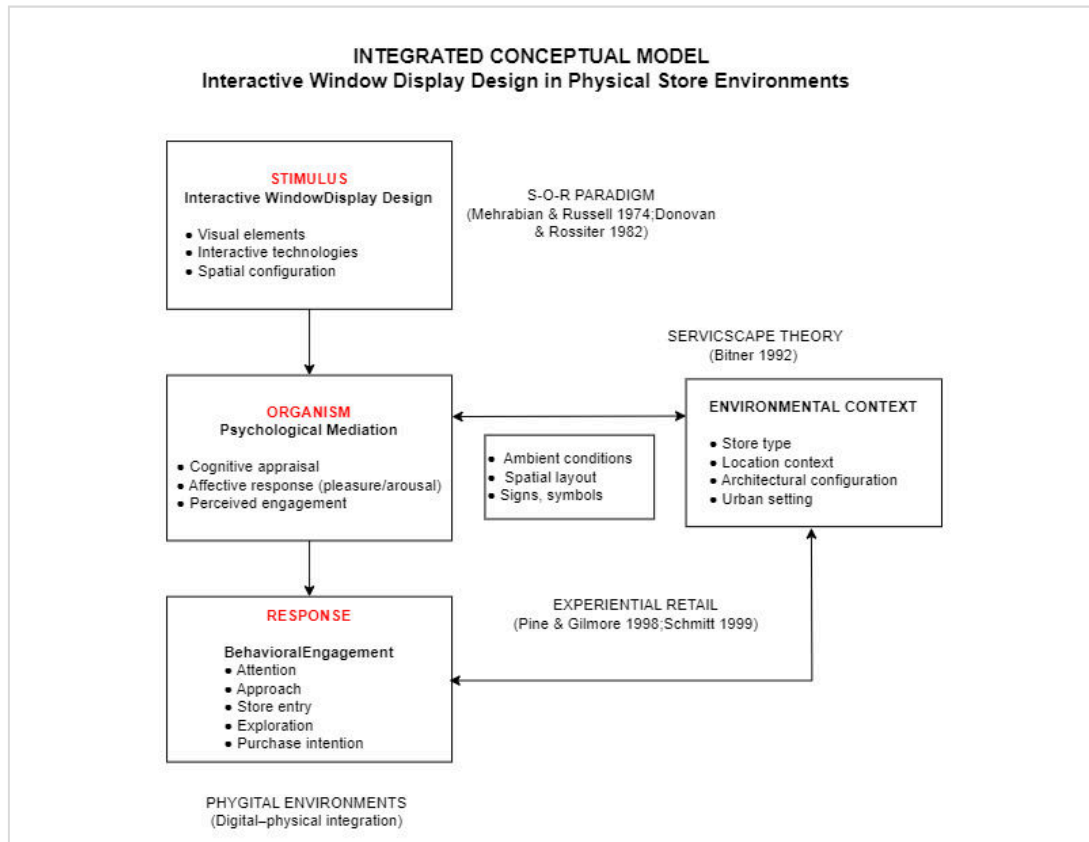


Figure 2. Integrated conceptual model

Future research and design directions

This section synthesizes the findings from the reviewed literature to identify critical gaps and propose future research directions for interactive window display design. The analysis reveals four interconnected themes that warrant further investigation: the evolution from visual merchandising to spatial interface, sustainability and environmental considerations, data-driven and adaptive displays, and cross-disciplinary research needs. Each theme is examined with attention to architectural implications and methodological considerations.

From visual merchandising to spatial interface

Recent studies indicate a conceptual shift in window displays from passive visual merchandising toward active spatial interfaces that mediate the relationship between street and store interior. Interactive technologies extend the

traditional communicative role of storefronts by enabling responsive engagement with pedestrians. However, current research largely treats these systems as technological add-ons rather than integrated architectural elements. Future studies should therefore explore how interactive window displays can be embedded within façade systems, addressing issues of structural integration, environmental performance, and urban visual impact. Considering concerns such as light pollution and glare, further investigation is also needed to ensure that interactive displays enhance architectural quality and urban experience.

Sustainability and environmental considerations

Sustainability remains an underexplored aspect of interactive window display design. Research has shown that non-static LED shop windows can generate excessive luminance

levels, contributing to urban light pollution. Despite the growing adoption of digital displays, their environmental impacts including energy consumption, lighting intensity, and lifecycle material costs remain insufficiently documented. Future research should therefore examine energy-efficient display strategies, adaptive lighting controls, and sustainable material systems that balance communicative effectiveness with environmental responsibility.

