Dokuz Eylül University Journal of Faculty of Business, Volume 26, Number 2, 2025, 412-436

Submission Date: June 23, 2025
Acceptance Date: September 5, 2025

Review Article
doi: 10.24889/ifede.1725774

Atıf/Citation:
Küçün, N. T. (2025). Evaluating Conscious and Unconscious Consumer Responses in Marketing Through Pupillometry: A Systematic Review. *Dokuz Eylül University Journal of Faculty Business*, 26(2): 412-436. https://doi.org/10.24889/ifede.1725774.

EVALUATING CONSCIOUS AND UNCONSCIOUS CONSUMER RESPONSES IN MARKETING THROUGH PUPILLOMETRY: A SYSTEMATIC REVIEW

Nihan TOMRİS KÜÇÜN*

ABSTRACT

Neuromarketing research has increasingly sought to transcend the limitations of traditional self-report and behavioral measures by incorporating physiological techniques that capture nonconscious consumer processes. Among these, pupil dilation has emerged as a valuable yet underutilized metric for assessing emotional arousal, cognitive effort, and motivational engagement. Despite its theoretical promise, pupil dilation remains secondary to fixation-based eye-tracking metrics in mainstream consumer behavior research. This study systematically reviews 30 empirical studies employing pupil dilation within marketing and consumer behavior contexts. Using the TCCM framework, we analyze how pupil-based metrics have been theorized, applied, and interpreted across diverse marketing settings. A bibliometric analysis complements the review, mapping the intellectual structure and thematic evolution of pupillometric consumer research. Findings reveal that pupil dilation is predominantly associated with visual attention, emotional arousal, cognitive load, and preference formation, offering a nonverbal, real-time window into consumers' subconscious responses. However, methodological limitations such as luminance sensitivity, emotional valence ambiguity, and lack of standardization persist across the literature. This review highlights the untapped potential of pupil dilation as a diagnostic tool in consumer neuroscience and calls for greater multimodal integration, ecological validity, cross-cultural exploration, and methodological rigor in future research. By moving beyond fixation-based metrics, scholars and practitioners can better capture the hidden cognitive and affective drivers of consumer behavior.

Keywords: Pupil Dilation, Pupillometry, Consumer Neuroscience, Consumer Behavior, Neuromarketing
JEL Classification: M31, M37

PUPİLLOMETRİ KULLANILARAK BİLİNÇLİ VE BİLİNÇDIŞI TÜKETİCİ TEPKİLERİNİN PAZARLAMA AÇISINDAN DEĞERLENDİRİLMESİ: SİSTEMATİK BİR DERLEME

ÖZ

Nöropazarlama araştırmaları, geleneksel öz-bildirim ve davranışsal ölçümlerin sınırlılıklarını aşmak amacıyla giderek daha fazla bilinçdışı tüketici süreçlerini yakalayabilen fizyolojik teknikleri içermeye yönelmiştir. Bu teknikler arasında, göz bebeği büyüklüğü (pupil dilation), duygusal uyarılma, bilişsel çaba ve motivasyonel katılımı değerlendirmek için değerli ancak yeterince kullanılmayan bir ölçüt olarak öne çıkmaktadır. Kuramsal vaatlerine rağmen, göz bebeği büyüklüğü, ana akım tüketici davranışı araştırmalarında halen odaklanma temelli göz takibi metriklerinin gölgesinde kalmaktadır. Belirtilen önceliklerle bu çalışma, pazarlama ve tüketici davranışı bağlamlarında göz bebeği büyüklüğü kullanan 30 ampirik çalışmayı sistematik olarak incelemektedir. TCCM çerçevesi kullanılarak, göz bebeği temelli metriklerin nasıl kuramsallaştırıldığı, uygulandığı ve yorumlandığı çeşitli pazarlama perspektiflerinden analiz edilmektedir. Bulgular, göz bebeği büyüklüğünün ağırlıklı olarak görsel dikkat, duygusal uyarılma, bilişsel yük ve tercih oluşumuyla ilişkili olduğunu ortaya koymakta; tüketicilerin bilinçdışı tepkilerine dair sözel olmayan, gerçek zamanlı bir pencere sunduğunu göstermektedir. Ancak literatürde, ışık hassasiyeti, duygusal değer belirsizliği ve standartlaşma eksikliği gibi metodolojik sınırlılıklar devam etmektedir. Özetle, bu derleme, göz bebeği büyümesinin tüketici sinirbiliminde tanılayıcı bir araç olarak henüz tam

* Assoc. Prof., PhD Cand., Anadolu University, Graduate School, Public Relations and Advertising, Eskişehir, Türkiye. E-mail: ntk@anadolu.edu.tr, ORCID: 0000-0001-5548-6093

olarak değerlendirilmemiş potansiyeline dikkat çekmekte ve gelecekteki araştırmalar için daha fazla çok modlu entegrasyon, ekolojik geçerlik ve kültürler arası incelemenin önemini ortaya koymaktadır. Odaklanma temelli metriklerin ötesine geçilmesinin, araştırmacılar ve uygulayıcılar için tüketici davranışının gizli bilişsel ve duygusal etkenlerini daha yakından inceleyebilmesine olanak tanıyacağı düşünülmektedir.

Anahtar Kelimeler: Göz Bebeği Büyüklüğü, Pupillometre, Tüketici Nörobilimi, Tüketici Davranışı, Nöropazarlama
JEL Sınıflandırılması: M31, M37

1. INTRODUCTION

In recent years, the field of neuromarketing has increasingly aimed to transcend the limitations of traditional self-report and behavioral measures by incorporating neurophysiological techniques that uncover nonconscious drivers of consumer behavior (Plassmann et al., 2015; Smidts et al., 2014). Among these techniques, eye-tracking has become one of the most widely adopted tools in consumer and marketing research due to its temporal precision, ease of application, and its ability to capture visual attention in real-time (Orquin and Loose, 2013; Wedel and Pieters, 2008).

However, a close examination of the literature reveals an important pattern: the vast majority of eye-tracking-based marketing studies rely almost exclusively on fixation-based metrics (such as fixation count, duration, and saccades) to infer consumer attention and interest (Lohse, 1997; Modi and Singh, 2023; Pieters and Wedel, 2004). While these metrics are informative regarding where a consumer looks and for how long, they fall short in explaining how stimuli are processed and what kind of emotional or cognitive responses they trigger (Holmqvist et al., 2011; Wook Chae and Chang Lee, 2013).

Ironically, it was not gaze behavior but pupil dilation that played a central role in the pioneering eye-tracking studies. Groundbreaking research by Hess and Polt (1960) and later by Kahneman and Beatty (1966) demonstrated that the pupil's response to cognitive and emotional load could provide a nonverbal, real-time window into mental effort, affective arousal, and motivational engagement. These findings positioned the pupil as a powerful indicator of internal psychological processes, well before the rise of gaze-based analyses.

As eye-tracking technology evolved and became more accessible, however, academic and commercial focus shifted toward spatially oriented fixation data, largely because these metrics are visually intuitive, easier to analyze directly via devices' software, and more readily mapped onto static stimuli such as advertisements or product pages. In this shift, pupillometry became increasingly underutilized, often recorded by modern eye-trackers but rarely analyzed despite its continued relevance and diagnostic power (McInnes and Sung, 2025).

In contrast to fixation metrics, pupil dilation is regulated by the autonomic nervous system and responds not only to changes in brightness but also to a wide array of cognitive and affective states (Dobovšek et al., 2022; Sirois and Brisson, 2014). Research has shown that pupil size varies systematically with emotional arousal (Bradley et al., 2008), cognitive load (Beatty, 1982; Kahneman and Beatty, 1966), reward processing (Preuschoff et al., 2011), motivational salience (Laeng et al., 2012), and uncertainty or surprise (Urai et al., 2017). This makes pupil dilation a uniquely valuable metric for understanding not just what attracts attention, but how deeply and with what intensity consumers engage with marketing content.

Yet, despite its strong theoretical grounding and technological feasibility, pupil dilation remains surprisingly underrepresented in marketing research. While hundreds of studies analyze eye-tracking data for gaze behavior, only a small subset includes pupil-based metrics, and even fewer treat it as a primary variable of interest. This represents a substantial gap in the literature, particularly given the rich insights that pupillometry can offer into subconscious consumer responses.

To address this gap, the present study conducts a systematic literature review of marketing and consumer behavior research utilizing pupil dilation as a central variable. Using the TCCM framework (Theory–Context–Characteristics–Methodology), this review identifies key patterns in how pupil-based measures have been theorized, applied, and interpreted across marketing contexts. Ultimately, it highlights the untapped potential of pupillometry in advancing the neurophysiological understanding of consumer engagement and calls for its integration as a core tool in future neuromarketing research.

2. PUPIL DILATION IN CONSUMER BEHAVIOUR AND MARKETING RESEARCH

Pupil dilation, or the fluctuation of pupil size in response to internal and external stimuli, has been increasingly recognized as a valuable indicator of unconscious psychological processes (Colombatto and Scholl, 2022; Franzen et al., 2022). While pupil size is primarily modulated by ambient luminance, a substantial body of research has demonstrated its sensitivity to a variety of cognitive and affective states, including mental effort, emotional arousal, uncertainty, and motivational salience (Bradley et al., 2008; Kahneman and Beatty, 1966; Kret and Sjak-Shie, 2019; Urai et al., 2017).

As a neurophysiological signal regulated by the autonomic nervous system, pupil dilation is uniquely suited to capture simultaneous changes in internal states that are otherwise difficult to access through self-report or behavioral observation (Chang et al., 2025; Laeng et al., 2012). This real-time, involuntary response provides researchers with a nonverbal measure of psychological intensity, making it particularly useful in contexts where conscious introspection may be unreliable or biased (Hershman et al., 2023).

In the domain of consumer research, pupil dilation has been employed to assess responses to advertising (King, 1972), packaging design (Laeng et al., 2016), user interfaces (Niknam and Botev, 2024), and brand-related stimuli (Ramsøy et al., 2017). For instance, greater pupil dilation has been observed in response to emotionally charged advertisements or unexpected product features, often preceding conscious recognition of the stimulus (Bradley et al., 2008; Preuschoff et al., 2011). In digital environments, pupil size has also been used to infer engagement, cognitive load, and impulse urge during e-commerce experiences (Szymkowiak et al., 2021; van Loon et al., 2022).

