



Customer oriented strategies for restaurant menu design: A study on visual attention patterns

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Abstract

Purpose: In modern gastronomy, competition is increasingly dependent on how food-related information is visually structured and presented to consumers. As digital platforms and image-based communication continue to shape consumer expectations, visual elements have become increasingly important in how menus are noticed, understood, and evaluated. Accordingly, menu design has begun to focus more systematically on visual perception and attention patterns. This study investigates predicted visual attention patterns in restaurant menus using an artificial intelligence-based visual attention analysis tool (3M VAS).

Method: A total of six menu designs were created within a 3×2 experimental structure. Two different layout types were used: a vertical single-page layout and a horizontal two-page layout. Within each layout type, three visual versions were designed: (1) text-only black-and-white menus, (2) menus with food images, and (3) menus with colored text without images. All other design elements were kept the same across versions. The menus were analyzed through heatmap, sequence, and region-based attention outputs to identify structural differences in visual attention distribution.

Findings: The findings indicate that menu layout functions as the primary structural variable shaping predicted pre-attentive visual attention patterns during the initial moments of menu exposure. Vertical single-page menus created a more continuous and consistent attention flow, while horizontal two-page menus led to more fragmented and divided attention patterns. Adding images increased attention in specific areas, but images did not eliminate the overall effect of layout structure. Color mainly helped clarify hierarchy and organization rather than strongly directing attention on its own. Across all menu types, price information tended to remain a secondary visual element.

Discussion: Overall, the findings suggest that layout structure may function as a primary organizational component in predicted early-stage visual attention patterns, while images and color may operate as supportive visual features within this predictive framework. By providing a predictive and descriptive framework for pre-attentive visual attention analysis, this study contributes to methodological discussions surrounding menu design evaluation and supports more systematic approaches to visual menu development.

Keywords: Menu Design, Visual Attention, Eye-Tracking, Menu Engineering

Introduction

Menu planning and design research has been continuously evolving with the aim of responding to changing consumer expectations and demands in the service sector. Contemporary consumers live in close interaction with technological advancements that have rapidly become integrated into everyday life. The wide range of stimuli and environmental factors encountered through these developments influence consumers' decision-making processes (Jiang and Chen, 2022).

Within the gastronomy sector, the general strategy of menu engineering is to communicate relevant information to customers in an efficient and comprehensible manner. Mainstream menu design approaches primarily focus on how attention can be directed toward specific menu items or categories, or how visual and informational emphasis can be enhanced (Kim et al., 2025). In this process, customers often evaluate menu information without physically experiencing the product and rely substantially on visually presented information during early evaluation stages. This decision-making context allows the overall dining experience, shaped in part by the selected food item, to be evaluated as an integrated whole (Yang, 2012). Human interaction with the surrounding environment occurs primarily through perception. Processes such as recognizing, interpreting, and responding to the environment are shaped by perceptual mechanisms. These

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processes are structured according to different sensory modalities and their interactions. However, previous research indicates that visual perception plays the most active role in human perceptual processes (Kandel, 2012).

Research on consumer preferences holds a prominent place in the literature and has been the subject of extensive investigation over many years. In general, preference formation and decision-making processes result from the interpretation of signals provided by multiple sensory inputs, ultimately leading to a final choice. However, the decision-making process mediated through menus differs from other contexts, as it is largely based on visual perception alone. For this reason, menu engineering constitutes a distinct field of inquiry. Menus designed in accordance with their intended purpose, when combined with factors such as restaurant ambiance and feedback from different user groups, convey positive signals to customers and support clearer information presentation and visual processing. The evaluation of whether a post-selection decision was appropriate becomes clearer when consumers interpret the overall process as a holistic gastronomic experience (Motoki et al., 2021; Mora et al., 2023).

The importance of visual elements and presentation in gastronomy has been increasing steadily. In particular, the growing influence of social media has enabled a much wider range of designs and presentations to be exposed to consumers and subjected to evaluation (Hwang et al., 2021). In this context, visual perception emerges as a considerably more powerful tool compared to previous periods. Menu design processes have similarly evolved toward a stronger focus on visual perception research. Except for fine-dining restaurants serving only tasting menus and establishments offering table d'hôte menus, consumers in standard restaurant settings generally make their choices from à la carte menus. Menus that were previously presented verbally or in printed form have increasingly been replaced by QR code-based menus or digital menus available on restaurant websites, especially following the COVID-19 pandemic and the heightened concerns related to hygiene and health. In a world where familiar experiences are rapidly being replaced, consumer-oriented developments are likely to positively influence individual decision-making processes (Lee and Kim, 2020; Leung et al., 2020). Within this evolving digital and visually driven context, understanding how consumers visually engage with menu content has become increasingly important.

The aim of this study is to examine predicted visual attention patterns in restaurant menus through the use of visual attention software and, based on these findings, to contribute to the more effective design of menu layouts and visual structures. In addition, the study seeks to support the development of visual design strategies employed in visually oriented communication contexts such as menu engineering and restaurant management, with a particular focus on the presentation and positioning of menu items. Furthermore, this research aims to provide a descriptive and scientifically grounded framework to inform menu design decisions.

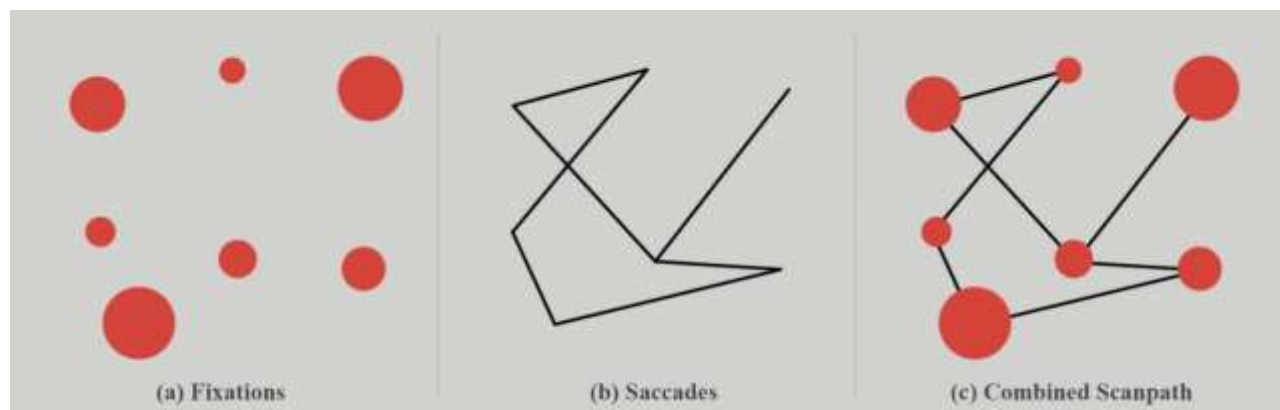
Conceptual Framework

Visual perception refers to the process by which images received through the eyes are processed and interpreted by the brain. This phenomenon, which encompasses concepts such as attention and awareness, is generally described as the cognitive interpretation of visual information (Yang et al., 2020). Nevertheless, explaining visual perception solely through what the eye records from the environment can be misleading. Studies on visual perception demonstrate that the meaning attributed to a stimulus and the observer's prior experiences play a decisive role in this process (Norberg-Schulz, 1968; Aydınli, 1986; Berger, 2004; Arnheim, 2007). Particularly in contexts such as selective menus, where decision-making relies primarily on visual perception and the interpretation of presented information, choices are formed through mental imagery and predictive judgements generated in the brain. This makes visual perception a critical factor in consumer decision-making. In recent years, the number of studies examining the effects of restaurant menu design on consumer attention patterns and customer perception through the use of eye-tracking applications has steadily increased in the literature. The advantages provided by eye-tracking technology in identifying consumers' visual attention and preferences have made it one of the important tools for consumer-oriented visual communication in menu design processes. Fundamentally, eye tracking refers to the process of monitoring eye movements over a specific period of time and recording states of visual fixation and omission (Duchowski, 2017).

