Product Web Page Design: A Psychophysiological Investigation of the Influence of Product Similarity, Visual Proximity on Attention and Performance

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Abstract. This research examines attention to distracting products unrelated to the shopping goal and its impact on performance when making online decisions. An experiment was conducted with thirty-eight participants in a laboratory setting. The study used a 2 (product similarity: similar vs. non-similar) × 2 (visual proximity: near vs. far) within-subject design. The attention of participants was measured with eye tracking during an online decision task. The results showed a significant effect of distractors' visual proximity as participants spent more time on products that were near the target stimulus. In addition, the analysis yielded an interaction between product similarity and visual distance on users' attention. Finally, distractors that were similar to the focal stimulus positively influenced decisions accuracy. These findings contribute to theory by providing quantitative measures of the Gestalt law of proximity. In addition, the user experience has become a cornerstone for the success of firms and the conclusions have HCI design implications about effective product presentations in online shops.

Keywords: Visual attention · Visual distance · Product similarity
Consumer behavior · Ecommerce · Online design · Web pages
Inhibition

1 Introduction

Human activity is driven by impulses that are biochemically and psychologically stimulated, which come from conscious and unconscious activity of the brain. These psychological impulses appear suddenly and are accompanied by a persistent and powerful desire to immediately proceed to an action [1]. In order to control their behavior, individuals must respond only to aspects of the environment that are related to their objectives, by avoiding being distracted by stimuli that are irrelevant to the current task [2]. One of the mechanisms that reduce impulse temptations is the control of visual attention called selective attention, which is the ability to differentiate between relevant and non-relevant information. This system involves two components: the processing of relevant information (i.e., activation) and the active suppression of

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distracting information (i.e., inhibition) [3]. Thus, once a stimulus is identified as irrelevant, inhibition dampens activation and blocks its access to the response system, reducing interference from distractors [4]. The concept of cognitive inhibition explains an individual's ability to control his attention to a task, since it refers to mental processes in the attentional processing of stimuli [5]. When cognitive inhibition is activated, other cognitive and behavioral processes are facilitated, resulting in adjustments of goal-oriented actions. As a result, the ability to direct visual attention away from tempting stimuli avoids unexpected impulses [6].

When shopping online, attention is directed to a myriad of stimuli (e.g., products and ads) [7]. Given that the electronic commerce industry is highly competitive and continuously expanding, users expect a flawless online experience forcing firms to find new ways to attract consumers. Indeed, eMarketer indicates that online sales were $34.04 billion in Canada in 2017 and estimates that they will reach $71.05 billion in 2021, an increase of 109% compared to 2017 [8]. In order to stay competitive, the scientific literature demonstrated that both the first impression of a webpage and its appearance are crucial in capturing users' attention [9]. The mechanism of attention has been the subject of many scientific studies [10], yet, to the best of our knowledge, online attention has not been investigated in depth.

In light of this gap in the literature, this article investigates how stimuli affect individuals' attention and decisions in an online context. More precisely, the present research posits that individuals' attention is greater towards distractors that are visually near and conceptually similar to the target stimulus, impacting online decision-making. The discoveries would have HCI design implications as they would help web engineers to optimize the design of web pages in order to capture users' attention, a key element in ensuring a firm's prosperity.

2 The Proposed Model

In an online shopping context, the hypothesis that individuals pay more attention to distractors that are near the target stimulus rather than the target itself came from research on vision. Numerous psychological and neurophysiological studies on object-based attention have revealed that attention and perceptual grouping are closely tied to each other in biological visual systems [11]. According to the sensory enhancement theory, object-based attention arises from the spreading of attention along Gestalt grouping cues [11]. These principles were formulated since the mind has an innate disposition to structure the elements that the eye perceives. One principle is the law of proximity, which suggests that individuals first group together the points closest to each other in such a way that they tend to perceive objects close to one another as a single group with a relationship, while objects that are farther apart are placed in different groups [12]. Studies in e-commerce showed that the Gestalt principles strongly influence web page design [13]. Therefore, when a desired product is available online, other products have a significant advantage when placed next to it [14], supporting the law of proximity. Thus, in a shopping context, it is suggested that individuals' attention will be preferentially drawn towards close products relative to the target stimulus.