Importantly, pupil dilation offers insights that go beyond spatial attention, which is typically captured through fixation-based metrics. While fixations indicate where attention is allocated, pupil dilation can reveal how intensely a stimulus is processed and with what emotional valence (Kret and Sjak-Shie, 2019). This distinction is particularly important in marketing, where attention alone does not always correlate with persuasion, preference, or purchase behavior.

Despite its diagnostic power, pupil dilation remains underutilized in marketing research. Most eye-tracking studies continue to focus predominantly on gaze behavior, often disregarding the rich data captured through pupillometry.

Despite all the mentioned advantages pupil dilation is not without limitations. First, pupil size is highly sensitive to ambient luminance, making it crucial to control for brightness and contrast in visual stimuli (Bradley et al., 2008; Mathôt and Vilotijević, 2023). Second, pupillary responses often reflect generalized arousal, lacking the specificity to distinguish between positive and negative emotional valence (Cash et al., 2024). Third, the response latency means that pupillary changes may trail behind stimulus onset (Hoeks and Levelt, 1993). Additionally, preprocessing of pupil data requires substantial effort to account for artifacts such as blinks, head movement, and missing values (Kret and Sjak-Shie, 2019). Finally, overreliance on pupillometry without triangulation from other data sources may risk oversimplifying complex psychological mechanisms (Kahneman, 1973; Laeng and Mathôt, 2024).

Beyond these methodological challenges several additional limitations of pupillometry warrant consideration. First, high-resolution pupillometric recording requires specialized and costly eye-tracking devices and controlled laboratory setups, which may restrict scalability in less resource-intensive contexts (Valliappan et al., 2020).

Second, participant comfort can be a concern, as extended pupillometric sessions may induce ocular fatigue/eye strain and general fatigue, thereby reducing the ecological validity of responses (Hopstaken et al., 2015; Sheppard and Wolffsohn, 2018; Rosenfield, 2011). Future research should aim to optimize measurement protocols that balance data quality with participant well-being.

Third, important ethical considerations arise because pupillary responses constitute biometric data. Issues of privacy, informed consent, and secure data handling are critical, and researchers must ensure that participants are fully informed about how their physiological information will be collected, stored, and used, especially when combined with other sensitive measures. Regulations such as the EU's General Data Protection Regulation (GDPR) define biometric data as physiological characteristics processed through specific technical means for identification purposes. In this context, pupillometric profiles can be considered biometric data, requiring explicit consent and enhanced data protection measures (European Commission, 2016: 33- 37). Furthermore, consumer-facing biometric tracking, especially in advertising or automated decision contexts raises serious privacy risks and mandates transparency and privacy-by-design approaches (Logan, 2019). Additionally, human subject research ethics demand that participants understand how their biometric data will be used, stored, and potentially shared—especially in multi-modal or identifiable datasets (Larsen et al., 2020). Taken together, these practical and ethical considerations underscore the need to balance the methodological promise of pupillometry with its inherent constraints.

To ensure a more grounded and nuanced interpretation of pupil-based findings, it is first essential to clarify how these data are obtained and processed. Thus, before elaborating on the current and potential applications of pupil dilation within the referenced literature, it is considered that addressing the stages of data collection, cleaning, and analysis would offer a valuable methodological contribution to the field.

3. COLLECTING, PREPROCESSING, AND ANALYZING PUPIL DILATION DATA

Pupil dilation offers a unique window into unconscious emotional and cognitive processes, yet its use in marketing research requires careful attention to data acquisition, preprocessing, and

analysis procedures. Without standardized handling, pupil data may be compromised by noise, measurement artifacts, or improper interpretation (Steinhauer et al., 2022).

3.1 Data Collection

In order to collect accurate pupillometric data it is needed to have a appropriate hardware. Eye-tracking devices available in the market offer a wide range of sampling rates, typically varying from 30 Hz to as high as 1000 Hz. But for better results higher frequencies (≥120 Hz) are preferred for capturing subtle changes in pupil size over time (Kret and Sjak-Shie, 2019).

According to Steinhauer et al. (2022) to minimize luminance-driven noise, ambient light conditions should be controlled, and stimuli should be presented on screens with consistent brightness and contrast. The use of gray or isoluminant backgrounds is recommended (Bradley et al., 2008). Calibration prior to data collection ensures accurate pupil tracking and helps avoid skewed measurements, particularly for participants who has corrected vision.

3.2 Preprocessing

Raw pupil diameter data are inherently vulnerable to several sources of noise, including blink-related signal loss, saccadic artifacts, and head movements (Siegla et al., 2003). To mitigate these issues and ensure the reliability of subsequent analyses, a series of preprocessing steps are commonly applied.

First, blink detection is performed to identify missing data points, which are then interpolated (typically using linear or spline methods) to reconstruct the signal (Onorati et al., 2013). Next, the data are smoothed to reduce microfluctuations and enhance signal clarity; filters such as Savitzky-Golay or moving average are frequently employed for this purpose (Kret and Sjak-Shie, 2019). Baseline correction follows, wherein a pre-stimulus baseline which is often the average pupil size before stimulus onset, is either subtracted from or used to normalize the data (Laeng et al., 2012), allowing for more accurate comparisons across conditions and participants. Finally, trials contaminated by extreme values, such as those exceeding three standard deviations, are either excluded or transformed using z-score normalization to control for inter-individual variability (Winn et al., 2018). In sum proper preprocessing is crucial for avoiding false positives and enhancing the interpretability of pupil-based findings (Meritt et al., 1999).

3.3 Analysis Techniques

Pupil data can be analyzed at different temporal resolutions and levels of granularity. One of the most common approaches involves calculating the mean pupil size within specific time windows (2– 5 seconds following stimulus), often averaged across trials and participants (Grujıc et al., 2024).

Another key metric is peak dilation latency, which captures the time point at which maximum pupil dilation occurs relative to stimulus onset (Larson et al., 2004). For a more detailed assessment, time-course analysis can be conducted by plotting average pupil changes across successive time bins (for example 100 ms), allowing researchers to visualize the dynamics of arousal and cognitive load over time (van Loon et al., 2022).

Finally, the Area Under the Curve (AUC) technique offers a comprehensive measure by reflecting both the magnitude and the duration of the pupil response (Vallejo-De la Cueva et al., 2023).

In advanced studies, pupil dilation is combined with fixation metrics, self-report measures, or even EEG or fMRI to triangulate the emotional and cognitive correlates of consumer decision-making (García-Carrión et al., 2025; Huseynov et al., 2019).

With its noted advantages and limitations, pupil dilation data hold considerable potential to open new avenues in consumer neuroscience research. In this context, the present study conducts a bibliometric and a systematic review of the existing literature to examine the current state of this research technique, identify key research gaps, and outline potential directions for future studies.

4. REVIEW PROTOCOL: A SEVEN-STEP METHODOLOGICAL APPROACH

Figure 1: SSM Flow

In order to systematically examine how pupil dilation is utilized as a physiological indicator in marketing and consumer behavior research, a structured seven-step methodological protocol was adopted. This protocol is consistent with recent best practices in systematic literature reviews (Snyder, 2019; Tranfield et al., 2003), ensuring methodological transparency, replicability, and rigor.

Step 1: Research Objectives

The core objective of this review was to synthesize empirical findings that use pupillometry as a measure of emotional arousal or decision-related cognitive processing in marketing and consumer-related settings. Specifically, the review sought to (1) identify in which consumer contexts pupil dilation is studied, (2) determine the dominant theoretical and methodological approaches, and (3) uncover research gaps that limit the integration of pupillary responses in mainstream marketing research.

Step 2: Keywords and Search Query

To achieve comprehensive coverage, a keyword strategy was developed to include both American and British spellings as well as relevant conceptual terms. The search query was as follows: ("pupil AND dilation" AND "marketing" AND "consumer AND behaviour" AND "consumer AND behavior") AND (LIMIT-TO (SUBJAREA: "BUSI", "SOCI", "ECON", "PSYC")) AND (LIMIT-TO (DOCTYPE: "ar")) AND (LIMIT-TO (PUBSTAGE: "final")) AND (LIMIT-TO (SRCTYPE: "j")) AND (LIMIT-TO (LANGUAGE: "English")).

This Boolean-based query ensured that only final-stage, peer-reviewed journal articles in relevant social science disciplines were considered.

Step 3: Selection Criteria

The inclusion criteria for this review were: (1) empirical studies published in peer-reviewed journals, (2) written in English, (3) conducted within the domains of marketing, psychology, consumer behavior, or related fields, and (4) employing pupil dilation as a primary or secondary dependent variable. Conceptual, editorial, or methodological papers without empirical data were excluded. Likewise, studies using only eye-tracking fixation or saccade data without pupillary measurement were omitted. This ensured that the final sample was aligned with the research aim focusing on pupil dilation and not visual attention more broadly.

Step 4: Databases and Search Engines

Two major scientific databases were used to conduct the literature search: Web of Science (WoS) and Scopus. These databases were selected due to their multidisciplinary coverage and advanced filtering capabilities, which facilitate systematic searches in business, psychology, and behavioral science literature (Mongeon and Paul-Hus, 2016). All searches were completed in April 2025.

Step 5: Results

The initial search yielded 159 results: 8 from Web of Science and 151 from Scopus. After removing duplicate records, and screening titles and abstracts based on the predefined inclusion criteria, non-relevant subject areas and non-empirical studies were excluded. As a result, 30 articles were retained for full-text evaluation and final inclusion in the review. These studies form the empirical basis for the bibliometric and thematic analyses reported in the subsequent sections.

