THE MODERATING ROLE OF DIGITAL LITERACY ON CONSUMER COGNITIVE BIASES IN E-COMMERCE: A COMPARATIVE EXPERIMENTAL STUDY

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Abstract

This paper experimentally investigates the influence of anchoring and halo effects on perceived quality, perceived value, and willingness to buy in e-commerce, testing the moderating role of digital literacy. A quasi-experimental three-group design (N = 155) was employed: a control group exposed to neutral stimuli, an experimental group exposed to active biases, and a mixed group exposed to both stimulus types simultaneously. Results confirm that both biases significantly increase product evaluations (d = 0.42-0.86), with halo outperforming anchoring across all dependent variables. Digital literacy selectively moderates bias effects: it attenuates economic and behavioural evaluations but not perceptual ones. Cross-bias analysis reveals a latent co-vulnerability factor (ρ = 0.52-0.67). The study offers actionable implications for digital platform managers regarding ethical pricing design, audience segmentation by digital competence, and consumer protection.

Keywords: *cognitive biases, digital literacy, consumer behaviour, e-commerce, e-commerce management.*

JEL classification: M31, D91, L81

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1. Introduction

In the European Union, 77% of internet users completed at least one online purchase in 2024 (Eurostat, 2024), while the Romanian e-commerce market reached EUR 11.7 billion, marking a 10% year-on-year increase (GPeC, 2025). However, Eurostat (2024) data reveal a significant gap by education level: 89% of individuals with higher education shop online, compared to only 58% of those with low educational attainment, suggesting that digital skills influence not only access to e-commerce but also how consumers process information in the online environment.

Behavioural economics has demonstrated that, despite expanded access to information, individuals do not process it rationally. Simon (1955) introduced the concept of bounded rationality, and Tversky and Kahneman (1974) showed that, under uncertainty, people systematically rely on heuristics that lead to predictable errors. The digital environment intensifies this dependence on heuristic processing: information overload, decision speed, and persuasive interface design predominantly activate fast, intuitive thinking (System 1), which is vulnerable to cognitive distortions (Kahneman, 2011; Shakir Ali, 2025). Among the biases most relevant to online product evaluation are the anchoring effect (the tendency to rely disproportionately on initial information, such as a reference price) and the halo effect (the generalisation of a favourable global impression onto independently unevaluated attributes).

Although the influence of these biases on consumer decisions has been extensively documented, experimental studies testing them simultaneously in the e-commerce context remain limited. Moreover, the moderating role of digital literacy - defined as the ability to navigate, critically evaluate, and efficiently use online information (Hargittai & Hsieh, 2012) - on susceptibility to these biases has been insufficiently explored. Guess, Nagler, and Tucker (2019) suggest that digital competence levels predict vulnerability to manipulative content. However, this relationship has not been experimentally tested in a comparative design within the context of consumer biases.

For e-commerce platform managers, understanding the mechanisms through which cognitive biases alter consumer perception is not an academic exercise but an operational necessity. Decisions regarding pricing architecture, branding policy, and interface design directly depend on how consumers process information. At the same time, variability in digital literacy among users creates segments with different degrees of susceptibility, a critical aspect for the ethical management of digital consumer relationships.

This paper pursues three objectives: (O1) to assess the influence of anchoring and halo effects on perceived quality, perceived value, and willingness to buy in online product evaluation; (O2) to test the moderating role of digital literacy on susceptibility to these biases; and (O3) to derive actionable implications

for digital platform managers, particularly regarding consumer segmentation by digital literacy level and ethical pricing design.

2. Literature review

2.1. Cognitive biases in online decision-making

Bounded rationality theory (Simon, 1955) and behavioral economics (Ariely, 2008) have demonstrated that intuitive processes systematically guide consumer decisions. Kahneman (2011) distinguishes between fast, automatic processing (System 1) and slow, analytical processing (System 2); when processing capacity is limited, System 1 takes over, and individuals resort to heuristics that generate predictable biases (Tversky & Kahneman, 1974). The digital environment intensifies this dependence through information overload, persuasive platform design, and algorithmic recommendation systems that narrow the choice space (Heo, 2025; Orzan et al, 2021; Shakir Ali, 2025). This structural vulnerability raises the question of whether certain individual characteristics can function as protective factors.

