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When Gaze Isn't Enough: A Systematic Review of Triangulated Eye-Tracking in Desktop E-Commerce

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Abstract: Desktop e-commerce research increasingly uses eye-tracking (ET), yet interpretation remains fragile when gaze is treated as a stand-alone indicator. This focused review integrates 24 ET-primary studies with explicit triangulation (ET plus ≥1 independent modality) and clarifies what eye-tracking can and cannot conclude in online shopping. Three consistent insights emerge. First, attention is strongly shaped by task intent and information architecture. Second, attention and behaviour often decouple: visual salience and recommender cues can attract gaze without reliably changing choices. Third, trust-relevant and sustainability cues more frequently show convergence between gaze allocation and subsequent judgments. At the same time, methodological mapping reveals uneven reporting of key ET parameters (sampling rate and data-quality handling), reducing comparability and cumulative inference. We argue that triangulation is essential for actionable UX conclusions and outline concrete priorities for future work: standardised ET reporting and explicit, multimodal workload measurement embedded in realistic shopping tasks.

Keywords: eye-tracking; triangulation; desktop e-commerce; online shopping; UX/usability; systematic review

JEL Classification: C91; M31; L81

1. Introduction

Eye-tracking (ET) provides granular evidence on visual attention during online shopping tasks, showing how users allocate gaze across product information, navigation elements, trust cues, and checkout interfaces. It complements conventional usability and experience measures by revealing attention patterns that are difficult to infer from self-report alone. ET studies in digital commerce vary in task realism, reporting completeness (e.g., device and sampling rate), and outcome operationalisation. They also differ in whether ET is paired with independent measures (e.g., questionnaires, interviews/think-aloud, psychophysiology, facial coding, or behavioural logs), which complicates evidence accumulation and comparability. We conducted a PRISMA-informed focused review with strict eligibility criteria requiring a desktop e-commerce website context, ET as the primary method, and triangulation—i.e., ET combined with at least one independent measure to strengthen interpretation beyond gaze alone. We report methodological mapping of included studies and a triangulation-informed thematic synthesis.

Recent syntheses have summarised eye-tracking evidence in (i) online shopping visual attention and interface factors (Li et al., 2024), (ii) eye-tracking-based usability/UX

evaluation across software systems (Santiago-Cruz et al., 2023; Novák et al., 2024), and (iii) design evaluation contexts where ET is increasingly combined with complementary metrics (Guo et al., 2024). Yet these reviews typically aggregate across platforms (desktop/mobile), contexts, and single-method ET designs. By restricting to desktop e-commerce tasks, requiring ET as the primary method, and enforcing explicit triangulation with ≥1 independent modality, our review provides a higher-validity synthesis of how attention relates to usability, trust cues, recommendation use, and user experience in online shopping.

Review questions. The thematic synthesis addressed four questions aligned with the reported themes:

We addressed four research questions: RQ1: How do task goals and information architecture shape attention allocation on e-commerce pages?; RQ2: How do trust and persuasion cues influence attention and downstream judgments/intentions?; RQ3: How do recommendation aids and decision supports affect attention and behavioural outcomes (e.g., choice/clicks)?; RQ4: How does triangulation improve inference about usability, affect, and decision processes beyond eye-tracking alone?

In addition, we provide a methodological mapping of study designs and reporting practices to contextualise the robustness of the triangulated evidence.

2. Methodology

This review follows PRISMA 2020 reporting principles (Page et al., 2021a/2021b). Methods and coding rules were defined a priori and recorded in an archived screening log.

2.1. Information Sources and Search Strategy

We searched Web of Science (WoS) as the sole source database (WoS-only backbone). Search documentation (full query strings and filters) was recorded by the authors and is available upon reasonable request. We adopted a WoS-only backbone to ensure a consistent indexing scope and a replicable single-export workflow for conference reporting.

The search was last executed on 6 January 2026. The WoS timespan covered 2015–2025. Note: Web of Science indexes Early Access/online-first items; records retrieved as Early Access within the search window and subsequently published with a 2025 year-of-record were included and treated as standard records in the PRISMA flow and eligibility assessment (counted by retrieval and full-text screening status).