For transparency, we summarize here the key elements of our review protocol regarding data sources, time frame, inclusion and exclusion criteria, and final sample size. The literature search was conducted in Web of Science and Scopus, two multidisciplinary databases that provide comprehensive coverage of business, psychology, and behavioral sciences. The search covered the period from 2015 to 2025, and employed a Boolean-based query combining terms such as "pupil dilation," "marketing," and "consumer behavior/behaviour." Inclusion criteria required that studies be (1) empirical, (2) published in peer-reviewed journals, (3) written in English, (4) conducted within the domains of marketing, consumer research, psychology, or related fields, and (5) employing pupil dilation as a primary or secondary dependent variable. Exclusion criteria eliminated conceptual, editorial, or methodological papers without empirical data, as well as studies focusing only on fixation or saccade measures without pupillary responses. After removing duplicates and screening for relevance, a total of 30 articles were retained for full-text analysis. These studies form the empirical basis for the bibliometric and thematic analyses presented in the subsequent sections.

Step 6: Types of Analysis

A two-stage analytical approach was conducted. First, a bibliometric analysis was performed using VOSviewer to identify publication trends, influential journals, author collaboration networks, and keyword co-occurrence patterns. Second, a TCCM (Theory–Context–Characteristics–Methodology) framework was applied (Paul and Rosado-Serrano, 2019) to categorize the selected studies. This enabled the classification of each article based on its theoretical grounding, empirical context, sample characteristics, and methodological design. This dual approach facilitated a robust synthesis of both quantitative and qualitative aspects of the reviewed literature.

Step 7: Future Research Agenda

The final stage of the review involved the development of a future research agenda, grounded in the observed gaps and methodological limitations. Several directions were identified: Multimodal integration: Combining pupillometry with GSR, EEG, or fMRI to deepen interpretations of emotional arousal.

Distinguishing cognitive load vs. emotional arousal: Many studies conflate these mechanisms; future work should aim for greater conceptual clarity.

Contextual variability: More cross-cultural and field-based studies are needed to enhance ecological validity.

Standardization of measurement protocols: There is a critical need for consistency in baseline correction, temporal window selection, and normalization methods in pupillary analysis.

By following this structured and validated review protocol, this study contributes a comprehensive and critical synthesis of how pupil dilation functions as a tool for understanding affective and cognitive responses in marketing and consumer psychology.

4.1. Bibliometric Analysis

Over the years, researchers have employed both qualitative and quantitative review techniques to gain a comprehensive understanding of specific research domains (Ahmi et al., 2019). Among these, bibliometric analysis has emerged as a robust method to map scientific progress, uncover structural trends, and visualize the intellectual landscape of a given topic.

In this study, bibliometric method is used to provide a static and systematic overview of how pupil dilation has been utilized in marketing and consumer behavior literature, offering insights into the evolution, concentration, and dispersion of research within this niche domain. This technique enables the identification of influential authors, institutions, source journals, and highly cited documents, as well as revealing keyword clusters and emerging topics (Mishra et al., 2018; Singh and Dhir, 2019).

Furthermore, bibliometric mapping supports transparent and reproducible analysis of academic knowledge flows and improves the overall quality and credibility of literature reviews (De Bellis, 2009; Garfield, 2006). Accordingly, our bibliometric analysis includes the examination of publication trends over time, co-occurrence of keywords, and author collaboration networks, providing a macro-level understanding of the intellectual structure of pupillometric studies in consumer and marketing research. To perform these analyses, we utilized VOSviewer, a specialized software tool developed for constructing and visualizing bibliometric networks (van Eck and Waltman, 2010). The co-occurrence analysis of keywords was generated using

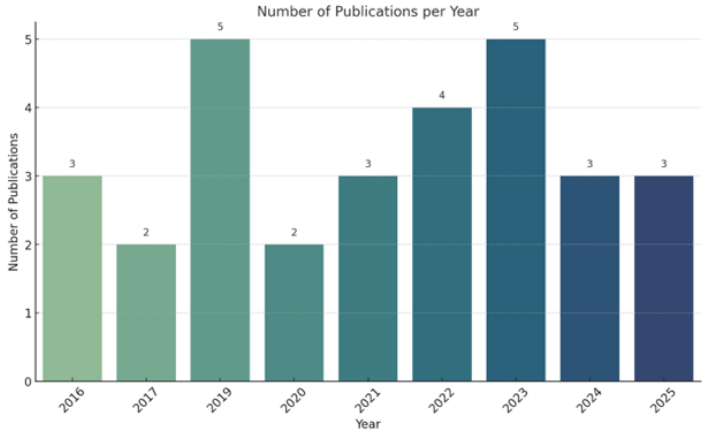
VOSviewer's full counting method, which enabled the identification of dominant thematic clusters and emerging areas of interest within the field.

4.1.1 Number of Publications Per Year

The publication trend over time reflects a gradual increase in scholarly attention toward pupil dilation research in consumer behavior and marketing contexts. As illustrated in Figure 2, the number of publications has notably increased in recent years, particularly in 2022 and 2023, suggesting a growing interest in pupillometric approaches among researchers. This trend highlights the expanding role of physiological measures in behavioral research and underscores the relevance of affective and cognitive response tracking in marketing sciences.

Importantly, no publication year restriction was applied during the dataset construction process. Therefore, based on the predefined inclusion criteria, it can be observed that the earliest empirical studies combining pupil dilation and consumer behavior were published in 2016. This suggests that the integration of pupillometry into marketing research is relatively recent but rapidly developing.

Figure 2: Number of Publications per Year



4.1.2 Distribution of Articles by Source Journals

An analysis of journal distribution within the review sample reveals a relatively even spread across various academic outlets. The Journal Psychology and Marketing appears most frequently, hosting two of the thirty included studies. All other journals in the dataset published only a single article each, indicating a homogeneous dispersion across diverse sources. This lack of concentration in specific outlets suggests that research integrating pupil dilation into consumer behavior studies is still emerging and interdisciplinary in nature, drawing interest from multiple academic communities rather than being centralized in a particular domain.

4.1.3 Co-Occurrence of Keywords

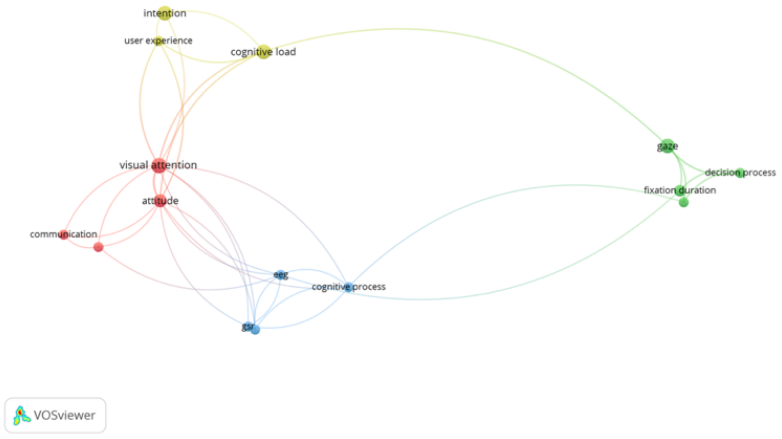
In order to identify the conceptual landscape of pupil dilation research within consumer behavior, a keyword co-occurrence analysis was conducted using VOSviewer. Bibliographic data from the 30 selected articles were exported in RIS format and imported into the software. The analysis applied the full counting method, where all occurrences of a keyword are counted

equally. The unit of analysis was set to all keywords, incorporating both author-supplied and indexed terms. A minimum occurrence threshold of 3 was defined, resulting in the inclusion of 89 terms out of an initial pool of 1,024 extracted terms. Then VOSviewer generated visual network and density maps based on co-occurrence strength, allowing for the detection of thematic clusters within the literature.

Based on these co-appearance patterns, four distinct clusters emerged (Fig 3). Cluster 1 includes the keywords attitude, communication, facial expression, and visual attention. This cluster reflects a focus on perceptual and expressive cues that modulate consumer reactions, often in emotionally loaded or persuasive communication contexts. Cluster 2 consists of decision process, fixation duration, gaze, and product preference. This cluster emphasizes the use of eye-tracking and pupillary metrics to understand how consumers process alternatives and make purchasing decisions. Cluster 3 includes cognitive process, EEG, GSR, and neuroimaging, representing studies that integrate multi-modal physiological data alongside pupillometry to explore the cognitive and neural mechanisms of consumer experience. Cluster 4 encompasses cognitive load, intention, and user experience. This cluster highlights research examining how task complexity and interface design affect user responses, especially in digitally mediated environments.

In addition to the thematic categorization, the quantitative strength of each keyword's network connectivity was assessed using metrics such as number of links, total link strength, and occurrence frequency. Across all clusters, keywords such as visual attention, gaze, and attitude emerged as central nodes with high co-occurrence frequencies and strong link strengths, suggesting their prominence and integrative role in the conceptual network.

Figure 3: Co-occurrence of Keywords



The presence of multiple, clearly defined clusters and central terms suggests that the field is not only expanding but also diversifying in scope. Pupil dilation is increasingly employed alongside other physiological and behavioral measures to capture both affective and cognitive dimensions of consumer engagement.

4.2 TCCM Analysis

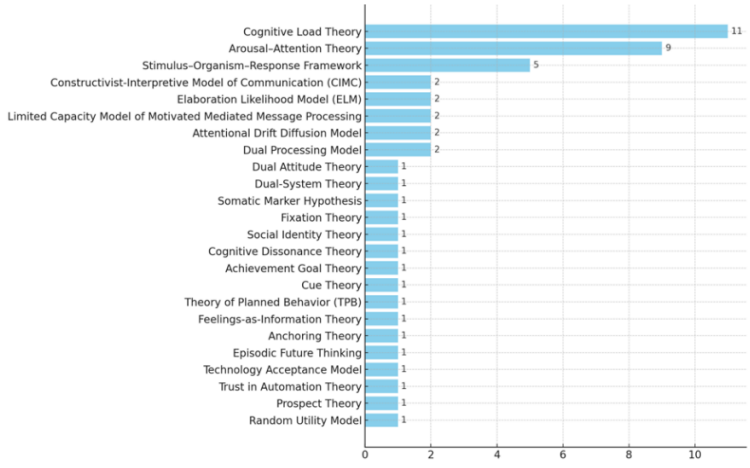
To further examine the structure and diversity of pupil dilation research in consumer behavior, a TCCM-based analysis was conducted. The TCCM framework offers a systematic lens for classifying and evaluating the intellectual landscape of a given field (Paul and Rosado-Serrano, 2019). The findings from the current review indicate that the sample of 30 studies is highly fragmented across all four dimensions.