Regardless of the eye-tracking technique employed, the process is generally based on two core measures: fixations and saccades (Figure 1). Fixations represent the points at which an observer looks at a stimulus, indicating which elements attract visual attention and which parts of the stimulus are consciously noticed. For this reason, fixations are considered the primary measure through which visual information is acquired from a stimulus (Weber et al., 2002). As an information-gathering measure, approximately 95% of the time the eyes

spend on a stimulus is allocated to fixations (Yarbus, 1967). Visual perception itself is also understood to occur predominantly during fixation periods (Hollander et al., 2020). Saccades, on the other hand, refer to the eye movements performed as the gaze shifts from one fixation point to another. Unlike fixations, saccades are not point-based but linear in nature and are characterized by rapid movement. Consequently, they are short in duration. During saccadic movements, visual information is not recorded, as visual processing is largely suppressed while the eye transitions between fixation points (Birawo and Kasproski, 2022).

Figure 1. Eye-Tracking Measures



Source: Created by the Authors

The historical development of eye-tracking research spans approximately 150 years. According to Poole and Ball (2005), the method was initially employed in reading research and was fundamentally based on the observation of visual behavior. With the beginning of the twentieth century, eye tracking entered an experimental research phase. Dodge and Cline (1901) conducted one of the earliest studies focusing on the measurement and analysis of eye movement velocity. Subsequently, Judd, McAllister, and Steel (1905) investigated horizontal and vertical eye movements using a kinetoscopic photography method, in which sequential images were presented to observers to simulate motion. By the mid-twentieth century, the first head-mounted eye trackers were introduced (Hartridge and Thompson, 1948). This development enabled the limitation of observers' head movements and facilitated more controlled and consistent experimental conditions. The 1970s marked a period during which the functioning principles of the human eye and its influence on perceptual and cognitive processes were extensively examined (Jacob and Karn, 2003). In the 1980s, advancements in computer and communication technologies shifted the focus of eye-tracking research toward human-computer interaction. The overall evolution of eye-tracking technology is summarized in Table 1.

Table 1. History of Eye-Tracking (Created by the Authors)

Year	Developments and Descriptions
1878	• First used in reading research • Observation of the act of seeing • Examination of eye movements with the aid of a mirror • Examination of the eye by magnifying it with the aid of a lens
Dodge and Cline, 1901	• Research through experiments • Measurement and analysis of speed in eye movements • Horizontal axis-based eye movements • Reflection of light on the cornea
Jude, McAllister, and Steel, 1905	• Motion picture photography • Vertical and horizontal axis based eye movements
1930	• Eye movements during the reading process • Examination of features such as font, size, and page layout
Hartridge and Thompson, 1948	• First overhead eye tracker • Limitation of head movements • More consistent study data
Fitts, Jones, and Milton, 1950	• The use of eye tracking in aviation • The use of cockpit instruments during descent • Examining the pilot's eye movements with motion-tracking cameras

Year	Developments and Descriptions
1970	• The operating principles of the human eye • Investigation of perceptual and cognitive processes • Studies in the fields of psychology and physiology
1980	• The development of computers and communication technologies • Human-computer interaction in eye tracking

Research on menu planning and design began to emerge in the late 1970s and gained particular momentum during the 1990s (Livingston, 1978; Stoner, 1986; Hug and Warfel, 1991; Miller, 1992; Main, 1994; Bowen and Morris, 1995; Scanlon, 1998). In subsequent years, alongside the development of eye-tracking applications and the growing body of research in this field, eye-tracking methods were increasingly integrated into studies focusing on restaurant menus.

Yang (2012) questioned widely accepted assumptions in the eye-tracking literature regarding focal areas in two-page restaurant menus. Contrary to the commonly cited “sweet spot” located in the upper-middle right section, the findings suggested that participants followed a book-reading-like viewing pattern, focusing first on the left page before moving to the right. These results indicate that attention distribution in two-page menus may be more structured and sequential than previously assumed. Reale and Flint (2016) investigated visual attention toward health-related information on menus using a between-subjects design. Their findings indicated that the use of color cues and health logos increased visual attention toward lower-calorie menu items compared to standard labeling approaches, highlighting the role of visual emphasis in directing attention to nutritional information. Kim et al. (2018) reported that supplementing numerical calorie information with physical activity-based visual labels increased consumers’ visual attention and supported healthier food-related evaluations. The authors suggested that incorporating diverse physical activity representations could further enhance the effectiveness of such labeling strategies. Özaydın and Güzeller (2021) investigated restaurant customers’ decision-making processes through differently designed menus using eye-tracking in a simulated restaurant setting. The findings indicated that the inclusion of visuals was not fully effective in directing attention. The first fixation point did not align with the area generating the most purchases, suggesting that the commonly assumed “sweet spot” was not supported. Moreover, gaze order did not directly influence purchasing behavior. Ngan et al. (2022) found that consumers with different levels of price consciousness exhibited distinct gaze patterns when viewing menus. The authors emphasized that identifying target customer segments may support the design of more fluid menu layouts aimed at attracting consumer attention and shaping spending-related tendencies. Mora et al. (2023) examined visual attention patterns using three different menu formats that varied in informational content. Their results showed that menus containing basic and descriptive information were associated with longer fixation durations and higher likelihoods of item selection, whereas the inclusion of colorful nutritional infographics reduced the predictive usefulness of eye-tracking measures. Despite the growing number of menu-focused eye-tracking studies, these findings collectively suggest that systematic gaps remain in the literature, indicating a need for further research. Recent developments in eye-tracking research have extended beyond foundational menu design assumptions. Kim et al. (2025) demonstrated how different menu formats influence visual attention and consumption attitudes, highlighting the role of icons and images in engaging consumers. Similarly, Capkan et al., (2025) provided evidence that visual design attributes such as informativeness and visual appeal are associated with visual attention processes relevant to choice behavior. These findings collectively suggest the importance of systematically examining visual attention patterns in menu design through structured and reproducible analytical methods.