2.2. The halo effect and anchoring bias

The halo effect, identified by Thorndike (1920), refers to the tendency to generalize a global impression to independently evaluated attributes. Nisbett and Wilson (1977) demonstrated that the halo operates unconsciously: subjects did not recognize the influence of their global evaluation on specific judgments. In marketing, Beckwith and Lehmann (1975) showed that individual attribute evaluations are contaminated by overall product attitude, and Leuthesser, Kohli, and Harich (1995) proposed the halo effect as an indicator of brand equity. Recent research confirms its manifestation in the digital environment: Nicolau, Mellinas, and Martín-Fuentes (2020) formally tested the halo in online ratings (N = 21,338), and Hsee, Zeng, and Hsee (2025) demonstrated that ratings themselves function as halos, with consumers underestimating the influence of price. The systematic review by Noor et al. (2023) confirms that the formation mechanism remains incompletely explained, while Westbury and King (2024) propose a complementary explanation based on contextual similarity. Nevertheless, no identified study has tested the role of digital literacy as a moderator of halo susceptibility.

The anchoring effect (Tversky & Kahneman, 1974) refers to the systematic tendency to rely disproportionately on an initial value when forming estimates under uncertainty. Anchoring operates through two mechanisms: an automatic one (System 1), in which the anchor automatically activates congruent information, and a deliberative one (System 2), in which the individual adjusts from the anchor (Kahneman, 2011). Epley and Gilovich (2006) demonstrated that adjustment consumes cognitive resources and stops prematurely at the first plausible estimate, explaining the persistence of the bias even when the individual is aware of the

anchor. The systematic review by Furnham and Boo (2011) confirms anchoring as one of the most robust cognitive biases, manifesting consistently in legal evaluations, negotiations, and pricing decisions. Adaval and Monroe (2002) demonstrated that price standards are constructed automatically: participants subliminally exposed to high prices evaluated a product as cheaper, an effect that persisted for 48 hours and transferred to different product categories. In e-commerce, Liu et al. (2022) modelled how the initially displayed price functions as an external anchor influencing sales volume, and Lin, Chen, and Wu (2023) demonstrated, through a 3×2 factorial design (N = 189), that brand awareness amplifies the price anchoring effect. The role of digital literacy as a moderator of anchoring in online product evaluation has not been experimentally tested.

2.3. Digital literacy as a moderating variable

Digital literacy is a multi-dimensional construct integrating technical, cognitive, and socio-emotional competences (Ng, 2012), and the institutional DigComp 2.2 framework (Vuorikari, Kluzer, and Punie, 2022) explicitly includes critical evaluation of digital content. Empirically, Guess and Munger (2023) demonstrated that digital literacy correlates with the ability to distinguish credible from manipulative content, and Shakir Ali (2025) found a positive correlation with digital decision quality ($r = 0.30$, $p < 0.01$).

The moderating mechanism can be conceptualized in terms of interface familiarity: competent consumers develop, through repeated exposure, an implicit skepticism toward persuasive platform patterns. However, the relationship is not necessarily linear - users with very high competencies may develop an overconfidence paradox (Tătaru et al., 2024).

In the present study, digital literacy is operationalized through the Hargittai and Hsieh (2012) scale, which measures self-reported operational competence. This choice is justified by the fact that operational competence constitutes a prerequisite for critical competence (Ng, 2012) and reflects the repeated exposure that generates resistance to persuasion. It is acknowledged that the scale does not directly measure critical digital thinking; this limitation is discussed in the limitations section.

2.4. Conceptual model and research hypotheses

The theoretical framework integrates the Dodds, Monroe, and Grewal (1991) price evaluation model, which posits that price influences purchase intention through perceived quality and perceived value. The investigated biases distort this chain at different levels: anchoring affects price perception, while halo affects quality perception. Digital literacy, as a moderating variable, is hypothesized to attenuate bias effects by fostering implicit skepticism through repeated exposure to e-commerce platforms (Orzan et al, 2012).