4.2.1 Theory

The theoretical foundations of the reviewed studies were analyzed using a frequency-based approach (Fig 4). The results reveal a high degree of diversity in the theoretical frameworks applied across the 30 studies. As shown in Table X, the most frequently employed theory is Cognitive Load Theory (n = 11), followed by the Arousal–Attention Theory (n = 9) and the Stimulus–Organism–Response (S-O-R) Framework (n = 5). These results suggest a strong inclination toward cognitive processing and emotional arousal paradigms within the domain of pupil dilation research in consumer behavior.

Several other theories were referenced across multiple studies, including the Constructivist-Interpretive Model of Communication (CIMC), Elaboration Likelihood Model (ELM), Limited Capacity Model of Motivated Mediated Message Processing (LC4MP), and Attentional Drift Diffusion Model (aDDM), each appearing in two studies. The presence of multiple dual-process theories, such as the Dual Processing Model, Dual Attitude Theory, and Dual-System Theory, reflects an increasing interest in understanding both automatic and controlled processing mechanisms in consumer cognition.

Figure 4: Distribution of Theoretical Frameworks



Other theories cited at least once include the Somatic Marker Hypothesis, Fixation Theory, Social Identity Theory, Cognitive Dissonance Theory, Achievement Goal Theory, Cue Theory, Theory of Planned Behavior (TPB), Feelings-as-Information Theory, Anchoring Theory, Episodic Future Thinking (EFT), Technology Acceptance Model (TAM), Trust in Automation Theory, Prospect Theory, and the Random Utility Model (RUM). Although many of these theories were referenced only once, their variety illustrates the interdisciplinary nature of the field, integrating insights from psychology, neuroscience, marketing, and behavioral economics.

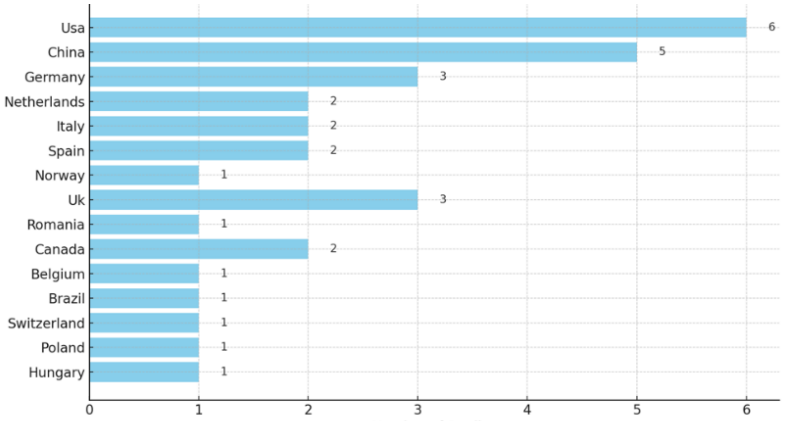
This theoretical heterogeneity points to the emerging status of pupil dilation research in consumer behavior. While Cognitive Load Theory currently serves as the dominant explanatory framework, the broad distribution of other theoretical models reveals opportunities for future studies to pursue more integrative or comparative theoretical applications.

4.2.2 Context

The contextual analysis of the 30 reviewed studies reveals a strong inclination toward laboratory-based experimental designs, with almost all studies (n = 29) conducted in controlled lab environments. Only one study (Cardamone et al., 2025) employed a mixed or quasi-naturalistic setting, indicating a dominance of highly controlled research conditions in the current literature.

In terms of geographic distribution, the majority of studies were conducted in North America (especially the United States), China, and various European countries such as Germany, the Netherlands, Spain, Italy, and Norway (Fig 5). This reflects a concentration in Western and East Asian regions, with underrepresentation of studies from emerging markets and the Global South.

Figure 5: Geographic Distribution



Regarding sectoral focus, the most frequently studied context was online shopping (n = 8), reflecting a strong interest in consumer behavior within digital retail environments. This was followed by social media contexts (n = 4), where visual stimuli from platforms such as Instagram and Facebook were examined. Other commonly explored domains included automotive (n = 2), packaging design (n = 2), consumer electronics (n = 2), and decision-making tasks (n = 2), each representing recurring themes in pupil dilation-based consumer research.

In addition to these dominant areas, several studies investigated more specialized or emerging sectors, including fashion and wine products, cosmetics, food packaging, tourism marketing, online advertising, food choice and advertising, pharmaceutical marketing, product design, online news, and financial risk-taking. These contexts were each represented in only one study, highlighting opportunities for future research to diversify and extend the sectoral applications of pupillometric methods.

These findings emphasize the contextual homogeneity of pupillometry-based consumer research. Future studies should aim to expand contextual diversity by engaging broader

demographic profiles, utilizing more ecologically valid environments, and examining underrepresented sectors and cultural regions to improve the external validity and generalizability of insights.

4.2.3 Construct

A large proportion of the reviewed studies employed pupil dilation as an indicator of visual attention (n=22), analyzing which stimuli captured consumers' focus and how cognitive processing intensity varied across different marketing contexts. Another major theme was the use of pupil dilation to capture emotional arousal (n=18), measuring consumers' physiological reactions to emotional triggers embedded in marketing stimuli.

Furthermore, pupil dilation was associated with preference/choice behavior (n=6), where studies explored the link between physiological responses and consumers' formation of preferences or final purchasing decisions. The construct of cognitive load (n=6) was also frequently examined, focusing on how mental effort and processing demands influence pupil size during decision-making processes.

In addition, some studies investigated constructs such as purchase intention (n=3) and cognitive effort (n=2), using pupil dilation to infer consumers' likelihood of purchasing or the cognitive resources allocated during information processing.

In summary, this analysis highlights that pupil dilation is employed as a multifaceted indicator in consumer behavior research, capturing both emotional and cognitive dimensions of consumer responses. Constructs such as emotional arousal, visual attention, cognitive load, and preference/choice behavior play central roles in understanding how consumers unconsciously process information and make decisions based on physiological signals.

4.2.4 Methodology

In this TCCM analysis, we systematically reviewed 30 independent studies that investigated consumer behavior through pupil dilation measures. Since the inclusion criteria required the use of eye-tracking and pupilometry, these methods were consistently employed across all reviewed studies to capture changes in pupil size as indicators of cognitive and emotional processes.

Beyond this shared methodological foundation, several studies incorporated additional physiological measurement techniques. Specifically, facial expression analysis (n=2), functional magnetic resonance imaging (fMRI) (n=1), and electroencephalography (EEG) (n=1) were used to complement pupil-based data and to provide a more comprehensive understanding of consumers' emotional and cognitive responses.

Behavioral data, including self-reported preferences, choice behaviors, and workload assessments, were often collected alongside physiological measures to triangulate findings.

In terms of data analysis, the reviewed studies predominantly applied regression techniques (linear, logistic, ordinal) to model the relationships between physiological responses and consumer behavior outcomes. ANOVA and MANOVA procedures were frequently utilized for hypothesis testing across experimental conditions, while some studies employed mediation analyses or multilevel modeling to explore more complex relational structures.

Overall, the methodological landscape reflects a strong emphasis on controlled experimental designs, multimodal data collection, and quantitative modeling approaches, aimed

at uncovering unconscious emotional and cognitive mechanisms underlying consumer decision-making.

5. CONCLUSIONS

The systematic review of the selected studies reveals several key findings regarding the use of pupil dilation in consumer behavior research. First, pupil dilation has been consistently associated with emotional arousal and visual attention mechanisms. Changes in pupil size were frequently predictive of consumer outcomes such as willingness to pay (Ramsøy et al., 2017) and choice behavior (Cardamone et al., 2025), demonstrating that unconscious physiological responses can serve as reliable indicators of underlying decision processes.

Second, multiple studies highlighted the role of visual attention (specifically gaze patterns and fixation metrics) in modulating consumer preferences (Ko et al., 2025; Songa et al., 2019). The relationship between gaze behavior and choice was particularly emphasized, suggesting that where consumers look, and for how long, critically influences their decision-making (Cardamone et al., 2025).

Third, findings point to the significance of cognitive load in shaping consumer responses. Increased complexity and higher task demands were associated with greater pupil dilation, indicating heightened cognitive effort during decision-making processes (Biswas et al., 2016).

Moreover, several studies emphasized the stronger influence of implicit attitudes over explicit ones, particularly when emotional or unconscious processes were dominant (Songa et al., 2019). In some cases, the effects of pupil-based measures were found to be weaker or context-dependent (Van Loon et al., 2022), highlighting the need for cautious interpretation and multimodal data triangulation. Overall, the evidence supports the use of pupil dilation as a valuable, although context-sensitive, physiological marker of emotional arousal, cognitive effort, and decision dynamics in consumer research.

6. MANAGERIAL IMPLICATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The findings of this systematic review suggest that pupil dilation provides a powerful yet underutilized physiological indicator for uncovering subconscious consumer reactions. Marketing managers can leverage pupil-based metrics to gain deeper insights into emotional arousal, cognitive load, and decision-making intensity/ dimensions that traditional surveys often fail to capture.

Specifically, managers in advertising, packaging design, e-commerce, and user experience (UX) fields can benefit from integrating pupillometry into A/B testing frameworks, allowing them to assess nonconscious engagement levels in response to different marketing stimuli. Pupil dilation measures can reveal which stimuli elicit higher emotional intensity or mental effort, thereby informing content optimization, message framing, and interface design strategies.

Moreover, considering that pupil size fluctuations can precede conscious choice behaviors, firms aiming for preference formation (during new product launches) could apply pupil-based diagnostics to pre-emptively detect which designs or offers are most likely to succeed. However, it is essential for practitioners to control for confounding factors such as lighting conditions and stimulus complexity, ensuring that physiological responses are accurately attributed to marketing content rather than external noise.

