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A Systematic Review and Meta-Analysis of Eye-Tracking Studies for Consumers' Visual Attention in Online Shopping

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As the marketing landscape continues to evolve, consumer is important for corporate profitability in online shopping. Extensive research has shown that neuromarketing is essential in consumer decision-making. However, a comprehensive meta-analysis of online shopping visual presentation has not been conducted. This paper applies various eye-tracking dependent variables to investigate consumer visual attention related to four common interface design factors: brand, endorser, product, and text. From the research, it is generally demonstrated that a variety of stimuli items including goods, wines, advertisements, and brand items within every commercial domain has a positive influence. On the other hand, textual components like ingredient lists may have a potentially adverse impact. It is worthy mention that we identified the subgroup analysis involving total time of fixation (SMD=-0.020, 95%CI: [-0.079,0.039], p=0.507), fixation count (SMD=-0.032, 95%CI: [-0.109,0.045], p=0.421) and time to first fixation (SMD=0.464, 95%CI: [0.346,0.582], p=0.000). In this paper, exposure time obviously impacted fixation count (Q-value=11.637, p=0.003) and time to first fixation (Q-value=10.316, p=0.006). Meanwhile consumer satisfaction highly related to fixation count (Q=10.953, p=0.001) and time to first fixation (Q=6.540, p=0.011) were under concern. Studies contained 17 papers with a total of 1071 participants. The publication bias was reasonable and the heterogeneity mainly resulted in subgroup and moderator differences. Our reanalysis study show that, to effectively employ the visual attributes that attract consumers, could prove advantageous to enhance consumer preference during online shopping interaction.

More factor and moderators related to visual attention should be concerned for neuromarketing progress. Eye trackers are utilized in various disciplines including medicine and psychology. Not only total time of fixation, fixation count, time to first fixation but also other indicators may be strongly correlated with consumer preference. In the future, eye tracking tests could potentially replace intuitive interface design methods. Other measurements such as ERPs (Event-Related Potentials), FMRI (Functional Magnetic Resonance Imaging) could be explored for making better consumer experience.

KEYWORDS: Neuromarketing, eye-tracking, visual attention, consumer preference, online shopping, systematic review, meta-analysis.

1. Introduction

Marketing competitiveness is crucial for a company's profitability and has become a popular topic in recent times [45]. To enhance their competitiveness, companies need to have a good understanding of the market. With the growing popularity of online shopping, companies; are shifting their focus from physical stores to online platforms. Online shopping provides convenient services, leading to increased sales in a shorter time [40, 70, 26]. A study by the Pew Internet and American Life Project [39] indicated that the percentage of American adults utilizing the internet had surpassed 90% a decade ago, and this percentages persists without any decrease at present. Internet usage is almost universal among individuals with an income of $75,000 or more, young adults aged 18-29, and those with college degrees. Online businesses offer greater convenience to customers compared to physical stores. Customers can place orders from home and pay with a credit card while waiting for their purchases to be delivered. Moreover, the pandemic has accelerated the growth of online shopping, creating new marketing opportunities. In the post-pandemic era, companies that can meet the demand for online shopping may see increased profits [3]. The adoption of digital technologies has also accelerated among companies. The challenge now is not whether to develop an online shopping platform but how to create one that meets consumer preferences. A platform with a good user experience will have higher sales and a better reputation. In the fast-paced internet era, retaining customers means gaining traffic and improving platform operations [35].

In simple terms, it is imperative to prioritize the consideration of consumer preferences as a viable approach towards economic development. Consumer preference is the degree to which a consumer favors a product. Consumers assess and rank available products based on their own desires, reflecting their individual needs and preferences [44, 59]. All other factors being equal, the higher the level of consumer favor for a particular product, the greater the demand for that product. According to a survey by BrizFeel in 2023, 57% of consumers prefer to shop online, 31% prefer to visit physical stores, while 12% say both ways are the same for them. In addition, 78% of consumers are more likely to shop at large online retailers, compared to the percentage 52% on marketplaces and 43% at smaller web stores. Consumer trend in online shopping is influenced by many factors. According to a study by SSRN [49], consumers' online shopping behavior is affected by factors such as demographic factors, social factors, consumer online shopping experience, website design, social media, situational factors, delivery of goods and after-sales services. To enhance the experience of consumers towards online shopping, it is imperative to acknowledge the significance of visual attention.

In detail, when the user is unsured about his purchase, the stimuli catch visual attention have higher rate of purchase [16]. In other word, visual attention can help us understand consumer judgment and decision-making processes through information search; and selection [46]. Research on visual attention has a long history in marketing and has been conducted for many purposes [38, 52]. Since vision is the dominant sense for most people, visual attention is crucial for higher-order cognitive functions. Research on visual attention spans multiple fields. Ladeira summarizes the importance and contributions of different neuromarketing to top-down and

bottom-up attentional control [18]. The top-down factors that are directly related to visual attention including consumer motivation, brand familiarity, amount of time spend and so on. On the contrary, the bottom-up factors related to visual attention including visual complexity, the size of the product, etc. Subdividing the elements, visual attention can be influenced by various factors such as Brand, Text, Product, and Endorser [68]. These stimuli can retain viewers' visual attention and explain the consumer preferences. Brand is an important factor in visual attention as it can shape perception and create an impression-that can be more persuasive than words. Brand usage can also moderate the effect of visual attention on good memory [57]. Text is another important factor in visual attention as it can guide viewers' attention towards relevant information. Text-based visual attention models can outperform classic saliency models by focusing on salient objects and eliminating irrelevant information. Endorsers could be a good method for getting more attention and increasing product sales. For these design elements above eye movement tests are often used in visual attention research to gain more word-of-mouth. After listing the definition of visual attention and types of design elements, how to measure the quantized data remain a question.

Eye tracking has emerged as a widely used and dominant method in research for measuring and evaluating visual attention through non-intrusive examination of eye movements, using advanced video-based technology [15, 20]. It has been used to provide insights into visual attention in various contexts such as reading, consumer preferences, emotion processing, social interaction, and psychopathology. Many studies have used eye tracking to investigate visual attention. For example, one study evaluated a new eye tracking setup for studying visual attention in face-to-face conversations and found it feasible for studying gaze behavior in dyadic interactions [65]. Another study examined the relationship between visual selection and the control of tracking eye movements and proposed a simple race-to-threshold model to explain the variable coupling of visual selection during pursuit, catch-up, and regular saccades [58]. Eye tracking experiments typically measure several indicators of eye movements, including fixation duration, saccade amplitude, saccade latency, pupil size, and blink rate [12]. Some common indicators used in eye tracking experiments include total time of fixation (TTF), fixation count (FC), time to first fixation (TTFF), pupil diameter, and exposure time. The three former factors mentioned, which have been previously utilized in a variety of studies on visual attention experiments, have been sporadically employed in the past with a noteworthy level of statistical significance [32]. By analyzing these indicators, researchers can gain a better understanding of the cognitive processes that underlie visual attention and eye movements [29, 36].