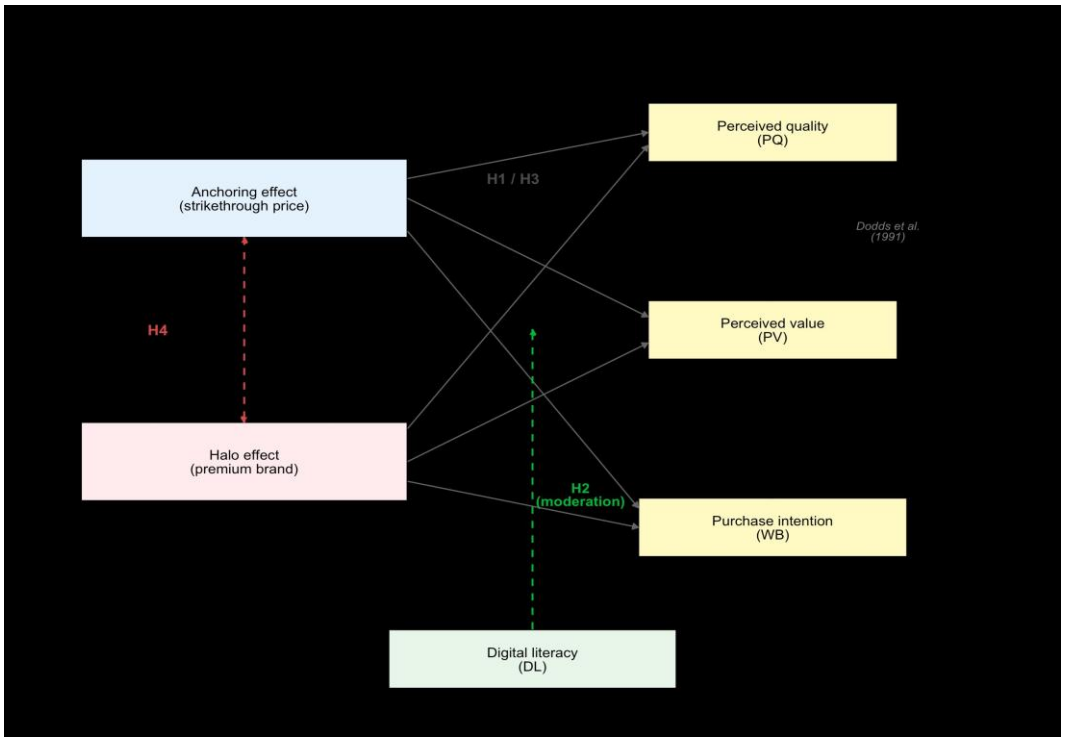

Figure 1. Conceptual model of antecedents of cognitive Biases in e-commerce
Source: Adapted from Dodds, Monroe, and Grewal (1991 &; (Orzan et al, 2012)

Research hypotheses:

H1: Participants exposed to stimuli with active biases (G2) will report significantly higher perceived quality, perceived value, and willingness to buy compared to the control group (G1).

H2: Digital literacy negatively moderates the relationship between bias exposure and dependent variables.

H3: Biases persist in the within-subject condition (G3), even in the simultaneous presence of neutral stimuli.

H4 (exploratory): Susceptibility to anchoring and to halo is positively correlated at the individual level, suggesting a common vulnerability factor.

3. Research methodology

The study employs a quasi-experimental design with three groups: G1 (control, neutral stimuli, n = 53), G2 (experimental, active biases, n = 50), and G3 (mixed, both stimulus types, n = 52), totalling N = 155. This structure enables

testing the main effect of biases (G2 vs G1, between-subjects), bias persistence under direct comparison (G3, within-subjects), and the moderating role of digital literacy (via a regression with an interaction term on G1+G2). Sample size was determined a priori through power analysis (G*Power 3.1: $\eta^2 = 0.08$, Cohen's $f = 0.295$, $\alpha = 0.05$, power = 0.80), indicating a minimum of 114 usable participants; a 15% attrition margin was applied, yielding a collection target of 150 participants. Participants were recruited through convenience sampling, with inclusion criteria: age ≥ 18, e-commerce browsing experience, and informed consent.

