

Neuro-UX for Fashion E-Commerce: Reviewing Eye-Tracking and Cognitive Load Frameworks in Online Apparel Buying

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Abstract

As fashion e-commerce platforms become increasingly visual, interactive, and choice-intensive, understanding how users cognitively and perceptually engage with online apparel interfaces has become critical. Traditional user experience (UX) research methods, such as surveys and usability testing, often rely on self-reported data and conscious user feedback, which may fail to capture subconscious attentional and cognitive processes influencing purchase decisions. This secondary review paper examines the application of Neuro-UX frameworks, specifically eye-tracking and cognitive load theory in evaluating and optimizing fashion e-commerce experiences. Drawing on interdisciplinary literature from neuroscience, human-computer interaction, consumer psychology, and digital retailing, the review synthesizes findings from prior empirical studies to identify how visual attention patterns and mental effort shape online apparel buying behaviour. The paper analyses key eye-tracking metrics, including fixation duration, scan paths, time to first fixation, and areas of interest, to understand how users process product imagery, textual information, interface elements, and recommendation cues. In parallel, it reviews cognitive load research to explore how interface complexity, excessive choice, dense information structures, and navigational inefficiencies contribute to decision fatigue and drop-off behaviour in fashion e-commerce contexts. By integrating insights from both domains, the paper highlights design implications for product pages, navigation systems, personalization strategies, and emerging technologies such as virtual try-on tools. The review concludes that Neuro-UX offers a robust, evidence-based foundation for designing fashion e-commerce interfaces that align with users' attentional capacities and cognitive limits, enabling smoother decision-making, stronger emotional engagement, and improved conversion outcomes.

Keywords: Neuro-UX; Fashion E-Commerce; Eye-Tracking; Cognitive Load Theory; Online Consumer Behaviour; Visual Attention; User Experience Design

1. Introduction

The rapid growth of fashion e-commerce over the past decade has transformed how consumers interact with apparel brands, evaluate products, and make purchasing decisions. Online retail has evolved from simple digital catalogues to sophisticated, visually dense ecosystems shaped by multimedia content, algorithmic recommendations, and interactive interfaces. As global fashion e-commerce continues to expand, with rising digital adoption, increased smartphone access, and accelerated post-pandemic shifts, user experience (UX) has emerged as one of the most important competitive differentiators for brands (Kumar & Reinartz, 2021). However, while traditional UX evaluation methods such as surveys, interviews, A/B testing, and usability checklists have proven valuable, they often fail to capture deeper, subconscious layers of user behaviour that strongly influence online shopping outcomes, especially in a

sensory-driven category such as fashion (Lindgaard, 2019). This has led to the emergence of Neuro-UX, an interdisciplinary approach that integrates neuroscience tools with UX research to reveal cognitive, attentional, and emotional responses that conventional methods may overlook.

Background: Fashion e-commerce presents a distinct set of UX challenges compared to other online retail categories. Unlike electronics or groceries, where functional specifications often outweigh visual appeal, fashion relies heavily on sensory cues such as texture, fit, drape, colour accuracy, and styling inspiration. The absence of tactile interaction in online shopping heightens the importance of visual design, product imagery, sizing guidance, and interface clarity (Park & Kim, 2020). As a result, users process significantly more visual information during fashion browsing, leading to increased cognitive effort. The expansion of fashion platforms has also led to a vast proliferation of product options, filters, size variants, and promotional messages, all of which contribute to cognitive overload and decision fatigue (Iyengar & Lepper, 2000).

Traditional UX methods, while informative, capture only the conscious aspects of user interaction, what users notice, what they recall, and what they articulate (Norman, 2013). Yet much of decision-making in online environments is subconscious, rapid, and driven by underlying cognitive and emotional responses. Users may not be able to accurately explain why certain images attract their attention or why they abandon a product page despite positive initial impressions. Thus, relying solely on self-reported data introduces bias and limits the ability of designers to understand real behavioural drivers (Falk et al., 2015).

In response, Neuro-UX has emerged as an advanced methodological space that applies physiological measurement tools, such as eye-tracking, EEG, galvanic skin response (GSR), and heart-rate monitoring, to UX evaluation. These tools help researchers examine where users look, how long they focus, what visual elements trigger mental effort, and how different interface features influence emotional engagement (Ariely & Berns, 2010). In fashion e-commerce, where visual attention and cognitive processing are central to consumer choice, Neuro-UX provides particularly rich insights. Eye-tracking, for instance, reveals fixations, saccades, scan paths, and areas of interest (AOI), allowing researchers to identify which product images, filters, or interface elements users engage with most. Similarly, cognitive load frameworks explain the mental effort required in navigating complex apparel pages, comparing items, choosing sizes, and evaluating fits, influencing key touchpoints that strongly shape purchase decisions (Sweller, 2011).

Problem Statement: Despite the growth of fashion e-commerce, existing UX research often overlooks the underlying cognitive and attentional mechanisms driving user behaviour. Most platforms depend on observational and self-report methods that cannot accurately capture subconscious responses such as visual overload, attention shifts, micro-confusions, and decision fatigue. The challenge is particularly acute in apparel shopping, where users face extensive choice sets, multiple decision layers (size, fit, colour, style), and heavy visual content. As a result, even well-designed platforms may cause cognitive strain or attention fragmentation without designers realising it (Djamasbi et al., 2014).

The fundamental problem lies in the limited understanding of how users actually perceive product images, interpret layout hierarchies, navigate filters, and process information-heavy product pages. For example, users may spend significant time fixating on product images that do not contribute to buying intent, or may miss critical interface elements such as size charts or return policies because of poor visual hierarchy. Similarly, cognitive overload may cause premature abandonment of sessions, increased bounce rates, or suboptimal decision-making, even when the interface appears functional and aesthetically appealing

(Petersen & Gerstheimer, 2020). Addressing these gaps requires the use of neuroscience-informed methods that can evaluate user interaction at a deeper, more objective level.

Purpose of the Review: Given these challenges, the purpose of this review is to examine how Neuro-UX approaches, specifically eye-tracking methods and cognitive load frameworks, enhance user experience evaluation for fashion e-commerce. This paper synthesizes prior research to explore how visual attention metrics, cognitive load indicators, and neurophysiological tools can provide nuanced insights into user behaviour. By reviewing diverse academic studies, UX experiments, neuromarketing findings, and usability research, the paper develops a consolidated understanding of how Neuro-UX can inform interface design, product page construction, navigation architecture, and personalization strategies in apparel shopping.

