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# Choices of Virtue and Vice Products and Their Impact on Visual Attention: A Meta-Analysis of Eye-Tracking Food Research

Wagner Junior Ladeira<sup>1,2</sup> | Weng Marc Lim<sup>3,4,5,6,7</sup>  | Marcelo G. Perin<sup>8</sup>  | Fernando de Oliveira Santini<sup>1,2</sup> | Tareq Rasul<sup>9,10</sup>  | Dogan Gursoy<sup>11,12</sup> | C. Michael Hall<sup>13</sup> | Shakeb Akhtar<sup>14</sup>

<sup>1</sup>Universidade do Vale do Rio dos Sinos (UNISINOS), Porto Alegre, Brazil | <sup>2</sup>School of Business, Woxsen University, Hyderabad, India | <sup>3</sup>Sunway Business School, Sunway University, Sunway City, Malaysia | <sup>4</sup>ASU-Cintana Alliance Global Partner Affiliate Faculty, Arizona State University, Tempe, Arizona, USA | <sup>5</sup>School of Business, Law and Entrepreneurship, Swinburne University of Technology, Melbourne, Australia | <sup>6</sup>Global Research Centre, Sungkyunkwan University, Suwon, Republic of Korea | <sup>7</sup>Jaipuria Institute of Management, Lucknow, India | <sup>8</sup>Fundação Getúlio Vargas, São Paulo, Brazil | <sup>9</sup>College of Business Administration, Gulf University for Science and Technology, Hawally, Kuwait | <sup>10</sup>University College, Korea University, Seoul, Republic of Korea | <sup>11</sup>School of Hospitality Business Management, Carson College of Business, Washington State University, Pullman, Washington, USA | <sup>12</sup>School of Tourism and Hospitality, University of Johannesburg, Johannesburg, South Africa | <sup>13</sup>School of Management and Marketing, Massey University Business School, Massey University, Albany, New Zealand | <sup>14</sup>Department of Economics and Business Administration, University of Technology and Applied Science, Ibra, Oman

**Correspondence:** Weng Marc Lim ([marcl@sunway.edu.my](mailto:marcl@sunway.edu.my))

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## ABSTRACT

This article aims to analyze the impact of attention drivers associated with food bottom-up processes (virtue, vice, and binary choices) on physiological measures (fixation count and fixation duration) of psychological constructs (attention allocation and cognitive processing) of visual attention. Existing studies have analyzed these relationships in an isolated and scattered manner, indicating the need for a new study that integrates the effect sizes to better understand the state of the art. To achieve this goal, a meta-analysis was carried out, compiling information from 54 articles, encompassing 21,756 participants and 153 effect sizes (Cohen's *d*), to discern patterns of attention allocation and cognitive processing across three product choice scenarios: choice of virtue food products, choice of vice food products, and choice of their combination. The results reveal that virtue and vice choice contexts influence attention allocation while virtue and binary choice contexts influence cognitive processing. The results also show that the heterogeneity of the effects of virtue, vice, and binary choice contexts can be explained by externally driven marketing factors such as the cause of allergy or intolerance (product), shopping channel (place), and vividness of product presentation (promotion), as well as internally driven socioeconomic indicators such as average supply of fat per day (health), average supply of food calories per day (health), body mass index (health), expenditure on food and non-alcoholic beverages (economic), and reading PISA score (education).

## 1 | Introduction

The concepts of virtue and vice in food choice categorize foods based on their perceived healthfulness and immediate

gratification (Ketron et al. 2021; Lee et al. 2018; Seo and Yoon 2022). Virtue foods are typically those associated with long-term health benefits, such as fruits, vegetables, and whole grains. They are often seen as less immediately

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rewarding but contribute to better health over time (Huyghe et al. 2017; Ikonen et al. 2020). Conversely, vice foods are associated with immediate pleasure or gratification, like fast food, fatty foods, and sugary snacks, but they tend to have negative health consequences in the long run, such as increased risk of obesity or other health issues (Ketron and Naletelich 2022; Lee et al. 2018).

The discourse on virtue and vice food choice extends beyond academic inquiry, resonating with pressing concerns among consumer advocates and policymakers over the influence of such choices on consumer behavior, health, and sustainability (Ashik et al. 2025; Bhattacharyya et al. 2022; Huyghe et al. 2017; Ketron and Naletelich 2022). Previous research has examined the impact of this dichotomy on visual attention—a composite of attention allocation and cognitive processing. Such investigations have revealed significant effects on consumer decision-making (Cornil et al. 2014; Londoño and de Maya 2022). This aspect has gained increasing significance, given the imperative for food businesses and marketers to navigate the fine line between guiding and potentially misleading consumers (Ikonen et al. 2020; Orquin and Scholderer 2015). As marketers strive to align their strategies with evolving consumer values (Lim et al. 2023), the potential to sway purchasing decisions by how products are framed becomes a central ethical consideration, especially when stakeholders demand that consumer autonomy be respected and not undermined by manipulations in visual cues that favor short-term sales over long-term consumer welfare (Bhattacharyya et al. 2022).