H1: Distractors close to the target stimulus attract more attention than distractors farther from the target stimulus.

We posit that a similar attentional bias exists for distractors that are conceptually similar to the target stimulus. This proposition arose from cognitive science research, namely the categorization process [15]. Product category schemas are organized prior knowledge structures stored in memory where a product matches a pattern. In order to identify objects and distinguish them from other categories, individuals unconsciously organize their memory. The categorization process helps to classify, interpret, and evaluate stimuli by defining all the alternatives with which a stimulus is compared [15]. It facilitates the assimilation and understanding of product-related information found in the environment [16]. The key concept that derives from categorization is similarity. Additionally, the perception of similarity is often seen as a primary influence on category representations [17]. Two types of categorization exist. First, there is the taxonomic categories, which is used to classify stimuli based on shared similar attributes. This suggests that people judge the similarity of one product to another based on common characteristics. Second, there are objective categories that are built ad hoc for a need sought in a consumption situation [18]. In comparison to objectives-related categorization, taxonomic categories are well-established in memory, making external similarities more accessible when considering a set of products. Therefore, through the activation in memory of objects associated with the target stimulus [19], attention is drawn to similar stimuli by information held in the working memory. Thus, in an e-commerce context, it is suggested that individuals' attention will be preferentially drawn towards products that are similar to the target stimulus.

H2: Distractors similar to the target stimulus attract more attention than distractors that are less similar to the target stimulus.

To prevent impulsive precursors from influencing behaviors, inhibitory control is necessary. Some consumers are less able to inhibit impulses, resulting in undesirable behavioral tendencies (e.g., impulsive purchase decisions) [20]. Hence, the shopping environment exposes consumers to many attractive products that grab their attention. Failed regulation in some people does not allow them to shift their visual attention away from stimuli [21]. Taken together, these findings indicate that the effect of visual distance and product similarity will trigger attentional bias.

H3: There is an interaction between product similarity and visual proximity on users' attention.

Moreover, in the literature, the definition of decision-making performance relates to rewards individuals obtained as a consequence of their choice. It was shown the stronger the activation of the attentional-control circuit, the better the decision [22]. This study suggested that individual' attention is drawn towards distractors that are similar and near the target stimulus, therefore these variables are expected to positively impact the performance of decisions.

H4: Distractors that are similar and near the focal product positively influence performance, i.e., product selection.

To test the hypotheses, we propose the following model (See Fig. 1).