The review focuses on presenting an integrated perspective: how eye-tracking reveals the distribution of visual attention; how cognitive load theory explains user effort and fatigue; and how combining both creates a more holistic picture of user interaction. Ultimately, the aim is to demonstrate why Neuro-UX should be considered a critical methodological component for fashion e-commerce companies seeking to improve usability, emotional engagement, and conversion performance.

Methodology: This paper adopts a secondary review methodology, relying exclusively on existing literature rather than conducting primary experiments. Academic journal articles, industry whitepapers, neuromarketing case studies, UX lab reports, and e-commerce design research were examined to synthesize findings related to eye-tracking, cognitive load, and fashion interface evaluation. Key areas of focus include:

- Eye-tracking studies in online shopping
- Cognitive load theory and mental effort measurement
- Apparel-specific UX research
- Neuro-marketing findings relevant to visual processing
- E-commerce decision-making literature

The review consolidates these sources to identify patterns, theoretical insights, design implications, and gaps in existing research. No new experiments, data collection, or physiological measurements were performed for this study.

Scope and Limitations: The scope of this review is intentionally restricted to apparel-based e-commerce platforms, such as fashion marketplaces, brand websites, and mobile shopping applications. While Neuro-UX is relevant to multiple product categories, the paper focuses exclusively on fashion due to its uniquely visual and choice-intensive nature.

Key limitations include:

- The absence of primary neurometric testing restricts empirical validation.
- Some eye-tracking and cognitive load studies reviewed have small sample sizes, limiting generalizability.
- Cultural differences in visual behaviour are not fully explored in all studies.
- The rapidly evolving nature of fashion technology, such as virtual try-on, AR, and AI-powered recommendations, means some findings may require future updates.

Despite these limitations, the review provides a theoretically grounded and empirically supported understanding of how Neuro-UX can strengthen UX strategy in fashion e-commerce.

2. Neuro-UX: Foundations and Concepts

Neuro-UX has emerged as a critical interdisciplinary field that bridges neuroscience, cognitive psychology, human–computer interaction, and user experience research to explore how users perceive, interpret, and engage with digital interfaces at a subconscious level. Unlike conventional UX methodologies, which rely on users’ conscious feedback and observable behaviour, Neuro-UX seeks to illuminate the underlying cognitive, emotional, and neural processes that shape interaction patterns. This distinction is essential because a considerable proportion of human decision-making occurs automatically and implicitly, often beyond conscious awareness. By applying neuroscientific tools to interface evaluation, Neuro-UX offers a more nuanced and objective understanding of user behaviour, enabling designers to develop experiences that align with the brain’s natural perceptual and cognitive tendencies. Its relevance becomes particularly pronounced in visually intensive environments such as fashion e-commerce, where user engagement depends heavily on visual attention, emotional resonance, and the efficiency with which the brain processes complex information.

2.1. Definition of Neuro-UX

Neuro-UX can be defined as the application of neuroscientific methods, physiological measurement tools, and cognitive theories to evaluate, interpret, and optimise user experience. It extends traditional UX research by incorporating objective indicators of attention, mental effort, engagement, arousal, and emotional response. While conventional UX relies on what users say and what researchers can see, Neuro-UX draws from what the user’s body and brain reveal during interaction (Ariely & Berns, 2010). In this sense, Neuro-UX does not replace traditional methods; instead, it complements them by removing self-report bias and capturing cognitive events that occur too quickly or implicitly for users to articulate. These insights are particularly valuable because digital interfaces often operate at a perceptual timescale, users make judgments about a website’s visual appeal, usability, or trustworthiness within milliseconds (Lindgaard et al., 2006). Such rapid evaluations cannot be reliably studied through post-task questionnaires alone.

Neuro-UX also emphasises the idea that UX is not merely a behavioural process but a neurocognitive one. Every user action on a digital interface, from clicking an image, scanning a product grid, navigating filters, or abandoning a page, reflects underlying attentional shifts, cognitive evaluations, emotional reactions, and neural resource allocation. By framing UX as a cognitive–emotional interaction rather than a purely behavioural task sequence, Neuro-UX provides a richer theoretical foundation for understanding usability and engagement.

2.2. Why Neuroscience Matters in Online Shopping

The relevance of neuroscience to online shopping arises from the cognitive and emotional complexity of digital consumer behaviour. Shopping is not a purely rational decision-making event; it involves affective responses, perceptual biases, mental heuristics, and subconscious processes that shape product evaluation and purchase intention. Several decades of research in neuropsychology and behavioural economics have demonstrated that the brain prioritises visual information, relies heavily on heuristics when processing large amounts of data, and responds strongly to emotional cues even in ostensibly rational contexts (Kahneman, 2011). These mechanisms are especially salient in online shopping, where users depend almost entirely on visual and textual information.

Fashion e-commerce creates a cognitively demanding environment because users must evaluate numerous attributes without the benefit of physical touch. They infer texture, fit, quality, and comfort by interpreting images, videos, and textual descriptions. This interpretative process requires significant mental effort and

continuous cognitive appraisal, which can be taxing for working memory. Neuroscience becomes relevant because cognitive load, attention, and emotional arousal substantially influence product evaluation, brand perception, and purchase decisions (Plass et al., 2010). For example, when users experience high cognitive load due to cluttered layouts or excessive choice, their ability to make satisfying decisions decreases, and their likelihood of abandoning the interface increases.

Emotions also play a critical role in online fashion consumption. Neuroscientific research has shown that emotional responses occur before conscious reasoning and can influence decision-making long before users become aware of their preferences (LeDoux, 1996). Product imagery, colours, models, styling, and interface aesthetics can all evoke affective responses that shape purchase likelihood. Traditional UX methods may fail to capture these responses because users often lack the introspective accuracy to describe how an image made them feel or why a particular layout resonated with them. Neuro-UX captures these implicit reactions through physiological measures, revealing the emotional undercurrents that shape behaviour.

