

Illuminating furniture e-retailing: an eye-tracking study on effects of image brightness and design complexity on visual attention and consumer perceptions through the AC-TER model

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Abstract

Purpose – Grounded in the Attention Capture and Transfer by Elements of Advertisements (AC-TEA) model, this study examines atmospheric variables, image brightness and design complexity, in furniture e-retail by integrating visual attention with perceptions of pleasantness and order.

Design/methodology/approach – An eye-tracking experiment measured consumers' visual attention in images simulating furniture e-retail storefronts or catalogues. Metrics included pupil dilation as an index of emotional arousal and cognitive effort, and fixation-based measures to capture visual attention and information processing. The study used home-interior images varying in brightness and design complexity, integrating physiological data with post-test perceptions of pleasantness and order.

Findings – Results show greater pupil dilation when consumers view dark-filtered or highly complex images, indicating higher emotional arousal and cognitive effort. Brighter lighting conditions are associated with reduced pupil dilation. Scene complexity also affects attentional metrics, leading to longer fixation durations but fewer fixations in high-complexity images, suggesting a more focused visual information processing. Furthermore, these visual attention patterns translate into perceptual judgements, with attention to dark and moderately structured scenes positively predicting pleasantness and order, respectively, while sustained attention to highly complex scenes is associated with lower perceived order.

Originality/value – This study provides novel evidence, integrating eye-tracking with subjective measures, on the effects of image brightness and design complexity on consumer attention and perceptions in furniture

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1. Introduction

E-commerce has transformed consumer behaviour and shopping experiences (Baek *et al.*, 2020; Jocevski *et al.*, 2019). Eroglu *et al.* (2003) established e-atmospheric as key for shaping consumer behaviour and ensuring retail success. Accordingly, retailers should develop e-atmospheric strategies to increase consumers' attentional focus (Cialdini, 2016; Jang *et al.*, 2018), website visit duration, and repeat patronage (Kim and Lee, 2020), critical elements for digital environments with minimal search costs (Mandel and Johnson, 2002).

In this context, increasing attention has been paid to how online stores present products to make shopping enjoyable (Essawy, 2019). The literature distinguishes between two primary e-atmospheric dimensions: "information design", related to structure, navigation, and data access, and "graphic design", which encompasses visual appeal and interface style (Loureiro and Roschk, 2014). The relevance of e-atmospheric is context-dependent; in the hotel industry, for instance, information design has been identified as the sole significant predictor of emotions and booking intentions, while graphic design appears to have no significant impact (Essawy, 2019). Nevertheless, e-atmospheric has not been explored in the furniture retail sector (de Oliveira *et al.*, 2019). In this context, graphic design (lighting, colour schemes, furniture arrangement, or decorative elements) is expected to be more pivotal; a well-designed atmosphere can inspire customers, demonstrate product relevance, and elicit emotional responses that encourage exploration and purchase. These considerations suggest that digital retail environments can deliver differentiated value when visual elements are strategically integrated to capture consumers' attentional focus (Cialdini, 2016).

As highlighted by Turley and Chebat (2002), a store's digital environment serves as a strategic variable; e-atmospheric factors directly shape consumer perception, emotion, and behaviour, specifically determining their navigation experience, attitudes toward the website, and subsequent behavioural intentions (Jiménez-Barreto and Campo-Martínez, 2018; Küster *et al.*, 2016). Research has examined the effects of store atmospherics on consumer behaviour in physical retail environments (Turley and Milliman, 2000) and alternative retail channels (Lyu *et al.*, 2022). Within brick-and-mortar settings, research has focused on auditory stimuli (Jain and Bagdare, 2011), colour (Martínez *et al.*, 2021), ambient scent (Ward *et al.*, 2007), and perceived crowding (Mehta *et al.*, 2013).

However, research on specific visual stimuli in digital interfaces remains limited and has predominantly relied on quantitative surveys or experimental designs (Lyu *et al.*, 2022). Consequently, few studies have employed neuroscience methodologies such as eye tracking to objectively measure the effects of digital features on consumers' attentional focus beyond self-reported data. In this regard, recent literature in consumer neuroscience underscores the capacity of neurophysiological tools to reveal underlying psychological mechanisms that often remain inaccessible through traditional metrics (Bigne *et al.*, 2025; Casado-Aranda and Sánchez-Fernández, 2022; Gheorghe *et al.*, 2023; Simonetti and Bigne, 2026; Song *et al.*, 2025).

Furthermore, several environmental variables remain underexplored in retail contexts. In particular, empirical research on lighting or brightness remains limited (Areni and Kim, 1994; Boyce, 2004; Briand and Pras, 2010; Quartier *et al.*, 2014). This gap is evident in digital furniture retail, where lighting and image brightness can be easily modified by retailers with significant implications for consumers' purchase-related behaviour (Rosenthal, 2005).

Overall, findings in this domain remain inconclusive, with studies reporting weak, context-dependent, or non-significant effects (Areni and Kim, 1994; Summers and Hebert, 2001). Reflecting the nascent state of e-atmospherics research, this lack of consensus highlights the

need to clarify how variations in image brightness influence consumer responses, particularly in terms of attentional focus and emotional arousal (Boyce, 2004).

Environmental visual complexity constitutes another graphic design dimension that has received limited attention in e-atmospherics. Complexity, understood as the degree of visual richness, information density, and variety within a space (Nasar, 2000), has primarily been examined in outdoor or architectural contexts, or as a general antecedent to emotional arousal in web interfaces (Deng and Poole, 2010). However, its effects on attentional focus and emotional responses in online furniture environments remain underexplored. Although studies such as Kerfoot *et al.* (2003) emphasise the importance of visual design elements in shaping shopping behaviour, they do not address how different levels of environmental complexity, particularly in website contexts, affect consumer responses. As such, there is a need for neuroscientific methodologies to clarify how these visual cues influence consumer focus and emotional arousal.