Representative WoS query (Topic search):

TS=((("eye track" OR eyetrack* OR "gaze track*" OR "eye movement*" OR fixation* OR saccad* OR scanpath* OR "pupil dilat*" OR "pupil diameter" OR pupillometr*)) AND (("e-commerce" OR ecommerce OR "online shop*" OR "online shopping" OR "online retail*" OR "digital retail*" OR "online purchas*" OR "product page*" OR "product listing" OR "checkout" OR "shopping cart" OR "online marketplace")) AND (("user experience" OR UX OR usability OR "user satisfaction" OR "customer experience" OR "purchase intention" OR "recommendation intention" OR conversion OR "decision making")))*

2.2. Eligibility Criteria

We included studies only if (i) tasks were performed on desktop e-commerce websites (web store or product page), (ii) gaze-based eye-tracking was the primary method driving the main inferences, and (iii) ET was combined with at least one explicitly independent method (e.g., questionnaire/self-report, interview/think-aloud/retrospective think-aloud, psychophysiology, facial coding, or behavioural logs). We excluded live-streaming commerce, pure banner/ads environments, and non-shopping web contexts. Single forced-choice/customer choice outcomes alone were not treated as triangulation.

All included tasks were performed on desktop web pages (desktop/laptop display) within an e-commerce website context; studies using remote/webcam/ETG equipment were included only when the shopping interaction remained a desktop website task.

2.3. Selection Process

Records were screened at title/abstract level, followed by full-text retrieval. Non-retrieved reports were documented and were never counted as included. Full texts retrieved were assessed for eligibility, with full-text exclusion reasons coded and reported in the PRISMA flow diagram. Screening was conducted by a single reviewer (JP) at both title/abstract and full-text stages; no automation tools were used. Duplicates: no duplicate records were identified (WoS-only single export).

2.4. Data Charting and Coding

We charted sample, tasks/stimuli, ET device model, sampling rate (Hz), calibration reporting, and AOI (Areas of Interest) definition/use. We also coded ET data-quality handling (e.g., track loss criteria and exclusions) and triangulation modalities. For methodological mapping, items were coded as “reported” only when explicitly stated in text/tables; otherwise, we coded Not reported. Data charting and coding were performed by a single reviewer (JP) using a predefined codebook. Where reported, we coded ET metrics using consistent definitions (e.g., fixation count as the number of fixations within an AOI and fixation duration/time as the duration of fixations in milliseconds, ms, within an AOI). Time-based measures are reported in ms and sampling in Hz; pixel/luminance values are noted only when explicitly reported by primary studies.

2.5. Synthesis Approach

We performed descriptive methodological mapping and a triangulation-informed thematic synthesis across included studies.

2.6. Quality Appraisal

Methodological quality was appraised using the Mixed Methods Appraisal Tool (MMAT) version 2018 (Hong et al., 2018). Item-level judgments were recorded by the authors and are available upon reasonable request.

Materials availability: Full search strings, screening log, extraction sheets, and MMAT 2018 item-level appraisal matrix are archived by the authors and are available upon reasonable request.

Protocol and registration: This review was not registered and no publicly accessible a priori protocol was prepared.

Reporting bias and certainty assessment: We did not formally assess reporting bias or certainty of evidence (e.g., GRADE), given the descriptive mapping focus and the heterogeneity of designs and outcomes.

3. Results

3.1. Study Selection

A total of 124 records were screened, and 30 were excluded at title/abstract stage. Ninety-four full-text reports were sought for retrieval; 21 were not retrieved. Seventy-three reports were assessed for eligibility, and 49 were excluded at full-text stage (not desktop e-commerce website, n=22; not triangulation, n=16; eye-tracking not primary method, n=6; not e-commerce/online shopping context, n=3; not eye-tracking/gaze-based measurement, n=1; not UX/marketing outcome, n=1). Twenty-four studies were included in the review. The study selection process is summarised in Figure 1.