Furthermore, the digital environment imposes unique perceptual constraints. Screen size, visual density, scrolling behaviour, and information architecture influence how users allocate attention. Neuroscience helps explain why certain layouts enhance engagement while others create confusion. For instance, research shows that the brain tends to focus on high-contrast or human-related imagery first, that attention is often guided by facial cues, and that visual clutter increases cognitive load by forcing the brain to filter irrelevant information (Cerf et al., 2008). For fashion e-commerce, these principles can inform product page design, imagery selection, and the organisation of visual elements.

Thus, neuroscience matters in online shopping because it reveals how consumers truly perceive digital experiences, how their cognitive resources are allocated, and how subconscious mechanisms shape their decisions. Without this foundation, UX design risks being guided by surface-level behavioural data rather than a deep understanding of human cognition.

2.3. Key Physiological Tools Used in Neuro-UX Research

Neuro-UX employs several physiological tools that enable researchers to capture objective data about user attention, emotional response, and cognitive load. Among these, eye-tracking, electroencephalography (EEG), and galvanic skin response (GSR) are the most widely used. Each tool offers unique insights into different aspects of user experience.

Eye-tracking measures eye movements to infer patterns of visual attention. It captures metrics such as fixations, saccades, scan paths, pupil dilation, and heatmaps, offering a real-time window into how users visually navigate an interface. Eye-tracking has been widely adopted in UX research because it directly reflects overt attention and correlates strongly with cognitive processing demands (Holmqvist et al., 2011). In e-commerce contexts, eye-tracking reveals which product images attract attention, how users scan product grids, which elements are ignored, and how visual hierarchy influences behaviour. For fashion platforms, this is especially significant because product evaluation is image-driven and depends heavily on attention allocation.

Electroencephalography (EEG) measures electrical activity in the brain through scalp electrodes. It provides insights into cognitive load, emotional engagement, and neural correlates of decision-making. EEG has been used in neuromarketing to evaluate advertising effectiveness, detect emotional resonance, and measure mental effort during digital interactions (Vecchiato et al., 2014). In UX research, EEG helps identify moments of confusion, cognitive overload, or emotional arousal, states that users may not explicitly report but that significantly influence their experience. Although EEG setups can be more

complex than eye-tracking, they provide rich data about the brain's immediate responses to interface elements.

Galvanic skin response (GSR), also known as electrodermal activity, measures changes in skin conductivity caused by sweat gland activity, which increases during emotional arousal or stress. GSR offers a physiological indicator of excitement, frustration, or heightened mental effort during tasks (Boucsein, 2012). In online shopping contexts, GSR can reveal moments when users feel overwhelmed by choice, frustrated by navigation challenges, or emotionally engaged with specific product imagery. While GSR does not specify whether arousal is positive or negative, it complements other tools by highlighting emotionally salient moments within the user journey.

Together, these tools form a comprehensive methodological framework. Eye-tracking uncovers where users look; EEG reveals how the brain responds; GSR indicates how strongly users react emotionally. When used alongside traditional UX evaluations, they provide a multi-layered understanding of behaviour that integrates overt actions, cognitive processes, and emotional experiences.

2.4. Relevance of Neuro-UX to Visual-Heavy Sectors like Fashion

The relevance of Neuro-UX becomes especially pronounced in sectors where visual perception is central to product evaluation. Fashion e-commerce represents one of the most visual domains of digital interaction. Users rely on imagery to assess style, fit, material properties, and aesthetic appeal. This reliance places enormous cognitive demands on the perceptual system. The brain must encode, compare, and interpret multiple images rapidly, often across product pages, tabs, or grids. Neuro-UX provides tools that can decode these rapid cognitive and perceptual processes.

Fashion products are inherently multisensory in the physical world, but online interfaces collapse this sensory richness into predominantly visual cues. As a result, the user's visual system compensates for the lack of tactile information by increasing attention to photographic detail, model presentation, texture cues, zoom features, colour accuracy, and style context. Eye-tracking helps researchers understand how users distribute their attention across these cues, whether they struggle to interpret specific images, and how visual hierarchy influences their decision-making. Studies show that when imagery is unclear or visually cluttered, cognitive load increases, leading to reduced evaluation accuracy and higher abandonment rates (Park & Kim, 2020).

Fashion e-commerce also involves high choice density. Users regularly navigate hundreds of product options, compare items, and move between categories. This creates a fertile environment for cognitive overload. Cognitive load theory suggests that the brain's working memory is limited; when interface complexity exceeds this capacity, users experience fatigue and decision difficulty (Sweller, 2011). Neuro-UX offers a method to measure these cognitive burdens directly. EEG can indicate mental effort, while eye-tracking patterns reveal whether users are scanning systematically or exhibiting disorganised behaviour, a common sign of overload. GSR can further detect stress responses during complex decision-making.

Furthermore, fashion consumption is deeply emotional. Buyers respond strongly to aesthetics, identity cues, and self-expression. Neuro-UX tools can capture emotional arousal triggered by product imagery or brand storytelling. In doing so, designers can better understand which visual elements generate delight, which cause hesitation, and which contribute to cognitive friction. This allows brands to craft digital experiences that are not only visually appealing but also emotionally resonant and cognitively effortless. In essence, Neuro-UX aligns perfectly with the needs of fashion e-commerce because it offers a scientifically grounded means of understanding how users perceive, process, and emotionally engage with

visual information. It reveals the cognitive architecture behind product evaluation and highlights opportunities to create interfaces that align with the brain's natural tendencies. As fashion becomes increasingly digital and competitive, Neuro-UX provides an essential lens through which brands can differentiate by enhancing the psychological clarity, emotional appeal, and cognitive efficiency of their user experiences.

3. Eye-Tracking in Fashion E-Commerce

Eye-tracking has become one of the most extensively used methods within Neuro-UX research due to its ability to provide direct, objective evidence of visual attention. In fashion e-commerce, where consumer decisions are predominantly guided by visual stimuli, eye-tracking offers a precise method to understand how users explore product pages, listings, and interface elements. Apparel shopping online requires users to infer fit, quality, and aesthetic appeal solely from visual cues, making attention allocation a critical determinant of user experience and purchase behaviour. Eye-tracking enables researchers to observe how users visually navigate these environments in real time, revealing patterns of interest, confusion, and cognitive effort that are often invisible to traditional UX methods (Holmqvist et al., 2011).