Addressing these gaps, the present study examines how variations in image brightness and visual complexity (the density of visual stimuli within a retail scene) independently influence consumers' attentional focus and emotional arousal in an online furniture retail context. To achieve these objectives and overcome the limitations of self-reported data predominant in the field, eye-tracking technology is employed to record consumer gaze behaviour and pupil response when viewing images with varying levels of brightness and complexity. This research focuses on furniture retailing, using images of home interiors as visual stimuli to identify how digital features modulate consumer attention and emotional arousal. By supplementing objective eye-tracking metrics with subjective perceptual measures of pleasantness and perceived order, this research provides a more holistic understanding of how e-atmospheric features influence consumer responses.

2. Theoretical framework

2.1 Store atmospherics and consumer visual processing

The environmental design of retail spaces plays a strategic role as a key attraction factor in shaping consumer experiences and driving visit intentions, structuring how shoppers perceive, attend to, and emotionally respond to atmospheric stimuli (Ortegón-Cortázar and Royo-Vela, 2017). Specifically, empirical evidence in retailing demonstrates that commercial and environmental cues shape consumers' internal perceptions and emotional states, which in turn drive subsequent behavioural outcomes such as purchase intentions (Cakici and Tekeli, 2022). With the advent of e-commerce, many researchers have investigated whether knowledge from offline stores can also be applied to online stores (Lombart *et al.*, 2020; Vrechopoulos *et al.*, 2004). Research on web atmospherics has consistently shown that e-store design environment influences consumer attitudes, attentional focus, emotional states, behaviour, and decision-making processes (Cialdini, 2016; Eroglu *et al.*, 2003; Wedel and Pieters, 2007).

According to the conceptual model of Muñoz-Leiva *et al.* (2025) and the Attention Capture and Transfer by Elements of Advertisements (AC-TEA) model (Pieters and Wedel, 2004), these visual stimuli are considered “bottom-up” factors that determine perceptual relevance through two mechanisms: baseline capture, which is fast and automatic, and incremental capture, which involves more effortful cognitive processing. “Top-down” factors, such as a consumer's motivations, opinions, gender, age and experience, modulate their attention to and perception of visual stimuli. Therefore, understanding how visual variables influence emotional arousal is essential for analysing consumer behaviour and informing effective store and website designs.

2.2 Brightness intensity, visual attention, and emotional arousal: proposed hypotheses

From an information-processing perspective, research in physical retail has shown that lighting intensity may alter visual exploration by affecting perceptual clarity and visual load.

Brighter settings enhance visual accessibility, exploration, and engagement with displayed products (Areni and Kim, 1994; Summers and Hebert, 2001). In digital environments, image brightness serves as the equivalent of physical lighting and constitutes a key design variable, as luminance contrast is essential for visual perception (Valberg, 2005).

Beyond visibility, image processing research reveals a “brightness bias”, where brighter naturalistic photographs are evaluated more positively than darker counterparts (Lakens *et al.*, 2013). This association between brightness and positive valence may reflect an evolutionary predisposition where darkness increases anxiety while brightness facilitates positive evaluations (Grillon *et al.*, 1997; Lakens *et al.*, 2013). Thus, by manipulating this graphic design element, online retailers can influence consumer emotional evaluations.

Empirical studies have associated brighter environments with changes in fixation-based attention metrics, including longer fixation durations and focused visual processing, although these effects appear to depend on task demands and stimulus characteristics (Li *et al.*, 2024; Wästlund *et al.*, 2015). At the same time, excessively bright conditions may increase visual load and reduce visual comfort, modulating these attentional patterns (Li *et al.*, 2024).

Eye-tracking research suggests a compensatory relationship between fixation duration and fixation count, whereby longer fixations are often accompanied by fewer fixations, reflecting focused, less exploratory visual processing, particularly under increased perceptual or cognitive engagement (Holmqvist *et al.*, 2011; Rayner, 1998; Wedel and Pieters, 2008a).

In this regard, the AC-TEA model provides a robust framework to explain the transition between stages of visual processing within e-atmospherics (Pieters and Wedel, 2004). High image brightness acts as a bottom-up factor that increases visual accessibility and provides the contrast essential for vision (Valberg, 2005), allowing consumers to construct a mental map of the e-store more efficiently. Image brightness facilitates a transition from the initial baseline capture phase (rapid, automatic, parallel processing of the scene’s “gist”) to an incremental capture or informative analysis phase wherein cognitive resources are redirected to specific product attributes. This transition explains the opposite effects observed in eye-tracking metrics: total fixations are replaced with longer, focused fixations when consumers process an e-store’s detailed elements.

Eye-tracking research has shown that fixation-based attention metrics and pupillary responses vary jointly with cognitive demand. For instance, Recarte and Nunes (2000) found that increased task demands are associated with longer fixations, fewer fixation points, and greater pupil dilation, reflecting coordinated changes in visual attention and cognitive load.

Beyond attentional processes, brightness also shape the perceptual context in which emotional responses to retail environments emerge (Boyce, 2004). Emotional arousal elicited by visual stimuli is reflected in psychophysiological indicators such as pupil dilation, with lower dilation indicating reduced arousal (Bradley *et al.*, 2008). In this regard, higher brightness enhances visual clarity and facilitates processing, as proposed by the AC-TEA model, reducing cognitive effort. Consistent with this, pupil size is a sensitive indicator of cognitive load and mental effort (Krejtz *et al.*, 2020). Consequently, brighter stimuli reduce cognitive demands, leading to lower emotional arousal and decreased pupil dilation.