The independent variables are the anchoring effect (crossed-out price vs simple price) and the halo effect (premium brand Sony vs unknown brand OneODIO), activated simultaneously in G2 - a deliberate confound accepted for ecological validity, as in the real e-commerce environment, consumers are simultaneously exposed to multiple persuasive cues (Veghes et al., 2023). The dependent variables are perceived quality (PQ), perceived value (PV), and willingness to buy (WB). The moderating variable is digital literacy (DL).

Digital literacy was measured using the Hargittai and Hsieh (2012) scale, adapted: 10 operational items (H1-H10, 5-point Likert) plus 3 trap items ($\alpha = 0.83$). Product evaluation used the Dodds, Monroe, and Grewal (1991) scale, reduced to 3 items per subscale: PQ ($\alpha = 0.87$-0.90), PV ($\alpha = 0.90$-0.92), WB ($\alpha = 0.84$-0.92).

Four e-commerce page mock-ups were created to replicate the visual appearance of a real platform. Each participant evaluated two product categories - a wireless mouse and over-ear headphones - in fixed order. For the anchoring effect (Keychron M6 wireless mouse): the neutral condition displayed the price of RON 272.06 without reference; the active condition displayed a crossed-out price (RON 389 → 272.06, 30% discount). For the halo effect (over-ear headphones): the neutral condition displayed OneODIO Studio Max 1 (low-awareness brand), and the active condition displayed Sony WH-CH720N (premium brand), both at RON 488.79. Maintaining identical pricing isolates the brand halo effect. Stimulus distribution: G1 - neutral only; G2 - active only; G3 - both pairs, with individually randomized order (50/50 between neutral-first and active-first per category).

The questionnaire was administered online, and participants were automatically randomised to the three conditions. The procedure followed the sequence: (1) informed consent; (2) digital literacy scale; (3) stimulus exposure and Dodds scale completion; (4) manipulation checks (MC1-MC6); (5) demographic data; (6) debriefing. Mean duration was 8 minutes for G1/G2 and 12 minutes for G3. Participants received no material compensation.

Data were analyzed in R (v4.5.3). Preliminary analyses: group equivalence (chi-square, Kruskal-Wallis), manipulation checks, normality (Shapiro-Wilk). Hypothesis testing: H1 - Mann-Whitney U (G2 vs. G1, FDR correction); H3 - Wilcoxon signed-rank (G3); H2 - moderated hierarchical regression on G1+G2 ($n = 102$), with simple slopes at DL ± 1SD; H4 - Spearman correlations with bootstrap CI. Nonparametric tests were preferred due to significant deviations from normality for most DVs

4. Results

4.1. Preliminary analyses

Groups did not differ significantly on gender ($\chi^2 = 2.95$, $p = 0.61$), education ($\chi^2 = 2.80$, $p = 0.94$), purchase frequency ($\chi^2 = 4.78$, $p = 0.80$), age ($H = 3.62$, $p = 0.16$), or DL ($H = 0.47$, $p = 0.79$). Manipulation checks confirmed stimulus efficacy: MC1 (anchoring) - G2 participants estimated the price significantly lower ($U = 1886$, $p < .001$); MC2 (price fairness) - G2 rated fairness lower ($U = 1749.5$, $p = .004$, $d = -0.61$); MC3 (halo) - no difference in brand recognition ($\chi^2 = 0$, $p = 1.00$), consistent with the unconscious operation of the halo (Nisbett & Wilson, 1977); MC4 (brand familiarity) - Sony rated significantly more familiar than OneODIO ($U = 411$, $p = .002$, $d = 0.96$).