The scrutiny of marketing practices highlights the instrumental role of visual attention strategies (Ladeira et al. 2025). These strategies enable marketers to influence consumers toward either virtue or vice products, often leveraging visual stimuli to influence not just the immediate choice but also shape long-term consumption patterns and preferences (de Vries et al. 2018; Huyghe et al. 2017; Meersseman et al. 2021). The ethical implications of such strategies necessitate examining how consumers' visual attention, both in terms of attention allocation and cognitive processing, is elicited by different products. Therefore, understanding visual attention strategies is vital, as they influence consumer food choices and, by extension, public health outcomes and industry practices.

Prior literature indicates that consumers' judgments of virtue and vice food products are context-dependent, varying when these products are presented separately or when they represent conflicting goals (Huyghe et al. 2017; Ikonen et al. 2020; Ketron and Naletelich 2022; Kivetz and Simonson 2002; Wilcox et al. 2011). This study extends beyond the surface level of expressed consumer judgment and resulting engagement—encompassing cognitive, affective, and behavioral aspects (Lim et al. 2022)—to examine its visual manifestation through the lens of attention allocation (fixation count or number of fixations) and cognitive processing (fixation duration or dwell time). The psychological constructs (physiological measures) of visual attention offer objective insights into consumer behavior, unmediated by self-report biases and reflective of unconscious processes (Lim 2018a, 2018b). Fixation count (physiological), quantifying how often an individual's gaze pauses within a specific area of interest, is a reliable measure of attention allocation

(psychological) (Holmqvist et al. 2011). This metric illuminates the distribution and frequency of visual attention across various stimuli, offering insights into the initial attraction and interest toward specific elements within the visual field (Rayner 1998). However, this initial attention does not necessarily imply a deeper processing or understanding of the content. Cognitive processing (psychological), as indicated by fixation duration (physiological)—the length of time the gaze remains fixed on a particular point—reflects deeper engagement with the cognitive processing aspect of visual attention (Holmqvist et al. 2011). Longer fixations indicate more extensive information processing, suggesting more profound visual attention to the content under observation (Just and Carpenter 1980; Rayner 2009). Together, these fixation count and duration dimensions encapsulate the multifaceted nature of visual attention, thereby providing a deeper understanding of how individuals allocate their attention and process information within a visual context.

Visual attention to food is directly stimulated by bottom-up processes (Cornil et al. 2014; Londoño and de Maya 2022). The bottom-up approaches involve the visual perception of saliency, surface size, visual cluster, and position of food and can be viewed in virtue, vice, and binary contexts (de Vries et al. 2021; Fenko et al. 2018; Steinhäuser et al. 2019). In this regard, food bottom-up processes can be defined as stimulus-driven mechanisms that guide consumers' attention to salient aspects of food items—such as saliency, surface size, visual cluster, and position—without depending on conscious intentions or goals but rather stemming from the inherent properties of the stimulus, which, in turn, can shape perceptions and decisions about virtue, vice, or combined food choices. More importantly, although many articles highlight the visual attention in these scenarios, these studies do not discuss the difference between the three scenarios. This study provides a meta-analytic model to analyze the drivers of attention to food bottom-up processes by addressing this concern. Therefore, this article aims to analyze the impact of attention drivers associated with food bottom-up processes (virtue, vice, and binary choices) on physiological measures (fixation count and fixation duration) of psychological constructs (attention allocation and cognitive processing) of visual attention, as well as identify the key moderators that may explain the heterogeneity of effects emerging from externally driven marketing factors and internally driven socioeconomic indicators, through a meta-analysis.

This article attempts to fill three crucial *gaps* through a meta-analysis.

First, there is a lack of integration across different food contexts (virtue, vice, and binary), which hampers the ability to capture how visual attention unfolds in real-world decision-making scenarios. Most studies focus on either virtue or vice foods in isolation (Table 1), leaving critical questions unanswered about how consumers allocate attention when confronted with conflicting goals (e.g., choosing between a healthy and an indulgent product). Neglecting these more complex (binary) contexts risks producing findings that are only partially applicable to everyday consumption choices. Incorporating binary contexts in this meta-analysis addresses this gap, providing a more complete picture of how consumers process visual information when multiple, often competing, food options are presented.