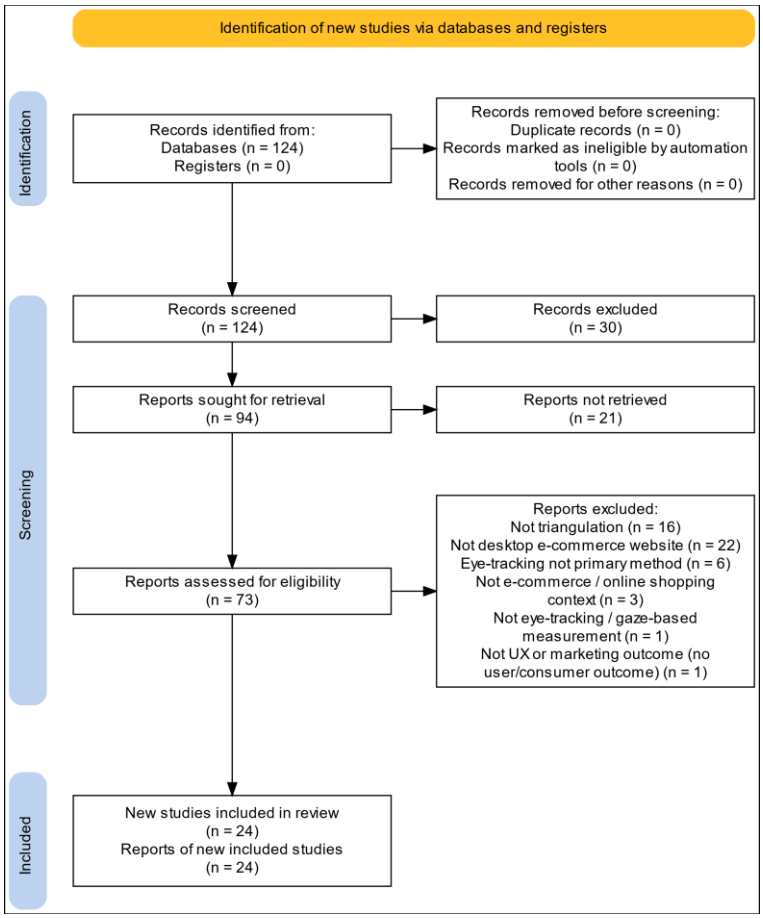

Figure 1. PRISMA flow diagram for the focused review (WoS-only backbone; included studies n=24).

Note: Flow diagram was generated using the PRISMA 2020 tool (Haddaway et al., 2022). The synthesis is reported in four themes corresponding to RQ1-RQ4.

3.2. Study Characteristics and Methodological Mapping

Table 1 summarises the included studies and their core methodological characteristics. Abbreviations: SR=self-report; BEH=behavioural measures/logs; PHYS=psychophysiology; QUAL=qualitative elicitation; NR=not reported.

Across the 24 included studies, reporting completeness varied by key methodological items. ET device model was explicitly reported in 23/24 (95.8%), while sampling rate (Hz) was reported in 18/24 (75.0%). Calibration procedures were described in 16/24 (66.7%). AOI use was reported in 21/24 (87.5%), and AOI definition/specification in 22/24 (91.7%). Handling of ET data quality (e.g., track loss criteria, exclusions, or preprocessing rules) was reported in 16/24 (66.7%). AOI use was coded as reported only when AOIs were explicitly defined in text/tables; papers showing only heatmaps without AOI definitions were coded as Not reported.

Triangulation modalities were heterogeneous and frequently combined (modalities were not mutually exclusive). Self-report measures were used in 23/24 (95.8%), behavioural logs/performance measures in 15/24 (62.5%), psychophysiology in 11/24 (45.8%), and qualitative elicitation (interview/think-aloud/RET) in 4/24 (16.7%). In terms of breadth, studies used 1 modality in 5/24 (20.8%), 2 modalities in 9/24 (37.5%), 3 modalities in 10/24 (41.7%).

Across the 24 included studies, participant sampling was predominantly convenience-based (often students or online panels), and reporting of participant characteristics and recruitment procedures was heterogeneous (Table 1). Primary outcome foci clustered around purchase/decision outcomes, UX/usability, trust/credibility and sustainability-related judgments, and recommendation/personalisation interfaces (Section 3.3). Quality appraisal was recorded as item-level MMAT judgments; consistent with MMAT guidance, we did not compute or interpret an overall MMAT score.

Table 1. Compact characteristics table for included studies (n=24).