Finally, firms are encouraged to triangulate pupil dilation with other metrics (eye gazemap, clickstream data, self-reports) to develop a holistic consumer insight system that captures both conscious and unconscious aspects of decision-making.

The findings of this review point to several important directions for future research. First, the integration of multimodal physiological measures (such as pupillometry combined with EEG, fMRI, or GSR) is essential for advancing our understanding of how emotional arousal and cognitive load interact during consumer experiences. Such integrative approaches would allow researchers to distinguish the overlapping yet distinct roles of emotional intensity and mental effort in shaping consumer decision-making.

Second, there is a critical need to improve the ecological validity of pupillometric studies. Given that the majority of existing research has been conducted under controlled laboratory conditions, future investigations should move towards real-world environments, employing mobile eye-tracking and field experiments to capture more naturalistic consumer behavior. This would enhance the external validity and applicability of findings to real marketing contexts.

Third, cross- cultural studies represent an underexplored yet vital area. Since the reviewed literature is heavily skewed toward North American and European populations, future research should examine whether pupillary responses differ across cultural and socio-economic backgrounds, considering how cultural values might moderate physiological reactions to marketing stimuli. For instance, future research could compare individualistic versus collectivistic cultures to examine whether pupillary responses to advertising differ in terms of emotional intensity or cognitive effort. Hofstede's cultural dimensions (individualism- collectivism, uncertainty avoidance) provide a useful framework for structuring such analyses. Moreover, multi-country experiments such as testing identical marketing stimuli in Western and East Asian contexts would generate valuable evidence of how cultural values shape physiological engagement with marketing content.

Fourth, temporal dynamics of pupil dilation warrant deeper investigation. Analyzing fine-grained changes in pupil size over time could uncover micro-patterns in attention shifts, emotional responses, and decision points, offering richer insights into the cognitive-affective processes that occur during marketing interactions.

Additionally, there is an urgent call for methodological standardization. Future studies should aim to develop consistent protocols for baseline correction, stimulus luminance control, and data normalization, facilitating comparability and reproducibility across pupillometric consumer research.

Finally, given that pupil dilation reflects general arousal but does not inherently distinguish between positive and negative valence, researchers should design innovative paradigms to disentangle positive excitement (delight) from negative high-arousal states (fear, stress) within consumer decision-making contexts. Addressing this gap would greatly refine the interpretative power of pupillometric findings. By pursuing these avenues, future research can fully harness the diagnostic potential of pupil dilation, moving beyond fixation-based metrics and offering deeper insights into the subconscious drivers of consumer behavior. At the same time, it is important to acknowledge that the present review is descriptive in nature and does not provide a quantitative meta-analysis. While the qualitative synthesis allows us to map conceptual and methodological trends, future research could complement this work with quantitative meta-analyses to statistically assess effect sizes and cumulative evidence.

REFERENCES

Ahmi, A., Elbardan, H., and Ali, R. H. R. M. (2019, January). Bibliometric analysis of published literature on industry 4.0. In 2019 International Conference on Electronics, Information, and Communication (ICEIC), 1-6. IEEE.

Alós-Ferrer, C., Jaudas, A., and Ritschel, A. (2021). Attentional shifts and preference reversals: An eye-tracking study. *Judgment and Decision Making*, *16*(1), 57-93. https://doi.org/10.5167/uzh-198757

Beatty, J. (1982). Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological Bulletin, 91*(2), 276–292. https://doi.org/10.1037/0033-2909.91.2.276

Biswas, P., Dutt, V., and Langdon, P. (2016). Comparing ocular parameters for cognitive load measurement in eye-gaze-controlled interfaces for automotive and desktop computing environments. *International Journal of Human-Computer Interaction*, *32*(1), 23-38. https://doi.org/10.1080/10447318.2015.1084112

Bradley, M. M., Miccoli, L., Escrig, M. A., and Lang, P. J. (2008). The pupil as a measure of emotional arousal and autonomic activation. *Psychophysiology, 45*(4), 602–607. https://doi.org/10.1111/j.1469-8986.2008.00654.x

Cao, Y., Ding, Y., Proctor, R. W., Duffy, V. G., Liu, Y., and Zhang, X. (2021). Detecting users' usage intentions for websites employing deep learning on eye-tracking data. *Information Technology and Management*, *22*(4), 281-292. https://doi.org/10.1007/s10799-021-00336-6

Cardamone, E., Miceli, G. N., and Raimondo, M. A. (2025). Color inside and outside the lines: Evidence from eye-tracking studies on conformity to and differentiation from category color codes. *Psychology and Marketing, 42*(1), 25–39. https://doi.org/10.1002/mar.22180

Cash, D. K., Pazos, L. A., and Russell, T. D. (2024). Interpersonal pupillometry: The pupil as an indicator of emotion and its utility as a social cue. In *Modern pupillometry: cognition, neuroscience, and practical applications*, 327-347. Cham: Springer International Publishing.

Chang, Y. H., Yep, R., and Wang, C. A. (2025). Pupil size correlates with heart rate, skin conductance, pulse wave amplitude, and respiration responses during emotional conflict and valence processing. *Psychophysiology*, *62*(1), 1-22. https://doi.org/10.1111/psyp.14726

Colombatto, C., and Scholl, B. J. (2022). Unconscious pupillometry: An effect of "attentional contagion" in the absence of visual awareness. *Journal of Experimental Psychology: General, 151*(2), 302- 308. https://doi.org/10.1037/xge0000927

D'Ambrogio, S., Werksman, N., Platt, M. L., and Johnson, E. N. (2023). How celebrity status and gaze direction in ads drive visual attention to shape consumer decisions. *Psychology and Marketing*, *40*(4), 723-734. https://doi.org/10.1002/mar.21772

De Bellis, N. (2009). *Bibliometrics and citation analysis: From the Science Citation Index to cybermetrics*. Scarecrow Press.

Desrochers, C., Léger, P. M., Fredette, M., Mirhoseini, S., and Sénécal, S. (2019). The arithmetic complexity of online grocery shopping: The moderating role of product pictures. *Industrial Management and Data Systems*, *119*(6), 1206-1222. https://doi.org/10.1108/IMDS-04-2018-0151

Dobovšek, T., Bernik, Š., and Strle, G. (2022, June). Pupil dilation and heart rate as responses to ad exposure. In *Proceedings of the MEi: CogSci Conference* (Vol. 16, No. 1).

European Commission. (2016). Regulation (EU) 2016/679 (General Data Protection Regulation). Official Journal of the European Union.

Franzen, L., Cabugao, A., Grohmann, B., Elalouf, K., and Johnson, A. P. (2022). Individual pupil size changes as a robust indicator of cognitive familiarity differences. *PloS one*, *17*(1), 1-22. https://doi.org/10.1371/journal.pone.0262753

García-Carrión, B., Del Barrio-García, S., Muñoz-Leiva, F., and Porcu, L. (2025). Exploring destination positioning and message congruence in tourism management: An eye-tracking and fMRI study. *Tourism Management*, 108-129. https://doi.org/10.1016/j.tourman.2024.105111

García-Carrión, B., Muñoz-Leiva, F., Del Barrio-García, S., and Porcu, L. (2024). The effect of online message congruence, destination-positioning, and emojis on users' cognitive effort and affective evaluation. *Journal of Destination Marketing and Management*, *31*, 101334. https://doi.org/10.1016/j.jdmm.2023.100842

Garfield, E. (2006). The history and meaning of the journal impact factor. *JAMA, 295*(1), 90–93. https://doi.org/10.1001/jama.295.1.90

Grujic, N., Polania, R., and Burdakov, D. (2024). Neurobehavioral meaning of pupil size. *Neuron*, *112*(20), 3381-3395. https://doi.org/10.1016/j.neuron.2024.05.029

Guo, F., Ding, Y., Liu, W., Liu, C., and Zhang, X. (2016). Can eye-tracking data be measured to assess product design?: Visual attention mechanism should be considered. *International Journal of Industrial Ergonomics*, *53*, 229-235. https://doi.org/10.1016/j.ergon.2015.12.001

Hershman, R., Milshtein, D., and Henik, A. (2023). The contribution of temporal analysis of pupillometry measurements to cognitive research. *Psychological Research*, *87*(1), 28-42. https://doi.org/10.1007/s00426-022-01656-0.

Hess, E. H., and Polt, J. M. (1960). Pupil size as related to interest value of visual stimuli. *Science, 132*(3423), 349–350. https://doi.org/10.1126/science.132.3423.349

Hoeks, B., and Levelt, W. J. M. (1993). Pupillary dilation as a measure of attention: A quantitative system analysis. *Behavior Research Methods, Instruments, and Computers, 25*(1), 16–26. https://doi.org/10.3758/BF03204445

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., and van de Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures*. Oxford University Press.

Hopstaken, J. F., van der Linden, D., Bakker, A. B., and Kompier, M. A. J. (2015). The window of my eyes: Task disengagement and mental fatigue covary with pupil dynamics. *Biological Psychology, 110*, 100–106. https://doi.org/10.1016/j.biopsycho.2015.06.013

Huseynov, F., Kassym, J., and Öztürk, L. (2019). Incorporating biometric data in models of consumer choice. *Applied Economics, 51*(57), 6076–6091. https://doi.org/10.1080/00036846.2018.1527460

Kahneman, D. (1973). *Attention and effort*. Prentice-Hall.

Kahneman, D., and Beatty, J. (1966). Pupil diameter and load on memory. *Science, 154*(3756), 1583–1585. https://doi.org/10.1126/science.154.3756.1583

King, A. S. (1972). Pupil size, eye direction, and message appeal: Some preliminary findings. *Journal of Marketing, 36*(3), 55–58. https://doi.org/10.1177/002224297203600310

Ko, E. S., Kim, J. N., Na, H. J., and Kim, S. T. (2024). Changes in pupil size according to the color of cosmetic packaging: Using eye-tracking techniques. *Applied Sciences*, *15*(1), 73. 1-18. https://doi.org/10. 3390/app15010073

Kret, M. E., and Sjak-Shie, E. E. (2019). Preprocessing pupil size data: Guidelines and code. *Behavior Research Methods, 51*(3), 1336–1342. https://doi.org/10.3758/s13428-018-1075-y

Laeng, B., and Mathôt, S. (2024). Methodological Aspects of Pupillometry. In *Modern pupillometry: Cognition, neuroscience, and practical applications*, 375-400. Cham: Springer International Publishing.