Mann-Whitney U tests confirmed significantly higher scores in G2 than in G1 on all six DVs ($p\_FDR < 0.05$), with medium-to-large effect sizes ($d = 0.42$-0.86). PV was the most sensitive variable ($d = 0.86$). Halo produced larger differences than anchoring across all DVs. H1 confirmed.

Table 1. H1 results: between-subjects comparisons (Mann-Whitney U, G1 vs G2)

DV	G1 M	G1 SD	G2 M	G2 SD	U	p (FDR)	Sig	d
anchoring_PQ	4.11	1.63	4.73	1.27	1608.5	.030	*	0.42
anchoring_PV	3.08	1.36	4.26	1.39	1917.5	< .001	***	0.86
anchoring_WB	2.52	1.13	3.17	1.57	1628.5	.027	*	0.48
halo_PQ	4.30	1.39	5.17	1.37	1816.5	.001	**	0.63
halo_PV	3.50	1.37	4.67	1.43	1924.5	< .001	***	0.83
halo_WB	2.96	1.54	4.04	1.73	1811.0	.001	**	0.66

Source: Author's analysis generated with R

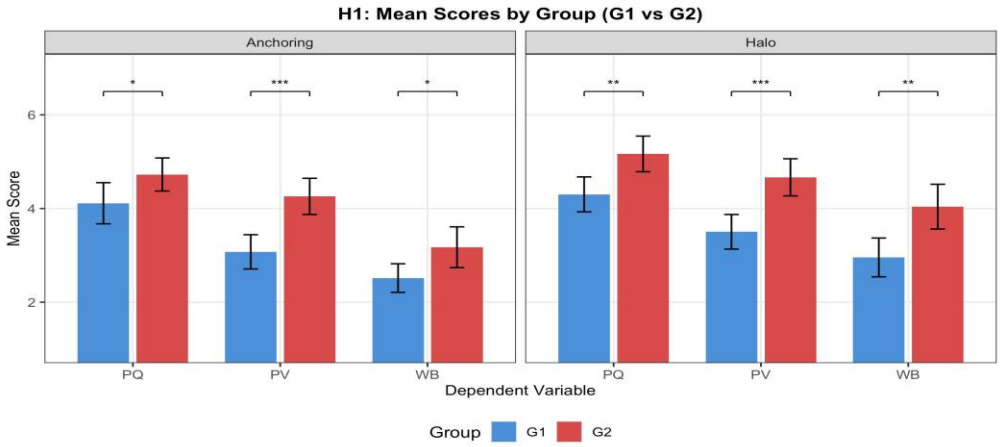

Figure 2. Mean Scores by Group for Anchoring and Halo Effects (H1)

Source: Author's analysis generated with R

Wilcoxon signed-rank confirmed significantly higher scores in the active condition across all DVs ($p_{FDR} < 0.05$, $r = 0.27$-0.78). The largest differences were observed in halo dimensions. Biases persist even when neutral stimuli are present simultaneously. H3 confirmed.

Table 2. H3 results: within-subject comparisons (Wilcoxon Signed-Rank, G3)

DV	Active M	Neutral M	ΔM	W	p (FDR)	Sig	r
anchoring_PQ	4.37	4.05	0.31	539.0	.023	*	0.29
anchoring_PV	4.24	3.92	0.32	664.0	.025	*	0.27
anchoring_WB	3.44	2.87	0.57	576.5	< .001	***	0.47
halo_PQ	5.41	4.24	1.17	1053.5	< .001	***	0.78
halo_PV	4.41	3.68	0.73	763.5	< .001	***	0.54
halo_WB	3.83	2.71	1.13	1036.5	< .001	***	0.75