**TABLE 1** | Key literature on vice and virtue choice context.

| <b>Author(s) (Year)</b>      | <b>Title</b>   | <b>Scope</b>  | <b>Key variable(s)</b>                           |
|------------------------------|--|---|--|
| Sela et al. (2009)           | Variety, vice, and virtue: How assortment size influences option choice  | Examine how assortment size impacts consumers' choices between vice (hedonic) and virtue (utilitarian) options, particularly whether larger assortments lead to shifts in consumer preference for more justifiable options due to increased decision difficulty and the need for justification. | Choice difficulty                                |
| Chernev and Gal (2010)       | Categorization effects in value judgments: Averaging bias in evaluating combinations of vices and virtues              | Examine how consumers evaluate combinations of vice (indulgent) and virtue (healthy) food items, particularly whether an averaging bias leads them to underestimate calorie content and perceive the combination as healthier and less caloric than a vice alone.                               | Calorie estimation                               |
| Chernev (2011a, 2011b)       | Semantic anchoring in sequential evaluations of vices and virtues  | Examine how sequential evaluation of items influences consumer judgment in vice and virtue contexts.  | Judgment   |
| Mishra and Mishra (2011)     | The influence of price discount versus bonus pack on the preference for virtue and vice foods                          | Examine how different price promotions (price discount vs. bonus pack) affect consumer preferences for virtue (healthy) and vice (unhealthy) foods.   | Preference                                       |
| van Doorn and Verhoef (2011) | Willingness to pay for organic products: Differences between virtue and vice foods                                     | Examine whether and why consumers' willingness to pay for organic products differs between vice (unhealthy) and virtue (healthy) food categories, focusing on how organic claims shape product perceptions and willingness to pay.  | Willingness to pay                               |
| Jiraporn et al. (2016)       | Sugar in disguise or healthy indulgence: A cross-cultural comparison of the perceptions of dietary vice/virtue bundles | Examine cross-cultural differences in how Western and Asian consumers evaluate vice/virtue food bundles (e.g., yogurt with Oreo toppings), focusing on perceptions of fit, healthiness, tastiness, and the role of regulatory focus.  | Choice likelihood                                |
| Haws and Liu (2016)          | Combining food type(s) and food quantity choice in a new food choice paradigm based on vice-virtue bundles             | Examine how a vice-virtue bundle paradigm, where consumers simultaneously consider food type and quantity, influences healthier consumption patterns by integrating smaller portions of indulgent (vice) foods with healthier (virtue) options.   | Healthiness and tastiness                        |
| Huyghe et al. (2017)         | Clicks as a healthy alternative to bricks: How online grocery shopping reduces vice purchases                          | Examine how shopping environments (online vs. offline) influence the purchase of vice (unhealthy) versus virtue (healthy) foods, particularly whether consumers buy fewer vices online and the psychological mechanism driving this behavior.   | Proportion of vice purchases in shopping baskets |
| Rudi and Çakır (2017)        | Vice or virtue: How shopping frequency affects healthfulness of food choices   | Examine how grocery shopping frequency impacts the healthfulness of food purchases, focusing on whether more frequent trips lead to healthier or less healthy choices.  | Healthfulness                                    |

(Continues)

TABLE 1 | (Continued)

| Author(s) (Year)             | Title  | Scope  | Key variable(s)                               |
|------------------------------|--|--|---|
| Siddiqui et al. (2017)       | Time window as a self-control denominator: Shorter windows shift preference toward virtues and longer windows toward vices                 | Examine how the time window for a consumption decision affects consumer preferences for vice (indulgent) and virtue (healthy) products.  | Preference                                    |
| Masters and Mishra (2019)    | The influence of hero and villain labels on the perception of vice and virtue products   | Examine how hero versus villain labeling influences preferences for virtue versus vice products.   | Preference                                    |
| Muñoz-Vilches et al. (2019)  | The impact of instructed mental simulation on wanting and choice between vice and virtue food products                                     | Examine how different types of instructed mental simulation (process vs. outcome) influence consumers' wanting and choices between vice (hedonic) and virtue (utilitarian) foods, considering the role of chronic health and sensory orientations. | Choice probability                            |
| Scarpi et al. (2019)         | Eating with your eyes: How packaging visual cues affect content estimation and self-control in virtue and vice food                        | Examine how visual cues on food packaging affect consumers' estimates of the contained amount and their self-control intentions.   | Perception and intention                      |
| Anghelcev et al. (2020)      | Marketing processed organic foods: The impact of promotional message framing (vice vs. virtue advertising) on perceptions of healthfulness | Examine how promotional message framing (vice vs. virtue advertising) influences consumers' perceptions of healthfulness of processed organic foods compared to conventional counterparts.   | Healthfulness                                 |
| Londoño and de Maya (2022)   | The influence of anthropomorphic cues in retailing: The moderating effect of the vice versus virtue products                               | Examine how anthropomorphizing retail cues (e.g., dump bins) influences consumer behavior and how the vice-virtue character of the displayed products moderates that effect.   | Attitude, perception, intention, and behavior |
| Ketron and Naletelich (2022) | Representational versus abstract imagery: Effects on purchase intentions between vice and virtue foods                                     | Examine how different types of visual imagery (representational vs. abstract) influence consumer purchase intentions for vice (unhealthy) versus virtue (healthy) foods.   | Intention                                     |
| Seo and Yoon (2022)          | Food waste perceptions: Vice versus virtue foods   | Examine how vice or virtue food categories determine cognitive and behavioral reactions to food waste.   | Perception and behavior                       |