Methodology

Within the scope of this study, an eye-tracking approach was selected as the primary research method. During the visual evaluation process, eye-tracking studies were compared with experience-oriented traditional evaluation methods, including surveys, interviews, and focus group discussions. The literature indicates that experience-based traditional methods may involve certain limitations due to their reliance on individuals’ subjective self-reports and may be insufficient in directly measuring cognitive processes such as attention (Rusnak, 2021; Li et al., 2022). In addition, some studies emphasize that these methods are often shaped by theoretical assumptions and provide limited data regarding observable processes (Ergan et al., 2019; Weber et al., 2002).

Eye-tracking studies, by contrast, extend beyond experience-oriented approaches by enabling the direct and objective documentation of moment-to-moment interactions between the observer and the visual stimulus (Junker and Nollen, 2018). This method reduces reliance on participant self-reports and provides process-

based data related to visual attention mechanisms. Furthermore, the visualizability of eye-tracking data allows for the analysis of attention patterns that are difficult to capture using traditional methods. A comparison between eye-tracking studies and experience-oriented traditional methods is presented in Table 2.

Table 2. Comparison of Eye-Tracking Studies with Traditional Studies

Features	Eye-tracking Studies (Stationary, mobile and software-based)	Traditional Studies (Surveys, interviews, and focus group discussions)
Scientifically grounded	+	+
Objectivity and reliability	+	+
Documentation of real-time interaction between the observer and the stimulus	+	
Data visualization	+	
Detailed dataset	+	
Compatibility with demographic studies	+	+
Compatibility with senses other than vision	+	+
Low margin of error	+	
Evaluation of demographic variables		+

Source: Created by the Authors

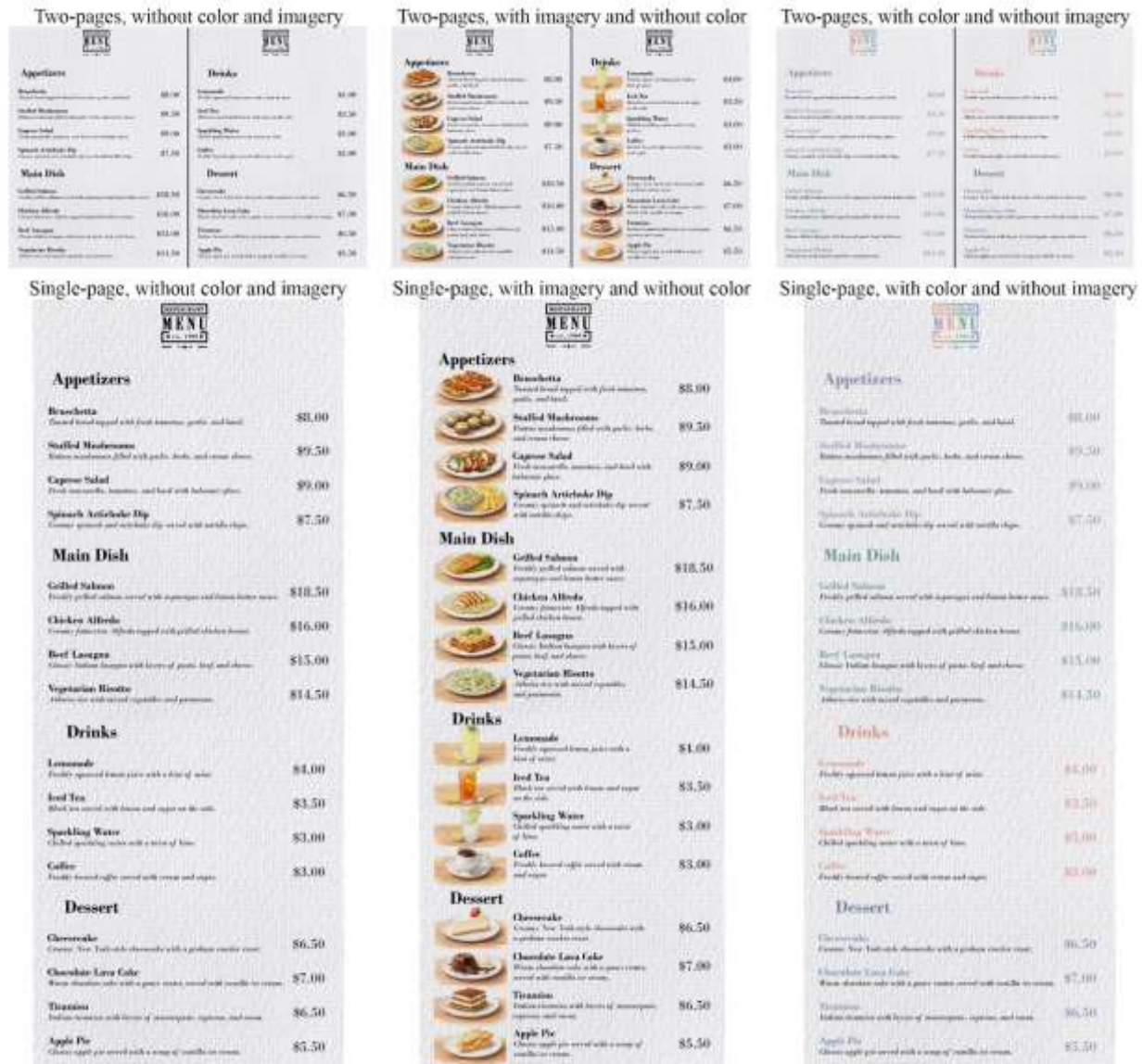
Eye-tracking studies can be categorized into three main types: static, mobile, and software-based approaches. Although the techniques differ, their underlying operational principles are largely similar. In all three approaches, data collection is primarily based on two core measures: fixations and saccades. The main differences among these techniques arise in relation to factors such as time requirements, cost, ease of implementation, suitability for demographic analyses, and the level of data detail required. Static and mobile eye-tracking studies allow for more detailed data collection regarding these core measures and enable the inclusion of demographic analyses. In contrast, software-based eye-tracking studies do not require laboratory setups or minimum participant involvement. Consequently, the selection of an eye-tracking technique should be guided by the specific aims and scope of the study.

Within the scope of the present research, the primary objective was to conduct a general evaluation of menu designs. For this reason, no demographic analysis was intended. Considering factors such as the appropriateness of validity testing, cost and time efficiency, and ease of application, a software-based predictive visual attention study approach was deemed suitable. Accordingly, among the predictive visual attention software options reviewed, Visual Attention Software (VAS) developed by 3M was selected for the analysis. The present study does not employ real-time human eye-tracking measurements; but utilizes an AI-based predictive visual attention framework to estimate pre-attentive attention patterns. Accordingly, findings generated within the present framework should not be interpreted as direct representations of consumer choice behavior, purchase intention, or final menu evaluation processes. The outputs produced by predictive visual attention software reflect estimated early-stage visual salience patterns rather than complex cognitive, motivational, or behavioral processes operating in real restaurant environments.