Source: Author's analysis generated with R

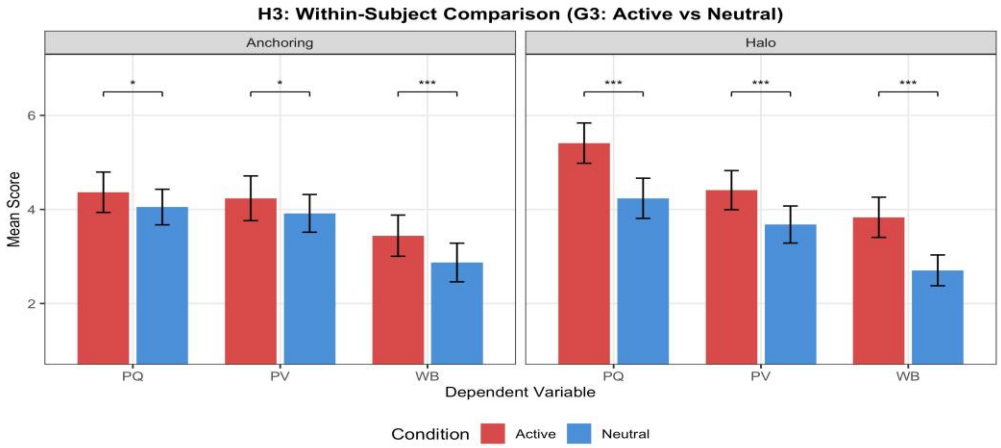

Figure 3. Within-subject comparison: active vs neutral conditions (H3, G3)

Source: Author's analysis generated with R

Moderated hierarchical regression (G1+G2, n = 102) identified significant moderation on two DVs: anchoring_WB (β = −0.33, t(98) = −2.45, p_FDR = 0.048, $\Delta R^2 = 0.053$) and halo_PV (β = −0.37, t(98) = −2.90, p_FDR = 0.027, $\Delta R^2 = 0.067$). Simple slopes: on anchoring_WB, the effect is strong at low DL (−1SD: b = 1.27, p = 0.001) and non-existent at high DL (+1SD: b = −0.01, p = 0.97). On halo PV: low DL (b = 1.95, p < .001), high DL (b = 0.37, p = 0.34). An unexpected result on halo_PQ: a positive interaction (b = +0.71, p = 0.07) suggests that DL amplifies the halo effect on perceived quality. H2 partially confirmed.

Table 3. H2 results: digital literacy moderation (hierarchical regression)

DV	**β (interaction)**	**SE**	**t**	**p (FDR)**	**Sig**	**ΔR^2**
anchoring_PQ	0.09	0.461	0.647	.519	ns	0.004
anchoring_PV	−0.222	0.425	−1.724	.132	ns	0.024
anchoring_WB	−0.328	0.412	−2.453	.048	*	0.053
halo_PQ	0.223	0.390	1.820	.132	ns	0.025
halo_PV	−0.369	0.423	−2.911	.027	*	0.067
halo_WB	−0.214	0.506	−1.598	.136	ns	0.023