It is true that there have been few systematic reviews and meta-analyses on eye tracking experiments related to visual attention and consumer preference while browsing online shopping. Conducting such research could help fill this gap and provide valuable insights into design methods for improving consumer preferences [9]. This article presents a study of visual attention in the context of online shopping marketing, with the goal of identifying ways to improve consumer preference. The study uses empirical research data collected from eye-tracking experiments and re-statistics. The first section of the article involves obtaining and selecting articles that meet the requirements through meta-analysis using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [48]. Eye movement values such as total time of fixation, fixation count, and time to first fixation are extracted from the articles to compute heterogeneity and subjected to subgroup analysis according to four items: brand, product, text, and endorser. The goal is to identify the most influential item for visual attention by comparison and to simultaneously construct forest plots and funnel plots. In the next section, meta-regression analysis [64] is used to compare the statistical significance of different exposure time (Long/Medium/Short) three-way classification and consumer satisfaction binary classification situations. This is done to determine the correlation between these two moderators: exposure time length and consumer satisfaction for each eye-tracking experiment indicator while also plotting meta-regression analysis graphs. Finally, the results obtained are discussed to find practical design reference for future marketing in online shopping webpages design.

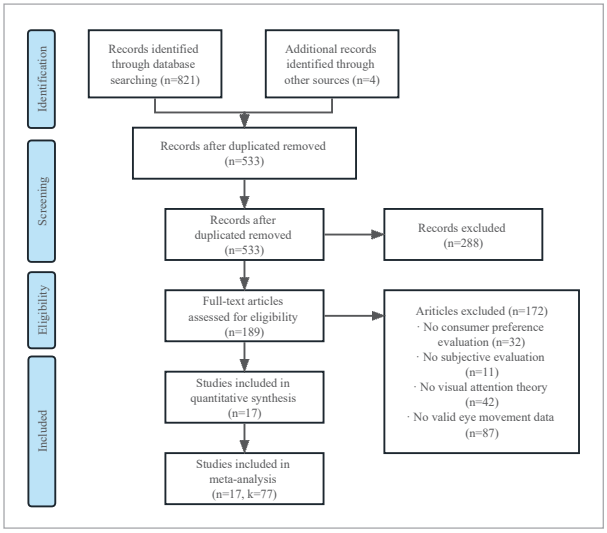
2. Materials and Methods

In the first step of our systematic review and meta-analysis, we conducted a literature search for relevant studies. We used keywords such as "visual attention", "eye tracking", "consumer preference", and "neuromarketing" across databases like Web of Science, Google Scholar, Scopus, and PubMed. To refine our search, we used two categories of keywords. The first category related to "consumer preference" and included terms like "purchase intention", "decision making", and "preference". The second category included terms like "visual attention", "fixation bias", "eye movements", and "eye tracking". We selected articles that contained terms from both categories for potential inclusion. To this study, a total of 821 papers were meticulously scrutinized and subsequently included in the process of identification. Additionally, we manually searched marketing, psychology, and ergonomic journals for four relevant articles. In the second place, during the screening phase, we opted to exclude the articles that were deemed incompatible with our inquiry, specifically those that failed to satisfy the prerequisites of being released prior to 2013. Consequently, a sum of 288 articles were discarded and because of this procedure. Both authors, XL and DBL, independently screened all articles that met the inclusion criteria for eligibility.

In the third phase, we incorporated a total of 189 studies that satisfied a set of specific criteria. These criteria included: 1) studies that fulfilled the requirements for consumer preference evaluations, 2) satisfaction tasks that were primarily based on subjective evaluations, 3) the utilization of visual attention theory in relation to goods, food, or advertisements, and 4) the presence of eye movement data such as total time of fixation, fixation count, and time to first fixation. We decided to remove any research articles that did not contain any elements related to brand, text, product, or endorser, or any experiments that solely relied on physiological measurements. Based on these standards, we constructed a PRISMA figure using the collected papers in Figure 1. Some of the papers solely contain total time of fixation data, whereas others encompass a multitude of invaluable data sources. Nevertheless, what unifies all the articles included in this compilation is their shared objective of conducting a comparative analysis between the original

Figure 1

The PRISMA flow diagram for systematic review detailing the selection process



scheme and various enhancement initiatives. In total, we collected 77 effect sizes from 17 papers with a total of 1071 participants in the samples.

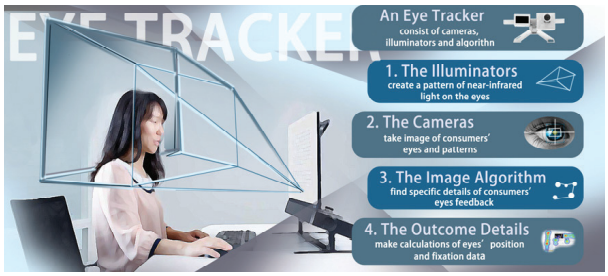
In the next step, we used Comprehensive Meta Analysis V3 [10] to compute the collected data from included articles. The statistics were coded regarding to the sample sizes, number of experiment groups in studies, effect size in estimation based on the difference between means and the individual standard deviation of each means were concerned. In meta-analysis experiments, the experimental results depend on the $Effect\ Size = \mu_1 - \mu_2$, not on a single experiment value. We collected the visual attention effect sizes determinate the consumer preference such as total time of fixation (TTF), fixation count (FC), time to first fixation (TTFF). All the variables were formal values in eye movement studies based on an eye tracker device with advanced technology, device, algorithms, and outcomes shown in Figure 2. For making better comparison of these three kinds of visual effect sizes above, we utilized cluster elements brand, text, product, and endorser to conduct meta-analysis subgroup computation. In the articles, experimental groups differ from the control group by improving visual effect. The total time of fixation were conducted by these four kinds of elements, the exams classified the control groups and experimental groups in milliseconds. The fixation count was recorded by summarizing the

gazing dots in areas of interest. The time to first fixation were recorded as the difference in milliseconds.