Taken together, prior research suggests that image brightness may influence attentional focus and emotional arousal in online retail environments, although the direction and magnitude of these effects remain inconclusive. Building on this literature, the present study examines whether image brightness is associated with differences in fixation-based attention metrics and pupil dilation in an online furniture retail context, as hypothesised below:

- H1.* Image brightness is expected to influence consumer attentional focus and emotional arousal, such that brighter online furniture retail environments will be

associated with (a) longer fixation durations, (b) fewer fixations, and (c) lower pupil dilation.

2.3 Environmental design complexity and visual information processing

Environmental design complexity represents another relevant but underexamined atmospheric variable in retail research. Defined as the degree of visual richness, information density, and variety within a space (Nasar, 2000), complexity has been shown to influence aesthetic preferences and cognitive appraisal in environmental psychology. In retail contexts, visual complexity is closely linked to how consumers allocate attention and process information within stores (Kerfoot *et al.*, 2003; Wedel and Pieters, 2007).

Research on visual attention suggests that environments high in terms of diversity of visual elements impose greater cognitive demands, leading individuals to adjust their gaze behaviour accordingly (Carrasco, 2011; Treue, 2003). Visually complex stimuli have been shown to elicit longer fixation durations, reflecting increased processing effort, while producing fewer fixations as attention becomes more focused on selected elements (Oliva *et al.*, 2004). Studies in marketing and advertising similarly indicate that higher visual complexity is associated with increased cognitive load and shapes visual exploration patterns (Wedel and Pieters, 2007, 2008a, b). In retail environments, excessive visual complexity exceeds consumers' processing capacity, resulting in sensory overload and impairing their ability to process information and identify relevant products.

In terms of emotion, visually rich environments may elicit higher arousal, insofar as greater stimulus density requires increased perceptual and cognitive resources (De Gee *et al.*, 2014). Despite these indications, limited empirical evidence exists on environmental complexity's effects on consumer attention in retail settings, particularly using objective eye-tracking measures. Accordingly, the present study investigates how furniture-store image complexity in an online context shapes visual attention and emotional arousal.

Within the AC-TEA model, furniture-store image complexity acts as a bottom-up factor that dictates the transition between attentional phases. While a simple scene may be processed through rapid baseline capture, a visually complex environment requires incremental attention and effortful cognitive processing. Therefore, high cognitive effort narrows attentional focus and increases emotional arousal (Krejtz *et al.*, 2020; Pieters and Wedel, 2004):

- H2.* Environmental design complexity is expected to influence consumer visual attention and emotional arousal, such that more visually complex retail environments will be associated with (a) longer fixation durations, (b) fewer fixations, and (c) higher pupil dilation.

2.4 Top-down processing mechanisms in the evaluation of e-retail environments

Visual attention allows consumers to make evaluative judgements. In our context, physiological metrics objectively measure how consumers encode e-atmospheric cues such as brightness, complexity, and organisation. From a top-down processing perspective, environmental evaluations are not solely determined by bottom-up sensory properties but also by attentional selection processes that shape interpretation and meaning (Orquin and Loose, 2013). In retail and service contexts, visual attention toward environmental design influences downstream judgements related to aesthetic appeal, comfort, and perceived organisation, even virtually (Vrechopoulos *et al.*, 2004).

Specifically, prolonged visual engagement with coherent spatial configurations may facilitate perceptual fluency, enhancing judgements of pleasantness and order, whereas sustained attention to visually cluttered environments may increase cognitive load and reduce positive evaluations (Deng and Kahn, 2009; Reber *et al.*, 2004). Therefore, attentional responses measured through fixation behaviour and pupil dilation are expected to predict

consumers' subjective assessments of brightness, pleasantness, and interior spatial orderliness, leading to this research question (RQ):

- RQ1. To what extent do visual attention metrics (fixation duration, fixation count, and pupil dilation) predict consumers' perceptions of brightness, pleasantness, and spatial orderliness in online furniture retail environments?

3. Methodology

3.1 Data collection procedure and participants

To achieve the research objectives, our experiment employed eye-tracking (ET). This study was conducted between February and June 2024 at a university laboratory in southern Spain. Participants were recruited through quota sampling via phone or email, with an incentive of participation in a drawing for an electronic device. Upon being informed of the study details, participants entered a dimly lit laboratory equipped with a 15.6-inch laptop running Tobii Pro Lab v.1.130 software, connected to a Tobii Pro Nano eye-tracker. This system has an accuracy of 0.3° and a precision of 0.10° RMS (utilising a built-in filter) under optimal conditions, with a sampling rate of 60 Hz.

The final sample included 60 individuals aged 18 and above. Participants were randomly assigned to one of four groups based on gender (male/female) and age (under 35 vs. 36 and above), ensuring a representative sample aligned with Spanish population demographics (INE, 2023). The sample distribution was as follows: (1) 53.3% of participants were male and 46.7% female; (2) Participants aged 18–35 represented 48.3% (25% male, 23.3% female); (3) Participants aged 36 and above represented 51.7% (28.3% male, 23.3% female).

During data collection, participants provided informed consent before the experimental task, which involved free image viewing. First, participants were asked to imagine themselves shopping for household products. They then observed home-scene images similar to those typically found on retail websites or digital catalogues, presented on screen. After the experiment, participants completed an online survey via Google Forms to gather demographic variables such as gender, age, education level, income, and occupation, as well as their perceptions regarding variables related to the brightness and design complexity of the home-scene images.