Source: Author's analysis generated with R

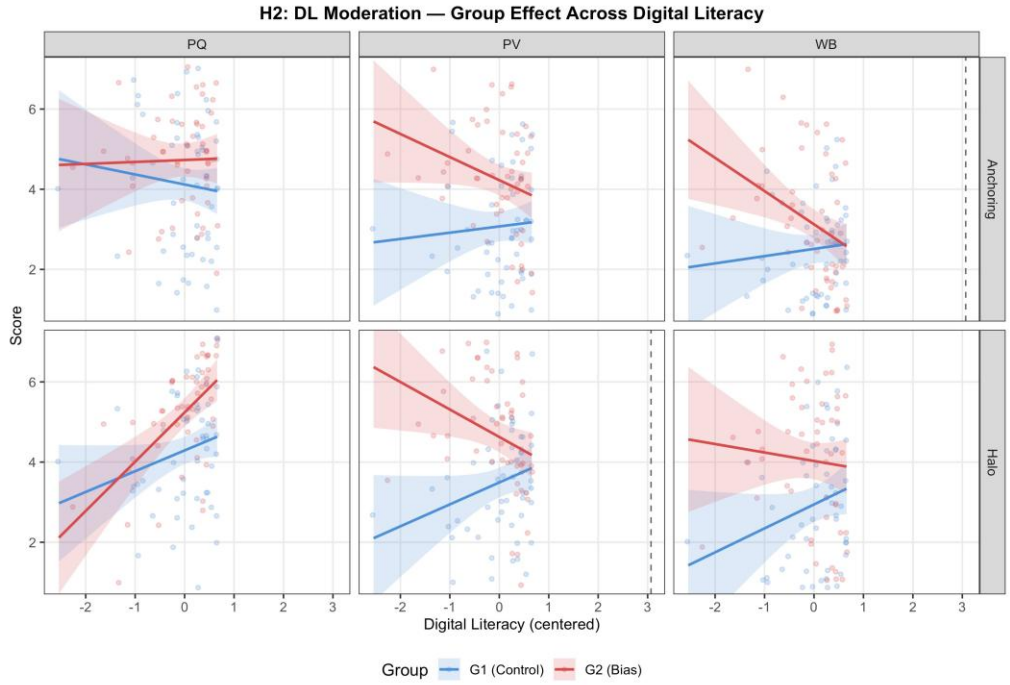

Figure 4. DL × group interaction effects across all DVs (H2)

Source: Author's analysis generated with R

Table 4. H4 results: cross-bias correlations (Spearman, G3)

DV	ρ	95% CI lower	95% CI upper	p (FDR)	Sig	n
PQ	0.52	0.30	0.68	< .001	***	52
PV	0.67	0.48	0.82	< .001	***	52
WB	0.65	0.43	0.80	< .001	***	52

Source: Author's analysis generated with R

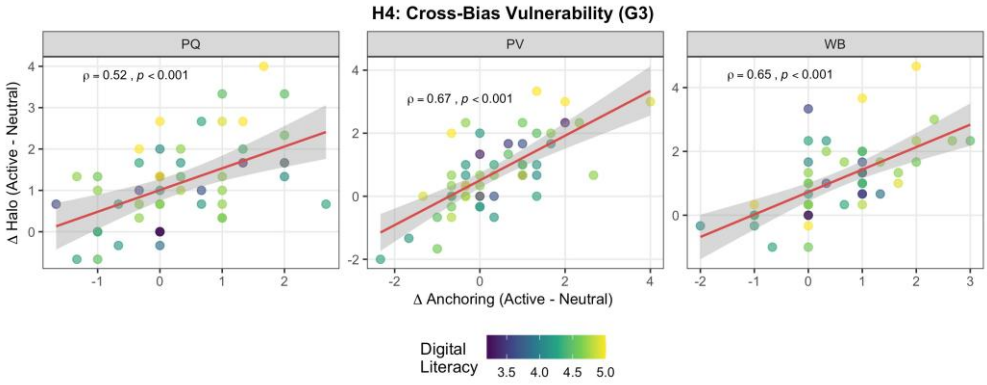

Figure 5. Cross-bias vulnerability: Δanchoring-Δhalo correlations (H4, G3)

Source: Author's analysis generated with R

Spearman correlations on G3 delta scores (n = 52) indicated strong positive associations between anchoring and halo susceptibility across all DVs (ρ = 0.52-0.67, p < .001), supporting the existence of a common vulnerability factor. H4 sustained.

5. Discussion

5.1. The effect of cognitive biases (H1 and H3)

Confirmation of H1 across all DVs (d = 0.42-0.86) validates the Dodds, Monroe, and Grewal (1991) model in e-commerce: both anchoring and halo significantly distort product evaluation. Results are consistent with Adaval and Monroe (2002) regarding the automatic construction of price standards and with Nisbett and Wilson (1977) regarding the unconscious alteration of judgments. The finding that PV was the most sensitive variable (d = 0.86) suggests that biases predominantly distort quality-price ratio assessment, not merely isolated quality perception - a finding with direct relevance for pricing strategies.

The dominance of halo over anchoring may be explained by stimulus nature: the Sony brand activates heuristic processing more efficiently than a crossed-out price, which requires numerical comparison - a processing mode closer to System 2 (Kahneman, 2011). This asymmetry may reflect differences in mechanisms rather than the superiority of one bias over the other. The finding is consistent with Lin, Chen, and Wu (2023), who showed that brand awareness amplifies the price anchoring effect.