Generally, the z-score represents how many standard deviations the variable is from the sample mean and p-value were computed. The z-score is a standardization method for different events under normal distribution, $z = (x - \mu) / \sigma$. In detail, each part has a different calculation method. (1) Heterogeneities were computed within three visual unit of measure [29]. The heterogeneities conducted Tau Squared (T^2) represents the absolute value of the true variance, Q-value, I^2 and so on. (2) The forest plots with both fixed and random effect models were shown in subgroup analysis results [42]. In the forest plots, the standardized mean difference (SMD) is a statistical measure used to quantify the difference between two groups of data. The value of SMD ranges from -1 to 1, where -1 indicates that the two groups of data are completely opposite, 1 indicates that they are completely the same, and 0 indicates no difference. The 95% confidence interval with lower limit and upper limit were shown [66]. This research tried to find out which element has the more serious influence by testing for sensitivity analysis. (3) After computations of subgroup analysis, we did meta-regression analysis [60] for testing the statistics relationship for display time with visual attention and consumer preference with visual attention. Thus, the moderators were set as exposure time and consumer satisfaction calculated. In detail, we set the exposure time moderator as a three-category variable, including short periods of less than 6 seconds, medium periods of 6 to 12 seconds and long periods of more than 12 seconds (including unlimited time). Furthermore, the consumer satisfaction was defined as either positive or negative by making difference values of the control group and experimental group in each study. The outcomes were presented in regression plots, cumulative analysis and tables testing the significance of regression coefficients. (4) Publication bias can be analyzed by funnel plots, it has 1/(*standard error*) as the vertical axis, the effect size as the horizontal axis, and the shape is like an inverted funnel. The classical fail-safe N (File drawer analysis) [14, 47] identified as how many insignificant studies are needed to be obtained and integrated into the analysis to make the p-value insignificant, were also computed.

In all the selected papers related to visual attention, some of the participants had dropout with uncomfortable visual influences. We made results presentation and further discussions after computing. All the statistics were gathered by XL and DBL.

Figure 2
The main parts in eye tracker experiment for visual attention



3. Results

3.1. Summary of Included Articles

At great length, we found 821 publications in the research papers that met the criteria. With additionally four articles added from source. Of the 17 articles reporting visual attention related to consumer preference, more than five articles contain more than three experiment groups. The difference between control groups and experiment groups were based on product design proposals, product display quantity, text font size and position, brand visual expression effect and the usage of endorsers. The four elements above played determinate roles in visual attention outcomes. The summary of the included studies, collected data, main limitations and devices information were presented in Table 1.

Of the 17 items, most of the participants were young adult range from 20 to 35 years old. Especially more than four articles do examinations with over 100 subjects. Analysis of the affiliation showed that six papers originated from China, two from USA, two from Spain, two from France. Other affiliations included Italy, Australia, South Korea. These publications have been recorded in SCI journal index, such as Frontiers in Psychology, International Journal of Industrial Ergonomics, Journal of Consumer Behavior and so on. The primary study topics of the review articles shown on WOS platform include “Customer Satisfaction” (n=10), “Persuasion” (n=1), “Humor” (n=1) in Social Science and “Health Claims” (n=3) in Agriculture,

Table 1
Overview of included studies

Author	Stimuli	Variables	Exposure Time	Satisfaction	Main Object	Summary	Limitation	Device (max. frequency)
Barbierato, 2023 [6]	Food	TTF	7000	Pre:1.41 Post:3.58/1.16	Evaluated labeling Italian winery.	Longer fixation indicates better satisfaction.	The food samples are homogeneous.	Pupil Invisible glasses 200 Hz
Ballco, 2019 [5]	Food	TTF, FC	15000	Pre:3.54/3.69 Post:3.57/3.33	Explored text and satisfaction on yogurt.	Fixation count increases satisfaction.	The experiment should be replicated in more countries.	Tobii X2–30 ET 50 Hz
Brigaud, 2021 [11]	Goods	TTF, FC	8000	Pre:3 Post:3.2	Tested the tobacco preventive ads.	Texts increase fixation time.	Eye tracking data might not relate to interface application.	SMI iView X™ RED-m 500 Hz
Chen, 2022 [17]	Goods items	TTF	28000	Pre:2.28/2.71 Post:3.51/1.49	Evaluated comment to phone.	Negative texts gain more visual attention.	Brand loyalty might be combined with visual attention.	Eyelink 1000 1000 Hz
Cummins, 2020 [19]	Ad. items	TTF	6240	Pre:1.93 Post:2.59	Tested ad components.	Total fixation time on text and brand increase satisfaction.	The findings only pertain to print magazine ads.	-
Guo, 2015 [28]	Goods items	TTF, FC, TTFF	10000	Pre:2.56/3.58 Post:3.2/2.695	Evaluated product.	First fixation time increase user attention.	Users with different backgrounds should be considered.	SMI iView X™ RED-m 500 Hz
Guo, 2017 [27]	Ad. items	TTF, TTFF	69000	Pre:1.7 Post:1.63	Measured the brand.	First fixation time and total fixation time decreases satisfaction.	Stimulus was limited.	SMI iView X™ RED-m 500 Hz
Hung, 2020 [33]	Ad. items	TTF, FC	10000	Pre:3.96 Post:3.58	Evaluated online booking websites.	Total fixation time and fixation count have different impacts.	The product arrangements were limited.	EyeNT-NU_120 120 Hz
Jiang, 2018 [34]	Goods items	TTF, FC, TTFF	3600	Pre:0.404 Post:0.407	Evaluated two appeal brands.	Total time of fixation, fixation count and time to first fixation decrease visual satisfaction.	Strategies for brands were needed.	SMI iView X™ RED-m 500 Hz

Table 1 (continued)