Laeng, B., Sirois, S., and Gredebäck, G. (2012). Pupillometry: A window to the preconscious?. *Perspectives on Psychological Science, 7*(1), 18-27. https://doi.org/10.1177/1745691611427305

Laeng, B., Suegami, T., and Aminihajibashi, S. (2016). Wine labels: An eye-tracking and pupillometry study. *International Journal of Wine Business Research*, *28*(4), 327-348. https://doi.org/10.1108/IJWBR-03-2016-0009

Larsen, E. P., Kolman, J. M., Rao, A. H., Masud, F. N., and Sasangohar, F. (2020). Ethical considerations when using a mobile eye tracker in a patient-facing area: Case study of an intensive care unit observational protocol. *Ethics and Human Research, 42*(6), 28–35. https://doi.org/10.1002/eahr.500068

Larson, M. D., Berry, P. D., May, J., Bjorksten, A., and Sessler, D. I. (2004). Latency of pupillary reflex dilation during general anesthesia. *Journal of Applied Physiology*, *97*(2), 725-730. https://doi.org/10.1152/japplphysiol.00098.2004

Logan, I. T. (2019). Window to the soul: Eye tracking as the impetus for federal surveillance oversight? *Penn State Law Review, 124*(3), 779–811.

Lohse, G. L. (1997). Consumer eye movement patterns on Yellow Pages advertising. *Journal of Advertising, 26*(1), 61–73. https://doi.org/10.1080/00913367.1997.10673518

Luan, J., Xiao, J., Tang, P., and Li, M. (2022). Positive effects of negative reviews: An eye-tracking perspective. *Internet Research*, *32*(1), 197-218. https://doi.org/10.1108/INTR-12-2019-0517

Ludwig, J., Jaudas, A., and Achtziger, A. (2024). The Zero Effect: An Eye-Tracking Study of Affect and Motivation in Risky Choices. *Journal of Behavioral Decision Making*, *37*(3), 1-19. DOI: https://doi.org/10.1002/bdm.2400

Lukovics, M., Prónay, S., and Nagy, B. (2024). Segmented trust assessment in autonomous vehicles via eye-tracking. *Journal of Intelligent and Connected Vehicles*, *7*(2), 151-161. https://doi.org/10.26599/JICV.2023.9210037

Mathôt, S., and Vilotijević, A. (2023). Methods in cognitive pupillometry: Design, preprocessing, and statistical analysis. *Behavior Research Methods*, *55*(6), 3055-3077. https://doi.org/10.3758/s13428-022-01957-7

McInnes, A. N., and Sung, B. (2025). A neglected consumer neuroscience technique: Pupillometry and its practical application to consumer research. *International Journal of Research in Marketing*, *42*, 827-843. https://doi.org/10.1016/j.ijresmar.2024.11.005

Meritt, S. L., Keegan, A. P., and Mercer, P. W. (1994). Artifact management in pupillometry. *Nursing Research*, *43*(1), 56-59.

Mishra, R. K., Gunasekaran, A., Papadopoulos, T., and Dubey, R. (2018). Supply chain performance measures and metrics: A bibliometric study. *Benchmarking: An International Journal, 25*(3), 932-963. https://doi.org/10.1108/BIJ-08-2017-0224

Modi, N., and Singh, J. (2023). Understanding online consumer behavior at e-commerce portals using eye-gaze tracking. *International Journal of Human–Computer Interaction*, *39*(4), 721-742. https://doi.org/10.1080/10447318.2022.2047318

Mongeon, P., and Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: A comparative analysis. *Scientometrics*, *106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

Niknam, S., and Botev, J. (2024, January). Predicting cognitive failures in virtual reality using pupillometry. In *2024 IEEE International Conference on Artificial Intelligence and eXtended and Virtual Reality (AIxVR)*, 261-264. IEEE.

Onorati, F., Barbieri, R., Mauri, M., Russo, V., and Mainardi, L. (2013, July). Reconstruction and analysis of the pupil dilation signal: Application to a psychophysiological affective protocol. In *2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 5-8. IEEE.

Orquin, J. L., and Loose, S. M. (2013). Attention and choice: A review on eye movements in decision making. *Acta Psychologica, 144*(1), 190–206. https://doi.org/10.1016/j.actpsy.2013.06.003

Paul, J. and Rosado-Serrano, A. (2019), "Gradual Internationalization vs Born-Global/International new venture models", International Marketing Review, 830-858. https://doi.org/10.1108/IMR-10-2018-0280

Pengnate, S. (2019). Shocking secret you won't believe! Emotional arousal in clickbait headlines: An eye-tracking analysis. *Online Information Review*, *43*(7), 1136-1150. https://doi.org/10.1108/OIR-05-2018-0172

Pieters, R., and Wedel, M. (2004). Attention capture and transfer in advertising: Brand, pictorial, and text-size effects. *Journal of Marketing, 68*(2), 36-50. https://doi.org/10.1509/jmkg.68.2.36.27794

Plassmann, H., Venkatraman, V., Huettel, S., and Yoon, C. (2015). Consumer neuroscience: Applications, challenges, and possible solutions. *Journal of Marketing Research, 52*(4), 427–435. https://doi.org/10.1509/jmr.14.00

Preuschoff, K., 't Hart, B. M., and Einhäuser, W. (2011). Pupil dilation signals surprise: Evidence for noradrenaline's role in decision making. *Frontiers in Neuroscience, 5*, 115. 1-12. https://doi.org/10.3389/fnins.2011.00115

Rahal, R. M., and Fiedler, S. (2019). Understanding cognitive and affective mechanisms in social psychology through eye-tracking. *Journal of Experimental Social Psychology*, *85*. https://doi.org/10.1016/j.jesp.2019.103842

Ramsøy, T. Z., Jacobsen, C., Friis-Olivarius, M., Bagdziunaite, D., and Skov, M. (2017). Predictive value of body posture and pupil dilation in assessing consumer preference and choice. *Journal of Neuroscience, Psychology, and Economics*, *10*(2-3), 95-110. https://doi.org/10.1037/npe0000073

Rosenfield, M. (2011). Computer vision syndrome: A review of ocular causes and potential treatments. *Ophthalmic and Physiological Optics, 31*(5), 502–515. https://doi.org/10.1111/j.1475-1313.2011.00834.x

Russell, C. A., Swasy, J. L., Russell, D. W., and Engel, L. (2017). Eye-tracking evidence that happy faces impair verbal message comprehension: The case of health warnings in direct-to-consumer pharmaceutical television commercials. *International Journal of Advertising*, *36*(1), 82-106. https://doi.org/10.1080/02650487.2016.1196030

Segovia, M. S., Palma, M. A., and Nayga Jr, R. M. (2020). Can episodic future thinking affect food choices?. *Journal of Economic Behavior and Organization*, *177*, 371-389. https://doi.org/10.1016/j.jebo.2020.06.019

Shaker, H., Sénécal, S., Grégoire, Y., and Taboubi, S. (2022). The effect of incidental prices in online display ads on consumer internal reference price. *International Journal of Electronic Commerce*, *26*(3), 279-310. https://doi.org/10.1080/10864415.2022.2076195

Sheppard, A. L., and Wolffsohn, J. S. (2018). Digital eye strain: Prevalence, measurement and amelioration. *BMJ Open Ophthalmology, 3*(1), 1-10. https://doi.org/10.1136/bmjophth-2018-000146

Shi, S. W. (2022). Assortment levels, pupillary response, and product preference. *Journal of Marketing Management*, *38*(17-18), 2035-2054. https://doi.org/10.1080/0267257X.2022.2078863

Siegle, G. J., Steinhauer, S. R., Stenger, V. A., Konecky, R., and Carter, C. S. (2003). Use of concurrent pupil dilation assessment to inform interpretation and analysis of fMRI data. *NeuroImage*, *20*(1), 114-124. https://doi.org/10.1016/S1053-8119(03)00298-2

Singh, S., and Dhir, S. (2019). Structured review using TCCM: A study of international marketing research agenda. *Journal of International Marketing, 27*(3), 1-24. https://doi.org/10.1007/s12208-019-00233-3

Sirois, S., and Brisson, J. (2014). Pupillometry. Wiley interdisciplinary reviews: *Cognitive Science, 5*(6), 679-692. https://doi.org/10.1002/wcs.1323

Smidts, A., Hsu, M., Sanfey, A. G., Boksem, M. A. S., Ebstein, R. B., Huettel, S. A., and Yoon, C. (2014). Advancing consumer neuroscience. *Marketing Letters, 25*, 257-267. https://doi.org/10.1007/s11002-014-9306-1

Snyder, H. (2019). Literature reviews as a research strategy: An overview and guidelines. *Journal of Business Research*, *104,* 333-339. https://doi.org/10.1016/j.jbusres.2019.07.039

Songa, G., Slabbinck, H., Vermeir, I., and Russo, V. (2019). How do implicit/explicit attitudes and emotional reactions to sustainable logo relate? A neurophysiological study. *Food Quality and Preference*, *71*, 485-496. https://doi.org/10.1016/j.foodqual.2018.04.008

Souza, M. T. D., Oliveira, J. H. C. D., and Giraldi, J. D. M. E. (2020). Organic and sponsored ads: study on online purchase intent and visual behaviour. *International Journal of Internet Marketing and Advertising*, *14*(3), 318-335. https://doi.org/10.1504/IJIMA.2020.108721

Steinhauer, S. R., Bradley, M. M., Siegle, G. J., Roecklein, K. A., and Dix, A. (2022). Publication guidelines and recommendations for pupillary measurement in psychophysiological studies. *Psychophysiology*, *59*(4), 1-36. https://doi.org/10.1111/psyp.14035

Szymkowiak, A., Gaczek, P., and Padma, P. (2021). Impulse buying in hospitality: The role of content posted by social media influencers. *Journal of Vacation Marketing*, *27*(4), 385-399. https://doi.org/10.1177/13567667211003216