(Continues)

TABLE 1 | (Continued)

| Author(s) (Year) | Title  | Scope   | Key variable(s)  |
|------------------|--|---|------------------|
| This article     | Presenting choices of virtue and vice products and their impact on visual attention: A meta-analysis of eye-tracking food research | Examine how food bottom-up processes (vice, virtue, and binary choices) impact physiological measures (fixation count and fixation duration) of psychological constructs (attention allocation and cognitive processing) of visual attention. | Visual attention |

Second, there is limited differentiation between attention constructs in bottom-up food processes. Previous research often measures visual attention as a single construct without distinguishing between attention allocation (fixation count) and cognitive processing (fixation duration) (Table 2). This can obscure subtle differences in how various visual elements are processed, thus preventing researchers and practitioners from pinpointing which specific aspects of attention drive consumer decision-making in virtue, vice, or binary contexts. This meta-analysis differentiates attention allocation and cognitive processing, providing empirical evidence that visual attention is a multi-dimensional construct, thus enabling a deeper exploration and understanding of how bottom-up processes influence consumer perception and decision-making differently across virtue, vice, and binary contexts.

Third, there is insufficient exploration of moderators related to internally-driven (socioeconomic) indicators and externally-driven (marketing) factors. While these are frequently cited about food choices, their role in moderating the impact of visual attention strategies has not been systematically explored, which, in turn, limits understanding of how they can shape consumer behavior. In other words, failing to examine these moderators impedes the field's capacity to identify which populations or market environments are most susceptible, potentially leading to incomplete or misleading conclusions about consumer behavior. This meta-analysis addresses this issue and offers insights into the heterogeneity of visual attention effects by testing marketing factors such as the causes of allergies or intolerance (product), shopping channel (place), and vividness of product presentation (promotion), as well as socioeconomic indicators such as average supply of fat per day (health), average supply of food calories per day (health), body mass index (health), expenditure on food and non-alcoholic beverages (economic), and reading PISA score (education). This, in turn, highlights the complex interactions in bottom-up food processes, which, when understood, can help to identify contexts that make consumers more susceptible to certain visual stimuli.

The contributions of this meta-analysis are threefold.

First, this study is anchored in the distinction between different types of foods (virtue, vice, and their combination) and provides a holistic understanding of how consumers visually perceive these differences and how the process of visualizing these foods takes place in the same context. Notably, when analyzing prior research on this topic, the meta-analysis herein found inconsistent findings regarding the variables that explain consumers'

visual attention and observed substantial variation in effect sizes across the means and standard deviations of experimental data.

Second, this study evaluates the elements of food bottom-up processes as attention drivers. To provide empirical evidence, the meta-analysis herein classified effect sizes into two constructs of visual attention: fixation count (physiological) as a measure of attention allocation (psychological) and fixation duration (physiological) as a measure of cognitive processing (psychological)—a separation that remains underexplored in past studies and enriched through the present study. Noteworthy, this approach unveils different ways of understanding how food bottom-up processes affect visual attention by revealing how these psychological constructs (physiological measures) operate in various food choice contexts.

Third, this study tests the impact of variables associated with marketing and socioeconomic conditions to understand the heterogeneity of food bottom-up processes. Evidence from the meta-analysis herein reveals that some intervening variables have not been tested, with the ensuing results highlighting extreme context-specific heterogeneity. Specifically, the results show that marketing factors such as the cause of allergy or intolerance, shopping channel, and vividness of product presentation, as well as socioeconomic indicators such as the average supply of fat per day and the average supply of food calories per day, moderate these effects. Whereas socioeconomic indicators such as consumers' expenditure on food and non-alcoholic beverages, body mass index, and reading PISA scores do not explain the heterogeneity of the effects of food bottom-up processes.