3.1 How Eye-Tracking Works (Fixations, Saccades, Heatmaps)

Eye-tracking technology functions by using infrared sensors to detect reflections from the pupil and cornea, allowing precise measurement of eye position and movement on a digital interface. These measurements are translated into gaze data that reflect how users visually interact with content. Two fundamental eye movement components underpin eye-tracking analysis: fixations and saccades. Fixations occur when the eyes remain relatively stable on a particular location, indicating focused attention and active information processing. In fashion e-commerce, fixations often correspond to moments when users examine product images, evaluate prices, or scrutinise details such as fabric texture or garment fit (Rayner, 2009).

Saccades, in contrast, are rapid eye movements between fixations and represent visual scanning rather than detailed processing. Frequent or erratic saccades may indicate search behaviour, comparison across options, or difficulty in locating relevant information. In apparel websites, saccadic movements are commonly observed when users browse product grids or switch attention between images and navigational elements. Together, fixations and saccades provide a temporal map of how attention unfolds during the shopping journey.

Heatmaps are aggregated visual representations of fixation data across multiple users. They illustrate areas of high and low attention intensity through colour gradients, offering an intuitive overview of collective visual behaviour. In fashion e-commerce studies, heatmaps consistently show concentrated attention on primary product images, model faces, and price information, while secondary content such as care instructions or delivery policies often receives minimal visual engagement (Djamasbi, Siegel, & Tullis, 2011). These patterns underscore the importance of visual prioritisation in interface design.

3.2 Metrics Used in Eye-Tracking Research

Several quantitative metrics are employed in eye-tracking research to interpret visual engagement and cognitive processing. Fixation duration is one of the most commonly used metrics and refers to the length of time a user's gaze remains on a specific element. Longer fixation durations are generally associated with deeper cognitive processing, higher interest, or increased complexity. In fashion e-commerce, extended fixations on product images may reflect detailed evaluation or emotional engagement, whereas prolonged fixations on navigation elements may indicate confusion or usability issues (Wedel & Pieters,

2018).

Scan paths represent the sequence and order of fixations and saccades across a webpage. They provide insight into how users navigate visual information and whether the interface supports a logical flow of attention. In apparel shopping contexts, scan path analysis often reveals iterative comparison behaviour, with users repeatedly shifting attention between images, prices, and recommendations. Fragmented or disorganised scan paths may signal cognitive overload, particularly when interfaces contain excessive visual elements or poorly structured layouts (Park & Kim, 2020).

Time to first fixation measures the speed with which a user's gaze lands on a particular element after page load. This metric is critical for understanding visual salience and first impressions. Research indicates that users typically fixate first on large, high-contrast elements, particularly images featuring human models, due to the brain's sensitivity to social and biological cues (Cerf et al., 2008). In fashion e-commerce, shorter time to first fixation on product images or call-to-action buttons is associated with more intuitive and effective visual design.

Areas of interest (AOIs) are predefined regions of a webpage that researchers analyse individually to assess attention distribution. Common AOIs in fashion e-commerce include product images, size selectors, filters, price tags, and recommendation sections. By comparing fixation counts and durations across AOIs, researchers can evaluate whether critical information is being noticed and processed. Studies have shown that essential elements such as size charts or return policies often receive insufficient attention, contributing to dissatisfaction and post-purchase issues (Petersen & Kumar, 2020).

3.3 Review of Findings From Prior Studies

Prior eye-tracking studies consistently demonstrate that product imagery dominates visual attention in fashion e-commerce, often preceding any engagement with textual information. Users typically form initial impressions of apparel based on images within milliseconds, relying on visual cues to assess style, fit, and desirability before consulting descriptions or specifications (Workman & Caldwell, 2007). This visual primacy highlights the role of imagery as the primary gateway to deeper engagement.

Research examining the number of product images has found that while multiple images enhance information richness, excessive image counts can overwhelm users and dilute attention. Eye-tracking evidence suggests that users tend to focus on the first few images presented and ignore later ones unless guided by strong visual cues or interactive features. Beyond an optimal threshold, additional images contribute to visual clutter rather than clarity, increasing cognitive load and reducing decision efficiency (Park & Kim, 2020).

The presence of human models has been shown to significantly influence visual attention patterns. Images featuring models attract longer fixations and faster initial attention compared to flat-lay or mannequin displays. Facial features and body posture guide gaze and help users imagine fit and usage contexts, which is particularly valuable in apparel evaluation (Cerf et al., 2008). Background simplicity also plays a crucial role; neutral or minimal backgrounds help concentrate attention on the garment, while complex or stylised backgrounds often divert attention away from key product attributes.

Eye-tracking studies on product recommendation systems reveal mixed outcomes. While recommendations can support discovery, they are frequently overlooked due to banner blindness or visual competition with the main product content. In some cases, recommendations interrupt visual flow and distract users from completing their primary task. These findings suggest that recommendation effectiveness depends heavily on placement and integration within the visual hierarchy rather than mere presence (Djamasbi et al., 2011).

3.4 Design Implications for Fashion E-Commerce

Eye-tracking findings offer clear design implications for fashion e-commerce platforms. The placement of buttons and filters should align with natural eye movement patterns, ensuring that critical actions such as size selection and add-to-cart options fall within high-attention zones near product imagery. Poorly positioned controls are often overlooked, increasing friction and abandonment rates.

Establishing a clear image hierarchy is equally important. Primary product images should dominate visual attention through size, contrast, and positioning, while secondary images should support comparison without overwhelming the user. Consistent spacing and alignment guide smooth scan paths, reducing cognitive effort and enabling more efficient decision-making (Wedel & Pieters, 2018).

Reducing visual noise is essential for maintaining attentional focus. Excessive promotional badges, pop-ups, or competing colour schemes fragment attention and disrupt visual flow. Eye-tracking research shows that cluttered interfaces generate scattered fixations and erratic scan paths, which are strongly associated with cognitive fatigue and drop-off behaviour (Sweller, 2011). Simplified layouts that prioritise clarity and visual coherence support more confident and satisfying shopping experiences.

4. Cognitive Load in Apparel Buying

Cognitive load plays a decisive role in shaping user experience and decision-making in fashion e-commerce environments. Apparel shopping online requires users to process large volumes of visual and textual information while simultaneously evaluating subjective attributes such as style, fit, and personal preference. Unlike utilitarian product categories, fashion consumption involves hedonic, emotional, and identity-related judgments, all of which increase mental effort. When digital interfaces impose excessive cognitive demands, users experience difficulty in processing information, reduced decision confidence, and a higher likelihood of abandoning the shopping journey. Understanding cognitive load, therefore, is essential for evaluating the effectiveness of fashion e-commerce interfaces and for designing experiences that align with the limitations of human cognition.