VAS is an image-processing software that utilizes artificial intelligence and machine learning technologies (3M, 2026). Widely used in visually oriented design fields such as product and web design, the software demonstrates approximately 90% consistency with real-time eye-tracking data, according to its validation report. The development of the software was supported by data obtained from research laboratories at the Massachusetts Institute of Technology (MIT) and the University of York, as well as proprietary datasets generated by 3M. According to the validation documentation, this data repository is based on approximately 30 years of accumulated research. VAS focuses on predicting areas of visual attention during the first 3-5 seconds of viewing, a phase referred to as initial fixation, which corresponds to automatic and pre-conscious eye movements. Company reports indicate that demographic variables such as age, gender, and experience have a limited influence on this initial fixation phase (3M, 2026). The scientific validity of VAS has been supported by various studies demonstrating a high level of consistency between its predictive outputs and empirical eye-tracking data (Lavdas et al., 2021; Mehaffy et al., 2023). In addition, predictive visual attention models similar to VAS have been increasingly adopted in peer-reviewed design, marketing, and architecture research. To the best of our knowledge, the present study represents the first attempt to examine restaurant menu layouts through the 3M VAS-based predictive visual attention framework.

In the present study, the predictive visual attention software VAS was selected due to its cost and time efficiency, lack of participant requirements, reported consistency with real-time eye-tracking data, and its ability to provide predictive insights relevant to visual design processes. In this study, a total of six menu designs constructed within a 3×2 experimental structure were evaluated using the VAS artificial intelligence framework, consisting of two layout orientations (vertical single-page and horizontal two-page) and three visual configurations based on the presence or absence of imagery and color, while all other design elements were held constant (Figure 2). The menu designs were systematically created by varying predefined design variables under controlled conditions, and each menu was analyzed using visual attention software outputs.

Figure 2. Designed Menu Layouts



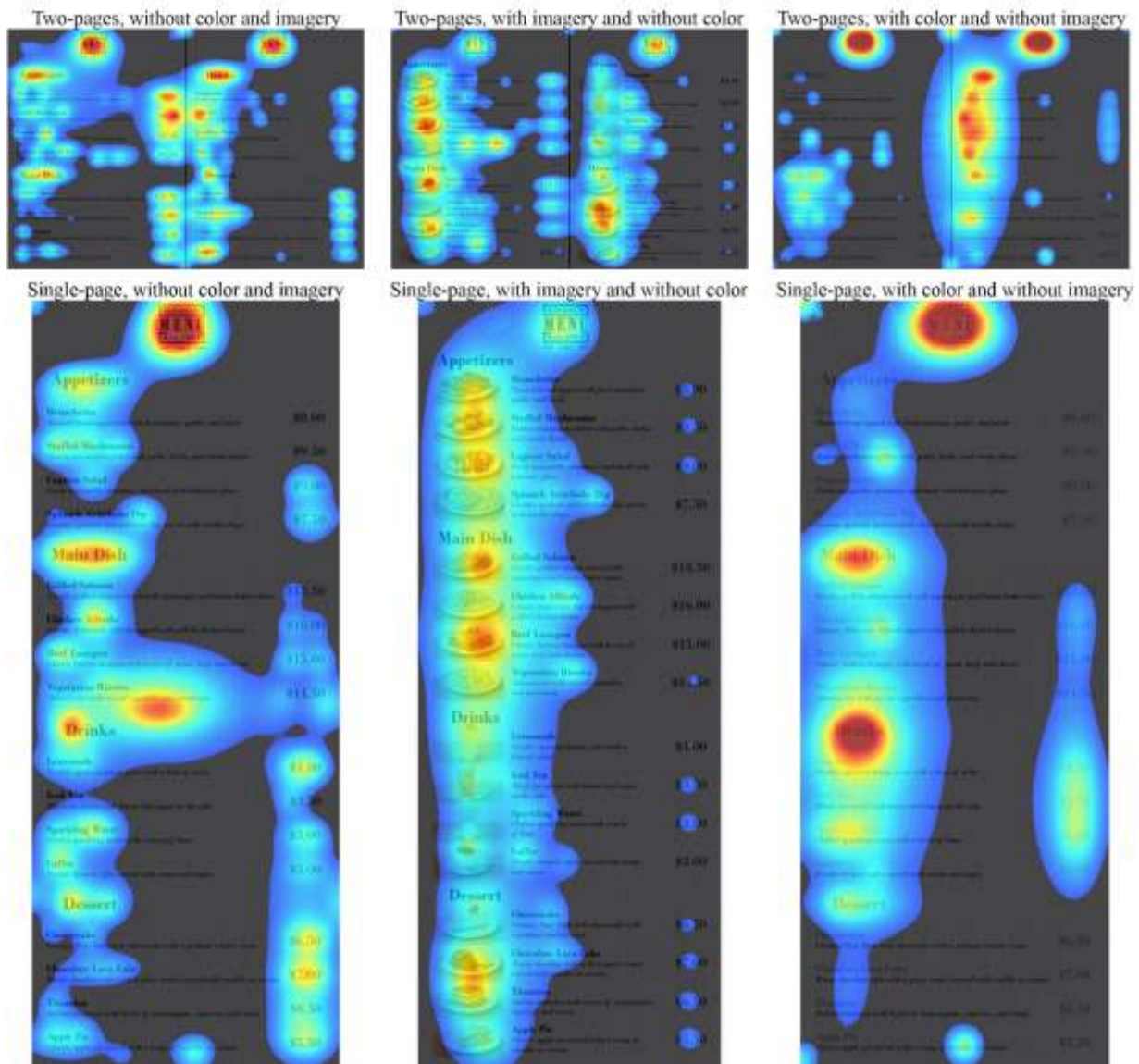
Within the scope of the analysis, three core visual attention outputs provided by VAS were examined: heatmap, sequence, and regions analyses. Together, these analytical layers allowed for a multidimensional evaluation of visual attention patterns across the six menu designs. These findings represent predicted pre-attentive visual attention patterns rather than observed behavioral eye-tracking data and should therefore be interpreted within a predictive visual attention framework rather than as direct indicators of consumer decision-making behavior.

Results and Discussion

Heatmap output estimates the intensity of predicted visual attention directed toward elements within the menu and visualizes this distribution through graded color transitions. The colors and ratios represent the probability of visual fixation within the first 3-5 seconds, ranging from low (0-40%, blue tones) to moderate (40-70%, yellow tones) and high (70-99%, red tones) levels of predicted attention intensity (3M, 2026). As the color scale shifts from blue to red, the level of predicted visual attention increases. Areas represented in blue and its

shades indicate lower levels of attention, whereas regions shown in red and its tones correspond to areas of highest predicted attention. Portions of the scene where visual attention is not predicted to occur are displayed in black. The Heatmap results obtained from the VAS analyses of the designed menus are presented in Figure 3.