## 2 | Literature Review

### 2.1 | Product Choices and Visual Attention

The foundational premise of this study is that consumer engagement with products, characterized by varying visual attention levels, is significantly influenced by the nature of the food products—be they virtue, vice, or a combination thereof. This differential engagement is encapsulated within two critical components of visual attention: attention allocation to and cognitive processing of stimuli. Exploring how food products—virtue, vice, and their combinations—affect consumer visual attention opens avenues for investigating potential moderators relating to marketing and socioeconomic conditions that may influence these relationships. A meta-analytic model, depicted in Figure 1, elucidates the main relationships and identifies marketing and

**TABLE 2** | Conceptualization and operationalization of variables.

| <b>Variable</b>  | <b>Conceptualization (definition)</b>   | <b>Operationalization (measure)</b>   |
|--|---|---|
| Panel A. Food bottom-up processes (saliency, surface size, visual cluster, and position) |   |   |
| Virtue choice context  | Refer to images of food items perceived as healthier, more nutritious, or environmentally friendly (Ketron et al. 2021; Seo and Yoon 2022).           | Images of healthier products (e.g., cereals, fruits, salad, and yogurt)   |
| Vice choice context  | Refer to foods considered indulgent, less healthy, or high in calories (Ketron et al. 2021; Seo and Yoon 2022).                                       | Images of less healthy products (e.g., chocolate, processed snacks, and sweets).  |
| Binary choice context  | Refer to images of food vice and virtue presented in the same context.  | Images of healthy and high-calorie products (e.g., fruits and chocolate, cereal and chips).   |
| Panel B. Physiological measures of visual attention                                      |   |   |
| Attention allocation   | Refer to selectively concentrating on specific sensory inputs while ignoring others (Egeth and Yantis 1997; Johnston et al. 1990).                    | Fixation count or number of fixations by eye-tracker.   |
| Cognitive processing   | Refer to the depth at which information is analyzed and encoded in the memory system (Craik and Lockhart 1972).                                       | Fixation duration or dwell time by eye-tracker.   |
| Panel C. Marketing factors   |   |   |
| Cause of allergy or intolerance  | Refer to foods that may or may not cause allergies and intolerances (Muthukumar et al. 2020).   | This meta-analysis considered foods that do not cause allergies or intolerance, such as fruits and vegetables (0), and foods that cause allergies or intolerance, such as nuts, shellfish, and wheat (1). |
| Shopping channel   | Refer to the retail environment as an important agent determining the meaning of the chosen food (Milosavljevic et al. 2012; Wang and Somogyi 2018).  | This meta-analysis separated channels into online shopping, where products are presented in an abstract and symbolic form (0), and offline stores, which offer a tangible, sensory-rich environment (1).  |
| Vividness of product presentation  | Refer to the level of clarity and richness of visual stimuli (de Vries et al. 2018; Meersseman et al. 2021).  | This meta-analysis used cartoon images as low vividness (0) and real images as high vividness (1).  |
| Panel D. Socioeconomic indicators  |   |   |
| Average supply of fat per day  | Refer to the total amount of fat available for human consumption, expressed in grams per person per day, derived from FAO food balance sheets.        | This meta-analysis ranked countries in the samples using their share of average fat supply per day and then divided them into low (0) and high (1) via the median.  |
| Average supply of food calories per day  | Refer to the total energy available for human consumption, expressed in kilocalories (kcal) per person per day, derived from FAO food balance sheets. | This meta-analysis ranked countries in the samples using their share of average food calorie supply per day and then divided them into low (0) and high (1) via the median.                               |

(Continues)

TABLE 2 | (Continued)