4.1 Cognitive Load Theory: Intrinsic, Extraneous, and Germane Load

Cognitive Load Theory provides a foundational framework for understanding how mental effort affects learning, decision-making, and task performance. The theory is based on the premise that human working memory has limited capacity and that performance deteriorates when this capacity is exceeded (Sweller, 1988; Sweller, Ayres, & Kalyuga, 2011). Cognitive load is typically divided into three components: intrinsic load, extraneous load, and germane load.

Intrinsic cognitive load refers to the inherent complexity of the task itself. In fashion e-commerce, intrinsic load arises from the nature of apparel evaluation, which involves interpreting multiple attributes such as size, fit, fabric, colour, and style. Users must mentally simulate how a garment will look and feel in real life, often relying on incomplete or ambiguous information. This complexity cannot be eliminated but can be managed through effective interface design.

Extraneous cognitive load is generated by the way information is presented rather than by the task itself. Poor interface design, cluttered layouts, inconsistent navigation, and redundant information increase extraneous load by forcing users to expend mental effort on interpreting the interface rather than evaluating the product. In fashion e-commerce, extraneous load is particularly problematic because visual overload and poorly structured information can obscure essential details and disrupt the decision-making process.

Germane cognitive load refers to the mental effort devoted to meaningful processing and schema formation. In online shopping, germane load supports productive engagement, such as comparing

alternatives, learning brand sizing patterns, or understanding fabric properties. Well-designed interfaces encourage germane load by guiding attention to relevant information and supporting efficient decision-making. The goal of effective UX design is not to eliminate cognitive load entirely, but to minimise extraneous load while supporting intrinsic and germane processing.

4.2 Factors That Increase Cognitive Load in Fashion E-Commerce

Several interface-related factors contribute to elevated cognitive load in fashion e-commerce environments. One major contributor is the presence of excessive filters. While filters are intended to help users narrow down choices, an overabundance of filtering options can overwhelm users, forcing them to evaluate too many parameters simultaneously. Eye-tracking and usability studies indicate that users often struggle to interpret complex filter menus, leading to hesitation and abandonment rather than improved decision efficiency (Petersen & Kumar, 2020).

Information-dense product pages also significantly increase cognitive load. Fashion product pages frequently include multiple images, videos, textual descriptions, fabric details, size guides, reviews, and recommendation modules. When this information is presented without clear hierarchy or visual separation, users must exert additional mental effort to identify what is relevant. Research suggests that users tend to skim such pages rather than engage deeply, increasing the risk of misinterpretation or decision fatigue (Park & Kim, 2020).

Complex navigation structures further exacerbate cognitive load. Inconsistent category labels, deep menu hierarchies, and unclear pathways make it difficult for users to maintain a coherent mental model of the website. In fashion e-commerce, where users often browse across categories and styles, navigation complexity disrupts the shopping flow and increases cognitive effort. Studies show that when users expend excessive mental resources on navigation, they are less able to evaluate products effectively (Norman, 2013).

Confusing size charts represent one of the most significant sources of cognitive load in apparel buying. Unlike physical stores, online platforms require users to interpret sizing information without direct try-on. Inconsistent size standards, poorly explained measurement methods, and overly technical charts force users to perform mental calculations and comparisons, increasing uncertainty and frustration. Cognitive overload related to sizing has been directly linked to higher return rates and purchase hesitation in fashion e-commerce (Shen, 2014).

4.3 Prior Research on Cognitive Load and Online Shopping

A substantial body of research has examined the relationship between cognitive load and online consumer behaviour. One key concept is decision fatigue, which refers to the deterioration of decision quality after prolonged cognitive effort. In fashion e-commerce, users frequently compare multiple similar products, leading to cumulative mental exhaustion. Research indicates that decision fatigue reduces satisfaction, increases reliance on heuristics, and raises the likelihood of abandoning the purchase altogether (Baumeister et al., 2008).

Choice overload is another well-documented phenomenon in online shopping contexts. When users are presented with too many options, their ability to make satisfying decisions declines. Studies in consumer psychology have shown that excessive choice increases cognitive load, reduces perceived control, and leads to avoidance behaviour (Iyengar & Lepper, 2000). In fashion e-commerce, where product assortments are often vast, choice overload can undermine the perceived value of variety and negatively impact conversion rates.

Drop-off behaviour has also been linked to elevated cognitive load. Users are more likely to abandon product pages or exit websites when they experience confusion, information overload, or navigation difficulty. Neuro-UX studies combining eye-tracking and physiological measures suggest that cognitive overload manifests as erratic visual scanning, prolonged fixations on navigational elements, and increased emotional arousal associated with stress (Vecchiato et al., 2014). These indicators often precede session termination, highlighting the importance of managing cognitive load to retain users.

4.4 Design Implications for Reducing Cognitive Load

Reducing cognitive load in fashion e-commerce requires deliberate design strategies that align with human cognitive limitations. Simplifying filter menus is a critical first step. Grouping related filters, using intuitive labels, and prioritising commonly used options reduce the mental effort required to narrow choices. Progressive filtering, where advanced options are revealed only when needed, helps prevent initial overload.

Highlighting key product specifications is another effective strategy. Rather than presenting all information simultaneously, designers can emphasise the most decision-critical attributes such as size, price, material, and fit. Visual cues, typographic hierarchy, and icons help users quickly identify relevant information without extensive scanning.

Progressive disclosure is particularly effective in managing information density. By revealing information gradually, interfaces allow users to access additional details only when they are ready, reducing extraneous cognitive load. This approach supports a smoother decision-making process by aligning information presentation with the user's cognitive readiness (Norman, 2013).

Overall, managing cognitive load is essential for creating effective fashion e-commerce experiences. By minimising extraneous demands and supporting meaningful cognitive processing, designers can enable users to make confident, satisfying decisions. When integrated with Neuro-UX tools such as eye-tracking, cognitive load theory provides a robust framework for understanding and improving online apparel buying experiences.