Study	N	Device	Hz	Triangulation (modalities)	Outcome
Menzel (2022)	18	Gazepoint GP3 HD	150	SR+BEH+PHYS	Visual attention + Trust
Naeini (2023)	30	Tobii X2-30	30	SR+BEH+PHYS	Website usability / UX
Luan (2016)	ET=40; Survey=140	Tobii T120	120	SR+BEH	Online review search behavior / visual attention to review types
Guo (2015)	30	SMI infrared (Experiment Center 2	Not reported	SR+BEH+PHYS	Emotional experience during online shopping
Chiang (2022)	80	Not reported	60	SR+BEH+PHYS	Age differences in visual attention
Najafabadiha (2025)	99	SMI iView RED 4	Not reported	SR	Decision/purchase
Ziemba (2017)	20	Not reported (eye-tracking device used with GazePoint software).	Not reported	SR+BEH+PHYS	UX/usability

Sulikowski (2022b)	30	Tobii Pro X3-120	120	SR+BEH+PHYS	Customer attention / UX: attention to recommendation area and product
Gorton (2024)	44	GazePoint (panel) on 22-inch monitor	60	SR+QUAL	Visual attention to marketplace “market signals” and purchase decision
Fu (2020)	141	SMI iView ETG type sensor	Not reported	PHYS	Online review search behaviour / decision-making
Deng (2021)	40	Tobii Pro X3-120	120	SR+BEH	Information acquisition
Wang (2019)	30	SMI RED500 (desktop)	50/60	SR+QUAL	Conformity / social proof effect in online shopping
Yang (2015)	108	EyeLink 1000 Desktop Mount (SR Research)	1000	SR	Purchase intention
AlSalem (2023)	10	RealEye v10	Not reported	SR+BEH	UX/usability
Koutroumpas (2025)	20	Gazepoint GP3 HD	60	SR	UX/engagement in recommender systems
Boardman (2023)	50	Tobii TX 300	300	SR+BEH+QUAL	Age-related differences in online fashion shopping behaviour and website
Weng (2019)	32	Not reported	Not reported	SR	Emotion
Sulikowski (2022a)	30	Tobii Pro X3	120	SR+BEH+PHYS	Attention / user perception / choice behavior
Lambillotte (2022)	58	Tobii X2-60 (Tobii Studio v3)	60	SR+BEH	Decision/purchase
Karmarkar (2021)	58	Tobii X2-60 (Tobii Studio v3)	60	SR+BEH	Decision/purchase
Shi (2017)	67 (of 76)	Tobii T60 (three devices)	60	SR+BEH+PHYS	Attention to recommendations
Chocarro (2022)	S1=58; S2=66	Study 1: EyeTribe Tracker	Study 1: 30; Study 2: 60.	SR+BEH+PHYS	Visual attention to product images vs name/price across shopping tasks and
Palcu (2017)	137	SMI RED 500	120	SR+PHYS	Visual attention + product evaluation / purchase intention
Boardman (2022)	52	Tobii TX300	300	SR+PHYS+QUAL	Attention, cognitive/affective responses and behavioural outcomes during

3.3. Triangulation-Focused Thematic Synthesis

We synthesised evidence across the focused cohort by grouping studies according to (i) where attention was directed on desktop e-commerce interfaces, (ii) which interface cues and decision supports were tested, and (iii) how triangulated modalities supported (or challenged) inferences from gaze behaviour. The synthesis is reported in four themes corresponding to RQ1–RQ4.

Across studies, gaze allocation was strongly shaped by task demands (browsing vs. searching; goal-directed vs. exploratory) and by the information architecture of product or listing pages. Product images typically captured attention early, but downstream attention

distribution varied across shopping stages and product categories. Attribute-oriented displays tended to promote cross-product comparisons and faster task completion in browsing contexts, whereas effects were weaker in explicit search tasks. Review-related information also showed differentiated attention patterns depending on the product type and the consumer's decision goal, suggesting that "what is fixated" is contingent on the consumer's information need rather than being purely stimulus-driven (Boardman & McCormick, 2022; Chocarro et al., 2022; Deng & Gu, 2021; Luan et al., 2016).

Several studies treated non-product elements as attention shapers and potential confounds. Marketplace cues such as price and photos were used as low-cost signals in low-involvement decision contexts, while higher-involvement choices relied more on credibility-relevant signals. Banner advertising with human faces was associated with greater attention to the banner area, and gaze direction was associated with both attention allocation and product judgements. Background features also modulated pupil-size-based indices of affective response, with stronger effects reported for experience-type products. Together, these findings reinforce that attention in e-commerce is jointly determined by interface structure, cue ecology, and goal state (Gorton et al., 2024; Palcu et al., 2017; Weng & Ye, 2019; Yang, 2015; Fu et al., 2020).