Author	Stimuli	Variables	Exposure Time	Satisfaction	Main Object	Summary	Limitation	Device (max. frequency)
Mou, 2018 [41]	Goods items	TTF, FC	20000/ 8000	Pre:3.76/4.06 Post:4.37/4.07	Investigated consumer satisfaction.	Time impact fixation count and total time of fixation.	The effect on fixation duration was not confirmed.	Tobii Pro X3-120 120 Hz
Madariaga, 2018 [23]	Food items	TTF, FC	5000	Pre:1.7/1.8 Post:2.9/2.9	Tested image, text, and color of packages.	First fixation time decrease satisfaction.	More isolated variables were needed.	Tobii X2-30 30 Hz
Ngan, 2020 [43]	Ad. items	TTF, FC	5000	Pre:1.38 Post:3.18	Evaluated visual patterns.	The total fixation time decrease satisfaction.	Research need larger samples.	Gazepoint GP3 Desktop ET 60 Hz
Puskarevic, 2016 [53]	Ad. items	TTF, FC	8000	Pre:4/4 Post:4/4.5	Analyzed image.	Total fixation time decrease satisfaction.	Study used only one gradation of rhetorical figures.	Tobii X120 120 Hz
Pfiffelman, 2019 [51]	Ad. items	TTF, FC, TTFF	10000	Pre:4.59 Post:4.81	Examined advertisement.	Total fixation time increase satisfaction, while first fixation time decrease satisfaction.	It uses a small sample, and the data were incomplete.	Tobii TX300 60 Hz
Segijn, 2021 [55]	Ad. items	TTF	30000	Pre:1.66 Post:1.34	Tested ads tablet.	Total fixation time does increase consumer satisfaction.	Future research could mechanisms of ad sequence on responses.	SMI ETG 2w 60 Hz
Wang, 2014 [67]	Goods items	TTF, FC	30513/ 37766	Pro:3.22/3.34 Post:4.08/3.25	Test visual element.	Total fixation time on clothes do increase consumer satisfaction.	The sample size was small.	iView X Hi-Speed ET 1250 Hz
Ye, 2019 [71]	Goods items	FC	8194	Pre:1.4/1.4 Post:1.8/3.89	Tested product.	Fixation count increase the consumer satisfaction.	Future studies should change the positions of the products.	SMI iView X™ RED-m 500 Hz

[1] Notes: TTF = Total Time of Fixation, FC = Fixation Count, TTFF = Time to First Fixation.

Environment & Ecology, "Visual Search" (n=2) in Clinical & Life Science. Apart from topics, the categories of the articles mainly include "Engineering" (n=5), "Business" (n=4), "Psychology" (n=3), "Food Science & Technology" (n=1), "Agronomy" (n=1). Results prove that the data had research significance. Regarding the eye tracking devices utilized in these experiments, most of the equipment consisted of "remote ET devices" (n=15) manufactured by various producers. These devices were displayed on a monitor measuring ten of inches. The monitors operated at a frequency of approximately 100-1000 Hz. Additionally, "head-mounted eye trackers" (n=2) were also employed.

3.2. Overall Analysis

Information about each heterogeneity test was shown in Table 2, with T^2, Q-value and I^2. It showed the results regarding the effects of visual attention such as TTF (total time of fixation), FC (fixation count) and TTFF (time to first fixation). Concerning the dependent variable below, the meta-analysis revealed that the overall pooled effect sizes of TTF (total time of fixation) ($|z - value| = 0.664 \leq 1.96$, P-value < 0.001***) and the FC (fixation count) ($|z - value| = 0.804 \leq 1.96$, P-value < 0.001***) were not significant in the difference of mean value, with strong heterogeneity in both. However, TTFF (time to first fixation) ($|z - value| = 7.691 \geq 1.96$, P-value < 0.001***) had not only high difference of each mean but high heterogeneity as well. The same conclusion can be reached by I^2. As could be shown in Table 2, the results had excessive difference which might be unreliable. This led to the further calculation of subgroup analysis, meta-regression approach, publication bias.

3.3. Subgroup Analysis

Regarding the subgroups segment, the elevated resolution diagrams exhibit total time of fixation, fixation count, and time to first fixation for four stimuli: brand, endorser, product, and text. The key values include SMD, the effect size and 95% confidence interval for each stimulus. Considering the heterogeneity present in certain subgroups, it has been determined that the remaining groups exhibit homogeneity, thus warranting the selection of the fixed effect model. The circles depicted in the image correspond to the magnitude of the cases under consideration. Additionally, the sensitivity analyses were computed independently.

For the TTF (total time of fixation) subgroup analysis, as shown in Figure 3, the overall value was deemed to be statistically insignificant (p-value > 0.05). The experimental stimulus may have an impact on gazing duration, either extending or reducing it, as indicated by the value; however, the group for endorser lacked articles, and none of the others were significant.

The analysis of the FC (fixation count) subgroup depicted in Figure 4 indicated that the total worth was not significant. (p-value > 0.05). The utilization of endorser elements has the potential to increase the frequency of respondents' attention towards the specific endorsers. Although the sample size in the subgroup was insufficient. Moreover, the product (SMD= -0.232, 95%CI= -0.359— -0.104) did make obvious effect to subjects' visual attention (p-value <0.001). By using the text (SMD=0.349, 95%CI=0.208—0.490), the fixation count might decrease according to the collected studies (p-value <0.001). The one study removed method indicated that no source was exceed in fixation count subgroup.

Table 2

Main effects of the eye movement data on consumers' visual attention

Dependent variable	N	k	Point Estimate	95%CI	Z-value	T^2	Heterogeneity		
							Q-value	P-value	I^2
Total Time of Fixation	2310	35	-0.020	[-0.079,0.039]	-0.664	0.334	391.554	0.000	91.317%
Fixation Count	1467	26	-0.032	[-0.109,0.045]	-0.804	1.056	678.330	0.000	96.314%
Time to First Fixation	600	10	0.464	[0.346,0.582]	7.691	0.549	140.638	0.000	93.601%

* Abbreviation: CI, confidence interval; k, number of effect sizes; N, total number of sample size.

Figure 3

Forest plot for the TTF (total time of fixation) subgroup analysis according to four elements