5. Integrating Neuro-UX Insights into Fashion UX Design

The integration of Neuro-UX insights into fashion e-commerce design represents a shift from intuition-driven aesthetics to evidence-based experience optimization. While traditional UX design focuses on usability heuristics and behavioural outcomes, Neuro-UX provides deeper insight into how users cognitively and emotionally respond to interface elements. By combining eye-tracking data, cognitive load measurements, and emotional response indicators, designers can create fashion e-commerce experiences that align more closely with human perceptual and cognitive processes. This integration is particularly valuable in apparel buying contexts, where visual complexity, emotional engagement, and decision uncertainty are inherent to the task.

5.1 Product Page Optimization

Product pages serve as the central decision-making environment in fashion e-commerce, making them a critical focal point for Neuro-UX-driven design interventions. One of the most extensively studied variables is the optimal number of product images. Neuro-UX research suggests that while multiple images enhance information richness and reduce uncertainty, excessive image counts can increase cognitive load and dilute attention. Eye-tracking studies indicate that users typically focus on the first few images and show diminishing engagement with subsequent visuals unless guided by clear visual cues or

interactive elements (Park & Kim, 2020). This suggests that an optimal image count balances informational sufficiency with visual clarity rather than maximizing quantity.

The use of video versus static visuals has also gained attention within Neuro-UX research. Videos can enhance understanding of garment fit, movement, and drape, offering dynamic information that static images cannot convey. However, videos also demand sustained attention and may increase cognitive load if poorly integrated. Eye-tracking data shows that users often delay engaging with videos until after initial image evaluation, suggesting that videos function best as supplementary rather than primary content (Djamasbi et al., 2011). Neuro-UX findings therefore support a layered approach, where static images establish first impressions and videos provide deeper engagement for users seeking additional reassurance. Eye-tracking-informed placement of critical elements such as size selectors, pricing, and call-to-action buttons further enhances product page effectiveness. Research consistently demonstrates that users' attention clusters around product images, making adjacent placement of key decision elements more intuitive and cognitively efficient (Holmqvist et al., 2011). When essential controls are positioned outside primary attention zones, users must actively search for them, increasing extraneous cognitive load and disrupting decision flow.

5.2 Enhancing Navigation and Search

Navigation and search functions play a crucial role in shaping the overall shopping journey, particularly in fashion e-commerce platforms with large product assortments. Neuro-UX insights reveal that poorly structured navigation systems significantly increase cognitive load by forcing users to maintain complex mental models of site structure. Eye-tracking studies show that users often exhibit prolonged fixations and erratic scan paths when navigation labels are ambiguous or when category hierarchies are overly deep (Wedel & Pieters, 2018).

Filter grouping is a key design strategy informed by Neuro-UX research. Grouping related filters and presenting them in a logical, visually segmented manner reduces the mental effort required to interpret options. Progressive filter disclosure further minimizes initial overload by revealing advanced options only when needed. This approach aligns with cognitive load theory by reducing extraneous load while preserving the user's ability to refine searches effectively (Sweller et al., 2011).

Reducing cognitive noise is equally important. Cognitive noise refers to unnecessary visual or informational elements that compete for attention without contributing to task completion. Eye-tracking evidence suggests that promotional banners, pop-ups, and visually dominant advertisements often divert attention away from core shopping tasks, leading to fragmented scan paths and increased frustration (Djamasbi et al., 2011). Minimizing such distractions supports sustained attention and smoother navigation.

Visually intuitive categorization further enhances navigational efficiency. Categories that reflect users' mental models, such as style-based or occasion-based groupings, reduce cognitive effort and support faster decision-making. Neuro-UX research emphasizes that intuitive categorization aligns with schema-based processing, enabling users to rely on existing cognitive structures rather than constructing new ones during interaction (Norman, 2013).

5.3 Personalization and AI-Driven Recommendations

Personalization and AI-driven recommendation systems are increasingly central to fashion e-commerce strategies, but their effectiveness depends on how well they manage cognitive load. Neuro-UX research indicates that personalization can reduce choice overload by narrowing options and increasing perceived relevance, thereby lowering intrinsic cognitive load (Iyengar & Lepper, 2000). However, poorly

implemented personalization may introduce additional complexity, particularly when recommendations are visually intrusive or poorly aligned with user intent.

Eye-tracking studies reveal that users often ignore recommendation modules when they compete visually with primary content, a phenomenon commonly referred to as banner blindness. Recommendations are more effective when integrated seamlessly within the visual hierarchy, supporting rather than interrupting the decision process (Djamasbi et al., 2011). Adaptive interfaces that adjust recommendation prominence based on user behaviour can further enhance relevance and reduce unnecessary cognitive demand.

AI-driven adaptive interfaces also hold potential for dynamically managing cognitive load. By responding to user signals such as browsing depth, hesitation, or repeated comparisons, adaptive systems can simplify interfaces, highlight key information, or reduce option sets in real time. Neuro-UX frameworks support this adaptive approach by providing physiological indicators of overload, which can inform responsive design interventions (Vecchiato et al., 2014).

5.4 Virtual Try-On and Interactive Elements

Virtual try-on technologies and interactive features represent one of the most significant innovations in fashion e-commerce, offering solutions to uncertainty related to fit and appearance. From a Neuro-UX perspective, these technologies can both alleviate and exacerbate cognitive load depending on their design and implementation. Well-designed virtual try-on tools reduce intrinsic load by providing concrete visual representations that support mental simulation, thereby enhancing confidence and reducing uncertainty (Shen, 2014).

However, interactive elements also introduce additional cognitive demands. Eye-tracking studies show that users may struggle to understand how to interact with virtual try-on features, leading to prolonged fixations and disorganised scan paths that signal confusion. Clear visual affordances, instructional cues, and gradual onboarding are therefore essential for ensuring that interactivity enhances rather than hinders user experience.

Eye-tracking insights into usage behaviour reveal that users typically engage with virtual try-on features after initial product evaluation rather than at the outset. This suggests that such tools function best as decision-support mechanisms rather than primary entry points. When integrated thoughtfully, virtual try-on technologies can reduce cognitive load, increase engagement, and bridge the gap between digital and physical apparel evaluation.

In summary, integrating Neuro-UX insights into fashion UX design enables a more precise alignment between interface design and human cognitive processes. By optimising product pages, navigation systems, personalization strategies, and interactive technologies through neuroscientific evidence, fashion e-commerce platforms can create experiences that are visually compelling, cognitively efficient, and emotionally engaging.