3.2 Experimental design and stimuli used

In the ET experimental session, a within-subject design was employed in which participants viewed 48 home-interior images, categorised into four room types: bathroom (BA), kitchen (KI), bedroom (BE), and lounge (LO) (see [Figure A1 in Online Supplementary Material](#)). The selection process involved an extensive internet search, resulting in 16 final images (four per room) that resembled those found in home websites, magazines, or catalogues. The selected images met the following criteria: (1) licenced for use; (2) high resolution (minimum 1400×1400 pixels); (3) consistent, neutral colour schemes (primarily earth tones); and (4) varying levels of visual richness.

These 16 images varied in brightness and complexity. To adjust brightness, gamma correction was applied, a technique used to align images with human luminance perception. While digital sensors capture light linearly, human vision perceives brightness non-linearly, necessitating gamma correction for accurate image representation (Poynton, 2012). Mathematically, gamma correction follows the transformation $I' = I^\gamma$, where γ (gamma) regulates brightness-values below 1 increase brightness, whereas values above 1 darken the image. In this study, two gamma transformations were applied in Photoshop, producing two brightness variations: “dark” and bright, while the original image was retained as a neutral condition.

To manipulate complexity, three commercial communication experts classified the 16 images into three levels: low, medium, and high. Given that certain room types inherently contain fewer visual elements (e.g. bathrooms and bedrooms compared to kitchens and

lounches), the experts considered this factor during classification. The final set of 48 images was presented in blocks by room type, with images randomised within each block (see [Figure 1](#)), and room presentation order randomised for each participant. Each image was displayed on a computer screen for 10 s, with a 2-second inter-trial interval.

3.3 Measuring instruments

ET methodology enables the extraction of various ocular metrics commonly used in consumer research. In this study, three ET metrics were considered: fixation count (FC), fixation duration (FD), and pupil dilation (PD). A detailed explanation of these metrics, as well as their relationship and the rationale for excluding other measures, is provided in the [Online Supplementary Material](#).

In addition to the objective eye-tracking metrics, the study incorporated subjective measures to capture participants' explicit perceptions of the visual stimuli. These measures focused on two dependent variables: perceived brightness and design complexity. Perceived brightness was assessed using the item: "The lighting in the rooms has created a pleasant atmosphere" (*pleasant lighting*). Design complexity was operationalised through two items: "The furniture retail scenes appear generally tidy" (*general tidiness*) and "The furniture retail scenes have a well-structured interior layout" (*interior layout quality*). These items were adapted from research on retail atmospherics and servicescape perception ([Eroglu et al., 2003, 2005](#)). These items were included in the post-task questionnaire to obtain self-reported evaluations of the environment, complementing the physiological data recorded during the free-viewing task.

Raw data were processed using Tobii Pro Lab v.1.130 software and exported for analyses. Fixation metrics were analysed using IBM SPSS Statistics 28. Specifically, repeated-measures analysis of variance (ANOVA) was employed, with eye-tracking metrics as dependent variables and image brightness and complexity as within-subject factors. The relationship between visual attention and perception variables was analysed through linear regressions. Variables retained in the final model were selected through backward stepwise elimination, retaining only predictors that contributed meaningfully to explained variance.

4. Results

4.1 Effect of brightness level of the images on visual attention

A preliminary analysis confirmed the suitability of including all eye-tracking indicators for the 16 images in the same model, as indicated by the correlation structure ($KMO_{BA1} = 0.673$,



Figure 1. Research design

Bartlett's $\chi^2_{BA1} = 845.38$, $p_{BA1} = 0.000$; $KMO_{BA2} = 0.584$, Bartlett's $\chi^2_{BA2} = 404.26$, $p_{BA2} = 0.000$; ...; $KMO_{LO4} = 0.465$, Bartlett's $\chi^2_{LO4} = 481.64$, $p_{LO4} = 0.000$). A multivariate test of within-subject effects revealed a significant overall effect of brightness level on key attention metrics (hypothesis H1), including fixation count (FC), fixation duration (FD), and pupil dilation (PD) (Wilks' $\Lambda = 0.206$, $F = 46.50$, d.f.1. = 6, d.f.2 or error = 232; $p = 0.000$; see [Table A1 in Online Supplementary Material](#)) on the attention measures considered together, independently of the image considered. When analysing the effect of images on combined metrics, a significant effect was also observed (Wilks' $\Lambda = 0.900$; $F = 2.10$; d.f.1 = 90; d.f.2 = 5,291.84; $p = 0.000$).

Mauchly's test confirmed the sphericity assumption, supporting the validity of the multivariate test results for individual images. Given the inherent heterogeneity among the 16 images (each repeated three times, independent of brightness level), significant effects on the three ocular metrics were expected ($F_{FD} = 3.41$, $p < 0.001$; $F_{FC} = 11.84$, $p < 0.001$; $F_{PD} = 45.27$, $p < 0.001$; see [Table 1](#), ANOVA 1). However, brightness level exhibited a pronounced effect on PD ($F = 214.29$, $p < 0.001$) but not on FD or FC, partially confirming Hypothesis H1 through significant differences in PD across brightness conditions and individual images (see [Figure 2](#)).

The interaction between brightness and image type was significant ($p < 0.05$), suggesting a combined influence on the dependent variables. Although the partial effect size ($\eta_p^2 = 0.051$) was moderate, its statistical power was very high ($1 - \beta = 0.999$), indicating strong reliability in detecting this interaction. A marginally significant interaction ($p = 0.049$), with a smaller effect size ($\eta_p^2 = 0.027$) suggested that while some influence existed, its impact on attentional metrics was less pronounced than for PD. The interaction results indicate that the effect of brightness on attentional measures is image-dependent, meaning that variations in brightness influence attentional responses differently depending on image characteristics.