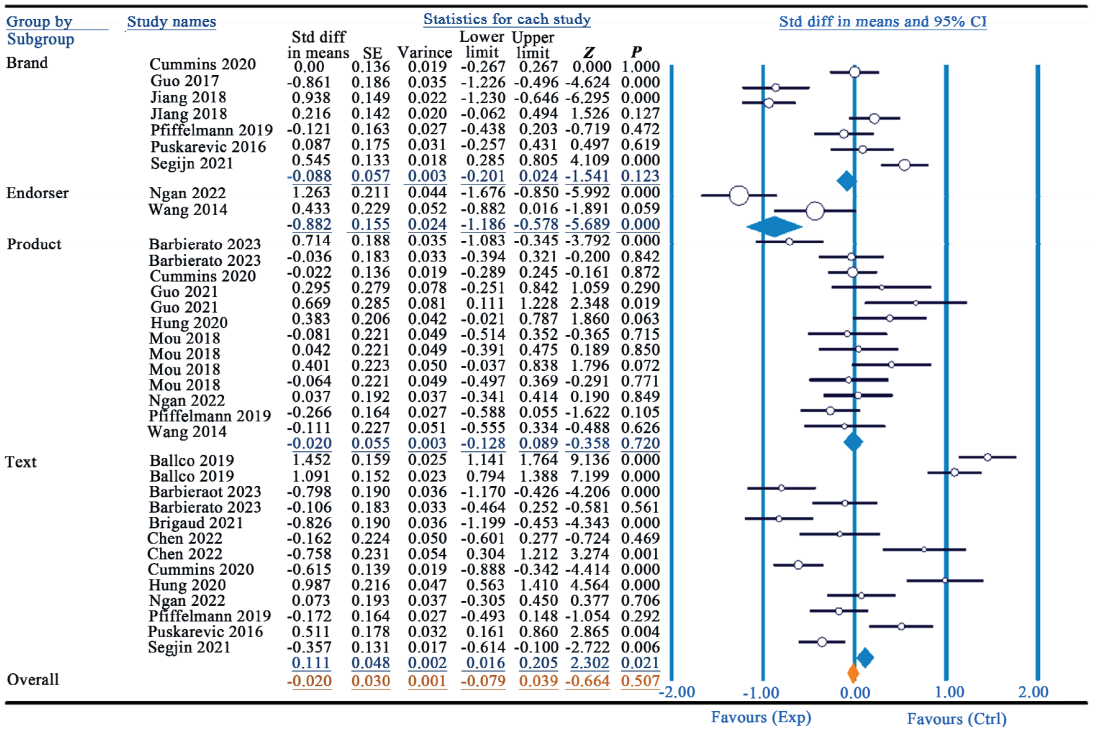


Figure 4

Forest plot for the FC (fixation count) subgroup analysis according to four elements

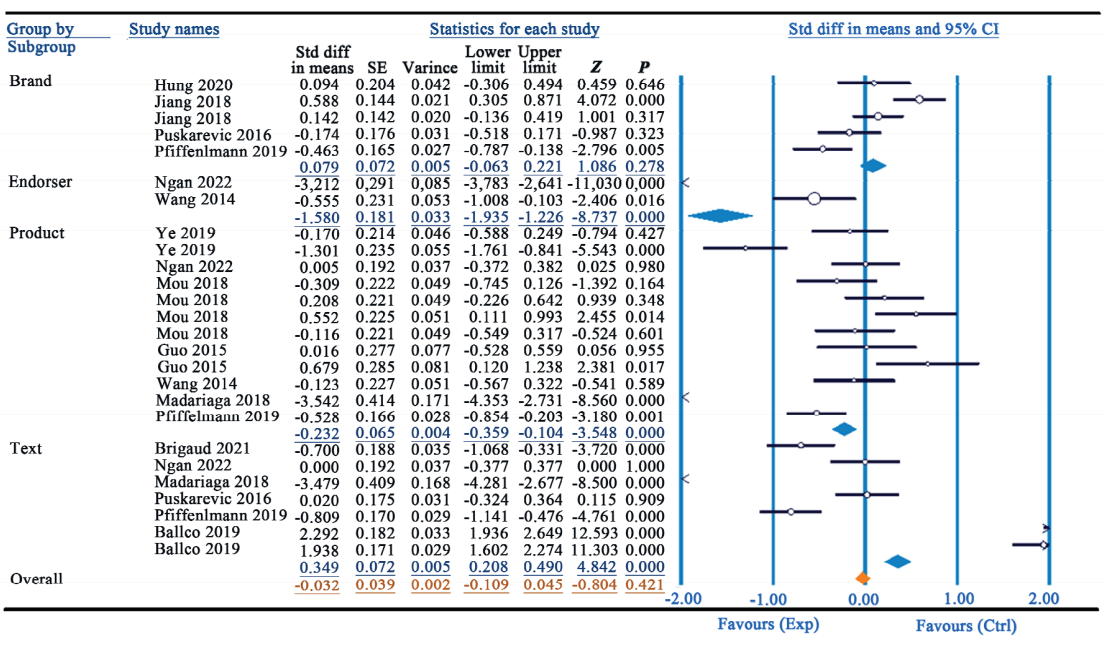
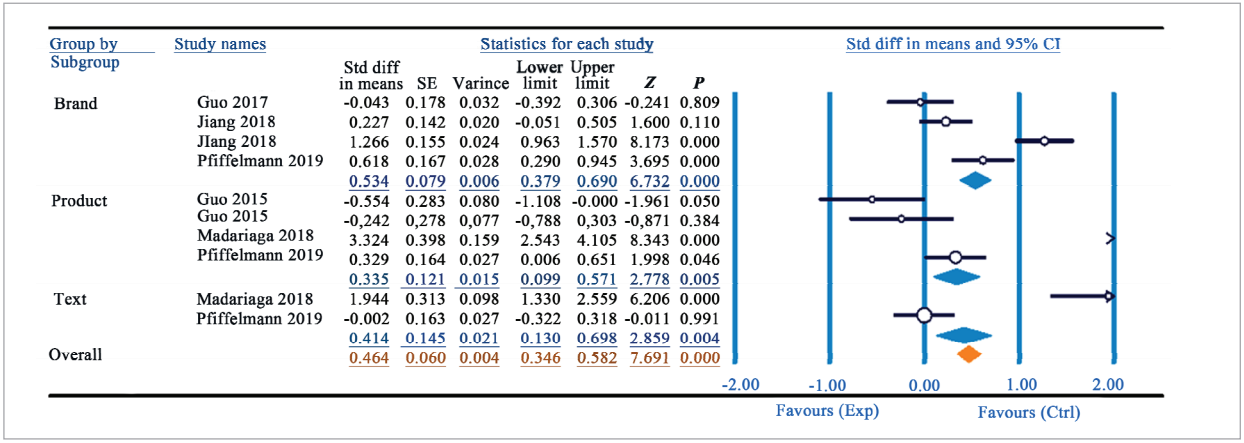


Figure 5

Forest plot for the TTFF (time to first fixation) subgroup analysis according to three elements



The first fixation duration value of all cases in the TTFF (time to first fixation) subgroup in Figure 5 exhibited significant results (p-value <0.001). This might tell us that subjects might discovered the area of interest (AOI) and fixated immediately if we add stimulus. In detail, adding brand in the experiments might cut down first sight time remarkably (p-value <0.001). Meanwhile, product as a design core induced the TTFF scores (p-value < 0.05). Text was another factor led to lessen the first gaze duration distinctly. When removed the important article by Madariaga in TTFF analysis, the outlier values are significantly different from those of other studies.