Data-Driven and adaptive displays

Emerging research highlights the potential of data-driven and adaptive technologies in interactive window displays. AI systems, computer vision, and machine learning enable displays to respond dynamically to viewer characteristics and environmental conditions. Experimental studies also demonstrate responsive storefront behaviors based on gaze, proximity, and user interaction. However, the integration of such technologies into retail environments

remains limited. Future research should explore real-time adaptive storefront systems that personalize content while balancing usability, privacy considerations, and spatial experience in retail environments.

Cross-Disciplinary research needs

Emerging research highlights the potential of data-driven and adaptive technologies in interactive window displays. AI systems, computer vision, and machine learning enable displays to respond dynamically to viewer characteristics and environmental conditions. Experimental studies also demonstrate responsive storefront behaviors based on gaze, proximity, and user interaction. However, the integration of such technologies into retail environments remains limited. Future research should explore real-time adaptive storefront systems that personalize content while balancing usability, privacy considerations, and spatial experience in retail environments.

Table 5. Future research agenda

Theme	Research gap	Architectural implication	Suggested methods
Spatial Interface	Integration of displays with façade systems	Development of construction details that accommodate technology while maintaining performance	Prototype development, technical testing, case study analysis
	Storefront as active architectural layer	Design of responsive interfaces that modulate environmental conditions	Research-through-design, performance simulation, field evaluation
Sustainability	Energy consumption of interactive displays	Development of energy performance metrics and optimization strategies	Lifecycle assessment, energy monitoring, comparative analysis
	Light pollution control	Evidence-based guidelines for display placement and operation	Field measurement, photometric analysis, urban-scale modeling
	Material lifecycle concerns	Design for repair, upgrade, and recycling	Material analysis, durability testing, end-of-life assessment
Data-Driven Design	AI personalization	Integration of sensing technologies without compromising architectural quality	Usability testing, privacy impact assessment, design prototyping
	Real-time responsiveness	Development of control systems that adapt to changing conditions	Sensor development, algorithm design, field deployment
Cross-Disciplinary Research	Architectural experimentation	Generation and testing of novel spatial and material propositions	Research-through-design, design prototyping, in situ evaluation
	Urban integration	Understanding of multi-display interactions and streetscape impacts	Urban analysis, behavioral observation, policy research
	Cultural contextualization	Investigation of culturally specific aesthetic preferences and display reception	Cross-cultural comparison, ethnographic study, participatory design

Conclusions

This systematic review has examined the current state of research on interactive window display design in physical store environments, synthesizing findings from seventeen core studies and six foundational theoretical works. The review reveals a field in transition moving from technological experimentation toward integrated spatial understanding, yet still grappling with fundamental questions about how interactive displays function as architectural elements, experiential interfaces, and retail communication tools. This concluding section summarizes key findings, articulates theoretical contributions, acknowledges limitations, and identifies implications for future research and practice.

Summary of key findings

This review synthesizes research on interactive window display design in physical store environments and identifies three key findings. First, window displays are increasingly conceptualized as spatial interfaces mediating the relationship between street and store interior rather than passive merchandising surfaces. Second, although interactive technologies such as gesture, gaze, and digital interfaces have been widely explored, research remains predominantly technology-driven, with limited engagement with architectural and spatial theory. Theoretical frameworks including the S-O-R paradigm and servicescape theory offer potential spatial interpretations but remain insufficiently applied. Third, design strategies are strongly influenced by retail and urban contexts, highlighting the need for context-sensitive approaches in interactive storefront design.

Theoretical contribution

This review makes three theoretical contributions to research on interactive window display design. First, it introduces an architectural perspective to retail display studies, conceptualizing window displays as spatial interfaces that mediate relationships between street and store environments. Second, it synthesizes interdisciplinary frameworks including the S-O-R paradigm and servicescape theory to explain how interactive technologies influence spatial experience and consumer behavior. Third, by systematically mapping existing studies, the review clarifies dominant

research themes and methodological approaches, providing a structured foundation for future research on interactive retail environments.

Limitations

Several limitations should be acknowledged. First, the review identified a relatively small corpus of core studies ($n = 17$), reflecting the emerging nature of research on interactive window displays in physical retail environments. Second, the search was limited to English-language publications indexed in Web of Science and Scopus, which may exclude relevant studies published in other languages or venues. Third, although foundational theories were incorporated through snowball sampling, earlier research on retail atmospherics and environmental psychology may not be fully represented. Consequently, the findings should be interpreted as an initial synthesis of an evolving research field.

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Chaojiang Hu contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Mohd Jaki Bin Mamat contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

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