Figure 3. Heatmaps

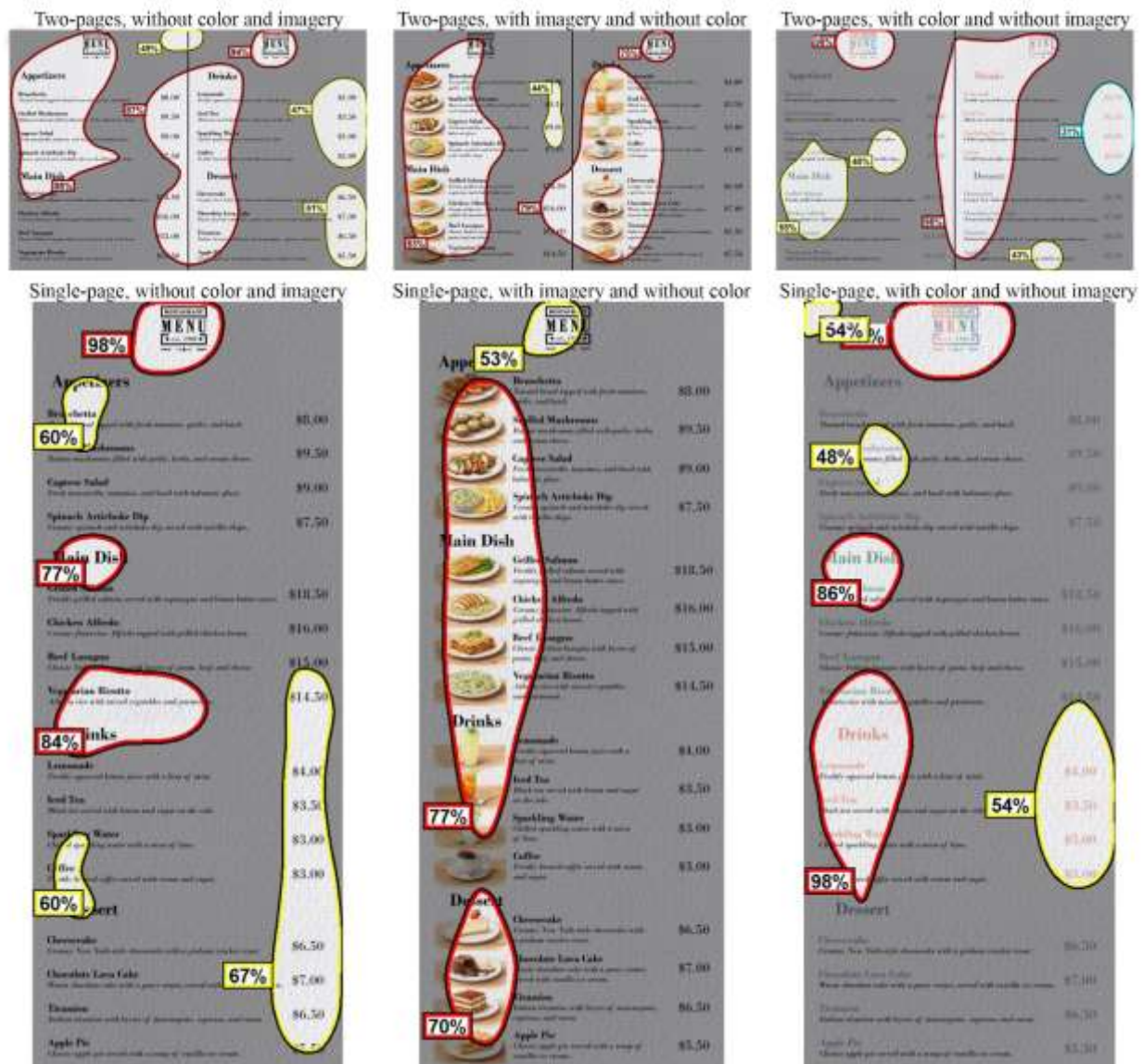


Heatmap analyses conducted across the six menu configurations reveal that layout orientation exerts a stronger structural influence on predicted visual attention than either color or imagery. In two-page layouts, attention tends to fragment into spatially separated clusters, often concentrating around headings, images, or price columns without forming a continuous perceptual flow between pages. The addition of images intensifies local attention, typically along visual columns, while color enhances the salience of headings and textual elements; however, neither element fully compensates for the spatial discontinuity inherent in the two-page structure. In contrast, vertically organized single-page menus consistently produce a more continuous and cohesive attention pattern extending from top to bottom. Even when images or color are introduced, the underlying vertical structure remains intact, guiding attention along a stable axis rather than dispersing it.

Regions function as a simplified representation of the Heatmap data. They indicate the areas of the menu where the observer is most likely to direct visual attention. Within the frame-probability scale, three different color-coded outputs are generated. Blue represents areas that are likely to be seen but have the lowest probability of attracting attention, indicating secondary-level importance. Red denotes areas with the highest probability of capturing primary visual attention. When multiple regions share the same color on the menu, the priority order

can be determined by examining the associated percentage values. The Regions results obtained from the VAS analyses of the designed menus are presented in Figure 4.