3.4. Meta-Regression Approach

In meta-regression approach, the moderator exposure time and consumer satisfaction for TTF (total time of fixation), FC (fixation count) and TTFF (time to first fixation) were presented in random effect models shown in the table and figures below.

In Table 3, regarding the exposure time in total time of fixation had insignificant effect size (Q-value=3.766, p-value=0.152). None of the three factors on exposure time was significant. However, the fixation count between-level effect size difference for exposure time (Q-value=11.637, p-value=0.003) was statistically significant. Especially for the fixation count value in short exposure time (z-value=-3.332, p-value=0.001), though the long exposure time (z-value=1.419, p-value=0.156) and medium exposure time (z-value=-1.036, p-value=0.300) in fixation count was lower than that of the former. As for the time to first fixation between-level difference (Q-value=10.316, p-value=0.006) was also significant. Though neither the long exposure time (z-value=-0.059, p-value=0.953) nor the medium exposure time (z-value=0.136, p-value= 0.892) were significant, the short exposure time data (z-value=4.186, p-value=0.000) was much important in time to first fixation.

Testing the influence of online webpage exposure time was essential for design project optimization. However, computing the consumer satisfaction scores could be a good solution for better understand the actual assessment of customers' satisfaction. The consumer satisfaction scores on total time of fixation were insignificant. Whereas the effect size of good comments (z-value=-3.064, p-value=0.002) related to fixation count was larger than that of bad comments (z-value=2.091, p-value=0.037). The effect size of positive evaluation in total time of first fixation (z-value=3.708, p-value=0.000) was much larger than the negative parts (z-value=-0.645, p-value=0.519).

Moderating variable analysis in Figures 6-7 can be used to study whether the true effect size is affected by the moderating variable. There were regression lines, 95% CI line and prediction interval in each scatterplot. We mainly focus on the regression line computed the coefficient of each moderator. It could

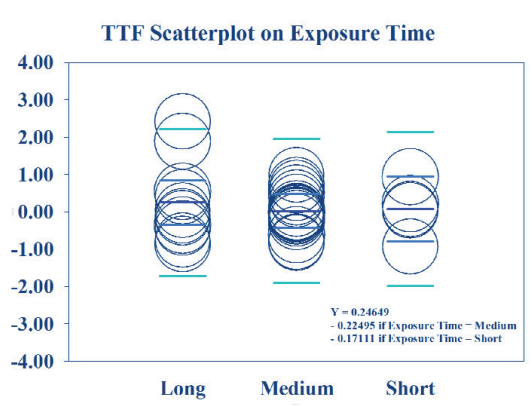
Table 3
Moderator analysis on visual attention

Variables	N	k	Effect size			Heterogeneity	
			Point estimate	95%CI	Z-value	Q-value	P-value
Exposure Time (TTF)						3.766	0.152
Long	739	11	0.223	[-0.124,0.570]	1.259		
Medium	1209	19	-0.056	[-0.320,0.207]	-0.420		
Short	362	5	-0.370	[-0.880,0.140]	-1.423		
Exposure Time (FC)						11.637	0.003**
Long	442	8	0.494	[-0.188,1.177]	1.419		
Medium	603	11	-0.307	[-0.889,0.274]	-1.036		
Short	422	7	-1.258	[1.998, -0.518]	-3.332		
Exposure Time (TTFF)						10.316	0.006**
Long	63	1	-0.043	[-1.481,1.395]	-0.059		
Medium	277	5	0.333	[-0.607,0.697]	0.136		
Short	260	4	1.589	[0.845,2.333]	4.186		
Consumer Satisfaction (TTF)						1.798	0.180
No	845	13	0.165	[-0.165,0.495]	0.979		
Yes	1465	22	-0.120	[-0.372,0.133]	-0.926		
Consumer Satisfaction (FC)						10.953	0.001**
No	378	6	0.790	[0.049,1.531]	2.091		
Yes	1089	20	-0.638	[-1.046, -0.230]	-3.064		
Consumer Satisfaction (TTFF)						6.540	0.011*
No	115	3	-0.273	[-1.100,0.555]	-0.645		
Yes	485	7	1.014	[0.478,1.550]	3.708		

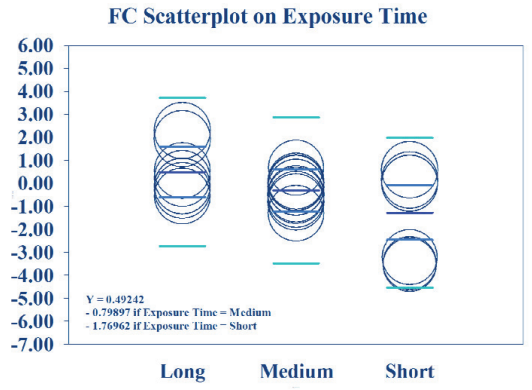
Notes: p <0.05*, p <0.01**, p < 0.001*** , TTF = Total Time of Fixation, FC = Fixation Count, TTFF = Time to First Fixation.

be seen from total time of fixation that the coefficient for long exposure time was 0.2465, higher that the medium duration -0.2249 and short duration -0.1711. The fixation count coefficient for long exposure time was 0.4924 higher that medium -0.7990 and short -1.7696. As for time to first fixation scatterplot, the long one was -0.0430 shorter than medium 0.0890 and short 1.6267. Difference did represent in consumer satisfaction as well. Positive altitude for total time of fixation was 0.3313 longer than negative comments -0.1278. However, fixation count had opposite results with lower coefficient for satisfaction feedback -1.4400 and higher one for disagreement 0.7884. Moreover, time to first fixation had high coefficient value in agreement 1.3135 and low value in bad review -0.2748.