Toma, F. M., Cepoi, C. O., Kubinschi, M. N., and Miyakoshi, M. (2023). Gazing through the bubble: An experimental investigation into financial risk-taking using eye-tracking. *Financial Innovation*, *9*(1), 1- 28. https://doi.org/10.1186/s40854-022-00444-4

Tong, X., Chen, Y., Zhou, S., Yang, S., and Jiang, H. (2023). Do atmospheric cues matter in live streaming e-commerce? An eye-tracking investigation. *Electronic Commerce Research and Applications*, *62*. https://doi.org/10.1016/j.elerap.2023.101334

Tranfield, D., Denyer, D., and Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British Journal of Management*, *14*(3), 207-222. https://doi.org/10.1111/1467-8551.00375

Urai, A. E., Braun, A., and Donner, T. H. (2017). Pupil-linked arousal is driven by decision uncertainty and alters serial choice bias. *Nature Communications, 8*. 1-11. https://doi.org/10.1038/ncomms14637

Vallejo-De la Cueva, A., Aretxabala-Cortajarena, N., Quintano-Rodero, A., Rodriguez-Nuñez, C., Pelegrin-Gaspar, P. M., Gil-Garcia, Z. I., ... and Parraza-Diez, N. (2023). Pupillary dilation reflex and behavioural pain scale: Study of diagnostic test. *Intensive and Critical Care Nursing*, *74*. 1-7. https://doi.org/10.1016/j.iccn.2022.103332

Valliappan, N., Dai, N., Steinberg, E., He, J., Rogers, K., Ramachandran, V., ... and Navalpakkam, V. (2020). Accelerating eye movement research via accurate and affordable smartphone eye tracking. *Nature Communications, 11*(1). 1-12. https://doi.org/10.1038/s41467-020-18360-5

van Eck, N. J., and Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523-538. https://doi.org/10.1007/s11192-009-0146-3

van Loon, A. M., Hermsen, R., and Naber, M. (2022). Predicting product preferences on retailers' web shops through measurement of gaze and pupil size dynamics. *Journal of Cognition, 5*(1), 1-14. https://doi.org/10.5334/ joc.240

Wals, S. F., and Wichary, S. (2023). Under pressure: Cognitive effort during website-based task performance is associated with pupil size, visual exploration, and users' intention to recommend. *International Journal of Human–Computer Interaction*, *39*(18), 3504-3515. https://doi.org/10.1080/10447318.2022.2098576

Wedel, M., and Pieters, R. (2008). *Eye tracking for visual marketing*. Now Publishers Inc.

Winn, M. B., Wendt, D., Koelewijn, T., and Kuchinsky, S. E. (2018). Best practices and advice for using pupillometry to measure listening effort: An introduction for those who want to get started. *Trends in Hearing, 22*, 1-32. https://doi.org/10.1177/2331216518800869

Wook Chae, S., and Chang Lee, K. (2013). Exploring the effect of the human brand on consumers' decision quality in online shopping: An eye-tracking approach. *Online Information Review*, *37*(1), 83-100. https://doi.org/10.1108/14684521311311649

Zhou, C., Shi, Z., Huang, T., Zhao, H., and Kaner, J. (2023). Impact of swiping direction on the interaction performance of elderly-oriented smart home interface: EEG and eye-tracking evidence. *Frontiers in Psychology*, *14*. 1-13. https://doi.org/10.3389/fpsyg.2023.1089769

Appendix A List of Reviewed Studies

Author(s) and Year	Title	Journal	Theory (T)	Context (C)	Construct(s) (C)	Methodology (M)	Key Findings	Notes / Codes
Ramsøy et al. (2017)	Predictive value of body posture and pupil dilation in assessing consumer preference and choice.	Journal of Neuroscience, Psychology, and Economics	Somatic Marker Theory	Denmark, fashion and wine products, lab setting, university students, 30	Arousal (pupil dilation), Valence (body posture), Preference, Willingness to purchase	Eye-tracking, Behavioral ratings, Regression models	Pupil dilation predicts preference; effect moderated by posture	posture-modulates-arousal, pupil→WTP
Van Loon et al. (2022)	Predicting Product Preferences on Retailers' Web Shops through Measurement of Gaze and Pupil Size Dynamics	Journal of Cognition	Arousal-Attention Theory	Netherlands, online shopping, lab setting, university students, 56	Attention (dwell time, fixation metrics), Arousal (pupil dilation), Preference	Eye-tracking, Pupillometry, Ordinal Regression	Gaze predicts choice best; pupil adds slight value	online-retail, weak-pupil-effect, gaze→ choice, ecological-validity
Ko et al. (2025)	Changes in Pupil Size According to the Color of Cosmetic Packaging: Using Eye-Tracking Techniques	Applied Sciences	Fixation Theory	South Korea, cosmetics, lab setting, university students, 50	Pupil Dilation, Fixation, Emotional Attention	Eye-tracking, T-test	Pink elicits max attention (fixation); fixation > saccade	packaging-color, attention, fixation-dominant, pink-highest-arousal
Songa et al. (2019)	How do implicit/explicit attitudes and emotional reactions to sustainable logo relate? A neurophysiological study	Food Quality and Preference	Dual Attitude Theory, Dual Processing Theory	Italy, Belgium, food packaging, lab setting, university students, 191	Implicit Attitude, Explicit Attitude, Emotional Arousal, Emotional Valence	Eye-tracking (Pupil dilation), Facial Expression Analysis, Self-Assessment Manikin, Implicit Association Test	Implicit attitude → pupil and facial reaction; explicit attitude → SAM only	sustainable-logo, attention-modulates-effect, implicit-dominant, dual-attitudes
Biswas et al. (2016)	Comparing Ocular Parameters for Cognitive Load Measurement in Eye-Gaze-Controlled Interfaces for Automotive and Desktop Computing Environments	Int. J. Human–Computer Interaction	Cognitive Load, Social Identity Theory	UK, India, Automotive, lab setting, university students, adults, 24	Cognitive Load	Eye-tracking, pupil dilation, eye blinks, gaze movements, Pulse oximeter, NASA-TLX, Fourier Transform, Repeated Measures ANOVA, Paired Samples t-Test	SI velocity most predictive; pupil and blink weaker; ICA least effective	cognitive-load, SI-dominant, gaze-interface, ICA-limitations
Desrochers et al. (2019)	The arithmetic complexity of online grocery shopping: the moderating role of product pictures	Industrial Management and Data Systems	Cognitive Load	Canada, Online shopping, lab setting, university students, adults, 38	Attitude toward the site, Visual attention, Cognitive load	Eye-tracking, Pupillometry, Regression analysis	Fixation boosts attitude (experience goods); pupil SD helps (complex tasks)	complexity× pupil-variance, diagnosticity, visual-attention, dual-moderation
García-Carrión et al. (2025)	Exploring destination positioning and message congruence in tourism management: An eye-tracking and fMRI study	Tourism Management	CIMC, Cognitive Dissonance, ELM	Spain, Tourism Destination Marketing, Social Media, lab setting, adults, 89	Cognitive Effort, Attention, Neural Activation (Conflict), Affective Evaluation, Destination Visit Intention	(Eye-tracking + fMRI), pupil dilation, Within-subject design, Behavioral measures, Advanced statistical modeling	LC→↑cognitive load (PD, SA); NE→↑positive affect and intention	congruence, positioning, MPFC-activation, pupil-emotion, fMRI+ET
García-Carrión et al. (2024)	The effect of online message congruence, destination-positioning, and emojis on users' cognitive effort and affective evaluation	JDMM	ELM, CIMC, Cognitive Load	Spain, Tourism Marketing, Social Media, lab setting, adults, 58	Cognitive Effort (fixation, saccade, pupil dilation), Affective Evaluation (reactions)	Eye-tracking pupil dilation, Facebook task, MANOVA	LC → ↑cognitive load (PD↑, FD↑, SA↓); Emojis ↓ PD but ↑ attention	emoji-modulates-cognition, HC→ positive-affect, congruence× positioning, tourism-communication