Regarding brightness effects, the greatest PD occurred for images with the dark filter applied ($PD_D = 3.0$ mm; see [Figure 2c](#)). Conversely, the lowest PD was observed for images with the bright filter applied ($PD_B = 2.8$ mm), suggesting that, as expected, these images generate lower arousal by decreasing perceptual load and cognitive effort in comparison to dark images. These results reaffirm the significant effect of brightness on visual attention, specifically its positive impact on PD (hypothesis H1c). For FD ([H1a](#)) and FC ([H1b](#)), no significant differences were observed across brightness conditions. FD was slightly lower in darker images ($FD_D = 315.9$ ms; see [Figure 2a](#)), but FC remained stable across brightness levels at approximately 24 fixations, contrary to expectations, leading to the partial confirmation of H1.

4.2 Effect of visual attention on perceived atmospheric brightness

Considering the aggregated metrics across the 16 images per condition, the backward regression analysis indicates that visual attention to images with different brightness levels significantly predicts participants' perception that room lighting creates a pleasant atmosphere. Specifically, FD on dark-condition images (FD_D) shows a positive, statistically significant association with perceived atmospheric pleasantness ($\beta = 0.486$, $p < 0.001$; see [Table A2 in Online Supplementary Material](#)). Likewise, the FC on neutral-condition images (FC_N) also exerts a positive and significant effect ($\beta = 0.496$, $p < 0.001$).

These findings suggest that sustained attention (FD) to darker environments and repeated engagement (FC) with neutral-brightness conditions are associated with more favourable evaluations of atmospheric pleasantness. These results clarify the previous eye-tracking analysis, in which brightness was not significantly associated with FD. Furthermore, while the physiological data suggested that bright images might be superior by requiring less cognitive effort and generating lower arousal, as indicated by lower PD, the current findings reveal a different pattern. In this analysis, darker images demonstrate a stronger statistical link to

Table 1. Univariate within-subjects tests for FD, FC and PD: ANOVA 1 and ANOVA 2

Source of variation/ measure	Metric	Type III sum of squares	df	Root mean square	F	Sig
<i>ANOVA 1</i>						
Brightness	FD ^b	11708.51	2	5854.253	0.414	0.662
	FC ^b	19.38	2	9.689	0.399	0.672
	PD ^a	21.86	1.311	16.68	214.29	< 0.001
Images	FD ^a	823143.08	7.842	104966.86	3.41	0.001
	FC ^a	4616.01	10.188	453.07	11.84	< 0.001
	PD ^a	17.24	8.253	2.09	45.27	< 0.001
Brightness*	FD ^a	529556.60	12.586	42075.54	1.33	0.194
	FC ^a	1051.20	18.239	57.63	1.61	0.049
	PD ^a	1.43	14.752	0.10	3.20	< 0.001
Error (Brightness)	FD ^b	1667923.16	118	14134.942		
	FC ^b	2865.12	118	24.281		
	PD ^a	6.02	77.348	0.08		
Error (Images)	FD ^a	14262425.86	462.674	30826.08		
	FC ^a	23007.97	601.106	38.28		
	PD ^a	22.47	486.941	0.05		
Error (Brightness*)	FD ^a	23554739.58	742.565	31720.77		
	FC ^a	38459.63	1076.106	35.74		
	PD ^a	26.43	870.345	0.03		
<i>ANOVA 2</i>						
Complexity	FD ^b	223018.87	2	111509.44	7.74	0.001
	FC ^b	938.20	2	469.10	22.98	< 0.001
	PD ^a	4.11	1.793	2.29	106.53	< 0.001
Images	FD ^a	180357.20	6.65	27138.19	0.98	0.440
	FC ^a	1500.88	8.42	178.31	4.70	< 0.001
	PD ^a	17.94	6.45	2.78	58.08	< 0.001
Images	FD ^a	428483.64	11.30	37904.52	1.58	0.099
	FC ^a	1483.67	15.46	95.98	3.29	< 0.001
	PD ^a	11.20	11.36	0.99	33.77	< 0.001
Error (Images)	FD ^a	10806560.48	392.11	27560.23		
	FC ^a	18848.92	496.61	37.95		
	PD ^a	18.22	380.67	0.05		
Error (Complexity)	FD ^b	1699591.85	118	14403.32		
	FC ^b	2409.19	118	20.42		
	PD ^a	2.28	105.79	0.02		
Error (Images*)	FD ^a	16028011.05	666.95	24031.69		
	FC ^a	26603.61	912.01	29.17		
	PD ^a	19.56	670.06	0.03		

Note(s) ^aAssumed sphericity, ^bGreen-House-Geisser transformation. The tables in this section have been compiled with the help of SPSS

sustained attention, reflected in longer fixation durations which correspond to higher perceived atmospheric pleasantness.

4.3 Effect of the complexity of the images

To test hypotheses group H2, another repeated-measures ANOVA was conducted. The within-subjects effects test confirmed the direct influence of visual complexity levels (low, medium, and high) on attentional metrics (Wilks' $\Lambda = 0.322$; $F = 29.50$; d.f.1 = 6, d.f.2 of error = 232; $p < 0.001$), as well as the effect of image complexity itself (Wilks' $\Lambda = 0.450$, $F = 17.98$, d.f.1. = 33, d.f.2. of error = 1,906.89; $p < 0.001$; see [Table A1 in Online Supplementary Material](#)). A significant interaction between these two factors was also observed (Wilks'