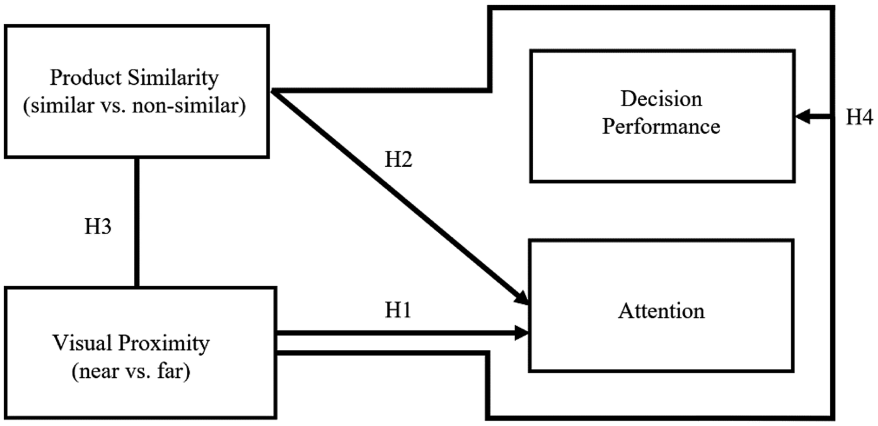

Fig. 1. Research model

3 Method

3.1 Participants and Design

An experiment was conducted in a laboratory using a 2 (similarity between the focal product and distractors: similar vs. non-similar) × 2 (proximity between the focal product and distractors: close vs. far) within-subject design. Thirty-eight students participated (Mage = 23.32, SD = 3.31) and received a $20 gift card for our University's store as compensation. The IRB of our institution approved this study. In the similar condition, the focal product and the distractors were conceptually close (e.g., cake vs. muffin), whereas in the non-similar condition they were far (e.g., cake vs. meat). In the near condition, the distance between all products was small (i.e., at the center of the screen), whereas in the far condition, the focal product was in the center of the screen and distractors were in the periphery.

3.2 Procedure and Measures

The study had two steps. First, participants accomplished two online shopping tasks separated between Scenario 1 and Scenario 2, in which the experimental factors were manipulated. The instructions indicated to focus on the target object. At first, instructions for Scenario 1 were displayed. It was about "Matthew", who needed to buy a birthday cake with fresh whole strawberries for his best friend. To reduce the variability of the response time that results from the distracted gaze of the subjects [23], it started with a fixation cross in the center of the screen. The latter was displayed during a random period of time (e.g., between 1000 ms and 3000 ms) to reduce a possible anticipatory effect. After the fixation cross, the screen that contained the distractors and the focal product was displayed for 4000 ms. It included one focal product and three distractors. When it disappeared, participants were asked to indicate if the focal product was a cake with or without strawberries. To increase the ecological validity and to limit

stress, participants had no time limit to make the decision. The sequence always consisted of three screens in the following order: one screen with a fixing cross, one screen containing the distractors as well as the focal product and one screen with the question related to the previous screen. This order was repeated until the final trial. After participants completed thirty-two decisions, Scenario 2 instructions were displayed. Participants read about their niece "Sarah". As she celebrated her 7th birthday, they were asked to find her a pink dress. Subjects were informed that the dress would always be in the center of the screen. It started with a fixation cross in the center that was displayed during a random period of time (e.g., between 1000 ms and 3000 ms). Then, the screen that contained both the distractors and the focal product was displayed for 4000 ms. It included one focal product and four distractors. When it disappeared, they were asked to indicate if the dress was pink, without no time limit for answering. The sequence always consisted of three screens in the following order: one with a fixing cross, one containing the distractors and the focal product and one with the question related to the last screen. This order was repeated until the thirty-second decision. Second, once the main task was completed, we asked participants to fill in a questionnaire designed to assess their demographic profile.

Attention was measured using a computer monitor with an integrated SMI eye tracker (Model: RED 250, SensoMotoric Instruments GmbH, Teltow, Germany) that had a sampling rate of 60 Hz. Each participant was seated on a chair with a viewing distance of approximately 24 inches from the monitor. The equipment was individually calibrated using a five-point calibration method, producing a low tracking error (less than 0.4). The pixels area of the distractors was defined as separate areas of interest (i.e., AOI) [24]. To measure the allocation of attention, time spent on distractors was assessed and the milliseconds of net dwell time on distractors were used. As for decisions analysis performance, response time and accuracy of the answer given were monitored.

3.3 Stimuli

Given that impulsive individuals are less capable of self-controlling their domains of interest [25], we used stimuli from the food and the fashion industry. They were separated in two different scenarios known to trigger impulsive behaviors [26, 27] to simulate attentional bias.

For Scenario 1, the target product was a picture of a cake, whereas pictures of pastries, frozen desserts, chocolates, and sweet snacks served as similar product distractors (within-subject condition; Fig. 2). Pictures of cheeses, meats, alcoholic beverages, and fish were used as non-similar distractors (within-subject condition; Fig. 2).