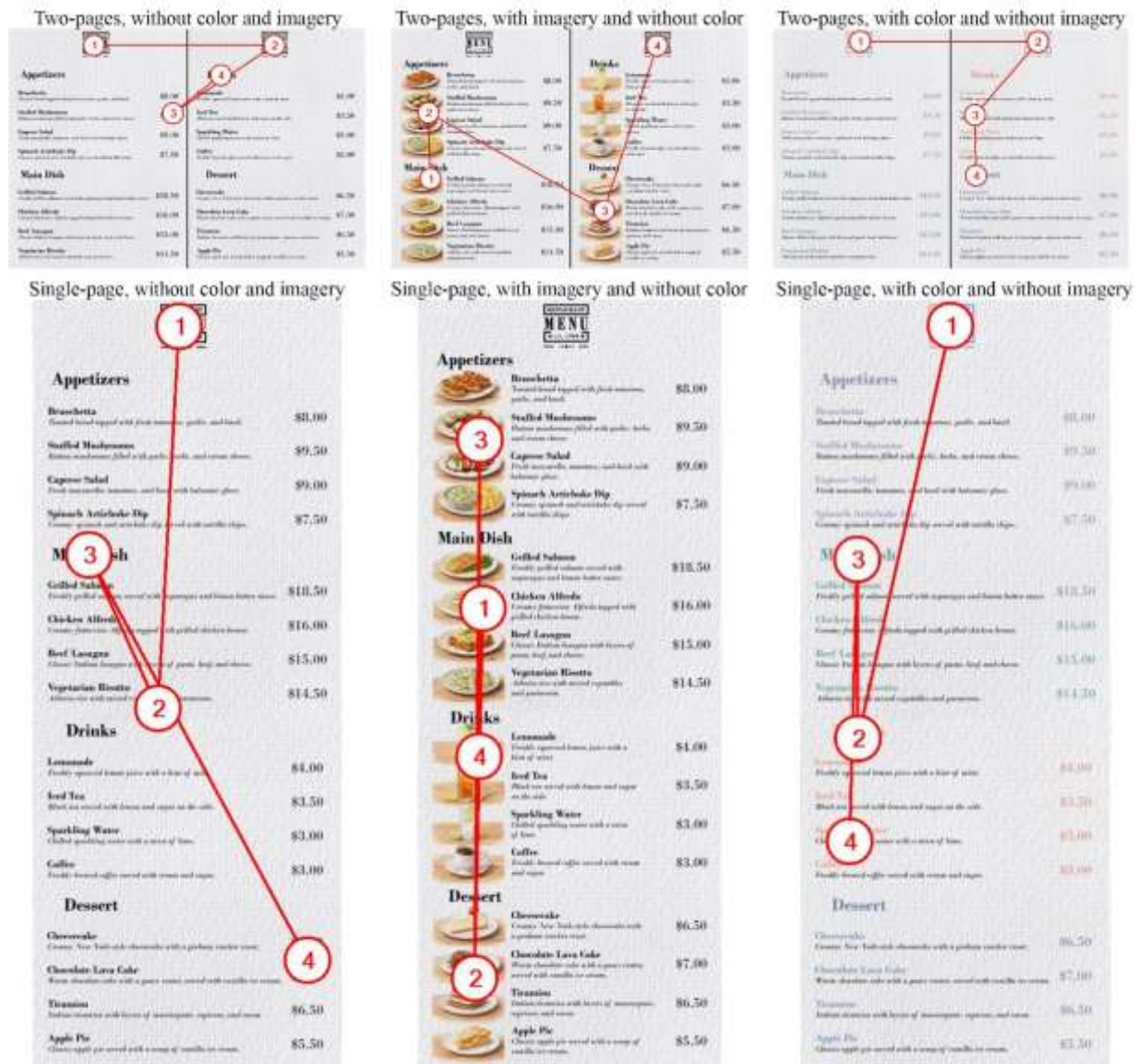
Figure 4. Regions



The Regions analysis further reinforces the structural role of layout orientation in shaping predicted visual dominance patterns. In the two-page menus, dominant areas tend to emerge as isolated or parallel centers, often concentrated around logos, category headings, or visual columns, without forming a unified perceptual core across the spread. Even when color or imagery strengthens specific elements locally, the overall structure remains spatially divided, resulting in multiple competing focal points rather than a single organized hierarchy. In contrast, vertically arranged menus display a more sequential and axis-based dominance pattern. High-probability regions align along a top-to-bottom flow, and the introduction of images or color layers this dominance without disrupting structural coherence. When considered alongside the Heatmap and Sequence outputs, the Regions findings show strong internal consistency: vertical menus consistently produce cohesive and stable attention structures, while two-page layouts reveal fragmentation across all three analytical layers. Observed differences across outputs reflect variations in analytical scale, local emphasis versus macro-structural flow rather than contradiction.

Gaze Sequences represent VAS output identifying the four most probable fixation points and the saccades occurring between them. Fixation number one indicates the most dominant point and corresponds to the area where the eye is most likely to focus first. Through gaze sequence data, it is possible to predict where visual exploration will begin and how the scanpath will develop across the menu. The Sequences results obtained from the VAS analyses of the designed menus are presented in Figure 5.

Figure 5. Sequences



The Sequence analysis highlights clear differences in predicted scan paths across layout types. In the two-page menus, gaze order tends to shift horizontally between page elements before settling on specific categories, producing fragmented and non-linear viewing patterns. In the text-only version, initial fixations move between logos across the spread, while content areas receive delayed attention. When images are introduced, gaze sequences prioritize visual elements and jump between image clusters across pages, with textual content entering the sequence later. Color strengthens category headings and slightly stabilizes the order within a single page, yet the overall two-page structure continues to generate cross-page shifts and uneven engagement. In contrast, vertically arranged menus consistently produce a more continuous top-to-bottom progression. In the text-only vertical version, fixations follow a single-axis reading flow aligned with habitual scanning behavior. When images are added, they become primary entry points, but the scan path remains confined within the same vertical column rather than dispersing. Similarly, the addition of color reinforces category transitions without disrupting structural continuity.

The present findings align with prior eye-tracking research suggesting that menu structure significantly shapes visual attention patterns. Mora et al. (2023) demonstrated that fixation duration and choice prediction vary depending on menu information structure, indicating that visual attention is sensitive not only to isolated elements but to how information is organized across the menu surface. Similarly, the current study shows that layout orientation operates at a macro-structural level, shaping predicted attention flow before individual elements such as images or color exert influence. In both cases, menu configuration appears to moderate attention distribution more strongly than isolated visual additions. Studies examining visual enhancements in menus further contextualize these findings. Capkan et al. (2025) reported that visual elements such as decoy

designs and imagery can redirect gaze allocation across menu components. In the present study, images increased local attention intensity; however, they did not override the structural continuity imposed by layout. This suggests that while visual stimuli act as local amplifiers of attention, their effect remains constrained by spatial organization. Research on informational elements such as calorie labels and price salience (Ngan et al., 2022) indicates that not all informational fields attract equal visual engagement. Consistent with these findings, price areas in the current study consistently appeared as secondary or spatially isolated regions across menu types. This does not imply behavioral irrelevance but rather suggests that in a pre-attentive visual phase, pricing information does not dominate perceptual organization unless structurally emphasized. Importantly, previous discussions in menu engineering literature have often centered on identifying presumed “sweet spots” within two-page menu layouts (Yang, 2012). The current findings challenge the stability of such fixed focal assumptions. Rather than identifying universal hotspots, the results indicate that attention is structured through spatial coherence and directional flow, particularly in vertically organized menus. This shifts the analytical focus from isolated high-intensity zones toward global perceptual architecture.

Beyond menu-specific literature, the methodological framework of this study aligns with emerging applications of 3M Visual Attention Software in design research. Lavdas et al. (2021) demonstrated the use of VAS in architectural analysis, showing that predicted attention maps correspond to perceptual impressions of spatial coherence. Their findings similarly emphasize structural composition over decorative elements, paralleling the present observation that layout orientation governs visual organization more strongly than color or imagery alone. Recent comparative methodological research (Volk et al., 2024) examining AI-based predictive attention tools and human-based eye-tracking systems further clarifies the epistemological position of VAS. While predictive models do not replace behavioral eye-tracking data, they may provide reliable estimations of early-stage, pre-attentive visual processing. The internal consistency observed across Heatmap, Regions, and Sequence outputs in the present study supports this predictive validity within a structural design context. Additionally, contemporary architectural and design applications (Özkaraca Özalp, 2024) confirm that VAS effectively identifies dominant spatial axes and perceptual hierarchies in complex visual environments. The present findings similarly indicate that VAS captures macro-level spatial logic—particularly the continuity produced by vertical layouts and the fragmentation associated with two-page spreads.

The differences observed between menu layouts may also be related to everyday viewing habits and digital reading behaviors. Most users are accustomed to scanning information from top to bottom, particularly in mobile and digital environments where vertically scrolling interfaces are common. This may help explain why vertical menus produced more continuous and stable attention patterns. In contrast, two-page menus may interrupt visual flow by dividing attention across separate spatial areas, resulting in more fragmented viewing patterns. These findings suggest that visual attention in menu design is shaped not only by individual visual elements such as color or images, but also by familiar reading and viewing habits developed through daily digital experiences. Accordingly, menu layout decisions may potentially support early-stage visual organization; however, these predictive findings should not be interpreted as direct indicators of consumer choice behavior or purchasing outcomes.

Importantly, the present study does not claim behavioral choice prediction but rather situates its findings within a pre-attentive predictive framework. The convergence across three analytical layers suggests that layout acts as a primary organizing variable in early visual processing. In this respect, the results contribute to methodological discussions by illustrating how predictive visual attention tools can inform evidence-based design decisions prior to behavioral testing.