Confirmation of H3 provides an additional contribution: biases persist even when participants have simultaneous access to neutral information, extending the findings of Hsee, Zeng, and Hsee (2025). The practical implication: the presence of other products on the same page does not protect the consumer from the persuasive effects of a strategically presented product.

5.2. Digital literacy (H2) and cross-bias co-vulnerability (H4)

Partial confirmation of H2 offers a nuanced picture: DL protects behavioral (WB) and economic (PV) evaluations but not perceptual (PQ) evaluations. This specificity suggests that digital literacy intervenes at later stages of the decision chain in the Dodds model - where the consumer transitions from perception to intention - without protecting initial quality impressions. On anchoring, the effect disappears completely at high DL ($b = -0.01$, $p = 0.97$), and on halo_PV, the pattern is similar. The probable mechanism: competent consumers have developed an implicit skepticism toward pricing tactics - a filter that operates at the decisional, not perceptual, level. However, the cross-sectional design does not allow for the establishment of causal direction; it is equally plausible that individuals with higher cognitive ability simultaneously develop both superior digital competencies and greater bias resistance.

The unexpected result on halo_PQ - DL amplifies the effect - suggests an "expertise paradox": competent consumers recognize Sony as a valid quality indicator and deliberately leverage it, which may reflect a rational update rather than a bias. The finding is consistent with Ng (2012).

Cross-bias correlations ($\rho = 0.52$-0.67) suggest a latent vulnerability factor for persuasion, which may reflect individual differences in the tendency toward heuristic processing (Kahneman, 2011). The empirical link between H2 and H4 suggests that participants with low DL are more vulnerable to both biases.

5.3. Managerial implications

The results offer several concrete directions for managerial practice in e-commerce. First, the significant effect of price anchoring through crossed-out prices ($d = 0.42$-0.60) confirms the efficacy of this pricing tactic. However, it imposes a transparency responsibility on platform managers: the use of artificial reference prices may erode long-term trust.

Second, the finding that the anchoring effect on willingness to buy disappears among consumers with high digital literacy ($\beta = -0.33$, $p = .009$) suggests that audience segmentation by digital competence is relevant not only for targeting but also for consumer protection. Marketing managers would benefit from differentiated, transparent, and informative communication for more vulnerable segments.

Third, the strong brand halo effect ($d = 0.57$-0.85) confirms the value of brand equity investment and underscores the need for UX managers to avoid designs that artificially amplify perceived quality without substance.

Finally, the experimental evidence that digital literacy functions as a protective factor justifies investments by public and corporate decision-makers in consumer-oriented digital education programs.

6. Conclusions

This study investigated the influence of anchoring and halo effects on online product evaluation and tested the moderating role of digital literacy. Results fully confirmed H1 and H3, partially confirmed H2, and sustained H4, demonstrating that: (a) both biases significantly increase all evaluation dimensions; (b) halo is stronger than anchoring; (c) biases persist even in the presence of neutral information; (d) DL selectively protects PV and WB but not PQ; (e) a cross-bias co-vulnerability profile exists.

Theoretically, the study contributes by simultaneously testing anchoring and halo in e-commerce, identifying the specificity of DL moderation, and documenting the latent cross-bias vulnerability factor. In practice, results inform platform managers about ethical pricing strategy design, audience segmentation by digital competence, and investment in digital education as a consumer-protection strategy.

Key limitations include: (a) the convenience sample limits generalizability; (b) the anchoring × halo confound in G2 does not allow complete isolation of individual effects; (c) the Hargittai scale measures operational competence, not critical digital thinking; (d) stimuli include only electronic products. Post-hoc power for anchoring_PQ ($d = 0.42$) was 0.67, below the 0.80 convention.

Full factorial design for anchoring × halo interaction; critical digital thinking instruments; testing moderated mediation (PQ → PV → WB with DL as moderator); replication with representative samples and diverse product categories.

From a managerial perspective, this study underscores that pricing transparency and investment in consumer digital education are not merely ethical imperatives but also sustainable strategies for building trust and loyalty in e-commerce.

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