5.5 Future Opportunities

The future of Neuro-UX in fashion e-commerce lies in its increasing integration with real-time data systems, advanced artificial intelligence, and immersive technologies. As digital fashion platforms grow more sophisticated, the ability to dynamically respond to users' cognitive and emotional states represents a significant opportunity to enhance user experience and decision-making efficiency. One promising direction is the use of real-time neurometric feedback to adapt interfaces as users interact with them. Advances in wearable sensors, webcam-based eye-tracking, and lightweight EEG technologies suggest the possibility of continuously monitoring indicators of attention, cognitive load, and emotional arousal during online shopping sessions (Vecchiato et al., 2014). Such real-time insights could allow systems to

detect moments of overload or confusion and respond by simplifying interfaces, reducing option sets, or highlighting key information, thereby supporting smoother decision pathways.

Another emerging opportunity lies in the development of AI models capable of predicting user attention and cognitive effort without requiring direct physiological measurement. By training machine learning models on large-scale eye-tracking and behavioural datasets, platforms can infer attention patterns based on interaction data such as cursor movement, scrolling behaviour, and dwell time. Predictive attention models could enable designers to simulate user gaze behaviour during the design phase, allowing for proactive optimization of visual hierarchy and layout before deployment (Wedel & Pieters, 2018). In fashion e-commerce, such models could be particularly valuable for testing product page designs, recommendation placements, and promotional content without the cost and complexity of traditional neurometric studies.

Cross-cultural Neuro-UX research represents another critical frontier. Visual attention patterns, aesthetic preferences, and cognitive processing strategies are influenced by cultural norms and perceptual habits. Existing eye-tracking and cognitive load studies are often conducted within limited cultural contexts, reducing their generalizability across global fashion markets. Expanding Neuro-UX research to include diverse cultural groups can help identify how factors such as colour perception, model representation, layout preferences, and information density affect users differently across regions (Nisbett & Miyamoto, 2005). For global fashion brands, such insights are essential for designing culturally adaptive interfaces that resonate with local audiences while maintaining brand consistency.

The growing adoption of augmented reality and virtual reality technologies in fashion e-commerce further amplifies the relevance of Neuro-UX. AR and VR-based interfaces promise to bridge the gap between digital and physical shopping by offering immersive, experiential interactions. From a cognitive perspective, these technologies have the potential to reduce intrinsic cognitive load by enhancing mental simulation of fit, movement, and appearance. However, they also introduce new forms of cognitive and perceptual demand that must be carefully managed. Neuro-UX tools can play a crucial role in evaluating how users navigate immersive environments, how attention is distributed in three-dimensional spaces, and how interaction complexity affects mental workload (Slater & Sanchez-Vives, 2016). Eye-tracking within AR and VR environments can reveal whether immersive features support intuitive exploration or introduce confusion and fatigue.

Collectively, these future opportunities highlight the evolving role of Neuro-UX as a strategic framework rather than a niche research method. As fashion e-commerce moves toward greater personalization, immersion, and real-time responsiveness, understanding the cognitive and emotional dimensions of user interaction becomes increasingly critical. Neuro-UX offers the tools and theoretical foundations necessary to guide this evolution, enabling fashion platforms to design experiences that are not only technologically advanced but also cognitively humane and psychologically aligned with users' needs.

6. Conclusion

This review set out to examine how Neuro-UX frameworks, particularly eye-tracking and cognitive load theory, contribute to a deeper understanding of user behaviour in fashion e-commerce environments. The synthesis of existing literature demonstrates that eye-tracking significantly enhances understanding of visual attention by revealing how users allocate gaze, process imagery, and navigate complex interfaces in real time. Fashion e-commerce, being a highly visual and experiential domain, relies heavily on these attentional mechanisms. Eye-tracking studies consistently show that product images, human models, and

visually salient elements dominate early attention and strongly influence subsequent engagement and evaluation. By uncovering patterns of fixations, scan paths, and attention distribution, eye-tracking provides objective evidence of how design elements support or hinder intuitive interaction.

The review also highlights the central role of cognitive load in explaining user drop-offs, decision fatigue, and reduced satisfaction in online apparel buying. Cognitive load theory offers a robust explanatory framework for understanding why users struggle in visually dense and choice-heavy environments. Intrinsic load arises from the inherent complexity of apparel evaluation, while extraneous load is frequently introduced by poor interface design, excessive filtering options, cluttered layouts, and confusing size information. Prior research demonstrates that when cognitive demands exceed users' mental capacity, decision quality deteriorates and avoidance behaviours such as session abandonment increase. By linking these outcomes to measurable design factors, cognitive load theory enables a more precise diagnosis of usability failures in fashion e-commerce platforms.

Taken together, the integration of eye-tracking and cognitive load research underscores the value of Neuro-UX as a stronger foundation for design decision-making. Unlike traditional UX methods that rely primarily on self-reported feedback or behavioural metrics, Neuro-UX captures subconscious cognitive and emotional processes that shape user experience. This deeper insight allows designers to move beyond surface-level optimisation and address the underlying psychological drivers of attention, engagement, and choice. Neuro-UX thus supports more evidence-based, human-centred design strategies that align interface structure with the realities of human perception and cognition.

The importance of these insights for fashion e-commerce is substantial. By applying Neuro-UX principles, platforms can create smoother user journeys that reduce friction and mental effort, leading to more confident decision-making and higher conversion rates. Optimised visual hierarchy, simplified navigation, and cognitively efficient product pages not only improve usability but also foster emotional engagement by allowing users to focus on the experiential aspects of fashion rather than interface complexity. As competition in digital fashion intensifies, the ability to deliver intuitive, emotionally resonant experiences becomes a critical differentiator.

Despite its contributions, the current body of Neuro-UX research in fashion e-commerce has notable limitations. Many eye-tracking and neurometric studies rely on relatively small sample sizes, which restricts the generalizability of findings. Additionally, much of the existing research is conducted within specific cultural contexts, limiting its applicability to global fashion markets. The rapid evolution of e-commerce technologies further complicates longitudinal comparisons, as interfaces and user behaviours continue to change. These limitations highlight the need for larger, more diverse studies and for continued integration of Neuro-UX with complementary research methods.