Although predictive visual attention systems can efficiently estimate early-stage visual salience, they may be limited in interpreting the semantic and cognitive dimensions of restaurant menus. Unlike human observers, algorithm-based systems do not fully account for factors such as food preferences, price evaluation, familiarity, dietary expectations, or category meaning. For this reason, the present findings should be interpreted as predictions of early-stage visual attention rather than direct representations of consumer evaluation or decision-making processes. Future studies combining predictive visual attention tools with empirical eye-tracking data may help strengthen the external validity of these findings and further improve the application of such systems in gastronomy-related contexts.

The results further indicate that visual elements such as images and color do not function as independent drivers of attention but instead operate in relation to the underlying layout structure. When aligned with a coherent spatial axis, visual elements appear to reinforce perceptual continuity; when misaligned, they contribute to fragmented attention patterns. This finding challenges common design practices that prioritize visual richness over structural clarity and supports a more hierarchical approach to menu design, in which layout decisions

precede visual enhancement. Importantly, the consistently secondary role of price information across menu types highlights that not all informational elements compete equally for visual attention. Rather than dominating the perceptual field, price areas tend to remain visually isolated when integrated in a balanced manner, suggesting that their presence does not inherently disrupt overall visual organization. This reinforces the notion that visually structured menu development is less about maximizing attention across all elements and more about regulating how attention is distributed and sequenced. From a broader perspective, these findings contribute to the ongoing discussion in menu engineering by shifting the focus from identifying presumed attention “hotspots” to understanding how visual attention is structured across an entire menu surface.

Conclusion

This study examined predicted visual attention patterns in restaurant menus using a multi-layered analytical approach based on heatmap, sequence, and regions outputs derived from visual attention software. By systematically evaluating six menu designs constructed within a controlled 3×2 experimental structure, the study provides empirical insights into how layout orientation, visual structuring, and design consistency influence early-stage visual attention. Rather than focusing on self-reported preferences or post-experience evaluations, the findings contribute to an understanding of how menu elements are visually processed during the initial moments of exposure, when attention is largely automatic and pre-conscious.

The combined interpretation of heatmap, sequence, and regions analyses revealed that visual attention in menu design is not uniformly distributed and cannot be explained by a single focal area assumption. Heatmap results demonstrated clear differences in attention density across layouts, while sequence analyses highlighted the importance of visual flow and reading direction in shaping attention order. Regions analysis further supported these findings by showing that predefined menu zones received significantly different levels of attention depending on layout structure and visual organization. Together, these results suggest that effective menu design depends not only on individual visual elements but also on their spatial arrangement and hierarchical coherence.

From a practical perspective, the findings provide preliminary design-oriented implications regarding predicted visual organization within restaurant menu environments. Menu designs aligned with predicted visual scanning tendencies and structured visual hierarchy may potentially facilitate early-stage visual processing within menu environments. Rather than relying on assumed “attention hotspots,” menu designers may consider predicted attention distribution patterns as a supplementary input during visual design evaluation processes. The study also suggests that predictive visual attention tools may serve as preliminary design-support instruments prior to empirical behavioral testing, particularly in digital and QR-based menu contexts where rapid design iterations are common.

Despite its contributions, the study is subject to certain limitations that open avenues for future research. The use of software-based predictive analysis does not replace empirical eye-tracking with human participants. Moreover, predictive software outputs do not incorporate contextual restaurant variables such as hunger level, budget considerations, prior consumption experience, personal preference structures, or individual reading tendencies. These factors may influence menu evaluation processes in real restaurant environments and therefore represent important limitations regarding external validity. Future research integrating predictive visual attention systems with human-based empirical eye-tracking approaches appears necessary to strengthen validation procedures and improve the interpretability of predictive findings. Additionally, extending the analysis to include different menu categories, cultural contexts, or dynamic digital menu formats could enhance the generalizability of results. Future research may also explore the relationship between predicted visual attention patterns and actual choice behavior to better understand how early-stage attention translates into evaluation outcomes.

Overall, this study demonstrates that integrating predictive visual attention analysis into menu design research may provide a structured and evidence-based approach to understanding predicted early-stage visual attention organization. By bridging design practice and analytical evaluation, the findings contribute to both academic discussions in menu engineering and practical applications within the gastronomy industry.

Ethics Statement: The ethics committee approval required for this study was obtained from the Ethics Committee of Alanya University on 10 May 2024, with decision number 05. If a contrary situation is identified, *Journal of Gastronomy Hospitality and Travel* (JOGHAT) shall bear no responsibility whatsoever, and all responsibility shall rest with the author(s) of the study.

Author Contribution Statement: Both authors contributed equally to this study, with each author contributing 50% to the work.

Conflict of Interest Statement: There is no conflict of interest among the authors.

References

- 3M. (2026). *Visual attention system validation study*. <https://multimedia.3m.com/mws/media/1006827O/3msm-visual-attention-software-vas-validation-study.pdf>
- Arnheim, R. (2007). *Görsel düşünme* (Çev. R. Ögdül). İstanbul: Metis Yayınları
- Aydınlı, S. (1986). *Mekânsal değerlendirmede algısal yargılara dayalı bir model* [Ph.D. Thesis]. İstanbul Teknik Üniversitesi. İstanbul.
- Berger, J. (2004). *Görme biçimleri* (Çev. Y. Salman). İstanbul: Metis Yayınları
- Birawo, B., and Kasprowski, P. (2022). Review and evaluation of eye movement event detection algorithms. *Sensors*, 22(22), 8810. <https://doi.org/10.3390/s22228810>
- Bowen, J.T., and Morris, A.J., (1995). Menu design: Can menus sell? *International Journal of Contemporary Hospitality Management* 7 (4), 4-9
- Capkan, E. N., Ozilgen, S., and Yildirim, F. (2025). Designing visual menus for a sustainable future: The role of non-meat decoys. *International Journal of Gastronomy and Food Science*, 101343.
- Dodge, R., and Cline, T. S. (1901) The angle velocity of eye movements, *Psychological Review*, 8, 145-157.
- Duchowski, A. T. (2017). *Eye tracking methodology: Theory and practice* (3. Baskı). Springer International Publishing. <https://doi.org/10.1007/978-3-319-57883-5>
- Ergan, S., Radwan, A., Zou, Z., Tseng, H., and Han, X. (2019). Quantifying human experience in architectural spaces with integrated virtual reality and body sensor networks. *Journal of Computing in Civil Engineering*, 33(2), [04018062]. [https://doi.org/10.1061/\(ASCE\)CP.1943-5487.0000812](https://doi.org/10.1061/(ASCE)CP.1943-5487.0000812)
- Hartridge, H., and Thompson, L. C. (1948). Methods of investigating eye movements. *British Journal of Ophthalmology*, 32, 581-591.
- Hollander, J. B., Sussman, A., Levering, A. P., and Foster-Karim, C. (2020). Using eye-tracking to understand human responses to traditional neighborhood designs. *Planning Practice & Research*, 35(5), 485-509. <https://doi.org/10.1080/02697459.2020.1768332>
- Hug, R.J., and Warfel, M.C., (1991). *Menu Planning and Merchandising*. McCutchan Pub. Corp., Berkeley, CA.
- Hwang, J., Eves, A., and Stienmetz, J. L. (2021). The impact of social media use on consumers' restaurant consumption experiences: a qualitative study. *Sustainability*, 13(12), 6581. <https://doi.org/10.3390/su13126581>
- Jacob R. J. K., and Karn, K. S. (2003). Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. *The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research*, 573-605. <https://doi.org/10.1016/B978-0-444-51020-4.X5000-2>
- Jiang, L., and Chen, Y. H. (2022). Menu design on small display user interfaces: measuring the influence of menu type, number of preview items, and menu breadth on navigation efficiency. *International Journal of Human-Computer Interaction*, 38(7), 631-645.
- Judd, C. H., McAllister, C. N., and Steel, W. M. (1905) General introduction to a series of studies of eye movements by means of kinetoscopic photographs, *Psychological Review*, 7, 1-16.
- Junker, D., and Nollen, C. (2018). Mobile eye tracking in landscape architecture: Discovering a new application for research on site. In A. Almusaed (Ed.), *Landscape architecture: The sense of places, models and applications* (45-65). IntechOpen. <https://doi.org/10.5772/intechopen.74992>
- Kandel, E. R. (2012). *The age of insight: The quest to understand the unconscious in art, mind and brain from Vienna 1900 to the present*. New York: Random House.