For Scenario 2, the target product was a pink dress, whereas pictures of t-shirts, skirts, sweatshirts, and jackets served as similar distractors (within-subject condition; Fig. 3). For the non-similar distractors, pictures of swimwear, accessories, underwear, and shoes were presented (within-subject condition; Fig. 3).

Images had the same pixels size and appeared only once. Finally, to measure the visual distance effect, four image layouts were tested: all distant, all close, distance in x, and distance in y. Distances (e.g., x distance) were held constant across trials.

Fig. 2. Scenario 1 conditions: left panel: small distance - high similarity; right panel: far distance - low similarity)

Fig. 3. Scenario 2 conditions: left panel: far distance - high similarity; right panel: small distance - low similarity (Color figure online)

4 Results

The experiment sought to investigate the influence of visual proximity and product similarity on online attention and decisions. To test the hypotheses, time spent on distractors was utilized as a dependent variable in a linear mixed-effects regression model [28]. The latter offers more information than ANOVAs about variance and covariance (i.e., variability of two random variables) [29]. The results of individuals' attention on distractors are summarized in Table 1. Moreover, to examine the

performance of decisions, response time and accuracy of the answer were dependent variables measured in a mixed-effects logistic regression model. The results of individuals' decisions performance are summarized in Table 2. Finally, to avoid errors of multiple comparisons, the Holm-Bonferroni method was used.

Table 1. Distractors' proximity and similarity results

Model	Estimate	Std. error	t-value	p-value
Scenario 1				
Visual proximity	501	340	1.47	.140
Product similarity	−281	341	−0.82	.410
Visual proximity × Product similarity	120	23.2	5.17	<.000
Scenario 2				
Visual proximity	582	264	2.21	.027
Product similarity	1.85	268	0.010	.995
Visual Proximity × Product similarity	106	17.4	6.07	<.000

We hypothesized that individuals allocate more attention towards distractors that are near the target stimulus. The significant effect showed that participants spent more time on distractors that were near the focal product ($t(4788) = 2.21$, $p = .027$, $d = 0.06$, Table 1). Importantly, it emerged when the focal product was at the center of the screen (i.e., Scenario 2: prior knowledge of the focal stimulus position). In sum, this finding supports H1: participants allocate more attention to distractors that are close, but only for Scenario 2.

We postulated that individuals allocate more attention towards distractors that are similar to the target stimulus. For both scenarios, the effect was not significant (Table 1), therefore, H2 is rejected.

We further analyzed the visual distance x product similarity interaction using a least- squares means model for the comparison of multiple factors. The analysis yielded a significant effect (See Fig. 4). More precisely, in the non-similar products condition, attention was greater on distractors that were near the focal product ($t(4788) = 6.07$, $p < .000$, $d = 0.18$). The effect was obtained for both scenarios, confirming H3: an interaction exists between product similarity and their distance on users' attention.

Moreover, we supposed that similar distractors that are near the focal product influenced the performance of decisions. For Scenario 1, the answer is more likely to be accurate with similar stimuli rather than non-similar distractors ($t(1161) = 3.39$, $p = .001$, $d = 0.20$; Table 2). As for Scenario 2, the answer is more likely to be incorrect when distractors are far from the target product ($t(1161) = -2.23$, $p = .026$, $d = 0.13$; Table 2). Hence, distractors that are similar to the focal product lead to accuracy of the answer. No significant effect was found on response time, which partially confirmed H4: distractors that are similar to the focal product positively influence answer accuracy, but only for Scenario 1.