In conclusion, Neuro-UX represents a powerful and evolving approach to understanding digital fashion consumption. When integrated with traditional UX research, it provides a comprehensive framework that captures both conscious behaviour and subconscious cognitive processes. By aligning design decisions with how users actually perceive, think, and feel, Neuro-UX can drive the next generation of fashion e-commerce experiences that are not only functional and efficient, but also intuitive, emotionally engaging, and deeply human-centred.

References

1. Ariely, D., & Berns, G. S. (2010). Neuromarketing: The hope and hype of neuroimaging in business. *Nature Reviews Neuroscience*, 11(4), 284–292.

2. Babiloni, F., & Astolfi, L. (2014). Social neuroscience and hyperscanning techniques: Past, present and future. *Neuroscience & Biobehavioral Reviews*, 44, 76–93.
3. Boucsein, W. (2012). *Electrodermal activity* (2nd ed.). Springer.
4. Cerf, M., Frady, E. P., & Koch, C. (2008). Faces and text attract gaze independent of the task: Experimental data and computer model. *Journal of Vision*, 8(6), 1–15.
5. Djamasbi, S., Siegel, M., & Tullis, T. (2014). Visual appeal and future intentions: A study of website designs. *International Journal of Human–Computer Studies*, 72(10), 816–826.
6. Falk, E. B., Berkman, E. T., & Lieberman, M. D. (2015). From neural responses to population behavior: Neural focus group predictors of population-level media effects. *Psychological Science*, 23(5), 439–445.
7. Garrett, J. J. (2011). *The elements of user experience: User-centered design for the web and beyond* (2nd ed.). New Riders.
8. Hassenzahl, M. (2010). *Experience design: Technology for all the right reasons*. Morgan & Claypool.
9. Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures*. Oxford University Press.
10. Iyengar, S. S., & Lepper, M. R. (2000). When choice is demotivating: Can one desire too much of a good thing? *Journal of Personality and Social Psychology*, 79(6), 995–1006.
11. Jacob, R. J. K., & Karn, K. S. (2003). Eye tracking in human–computer interaction and usability research. *Ready-to-Hand*, 573–605.
12. Kahneman, D. (2011). *Thinking, fast and slow*. Farrar, Straus and Giroux.
13. Kumar, V., & Reinartz, W. (2021). Creating enduring customer value. *Journal of Marketing*, 85(1), 14–36.
14. LeDoux, J. (1996). *The emotional brain: The mysterious underpinnings of emotional life*. Simon & Schuster.
15. Lindgaard, G. (2019). Early impressions of websites: Quantifying the importance of first impressions. *Behaviour & Information Technology*, 38(8), 873–885.
16. Lindgaard, G., Fernandes, G., Dudek, C., & Brown, J. (2006). Attention web designers: You have 50 milliseconds to make a good first impression! *Behaviour & Information Technology*, 25(2), 115–126.
17. Moreno, R., & Mayer, R. E. (2007). Interactive multimodal learning environments. *Educational Psychology Review*, 19(3), 309–326.
18. Norman, D. A. (2013). *The design of everyday things* (Revised and expanded ed.). Basic Books.
19. Park, J., & Kim, J. (2020). The role of fashion product presentation in online shopping: Visual cues and consumer responses. *Journal of Retailing and Consumer Services*, 52, 101923.
20. Petersen, B., & Gerstheimer, O. (2020). Cognitive load in e-commerce decision-making: The role of interface complexity. *Journal of Retailing and Consumer Services*, 54, 102002.
21. Plass, J. L., Moreno, R., & Brünken, R. (2010). *Cognitive load theory*. Cambridge University Press.
22. Riegelsberger, J., Sasse, M. A., & McCarthy, J. D. (2005). The mechanics of trust: A framework for research and design. *International Journal of Human-Computer Studies*, 62(3), 381–422.
23. Schweiger, S., Otterbring, T., & Gidlöf, K. (2020). Visual attention, purchase decisions, and eye-tracking research: A review and future directions. *Psychology & Marketing*, 37(9), 1216–1241.
24. Sweller, J. (2011). Cognitive load theory. *Psychology of Learning and Motivation*, 55, 37–76.
25. Tuch, A. N., Presslauer, E. E., Stöcklin, M., Opwis, K., & Bargas-Avila, J. A. (2012). The role of visual complexity and prototypicality regarding first impression of websites. *International Journal of*

- Human–Computer Studies, 70(11), 794–811.
26. Vecchiato, G., Astolfi, L., Fallani, F. D. V., Cincotti, F., Mattia, D., Salinari, S., Soranzo, R., & Babiloni, F. (2014). Changes in brain activity during the observation of TV commercials using EEG, GSR and HR measurements. *Brain Topography*, 23(2), 165–179.
 27. Wedel, M., & Pieters, R. (2008). Eye tracking for visual marketing. *Foundations and Trends® in Marketing*, 1(4), 231–320.
 28. Bateman, S., Mandryk, R. L., Gutwin, C., Genest, A., McDine, D., & Brooks, C. (2010). Useful junk? The effects of visual embellishment on comprehension and memorability of charts. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2573–2582.
 29. Cowan, N. (2010). The magical mystery four: How is working memory capacity limited, and why? *Current Directions in Psychological Science*, 19(1), 51–57.
 30. Dhar, R., Nowlis, S. M., & Sherman, S. J. (2000). Trying hard or hardly trying: An analysis of context effects in choice. *Journal of Consumer Psychology*, 9(4), 189–200.
 31. Duchowski, A. T. (2007). *Eye tracking methodology: Theory and practice* (2nd ed.). Springer.
 32. Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology*, 47(6), 381–391.
 33. Guo, F., Liu, C., & Wang, J. (2016). Eye tracking study of website layout and navigation. *Information & Management*, 53(5), 605–617.
 34. Lavie, N. (2005). Distracted and confused? Selective attention under load. *Trends in Cognitive Sciences*, 9(2), 75–82.
 35. Pieters, R., & Wedel, M. (2004). Attention capture and transfer in advertising: Brand, pictorial, and text-size effects. *Journal of Marketing*, 68(2), 36–50.
 36. Rosenholtz, R., Li, Y., & Nakano, L. (2007). Measuring visual clutter. *Journal of Vision*, 7(2), 1–22.
 37. Xu, Y., & Kim, H. (2008). Order effects in online product customization: The role of cognitive load. *Journal of Marketing Research*, 45(4), 427–437.