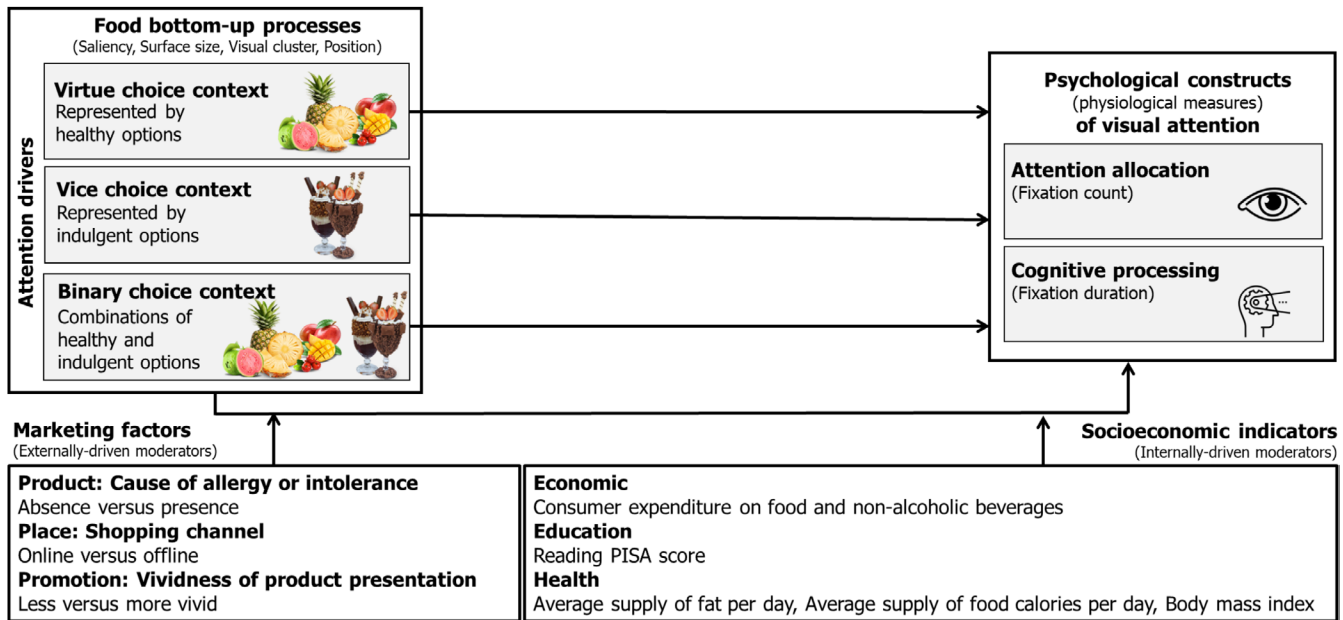
| Variable  | Conceptualization (definition)   | Operationalization (measure)   |
|---|--|--|
| Body mass index                                 | Refer to a measure indicating the average body mass index (BMI; a measure of body fat based on height and weight) of adults in different countries, used to assess and compare the prevalence of overweight and obesity worldwide. | This meta-analysis ranked countries by their average BMI and divided them into (0) low and (1) high via the median.  |
| Expenditure on food and non-alcoholic beverages | Refer to how much households spend on food and non-alcoholic beverages, capturing changes in consumer spending patterns over time.   | This meta-analysis ranked countries using their consumer expenditure scores on food and non-alcoholic beverages and split them into (0) low and (1) high via the median. |
| Reading PISA score                              | Refer to reading proficiency across countries, focusing on the ability to understand, use, evaluate, and engage with written texts.  | This meta-analysis ranked countries based on their reading PISA scores and divided them into (0) low and (1) high via the median.  |
| Panel E. Methodological moderators              |  |  |
| Geographic region                               | Refer to a classification used to evaluate whether the effect sizes of studies vary depending on the geographical context (Bitencourt et al. 2020).  | This meta-analysis created a variable indicating whether participants were from (0) Eastern or (1) Western countries.  |
| Publication ranking                             | Refer to a classification used to evaluate whether the quality or reputation of the journals influences the pooled effect size (Hedges and Olkin 1985).  | This meta-analysis identified a publication h-index ranking, separating journals into (0) low and (1) high relative to the median.                                       |
| Sample size                                     | Refer to how variations in the sample size of individual studies affect the overall findings of the meta-analysis (Jadil et al. 2021; Jeyaraj 2022).   | This meta-analysis created two groups (small or large) based on the declared sample sizes, using the median as the cut-off point.  |
| Sample type                                     | Refer to the characteristics of the participants or observations in the studies (Jeyaraj 2022).  | This meta-analysis created a dummy variable indicating if the study used (0) non-consumers or (1) consumers.   |

socioeconomic moderators informed by the literature, satisfying the criteria necessary for a meta-analysis (Lim 2025).

A prevailing belief among consumers is that their food choices bear a direct correlation to their health and longevity (Huyghe et al. 2017; Ikonen et al. 2020). Numerous studies have sought to understand how consumer perceptions drive the selection of health-oriented products and the subsequent impact on purchasing behaviors. However, the growing diversity of food products presents a conundrum for consumers' ability to discern and opt for healthier alternatives (Ketron and Naletelich 2022; Laran 2010; Raghunathan et al. 2006). A significant strand of literature explores the notion that consumers dichotomize product options into "good" and "bad" within their mental model, influencing their categorization and choice (Huyghe et al. 2017; Ketron and Naletelich 2022). This dichotomy in product choices is further explored by researchers who suggest that consumer decisions are often a tug-of-war between the allure of immediately

gratifying options and the pursuit of health-beneficial products (Kivetz and Simonson 2002; Laran 2010; Wilcox et al. 2011). Table 1 provides an overview of the seminal studies that preceded this meta-analysis.

The meta-analytic model draws on the theory of visual attention (Katsuki and Constantinidis 2014; Wedel and Pieters 2017), which suggests that consumers' attention is shaped by both the salience of visual stimuli (bottom-up processes) and their relevance to personal goals (top-down processes). Noteworthy, marketers strategically deploy visual cues to attract consumers' attention and generate immediate appeal (Wedel and Pieters 2017). In this study, bottom-up processes explain consumers' evaluations by demonstrating how attention is guided primarily by the inherent salience of external stimuli rather than by internal goals or expectations. Thus, bottom-up processes are fundamentally stimulus-driven, with visual cues automatically capturing attention (Katsuki and Constantinidis 2014).