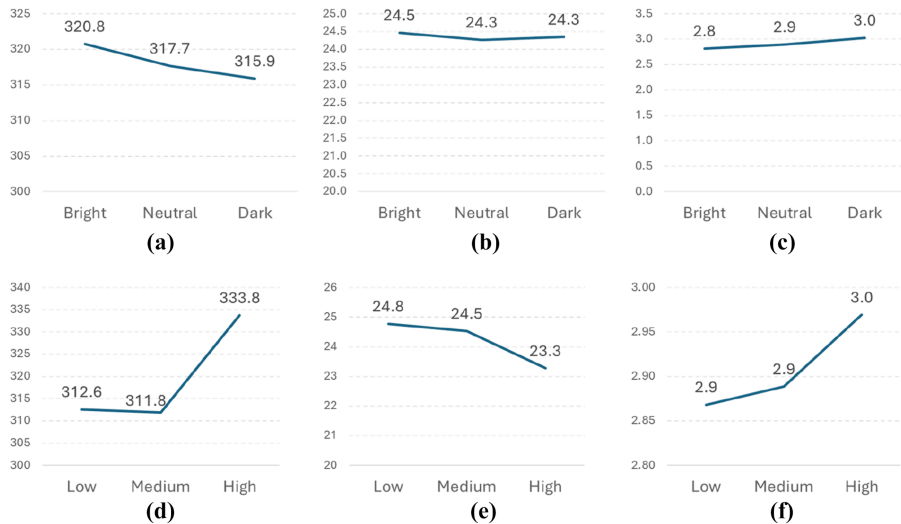


Figure 2. FD (a), FC (b) and PD (c) by level of brightness and FD (d), FC (e) and PD (f) by level of complexity

$\Lambda = 0.590$; $F = 11.34$; d.f.1 = 66, d.f.2 error = 16; $p < 0.001$). The p -values in this Table A1, all ≤ 0.01 , confirm that image complexity and type significantly impact FC, FD, and PD.

After verifying sphericity using Mauchly's test, we observed that image complexity produced significant differences in FD, PD, and FC, both independently ($F_{FD} = 7.74$, $p < 0.001$, $F_{PD} = 106.53$, $p < 0.001$, $F_{FC} = 22.98$, $p < 0.001$; see Table 1, ANOVA 2) and in interaction with images ($F_{FD} = 1.58$, $p < 0.099$, $F_{PD} = 33.77$, $p < 0.001$, $F_{FC} = 3.29$, $p < 0.001$). Images also showed a significant effect, except for FC ($F_{FC} = 0.98$; d.f. = 6.65; $p = 0.440$). Thus, empirical evidence supports hypothesis H2.

As illustrated in Figure 2, PD increased with higher visual complexity ($PD_H = 3.0$ mm; see Figure 2f), suggesting heightened emotional arousal in response to visually dense environments. This aligns with previous research indicating that greater visual complexity, due to an abundance of elements and decoration, enhances cognitive and emotional engagement.

4.4 Effect of visual attention on perception of spatial orderliness

The regression results showed that FD on medium-complexity images (FD_M) has a strong positive, statistically significant relationship with perceived order, in terms of general tidiness ($\beta = 0.919$, $p = 0.001$; see Table A2 in Online Supplementary Material). Similarly, FC on medium-complexity images (FC_M) is positively associated with this tidiness perception ($\beta = 0.494$, $p < 0.001$). By contrast, FD on highly complex images (FD_H) shows a negative coefficient ($\beta = -0.431$, $p = 0.097$), indicating that longer visual processing of highly cluttered environments tends to reduce perceived order. However, this effect does not reach statistical significance at the 5% level and should therefore be interpreted cautiously as a marginal tendency.

FC on low-complexity images (FC_L) emerges as the strongest, most robust positive predictor ($\beta = 0.470$, $p < 0.001$), indicating that repeated visual engagement with environments enhances perceived order. Similarly, FD on medium-complexity images (FD_M) shows a positive, statistically significant effect ($\beta = 0.575$, $p = 0.017$), suggesting that sustained attention to moderately structured spaces also contributes to order judgements. In addition, FD on low-complexity images (FD_L) presents a positive but marginally significant

association ($\beta = 0.416$, $p = 0.055$). Conversely, FD on highly complex images (FD_H) exhibits a negative marginal effect ($\beta = -0.472$, $p = 0.051$), indicating that longer visual processing of cluttered environments tends to slightly reduce perceived order.

Overall, the results suggest that perceptions of orderliness are reinforced by attentional engagement with visually simple and, above all, moderately structured environments, whereas prolonged processing of highly complex scenes weakens such evaluations, answering the research question.

5. Discussion of results and implications of the study

5.1 Main conclusions

5.1.1 Image brightness: attention versus emotional arousal. With regard to image brightness (H1), the results show that variations in this graphic design element did not produce significant differences in fixation-based attentional metrics such as fixation duration (FD). This finding is consistent with prior research suggesting that brightness effects on visual attention are often weak or highly context-dependent (Areni and Kim, 1994; Summers and Hebert, 2001). Within the AC-TEA model, these findings suggest that image brightness facilitated the initial global perception of the scene's "gist" but did not systematically redirect consumers' incremental attention or attentional focus in visually rich e-retail environments such as furniture e-stores. Consequently, brightness appears to be primarily evaluative, affecting internal affective states, rather than steering active visual exploration.

In contrast, image brightness exerted a clear influence on emotional arousal, as reflected by significant differences in pupil dilation (PD). Dimly lit environments were associated with greater PD, whereas brighter conditions elicited stronger pupillary constriction, interpreted as a "calming effect" derived from visual clarity and structural ease. Given that PD is a well-established indicator of emotional arousal and cognitive effort (Bradley et al., 2008), these results suggest that brightness primarily modulates consumers' emotional experience rather than visual attention. This pattern is substantiated by the "brightness bias" documented by Lakens et al. (2013), which demonstrates that brighter visual stimuli are evaluated more positively, independent of content, whereas darkness may reflect an evolutionary predisposition to anxiety and negative feelings. Within the AC-TEA framework, high image brightness facilitated a more fluent transfer of attention from initial capture to product analysis, reducing the cognitive and emotional effort required to decode the scene.