Table 2. Performance results

Model	Estimate	Std. error	t-value	p-value
Scenario 1: response time				
Visual proximity	2751	2180	1.26	.207
Product similarity	237	1546	0.15	.878
Scenario 1: accuracy				
Visual proximity	−14.4	−15.0	−0.96	.335
Product similarity	29.4	8.67	3.39	.001
Scenario 2: response time				
Visual proximity	−109	1445	−0.080	.940
Product similarity	96.3	1025	0.090	.925
Scenario 2: accuracy				
Visual proximity	−37.8	16.9	−2.23	.026
Product similarity	13.0	10.8	1.21	.227

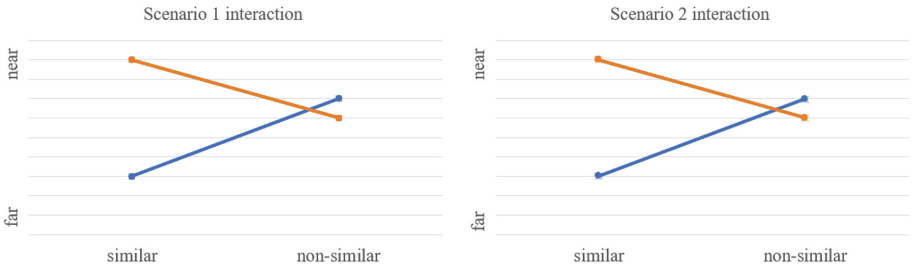

Fig. 4. Interaction effects

5 Discussion

An important finding of this research is that attentional bias is more pronounced when distractors are visually near the focal product. This supports our hypothesis that individuals are less successful in keeping their attention on the focal product when distractors are at a close distance. In addition, we discovered an interaction between visual proximity and product similarity on users' attention. Finally, distractors that are similar to the target stimulus positively impacted accuracy of the answer given during the decision task.

The results have theoretical contributions and managerial implications. First, this research quantitatively measures the Gestalt law of proximity (i.e., time spent on distractors) with attentional data (i.e., eye-tracking), thereby contributing to the general literature on vision through quantitative measurement [30]. Second, the user experience has become the cornerstone for designers and the concern of senior executives considering a great online experience has the potential to grow business revenues. Thus, understanding users' behavior is crucial to meeting their needs. The study provides relevant insights for web page design. For instance, the findings can guide

recommendation system developers and web page designers about what type of products should be presented together and how far apart to capture and keep users' attention.

Two limitations should be noted. First, studies have shown cross-cultural variations in visual attention [27]. Thus, future research should consider adding this element as a control variable. Second, the main limitation stems from the artificial nature of the task. Because participants were not buying the product at the end, they could have been less capable of self-controlling their attention towards the focal product knowing that the goal was simulated.

Some results require further investigation. The discovery that individuals' attention to distractors that are near the focal product operated only for Scenario 2, can be explained by the top-down guidance theory of attention. The biased-competition model of visual attention suggests that objects are competing for access to higher levels of processing in the brain. The attention is controlled by the pre-activation of neural channels towards a relevant object [31]. Therefore, during a searching task, visual attention is guided to a stimulus matching the content in the working memory. Brain imaging studies showed that food-related stimuli are strongly represented in the working memory, thereby, it could generate attentional bias. Inhibiting food-related stimuli can be more challenging for individuals, since they are well represented in memory [32]. Consequently, the experiment scenario design (e.g., food industry) can explain the rejection of H2. Furthermore, this theory can give an explanation to the significant effect of answer accuracy for Scenario 1 only. Therefore, future research should consider combining eye tracking with electroencephalography signals (i.e., EEG) to measure cognitive load during the shopping task [33]. This would provide a timely alert for conveying high-attention level feedback against the distractors to gain additional information. Alpha waves' neural oscillations would be useful to measure attention and to analyze the brain activity [34] during the shopping task. Forthcoming research should also extend the participant pool to form gender groups to measure the level of attention against products that are known to trigger impulsivity in some groups [26]. Finally, regulating affective responses is harder for impulsive individuals [35], thereby, facial emotions could help to understand how emotions mediate visual attention.

Now that designers only have 50 ms to capture users' attention [36], web page design needs to be impeccable. One of the powerful factors influencing attention is the appearance of a website [9]. Despite the prevalence, a fairly limited scientific knowledge is available regarding online attention. With these facts, there is a relevance of pursuing research in this field.

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