A smaller cluster of studies examined links between visual attention and trust- or persuasion-relevant constructs. Embedding regional cues in the interface was associated with greater visual attention and higher perceived regional presence, which was in turn related to trusting belief and intention. Social proof cues (e.g., high sales volumes) attracted longer fixations and were associated with stronger conformity tendencies, with qualitative accounts suggesting that such cues may act as decision heuristics. Sustainability-oriented interventions (e.g., environmental educational messages shown before browsing) were associated with greater attention to eco-friendly information and with shifts toward greener preferences, alongside reduced price sensitivity. In parallel, neuroscience-based work reported age-related differences in eye-movement patterns and complementary psychophysiological responses during sustainable-product browsing. Overall, these studies suggest that persuasive cues can operate via attentional capture and downstream interpretation, and that user characteristics and involvement may moderate observed associations (Menzel et al., 2022; Wang et al., 2019; Najafabadiha et al., 2025; Chiang et al., 2022; Gorton et al., 2024; Yang, 2015).

Decision-support elements-particularly recommendations, personalisation widgets, and visual highlighting-were frequently evaluated with triangulated designs. Recommendation presentation characteristics were associated with differences in gaze distribution and engagement: recommendation types differed in whether viewing was text-focused and predictable versus more distributed and exploratory, and blink-based indicators were interpreted as reflecting arousal or disengagement for low-relevance items. Source cues also mattered: recommendations attributed to consumer reviews attracted greater interest/attention than those attributed to expert reviews, whereas earlier presentation was not consistently associated with higher attention than later presentation. Visual highlighting showed a recurring dissociation between attention capture and choice: highly salient

animation could be associated with longer fixation time but lower selection likelihood, while lower-intensity highlighting (and aesthetic store design) tended to coincide with both higher attention and greater behavioural engagement in recommendation areas. (Koutroumpas et al., 2025; Shi et al., 2017; Sulikowski et al., 2022a; Sulikowski et al., 2022b).

Personalisation via display-only products showed another form of attention-outcome dissociation. Across experiments manipulating category congruence, mismatched display items reliably attracted more attention than matched items; however, matched displays were associated with higher purchase likelihood for the target product. In these studies, target fixation time often did not differ by condition, implying that purchase differences were not simply mediated by higher visual attention to the target AOI. This pattern suggests that some decision-support interventions may operate through interpretation or affective appraisal rather than through straightforward attentional amplification alone (Karmarkar et al., 2021; Lambillotte et al., 2022).

Triangulated measurement designs were used to strengthen inference about usability and affective experience, and to clarify when ET adds value beyond self-report. Several studies reported systematic associations between ET metrics (e.g., fixation- and saccade-based indicators, scan path characteristics, pupil size) and standard usability questionnaires, and indicated that user experience moderated visual search efficiency. Mixed-method evaluation frameworks combined expert heuristic review, usability testing, and ET to identify complementary classes of usability issues-ET being particularly useful for diagnosing inefficient attention paths and problematic element placement. Survey+ET approaches similarly produced website rankings that differed from survey-only rankings, supporting the incremental diagnostic value of gaze measures. (Naeini et al., 2023; AlSalem & AlShamari, 2023; Ziemba et al., 2017).

Cognitive load and mental workload were only indirectly addressed in this focused cohort, most often via proxy indicators (e.g., pupil size/dilation or blink activity) or via affective/effort-related self-report instruments rather than through standardised workload paradigms. This points to a research gap: future triangulated studies could more explicitly operationalise cognitive load (e.g., validated workload scales and/or complementary psychophysiology) and report ET parameters consistently to support cross-study comparability and mechanism-level interpretation (Naeini et al., 2023; Guo et al., 2015; Deng & Gu, 2021; Koutroumpas et al., 2025; Weng & Ye, 2019; Shi et al., 2017).

Affective responses were most convincingly characterised when subjective ratings were paired with ET and physiological measures. In a multimodal emotional-experience study, differences between websites were reflected primarily in subjective ratings and eye-movement indicators, whereas physiological responses differentiated shopping from rest but did not clearly discriminate between websites-highlighting both the potential and the limits of physiological convergence. Related work linked positive emotion and approach tendency to attention patterns under different task modes, and demonstrated that interface aesthetics/background features can influence pupil-size-based indices of emotional response. Finally, age-related differences in attention and behaviour were observed in fashion and sustainable shopping contexts, with qualitative data emphasising specific usability barriers

and design preferences relevant to inclusive desktop e-commerce. (Guo et al., 2015; Deng & Gu, 2021; Weng & Ye, 2019; Boardman & McCormick, 2022; Boardman & McCormick, 2023; Chiang et al., 2022).