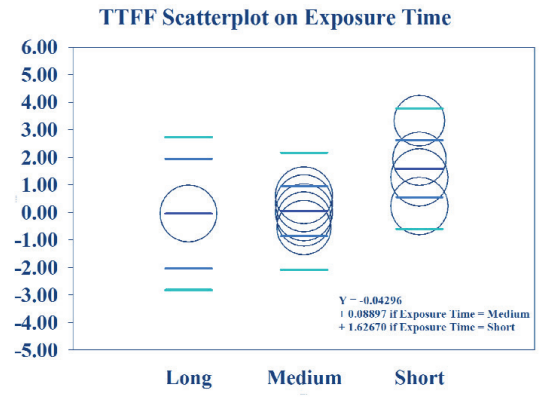
Figure 6
Regressions of Std in means for exposure times on visual attention



(a) Total Time of Fixation

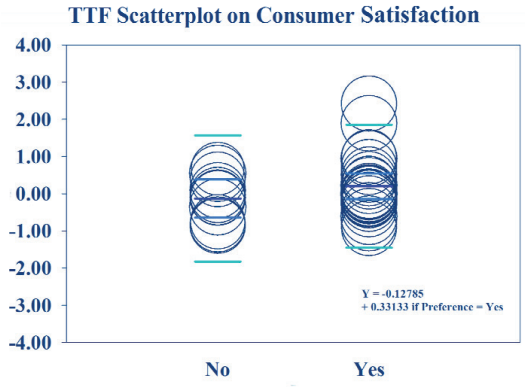


(b) Fixation Count

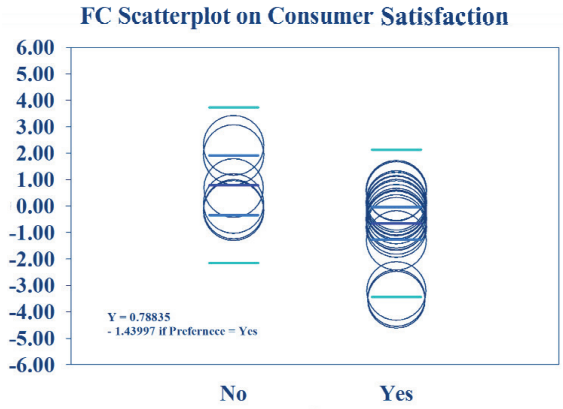


(c) Time to First Fixation

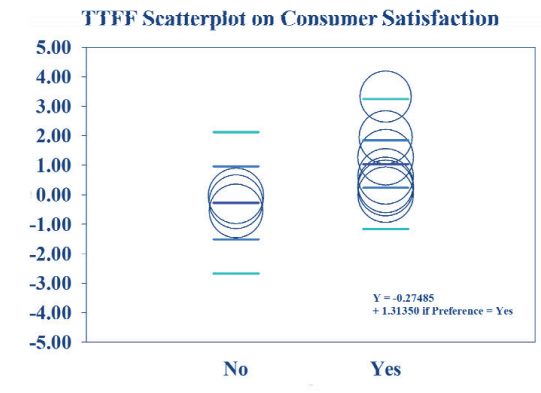
Figure 7
Regressions of Std in means for consumer satisfaction on visual attention



(a) Total Time of Fixation

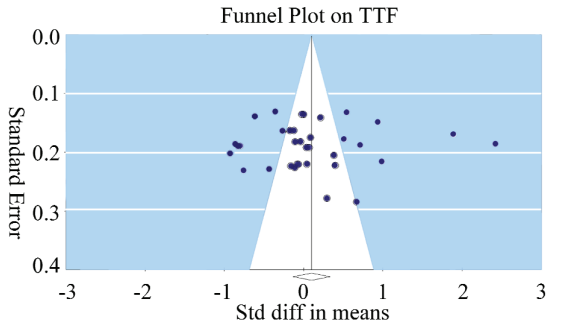


(b) Fixation Count

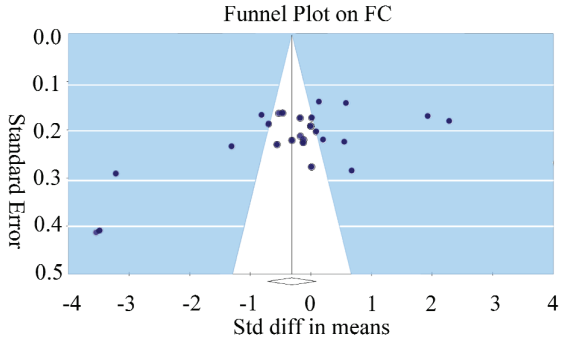


(c) Time to First Fixation

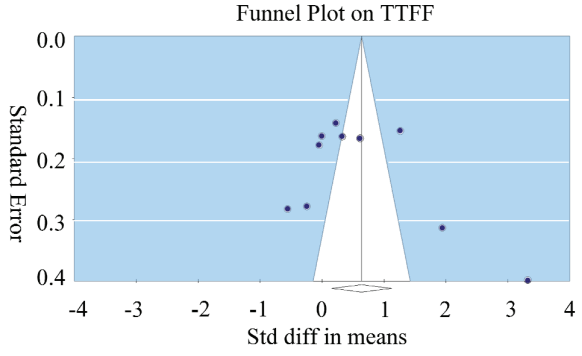
Figure 8
Funnel Plots of Standard Error by Std diff in means on visual attention



(a) Total Time of Fixation



(b) Fixation Count



(c) Time to First Fixation

3.5. Publication Bias

Publication bias is the selective sharing of research studies that have positive results, resulting in a difference between published and unpublished studies [61]. The funnel plots presented for publication bias examinations with Classic fail-safe N. From the subsequent three figures, it is evident that the effect values of most of the studies are uniformly and symmetrically distributed on either side of the average effect value, which suggests that publication bias is improbable. The Classic Fail-safe N is principally employed to evaluate the number of unpublished studies required to nullify the overall effect size of published studies and achieve a non-significant level. Evidence of publication bias of total time of fixation (z-value=3.263, p-value=0.001), fixation count (z-value=-3.792, p-value=0.000) and time to first fixation (z-value=8.516, p-value=0.000) were all insignificant.

4. Discussion

The importance of online shopping will increase over time in the era of intelligence, emphasizing the need to attract consumer attention visually. The utilization of data re-analysis technique in this paper provides a significant reference for future research and development, encompassing a summary of previous research efforts. Analyzing neuromarketing content from multiple perspectives alongside eye movement experiments is crucial for substantiating variations in data outcomes and the necessity of data science in eye movement research [21]. The study's primary indices were total time of fixation, fixation count, and the duration for the first fixation, while consumers' visual cognition, subjective satisfaction, and objective experimental design were examined. With a comprehensive and thorough analysis of this information, it is possible to understand the importance of eye movement research in the field of neuromarketing and its potential impact on consumer behavior.

4.1. Heterogeneity

Data heterogeneity can be attributed to diverse research designs, varying participant counts, and even the quality of literature [29]. These factors contribute significantly to the presence of heterogeneity in this pa-

per. As a solution, we tried to find out the heterogeneity by doing one study removed and it is basically within the reasonable range. From the tests of subgroup analysis, meta-regression analysis and publication bias, the re-analysis data employed in this study exhibits a total deviation that lies within the range of acceptability.