- Kim, E., Tang, L. R., Meusel, C., and Gupta, M. (2018). Optimization of menu-labeling formats to drive healthy dining: An eye tracking study. *International Journal of Hospitality Management*, 70, 37-48.
- Kim, S., Nguyen, T. P. P., Riswanto, A. L., Sherpa, S., and Kim, H. S. (2025). Exploring visual attention, consumption vision, and attitude toward café menus using eye-tracking analysis. *International Journal of Tourism Research*, 27(5), e70133.
- Lavdas, A. A., Salingeros, N. A., and Sussman, A. (2021). Visual attention software: A new tool for understanding the “subliminal” experience of the built environment. *Applied Sciences*, 11(13), 6197. <https://doi.org/10.3390/app11136197>
- Lee, A., and Kim, M. G. (2020). Effective electronic menu presentation: From the cognitive style and mental imagery perspectives. *International Journal of Hospitality Management*, 87, 102377.
- Leung, X. Y., Josiam, B. M., and Moody, B. M. (2020). “I’d like to order with a server.” an experimental study of restaurant menu performance. *Asia Pacific Journal of Tourism Research*, 25(7), 766-779.
- Li, N., Zhang, S., Xia, L., and Wu, Y. (2022). Investigating the visual behavior characteristics of architectural heritage using eye-tracking. *Buildings*, 12(7), 1058. <https://doi.org/10.3390/buildings12071058>
- Livingston, J.S., (1978). Menu design: For effective merchandising. *Cornell Hotel and Restaurant Administration Quarterly*, 19 (3), 38-46.
- Main, B., (1994). Mining the menu. *ID* 30 (11), 79.
- Mehaffy, M. W., Salingeros, N. A., and Lavdas, A. A. (2023). The “modern” campus: Case study in (un)sustainable urbanism. *Sustainability*, 15(23), 16427. <https://doi.org/10.3390/su152316427>
- Miller, J.E., (1992). *Menu pricing & strategy*, 3rd ed. Van Nostrand Reinhold, New York, NY.
- Milton, J. L., Jones, R. E., and Fitts, P. M. (1950). *Eye fixations of aircraft pilots: Frequency, duration, and sequence fixations when flying selected maneuvers during instrument and visual flight conditions* (No. 6018). United States, Air Force, Air Materiel Command.
- Mora, M., Romeo-Arroyo, E., Chaya, C., Gayoso, L., Larrañaga-Ayastuy, E., and Vázquez-Araújo, L. (2023). Eating with the eyes? Tracking food choice in restaurant’s menu. *Food Quality and Preference*, 110, 104956.
- Motoki, K., Saito, T., and Onuma, T. (2021). Eye-tracking research on sensory and consumer science: A review, pitfalls and future directions. *Food Research International*, 145, 110389.
- Ngan, H. F. B., Bavik, A., Kuo, C.-F., and Yu, C.-E. (2022). Where you look depends on what you are willing to afford: Eye tracking in menus. *Journal of Hospitality & Tourism Research*, 46(1), 100-124.
- Norberg-Schulz, C. (1968). *Intentions in architecture*. USA: MIT Press.
- Özaydın, C., and Güzeller, C. O. (2021). Examining the selections in restaurant menus with eye-tracking technique. *Journal of Tourism & Gastronomy Studies*, 9(3), 1460-1481.
- Özkaraca Özalp, N., and Halaç, H. H. (2024). Analysis of additional building effects in historic buildings with visual attention software: The case of dresden military history museum. *Proceedings of the International Conference of Contemporary Affairs in Architecture and Urbanism-ICCAUA*, 7(1), 1210-1222. <https://doi.org/10.38027/ICCAUA2024TR0002>
- Poole, A., and Ball, L. J. (2005). Eye tracking in human-computer interaction and usability research: Current status and future prospects. In C. Ghaoui (Ed.), *Encyclopedia of human computer interaction* (211-219). Pennsylvania: Idea Group.
- Reale, S., and Flint, S. W. (2016). The impact of menu label design on visual attention, food choice and recognition: An eye tracking study. *Journal of Sensory Studies*, 31(4), 328-340.
- Rusnak, M. (2021). Eye-tracking support for architects, conservators, and museologists. Anastylosis as pretext for research and discussion. *Heritage Science* 9, 81. <https://doi.org/10.1186/s40494-021-00548-7>
- Scanlon, N.L., (1998). *Marketing by menu*, 3rd ed. John Wiley & Sons, Inc., New York, NY.
- Stoner, C.L., (1986). Menus: Design makes the difference. *Lodging Hospitality*, 42 (9), 70-72.

- Volk, I., Ivanov, O., Artyukhov, A., Dluhopolskyi, O., and Artyukhova, N. (2024). Comparative study of pre-attentive visual attention analysis instruments: 3M VAS and iMotions as AI-based vs human-based experiments. In *International Scientific-Practical Conference "Information Technology for Education, Science and Technics"* (pp. 14-26). Cham: Springer Nature Switzerland.
- Weber, R., Choi, Y., and Stark, L. (2002). The impact of formal properties on eye movement during the perception of architecture. *Journal of Architectural and Planning Research*, 19, 57-69.
- Yang, J., Wang, C., Jiang, B., Song, H., and Meng, Q. (2020). Visual perception enabled industry intelligence: State of the art, challenges and prospects. *IEEE Transactions on Industrial Informatics*, 17(3), 2204-2219.
- Yang, S. S. (2012). Eye movements on restaurant menus: A revisitation on gaze motion and consumer scanpaths. *International Journal of Hospitality Management*, 31(3), 1021-1029.
- Yarbus, A. (1967). *Eye movement and vision* (Çev. L. A. Riggs). New York: Plenum Press.