4. Discussion

This focused review combines focused eligibility criteria (desktop e-commerce tasks, ET-primary designs, and explicit triangulation—ET plus ≥1 independent modality) with transparent PRISMA reporting and item-level quality appraisal. The methodological mapping highlights recurring reporting gaps (e.g., ET sampling rate) that constrain comparability, while the thematic synthesis shows how triangulated evidence links gaze behaviour to usability, affect, and consumer outcomes in desktop e-commerce.

Most studies combined ET with self-report (23/24) and behavioural measures (15/24). Psychophysiology (11/24) and qualitative elicitation (4/24) were less common. Most studies used multiple independent modalities (1: 5/24; 2: 9/24; 3: 10/24), which supports convergent interpretation; however, inference still depends on modality validity and reporting quality.

Implications for practice. The triangulated evidence suggests three design-relevant takeaways. First, match information architecture to shopping intent (search vs browse): support goal-directed search with scannable attributes and filters, and support browsing with clear visual hierarchy and curated comparisons. Second, treat trust/sustainability cues and recommendations as attention drivers, but validate impact with outcomes such as clicks, add-to-cart, or purchase intention (attention ≠ choice). Third, use disciplined triangulation and transparent ET reporting (self-report/behaviour/physiology/qualitative elicitation where feasible), including sampling rate (Hz), calibration, AOI definition, and data-quality handling.

Theoretical implications. The recurring attention–behaviour dissociation cautions against treating gaze as a direct proxy for preference or choice. Trust- and sustainability-related cues more often aligned attention with subsequent judgments, consistent with credibility and signaling mechanisms. Overall, triangulation supports stronger mechanism-level inference by separating what users look at from what they decide.

5. Limitations

This focused review used a WoS-only search backbone and therefore may not capture all eligible studies indexed exclusively in other databases. We did not conduct a meta-analysis because study designs, tasks, and outcomes were highly heterogeneous; the intended contribution was methodological mapping and thematic synthesis. In addition, 21 reports were not retrieved and were not counted as included; this constrains completeness and may introduce availability bias and related reporting bias. We applied a strict triangulation definition (ET plus at least one explicitly described independent method), excluding studies where 'triangulation' was operationalised only as single forced-choice/choice labels; this improves construct clarity but narrows scope. At the same time, many included studies collected ET and self-report within the same session, which may be susceptible to demand characteristics and common-method bias; future work should strengthen independence by

incorporating objective behavioural traces (click/log data), temporally separated measures, or multi-sensor designs. Finally, more standardised reporting of ET hardware, sampling rates, calibration, AOI specification, and data-quality handling would improve comparability. Screening and data charting/extraction were performed by a single reviewer, which may increase selection and extraction bias; mitigation included a predefined codebook and an archived screening log.

Future research. None of the included triangulated desktop e-commerce studies directly operationalised cognitive load or mental workload as a primary outcome. This omission aligns with broader eye-tracking usability/UX reviews that call for richer outcome constructs beyond attention metrics and more systematic integration of complementary measures (Santiago-Cruz et al., 2023; Novák et al., 2024; Guo et al., 2024). A pragmatic minimum package for workload-oriented triangulation in shopping tasks could include: (i) a validated workload scale (e.g., NASA-TLX) administered at task level; (ii) an ET/physio proxy sensitive to cognitive effort (e.g., pupil dynamics and blink metrics, with luminance controlled) alongside optional EDA/GSR for arousal; and (iii) an explicit workload manipulation (e.g., time pressure, information density/complexity, or multitasking) embedded in a standardised shopping task. In reporting and interpretation, studies should distinguish cognitive effort (information processing demands) from affective arousal/valence, which can influence pupil and EDA signals. Recent ergonomics work in online shopping has begun to connect webpage complexity and shopping motivation to workload using eye-tracking (Chen, 2025), but multi-modal triangulation remains rare. Standardised reporting of ET parameters (sampling rate, calibration and data-quality handling) and shared analysis conventions would further support cross-study comparability and stronger inference.

6. Conclusions

We synthesised 24 triangulated, ET-primary studies in desktop e-commerce, mapping methodological reporting and distilling four themes on attention, trust cues, recommendations, and usability. Persistent reporting gaps (e.g., sampling rate, calibration, data-quality handling) limit comparability; future work should standardise reporting and explicitly operationalise cognitive workload.

Conflict of interest: none

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