**FIGURE 1** | Choices of virtue and vice products and visual attention.

Understanding bottom-up processes in food consumption is crucial because these processes drive involuntary attention toward highly salient food cues, such as bright packaging or high-contrast labels, which can significantly influence consumer decisions (Katsuki and Constantinidis 2014). Such cues are designed to capture visual attention automatically, impacting impulse purchases, especially for hedonic or vice foods. This automatic attentional capture can override self-control mechanisms, leading consumers to make unplanned or unhealthy choices (Corbetta and Shulman 2002). In food marketing, strategically placing and designing food items that leverage bottom-up processes can encourage healthier options or promote less healthy, indulgent choices (Wedel and Pieters 2017).

## 2.2 | Attention Drivers in Food Bottom-Up Processes

Consumers commonly believe that their food choices influence their ability to lead long and healthy lives (Huyghe et al. 2017; Ikonen et al. 2020). Prior research has extensively investigated how perceptions guide consumers toward healthier products and influence their food purchasing behaviors, yet the growing diversity in food supply complicates consumers' ability to clearly identify and choose healthier options (Laran 2010; Ketron and Naletelich 2022; Raghunathan et al. 2006). Numerous studies assume that consumers mentally categorize food options according to a good/bad dichotomy (Huyghe et al. 2017; Ketron and Naletelich 2022), which is often driven by either a conscious pursuit of health benefits or immediate temptation (Kivetz and Simonson 2002; Laran 2010; Wilcox et al. 2011).

The health-related context is crucial for understanding food choices (Ikonen et al. 2020; Ketron and Naletelich 2022). Two primary contexts have been frequently identified in the literature: virtue and vice (Chernev and Gal 2010; Ketron and

Naletelich 2022; Siddiqui et al. 2017). Both contexts utilize health perspectives but differ regarding perceived benefits and associated guilt (Ikonen et al. 2020; Ketron and Naletelich 2022). The virtue context involves healthy food options, such as almonds, eggs, fish, fruits, meats, and vegetables, which may lack immediate appeal but offer substantial long-term health benefits (Huyghe et al. 2017; Ikonen et al. 2020). Choices within the virtue context typically produce less guilt (Lee et al. 2018; Ketron and Naletelich 2022). Conversely, the vice context typically involves tempting but unhealthy options, such as candy bars, chocolates, chips, and sweets, offering limited long-term benefits (Huyghe et al. 2017; Lee et al. 2018). Such food choices often evoke feelings of guilt (Ikonen et al. 2020; Ketron and Naletelich 2022).

Another vital context to analyze is when vice and virtue contexts are presented simultaneously, termed the binary choice context (Huyghe et al. 2017; Kivetz and Simonson 2002; Wilcox et al. 2011). Consumers generally find decisions challenging in this scenario due to conflicting desires: immediate indulgence versus long-term health goals (Laran 2010; Chernev and Gal 2010). This conflict often reduces cognitive resources available for making healthy choices, thereby increasing vulnerability to tempting but unhealthy options (Huyghe et al. 2017).

These three contexts significantly impact psychological constructs (physiological measures) of visual attention, specifically attention allocation (fixation count) and cognitive processing (fixation duration) (de Vries et al. 2021; Samant and Seo 2016; Steinhäuser et al. 2019; King et al. 2019). Attention allocation measures the extent of attention directed toward a specific area of interest (AOI) (Meißner and Oll 2019), wherein a higher fixation count indicates greater attention (King et al. 2019). Cognitive processing, in turn, measures the depth of information processing occurring within an AOI, where longer fixation durations signal more extensive cognitive processing (Meißner and Oll 2019). Both attention allocation and cognitive processing are driven by bottom-up processes, defined by stimuli that

inherently stand out due to distinct perceptual features such as brightness, color, or motion (Wedel and Pieters 2017).

Empirical research across various food studies highlights the significant effects of bottom-up processes (de Vries et al. 2021; Fenko et al. 2018; Steinhäuser et al. 2019). Virtue contexts, for example, have been shown to elevate visual attention (Ikonen et al. 2020; Samant and Seo 2016). Studies involving yogurt packaging demonstrated a positive relationship between health claims and increased visual attention (Fenko et al. 2018), and similarly, labels on chicken meat products effectively captured consumer attention (Samant and Seo 2016). Conversely, vice contexts have also been adapted to enhance visual salience and thereby attract consumer attention (Peschel et al. 2019; Wilcox et al. 2011). Foods characterized by high-calorie bias, such as chocolates and popsicles, significantly influence visual attention and food selection behaviors (de Vries et al. 2021; Peschel et al. 2019).