Cardamone et al. (2025)	Color Inside and Outside the Lines: Evidence From Eye-Tracking Studies on Conformity to and Differentiation From Category Color Codes	Psychology and Marketing	LC4MP	Italy, packaging, retail, Lab + Field, Students, adults, 66	Visual Attention, Choice Behavior, Color Conformity	Lab + Field experiments, Eye-tracking pupil dilation, Multilevel Regression, Structural Equation Modeling	MCC × SCC → neg. interaction; hybrid color combos ↑ attention + choice	hybrid-color-optimal, attention→ choice, LC4MP, visual-strategy
Wals and Wichary (2023)	Under Pressure: Cognitive Effort During Website-Based Task Performance is Associated with Pupil Size, Visual Exploration, and Users' Intention to Recommend	IJHCI	Cognitive Load, AGT	Netherlands, online shopping, lab setting, university students, 52	Cognitive Effort, Visual Attention/Exploration, User Satisfaction (recommendation intention)	Eye-tracking, NASA-TLX, ANOVA and regression	↑ Pupil and ↓ K under pressure; ↑ load → ↓ recommend intention	adaptive-gain-theory, UX-load, pupil× exploration, K-index, e-commerce-task
Luan et al. (2022)	Positive effects of negative reviews: an eye-tracking perspective	Internet Research	Cue Theory, Arousal-Attention Theory	China, online shopping, lab setting, university students, 131	Attention, Arousal, Memory, Purchase Intention	Eye-tracking (fixation and pupil size), Behavioral tests, Repeated Measures ANOVA, Two-way ANOVA for behavioral data	Neg. review ↑ pupil and fixation; pop.-low brand + delay → ToP	sleeper-effect, valence-fade, negative-positive-shift, attention→ memory
Shi (2022)	Assortment levels, pupillary response, and product preference	J. of Marketing Management	Cognitive Load	USA, online shopping, lab setting, university students, 53	Cognitive Load (pupil size changes), Product Preference (price, brand familiarity)	Eye-tracking, Pupillometry, Linear Mixed Models, Mediation Tests	Pupil mediates assortment→ choice; ↑pupil → ↑price and ↓familiarity	assortment-cognition-choice, mediation, pupil→ preference, low→ explore
D'Ambrogio et al. (2023)	How celebrity status and gaze direction in ads drive visual attention to shape consumer decisions	Psychology and Marketing	aDDM	USA, food advertising, lab setting, adults, 60	Visual Attention, Arousal, Preference/Choice, Decision Confidence	Eye-tracking, Pupillometry, Drift Diffusion Model, Attentional Drift Diffusion Model	Celebs → ↑bias (z), ↓pupil → ↑confidence; gaze-cueing works for some	vampire-effect, decision-bias, aDDM, pupil-confidence, celebrity-gaze
Shaker et al. (2022)	The Effect of Incidental Prices in Online Display Ads on Consumer Internal Reference Price	Int. J. of Electronic Commerce	Anchoring Theory, Cog Load	UK, Canada, online advertising, consumer electronics, lab setting, online experiment, adults, 73	Internal Reference Price (IRP), Expected Price (EP), Attention (pupil size, fixation)	3 Online experiments + 1 Eye-tracking lab study; ANOVA, Linear Mixed-Effects Model	Low-price + repeat → ↓IRP; High-price → semantic, stable IRP; pupil ↑ = cognitive load ↑	incidental-processing, repetition-anchor, eye-pupil-load, semantic-vs-numerical
Cao et al. (2021)	Detecting users' usage intentions for websites employing deep learning on eye-tracking data	IT and Management	TPB	China, online shopping, lab setting, university students, 30	Behavioral Intention, Cognitive Load, Visual Attention, Emotional Arousal	Eye-tracking (fixation, saccade, blink, pupil), Deep Neural Network classification	DNN: ↑accuracy (%85); menu size+location modulates intention	usage-detection, deep-learning, UX-design, all-metrics-best, pupil→intent
Segovia et al. (2020)	Can episodic future thinking affect food choices?	JEBO	EFT, Arousal-Attention	USA, food choice, lab setting, university students, 332	Food Choice, Visual Attention, Emotional Arousal	Eye-tracking, Pupillometry, Panel Logit Model	EFT → arousal↑ + attention→ lite → healthy choices↑ (only obese)	BMI-specific, arousal→ attention→ choice, food-EFT, healthinfo-vs-EFT
Toma et al. (2023)	Gazing through the bubble: an experimental investigation into financial risk-taking using eye-tracking	Financial Innovation	Arousal-Attention, PSTR	Romania, financial assets, lab setting, university students, 28	Attention, Arousal, Disengagement, Decision Performance	Eye-tracking, Panel data models (PSTR)	Arousal helps only when attention low; disengagement bad when attention low	bubble-risk, arousal-threshold, PSTR, pupil→gain, disengage-loss

Szymkowiak et al. (2021)	Impulse buying in hospitality: The role of content posted by social media influencers	J. of Vacation Marketing	Dual-System Theory	Poland, Malaysia, tourism, social media, lab setting, university students, 74	Impulse Buying Tendency, Purchase Intention, Arousal (Pupil Dilation), Thematic Compatibility	Eye-tracking, , pupil dilation Self-report measures, ANOVA	Arousal ↑ urge and intention; compatibility ↑ intention only; pupil correlates with both	impulse-vs-intention, socialmedia-fluency, arousal-effect, influencer-study
Tong et al. (2023)	Do atmospheric cues matter in live streaming e-commerce? An eye-tracking investigation	ECRA	SOR, Cog Load, Arousal-Attention Theory	China, online shopping, social media, lab setting, university students, 55	Cognitive Load, Emotional Arousal, Visual Attention, Purchase Intention	Eye-tracking, pupil dilation Pupillometry, MANOVA, Mediation Analysis	↑BVC and fast MT → ↑pupil; ↑arousal and AOI fixations → ↑PI and CWI	live-streaming-arousal, AOI-load, BVC-MT, cognitive-affective-dual
Alós-Ferrer et al. (2021)	Attentional shifts and preference reversals: An eye-tracking study	Judgment and Decision Making	aDDM	Switzerland, Germany, decision making, lab setting, university students, 59	Visual Attention (fixations), Preference Reversal, Overpricing	Eye-tracking, Pupil dilation, Behavioral Tasks, Wilcoxon Signed-Rank Test, Mann-Whitney-Wilcoxon Test, Random Effects Panel Regression, Random Utility Model (for utility estimation)	Price → ↑attention on outcomes → ↑overpricing; Rank → attention to probability	preference-reversal, monetary-evaluation-bias, attention-shift, pricing-frame
Lukovics et al. (2024)	Segmented trust assessment in autonomous vehicles via eye-tracking	JICV	Trust in Automation Theory, Arousal-Attention Theory	Hungary, automotive, lab setting, adults, 102	Trust, Visual Attention (Fixations), Emotional Arousal (Pupil Dilation)	Eye-tracking, Segment-specific Analysis, Posttest Interviews	Low trust across segments; pupil ↑ internal AOIs; tablet info ↑ trust	segment-trust, fixation→ trust, pupil-engagement, AV-design-implication
Zhou et al. (2023)	Impact of swiping direction on the interaction performance of elderly-oriented smart home interface: EEG and eye-tracking evidence	Frontiers in Psychology	Cog Load, Arousal-Attention Theory	China, UK, consumer electronics, lab setting, older adults, 17	Attention (fixation), Arousal (pupil diameter), Cognitive Load (EEG), Subjective Preference	Eye-tracking, pupil dilation + EEG + Questionnaire, Multivariate/Two-way ANOVA	Vertical swipe → ↑EEG δθ and pupil; ↑comfort and ↓task time	elderly-UX, swipe-direction, pupil-arousal, EEG-support, visual-comfort
Rahal and Fiedler (2019)	Understanding cognitive and affective mechanisms in social psychology through eye-tracking	JESP	Cog Load, Dual-Proc, SOR	Germany, Social Psychology, lab setting, university students, 38	Cognitive Load, Emotional Bias, Decision Bias, Pupil Dilation	Eye-tracking, pupil dilation Mixed-Effects Models, Mediation analysis	Fix. duration = depth; Pupil = load and arousal; ICA = task difficulty ↑ → dilation ↑↑	review-core, pupil-load-index, fixation-depth, AOI-standards
Souza et al. (2020)	Organic and sponsored ads: study on online purchase intent and visual behavior	IJIMA	SOR	Brazil, Online Shopping, Search Engine Advertising, lab setting, university students, 100	Visual Attention (fixation duration, pupil dilation), Visual Behavior Type (holistic/analytical), Online Purchase Intention	Eye-tracking, pupil dilation, Logistic Regression	Fixation→ intent↑; Pupil dilation→ n.s.; Ad type: sponsor↑	organic-vs-sponsored, fixation-driven-choice, no-pupil-effect, visual-behavior-flexible
Pengnate (2019)	Shocking secret you won't believe! Emotional arousal in clickbait headlines An eye-tracking analysis	OIR	SOR, Arousal-Attention Theory	USA, online news, lab setting, university students, 54	Emotional Arousal, Intention to Read News	Eye-tracking (pupil dilation), SAM, Regression and ANOVA analyses	SAM: clickbait > neutral; PDC: news > all; arousal → intent↑	textual-arousal, real-time-pupil, SAM-vs-PDC, clickbait-behavior
Ludwig et al. (2024)	The Zero Effect: An Eye-Tracking Study of Affect and Motivation in Risky Choices	JBDM	Prospect Theory, SOR, Arousal-Attention Theory	Germany, decision making, lab setting, university students, 72	Emotional Arousal (pupil dilation), Attention (fixations), Choice behavior, Decision latency	Eye-tracking, Pupillometry, Logistic and Linear Mixed-Effects Models	Gains: zero→↓choice/fix, ↑arousal; Losses: zero→↑choice, pupil↑	zero-effect, risk-choice, gain-vs-loss, motivation-arousal, cert-vs-zero
Huseynov et al. (2019)	Incorporating biometric data in models of consumer choice	Applied Economics	Random Utility Model	USA, consumer goods, lab setting, university students, 115	Visual Attention (Fixation, Pupil Size), Emotional Arousal (Facial Expressions), Cognitive Engagement (EEG	Eye-tracking, EEG, Facial Expression Analysis, Logistic Regression, ROC, LASSO	Pupil strongest; Mix > indiv.; LASSO: optimal sparse predictor	biometric-choice-model, pupil-dominant, lasso-enhanced,

					Metrics), Purchase Decision			ROC-prediction
Russell et al. (2017)	Eye-tracking evidence that happy faces impair verbal message comprehension: the case of health warnings in direct-to-consumer pharmaceutical television commercials	IJA	Cog Load	USA, Pharmaceutical Advertising, lab setting, university students, 223	Cognitive Load, Message Comprehension, Visual Attention, Attitudes	Eye-tracking (fixation, dwell, pupil), Regression, Mediation	Pos. face → ↑pupil, ↓comprehension; Banner restores understanding	face-vs-message, congruency-cost, mediation-load, policy-banner-effect
Guo et al. (2016)	Can eye-tracking data be measured to assess product design?: Visual attention mechanism should be considered	IJIE	Cog Load	China, product design, cell phone, lab setting, university students, 26	Attention (fixation metrics), Arousal (pupil dilation), User Experience	Eye-tracking, Subjective Rating Scales, Repeated Measures ANOVA	Task 1: high UX→ fixation faster, low UX→pupil↑; Task 2: high UX→ fixation↑ and pupil↑	dual-task-difference, pupil-contextual, UX-assessment, gaze-UX-choice
Laeng et al. (2016)	Wine labels: an eye-tracking and pupillometry study	IJWBR	Cog Load	Norway, wine, packaging, lab setting, university students, 26	Attention (fixation measures), Arousal (pupil dilation), Preference, Aesthetic Evaluation, Willingness to purchase	Eye-tracking, Pupillometry, Aesthetic ratings, Regression, ANOVA	Fixation→ choice (r=.84); Pupil: U-shaped; Aesthetics→ Price (r=.83)	wine-labels, gaze-predicts-choice, pupil-aesthetic-nonlinear, pricing-by-appearance