4.2. Overall Analysis

Total time of fixation metric can provide a good reflection of the subject's processing of different areas of interest during a single trial [22, 62]. However, the duration of fixation time in the experiment did not seem to be impacted by any design innovations when it comes to specific eye movement experimental. Secondly, fixation count has a good reference significance for improving visual attention. The measurement is commonly used in eye-tracking studies due to its ability to provide important insights into the most prominent aspects of a visual stimulus that capture the viewer's attention. A greater fixation count on a specific region or entity could potentially signify its elevated significance or interest to the viewer. In other words, fixation count serves as an invaluable tool to gauge an individual's visual preferences and attentiveness towards various stimuli [31]. Lastly, time to first fixation pertains to the duration required for an individual's eyes to fixate on a particular region or item after the exhibition of a visual impetus [25]. This measurement is frequently utilized in eye-tracking investigations to quantify the rate of visual processing and attention distribution [69].

To go further, in subgroup analysis the brand, endorser, product and text had different effect to eye tracking indicators. Firstly, the design of the brand logo, endorser, and text may have a slight effect on the gaze duration. It should be acknowledged that the inclusion of an endorser could lead to increased fixation time, but this subgroup requires further examination due to a lack of cases. Continuously, regarding fixation count, it has been observed that the brand logo, lacking intricate details, does not expand the focus point upon adding the brand image. Moreover, the product and the endorser contain more detail and therefore garner more focus in the experiment. On the contrary, it is imperative to note that increasing the length of text without due cause may have the opposite effect of reducing fixation points [4]. As for time to first fixation, a reduced time to first fixation on a specific area or object can suggest that it is more conspicuous or eye-catching to the observer [64]. This parameter can be employed to evaluate the significance of various visual stimuli.

Regarding meta-regression in this research, increasing the exposure time of the experiment does not significantly impact the effect size of fixation time. This difference might be related to the limitation of time sets. In general, the longer the exposure time, the subject's fixation time will slightly increase [36]. Because visual fatigue might lead to dementia [8, 50]. In addition to objective factors, it could be found in the experiment above that, when the subjects exhibit an interest in the display content, the gaze time and product satisfaction are positively correlated. In detail, when people facing the interested, they will pay more attention [54]. The satisfaction also related to their knowledge about stimulus appearance that fits their taste [24]. This finding highlights the importance of creating captivating and engaging content to capture consumers' attention and influence their satisfaction moderately. For fixation count, daily visual habits support the notion that fixation points increase as the interface display time limit becomes longer. When users display an interest in the content, the total fixation point of the eyes reduces, indicating a correlation between user interest and fixation count. Users that find the interface content intriguing will spend more time scrutinizing it and as a result, capture more useful information. Conversely, users that are not interested will browse quickly, leading to more eye fixation points as they move their focus of sight [7, 56]. Finally, due to the constraints of time, the participants in the studies were more inclined to focus on the content of the interface. The excitement they experienced encouraged them to quickly process and retain information. This resulted in a reduction in the length of their initial fixation time. As the duration of the display interface increased during the experiment, the duration of the first fixation time decreased. This downward trend could be attributed to the pressure of time constraints.

In addition, it should be noted that the experiment has its limitations. The issue is that the experiment's sample size was relatively small, necessitating the need for further literature data to identify any potential patterns in the future.

4.3. Strengths and Limitations

The diverse subgroup elements and moderators including but not limited to total time of fixation, fixation count and time to first fixation, can serve as a valuable point

of reference for designers, merchants, and researchers alike. As we look towards the future, human-computer interaction will continue to become more and more humanized [13], and this trend will depend not only on the interactive hardware device, but also on the content and image presented. In this context, it is important to note that the study of visual attention can provide invaluable insight into the needs and preferences of different groups, which can be used to develop more effective and humanized design methods for online shopping in marketing. By leveraging these insights, designers and merchants can create more engaging and effective online shopping experiences by brand, endorser, product, and text that cater to the specific needs and preferences of diverse audiences.

However, the present study's chosen design elements are inadequate in scope, and the quantity of experimental data is insufficient. In order to carry out further research on eye movement experiments, it is imperative to acquire a greater quantity of data by collecting valuable studies and more precise research content such as headline, price, pectoral and so on. Other device could be applied such as EEG, ERP and FMRI for more consumer physiology data [1, 2] Such measures will aid in the acquisition of more comprehensive insights into the phenomenon under investigation. Moreover, the utilization of electronic devices entails certain unavoidable drawbacks. Specifically, the extent of cognitive load may significantly impact various test indicators, including individual interactions, social norms, task workflow, and experimental environment. These aforementioned factors might pose obstacles to obtaining accurate eye tracking data. For instance, not only can fixation time on the screen be influenced by interests, but it can also be affected by cognitive load. To address this issue, employing physical or tangible materials, such as paper resources or real objects, could be deemed appropriate.

5. Conclusions

The application of neuromarketing has led to significant changes in consumer behavior in the digital online shopping due to the growth of e-commerce and the use of digital devices in shopping and other activities. A wide range of disciplines like biology, psychology, medicine, and computer science are trying to understand human sensory organs and their impact on consumer decision-making.

Previous research has focused on the influence of visual attention related to eye-tracking [26, 62]. This systematic review significantly enhances our understanding by quantifying the total time of fixation, fixation count, and time to first fixation as critical determinants in the process of consumer decision-making. The results from our extensive inquiry provide compelling evidence that the inclusion of captivating design elements, including the brand, endorser, product, and text, can bring about a significant change in the number of fixations observed and the time delay before the first fixation occurs. It is crucial to recognize, however, that diverse design features may produce differing effects on fixation count, even though it is probable that all visually appealing stimuli can decrease the time taken for the initial fixation to happen. Nevertheless, it is unlikely that visual stimulation will affect the overall length of fixation. These findings underscore the importance of carefully considering various design elements when attempting to capture and hold the attention of individuals. Moreover, considering objective factors, the duration of exposure substantially affects fixation count and time to first fixation. These two interdependent variables may be utilized to make inferences about consumer subjective satisfaction and even their ultimate purchase decisions. A more profound comprehension of consumer visual attention in online shopping could be exceptionally beneficial for neuropsychological researchers, as it could result in better design innovations and have a quantifiable influence on the online market's turnover. It is crucial to persist in exploring and investigating the intricate relationship between design elements, visual attention, and consumer behavior in the online shopping milieu. To achieve this, researchers could employ eye-tracking technology to gather more accurate data that could help to enhance the understanding of the complex dynamics involved in online shopping. Additionally, this research could contribute to the development of practical guidelines for online retailers to optimize their visual merchandising strategies.

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