5.1.2 Visual complexity: focused attention and heightened arousal. The results for visual complexity (H2) provide strong, consistent support for its influence on both visual attention and emotional arousal. Participants viewing complex interiors exhibited longer FDs and fewer fixations, indicating focused, sustained visual processing. These attentional patterns suggest that complex environments encourage deeper engagement with selected elements rather than rapid, superficial scanning, in line with prior research on visual attention and information processing (Oliva et al., 2004; Wedel and Pieters, 2007).

In addition to these attentional effects, visually complex environments elicited greater PD, reflecting higher emotional arousal. This finding is consistent with Nasar's (2000) work linking environmental complexity to increased interest and arousal and supports the view that visually rich environments demand greater perceptual and cognitive resources. Moreover, the prolonged FDs observed in complex environments suggest that consumers devote more time to processing visual information, examining details, and comparing alternatives. Rather than engaging in brief glances, consumers appear to adopt a more deliberate viewing strategy, which may support informed decision-making and enhance the experiential value of the shopping process.

5.1.3 Visual attention on perceptual evaluations. Our findings demonstrate that visual attention patterns reliably predict how consumers evaluate indoor environments. Specifically, darker lighting conditions were perceived as more pleasant, with longer FDs serving as a significant predictor of this evaluation. Although brighter images required less cognitive

effort, this did not translate into greater pleasantness. This aligns with evidence that excessive brightness can increase visual strain and reduce perceived warmth and comfort (Li et al., 2024; Park and Farr, 2007). While traditional retail research has advocated bright lighting to boost arousal and purchase intent (Areni and Kim, 1994; Birren, 1969), our results highlight a different consideration in home furniture e-contexts. Within the AC-TEA framework, top-down drivers dominate: the goal of seeking pleasantness guides attention toward darker scenes despite higher cognitive effort. Consequently, lower PD in bright conditions may reflect reduced emotional activation or “affective coldness” toward overly sterile environments.

Beyond atmospheric pleasantness, visual attention also predicts perceived spatial order, which is strongest in low- and moderately complex environments. In contrast, prolonged processing of highly cluttered scenes weakens perceptions of order appearing as a marginal negative tendency, and consistent with aesthetic theories suggesting that intermediate complexity is more harmonious and orderly (Berlyne, 1974). Applying the AC-TEA model, top-down drivers guide perception of order, guiding attention toward environments that are easier to decode (Pieters and Wedel, 2004). Although high complexity captures attention through bottom-up salience, the resulting cognitive load makes sustained processing counterproductive for order judgements.

Figure 3 illustrates the proposed model of visual Attention Capture and Transfer within a furniture E-Retailing context (AC-TER), integrating bottom-up factors (brightness and visual complexity) and top-down factors (pleasantness and orderliness) within the AC-TEA framework. Conceptually, the AC-TER framework represents a significant evolution of the original AC-TEA model. While the AC-TEA was designed to explain how discrete advertising elements capture and transfer attention, AC-TER extends this logic to the holistic experience of e-retail atmospherics. A fundamental difference lies in the nature of the stimuli; AC-TER replaces advertising components with environmental variables (brightness and complexity) that define the digital servicescape. Furthermore, our proposal offers a novel theoretical contribution by explicitly incorporating pupil dilation as a physiological marker of emotional arousal and cognitive effort. Within the AC-TER framework, this biometric response acts as a critical mediator that shapes the transfer from initial visual capture to final perceptual

Explanatory model of Attention Capture and Transfer in E-retailing (AC-TER model)

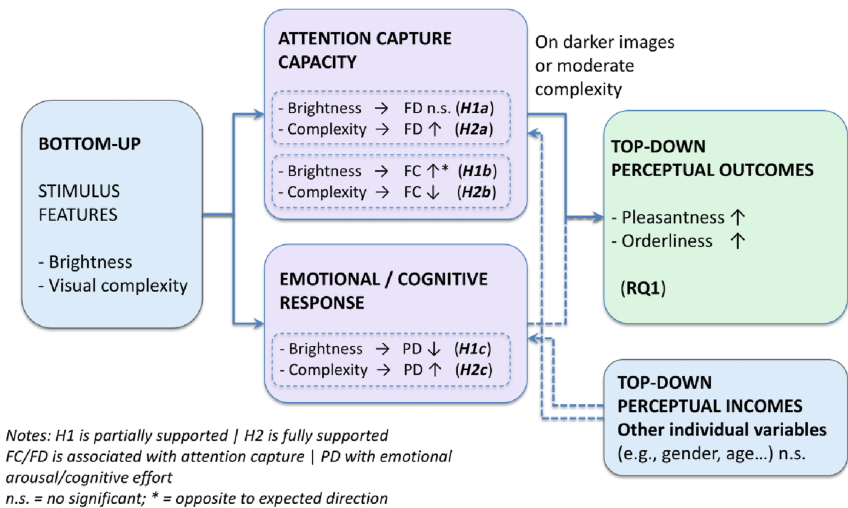


Figure 3. AC-TER model. Source: authors' own work

judgements of pleasantness and order. This integration provides a more granular understanding of the underlying psychological mechanisms that traditional self-reported models often overlook.

Ultimately, this integration highlights how non-conscious physiological reactions drive and explain consumers' subjective evaluations. Within online furniture catalogues, AC-TER serves as an objective, data-driven diagnostic tool, demonstrating how managers can strategically manipulate image brightness and design complexity to modulate emotional arousal and capture visual attention, respectively, and foster more positive perceptions of the digital servicescape. Rather than assuming that brighter or more complex images are inherently more effective, the findings suggest that these atmospheric variables should be strategically calibrated according to the desired consumer response: brightness primarily influences emotional arousal, whereas visual complexity affects both attentional engagement and arousal. In this regard, AC-TER provides a more nuanced basis for designing furniture e-retailing environments that balance visual engagement, cognitive effort, and positive perceptual evaluations.

5.2 Business and academic implications

From a managerial perspective, the findings highlight the importance of distinguishing between the attentional and emotional effects of e-atmospheric variables. Image brightness appears to play a more prominent role in shaping emotional responses than in directing visual attention. For furniture e-retailers, image brightness appears to influence emotional responses more than visual attention. Lower brightness or warmer lighting may enhance emotional engagement and perceived pleasantness, whereas increasing brightness alone is unlikely to improve attentional engagement. In line with the AC-TEA/AC-TER frameworks, these findings suggest that e-retailers should strategically manage atmospheric cues according to the specific consumer response they aim to stimulate. While darker images appear to enhance emotional arousal and pleasantness, brightness does not necessarily improve attentional engagement, indicating that different visual variables activate distinct cognitive and emotional mechanisms.

Visual complexity also emerges as a key driver of consumer engagement in furniture e-retail. While highly complex digital storefronts increase cognitive demands, the present findings indicate that such environments can simultaneously foster deeper visual processing and higher emotional arousal. Carefully designed, visually rich image layouts may help e-retailers inspire consumers, support product evaluation, and enhance experiential value. At the same time, web designers should balance complexity with perceived order to avoid sensory overload and ensure that key products remain visually accessible, as results indicate that moderately structured environments generate more favourable perceptions of order and layout. Managers should therefore adapt visual complexity to different stages of the customer journey, using more immersive scenes and clearer visual compositions. In this sense, moderate informational density appears to provide the best balance between attentional capture and positive evaluations of spatial organisation, thereby improving the time spent on a website and the amount of revisits.

From a strategic digital management perspective, the AC-TEA/AC-TER model also supports the development of adaptive or personalised online storefronts. Because brightness and visual complexity influence distinct attentional, emotional, and perceptual mechanisms, retailers could dynamically adjust interface aesthetics according to user behaviour, shopping motivations, or browsing stages. Such adaptive atmospheric strategies may improve consumer experience when browsing the website, increase engagement and facilitate online decision-making in furniture e-retailing.

Academically, this study contributes to the e-retail atmospherics research by demonstrating the distinct effects of image brightness and design complexity on visual attention and consumer perception, using objective eye-tracking measures integrated with subjective

evaluations. The findings advance understanding of how e-retail environments shape consumer experience (Jiménez-Barreto and Campo-Martínez, 2018; Küster *et al.*, 2016) and highlight the value of integrating psychophysiological indicators into consumer research. The main practical, theoretical and interdisciplinary implications derived from the findings are summarised in [Figure A2 \(in Online Supplementary Material\)](#).

6. Limitations and future research directions

This study examines the effects of brightness intensity and design complexity on consumer attention and emotional arousal using static images of furnished interiors. Although previous research has shown that perceptual evaluations based on photographs and renderings of lighting configurations can yield results comparable to real-world scenarios (Engelke *et al.*, 2013), static images cannot fully capture the dynamic and multisensory nature of in-store experiences. Future research should therefore examine these effects in real retail environments, where consumers interact freely with products and multiple concurrent stimuli, as well as in dynamic or immersive contexts such as video-based scenarios or virtual and augmented reality environments.

These approaches are essential to further validate the AC-TER framework, testing whether the identified mechanisms of attention capture and transfer remain consistent in more complex and interactive digital servicescapes. Advances in artificial intelligence and immersive technologies also offer promising opportunities to further explore how environmental factors shape consumer perception and behaviour.

Another limitation concerns the relatively small sample size, which may restrict the generalisability of the findings. Replication studies using larger and more diverse samples would help assess the robustness of the results across different consumer segments and retail contexts. In addition, the present study focuses on two atmospheric variables: brightness intensity and visual complexity, within the specific context of furniture e-retail. Consequently, the findings may not be directly transferable to other retail formats. Future research could extend this work by examining additional environmental factors, such as colour schemes, spatial layout, or furniture styles, as well as by comparing different retail sectors.

Finally, while this study relies primarily on objective eye-tracking measures to capture visual attention and emotional arousal, these indicators provide an indirect assessment of consumer experience. Furthermore, the absence of attitudinal or behavioural outcome variables (such as purchase intentions or attitude toward the website) constitutes a limitation, as our focus remained on immediate visual attention and consumer perceptions. Incorporating these variables in future studies will be critical to fully develop and validate the predictive power of the AC-TER model, specifically by examining how the transfer from attention and perception ultimately drives purchase decisions. Future research could integrate both broader self-reported measures of perception, emotion, cognitive load or engagement, and explicit behavioural and attitudinal outcomes, to complement biometric data and offer a more comprehensive understanding of how consumers experience retail environments.

Ethical statement

The study involved non-invasive eye-tracking procedures in which adult participants viewed images of everyday furniture. The research posed minimal risk and did not include the collection of sensitive personal or clinical data. All participants were informed about the purpose of the study and provided written informed consent prior to participation. Participant anonymity and data confidentiality were ensured throughout the research process.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT-GPT-4o to check the spelling and writing of some of the included sentences. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Supplementary material

The supplementary material for this article can be found online.

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