Our study extends existing literature by examining how the simultaneous presentation of virtue and vice options influences visual attention, supported by eye-tracking evidence from multiple studies. For instance, displays featuring chocolates and orange juices influenced gaze duration on product claims (Steinhäuser et al. 2019) while foods varying in caloric density—ranging from fruits and vegetables to chocolates and hamburgers—demonstrated distinct effects on visual attention (Songa and Russo 2018). Similarly, an experiment using cookies and crackers reported increased total fixation durations, indicating heightened cognitive processing (Tórtora et al. 2019). Accordingly, we advance the following hypotheses:

**H1.** *Bottom-up processes in virtue choice contexts positively influence visual attention.*

**H2.** *Bottom-up processes in vice choice contexts positively influence visual attention.*

**H3.** *Bottom-up processes in binary choice contexts positively influence visual attention.*

### 2.3 | Marketing-Related Moderators

Public health concerns, particularly related to food allergies and intolerances, significantly influence consumer behavior and decision-making processes. A substantial portion of the population is affected by allergies or intolerances to common food ingredients such as dairy, nuts, shellfish, and wheat (Muthukumar et al. 2020). Clear and conspicuous cautionary labels serve as vital sources of information for consumers managing specific dietary restrictions, influencing broader perceptions of product safety and transparency. Consumers affected by food allergies or those caring for individuals with such conditions engage more actively in information searches, specifically targeting labels that clearly indicate the presence of potential allergens (Soon 2019; Voordouw et al. 2009). This increased vigilance highlights the critical role of transparency in food labeling, thus underscoring its potential to influence consumer attention significantly toward virtue and vice food options. As such, we formulate the following hypothesis:

**H4.** *Cautionary labels (presence versus absence of allergy or intolerance information) moderate the effects of food bottom-up processes on visual attention.*

The retail environment substantially shapes consumer interactions with food products, differing markedly between online and offline shopping contexts (Milosavljevic et al. 2012; Wang and Somogyi 2018). Offline retail stores offer tangible, sensory-rich environments, thereby enabling consumers to physically interact with products, facilitating immediate sensory evaluations, and enhancing consumer engagement. Such multisensory experiences can intensify consumer interest and attention toward both virtue and vice food choices. Conversely, online shopping environments present products through visual and textual representations, thus creating a symbolic rather than sensory-rich interaction (Wang and Somogyi 2018). This abstract, digital presentation introduces sensory distance, potentially reducing consumer engagement and immediate desire compared to physical retail contexts (Huyghe et al. 2017; Milosavljevic et al. 2012). Consequently, diminished sensory engagement in online settings could lead to lower visual attention due to reduced opportunities for direct interaction and sensory assessment. The distinct differences between sensory-rich offline and sensory-limited online environments suggest that the retail channel significantly affects visual attention to virtue and vice food products. Against this backdrop, we offer the following hypothesis:

**H5.** *The retail channel (online versus offline stores) moderates the effects of food bottom-up processes on visual attention.*

Product vividness, characterized by clarity, detail, and richness of visual stimuli, significantly influences consumer visual attention. Highly vivid product presentations enhance sensory appeal, which, in turn, encourage deeper and more detailed consumer inspections, hence increasing visual attention (de Vries et al. 2018; Meersseman et al. 2021). Vivid imagery effectively simulates sensory experiences, thereby amplifying cognitive processing as consumers more intensively engage with presented details and product attributes (Huyghe et al. 2017). This relationship indicates that clearer, more detailed presentations are more likely to capture and maintain consumer attention, thus highlighting the importance of presentation quality in showcasing virtue and vice food products. Given these insights, we posit the following hypothesis:

**H6.** *The vividness of product presentation moderates the effects of food bottom-up processes on visual attention.*

### 2.4 | Socioeconomic-Related Moderators

The influence of contextual factors on consumer behavior, particularly visual attention, represents a complex interplay that varies across socioeconomic backgrounds (Huyghe et al. 2017; Martinho et al. 2022). This study proposes that the socioeconomic context in which consumers encounter virtue and vice food products—comprising economic, educational, and health dimensions—significantly moderates visual attention to these products. The economic dimension, indicated by consumer expenditure on food and non-alcoholic beverages, reflects a country's purchasing power and the importance

placed on food choices, thereby influencing consumer interest and engagement with product types. The educational dimension, measured by reading PISA scores, likely affects consumers' capacity to interpret nutritional information, thus influencing their visual attention toward labels and detailed product information. Lastly, the health dimension, captured by the average supply of daily fat and food calories as well as population body mass index, offers insight into a society's nutritional environment and collective health awareness, potentially influencing the degree of consumer scrutiny applied to food choices. Given these considerations, we propose the following hypothesis:

**H7.** *The socioeconomic context related to economic, educational, and health dimensions moderate the effects of food bottom-up processes on visual attention.*

### 3 | Methodology

The meta-analytic process used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al. 2009; Page et al. 2021) in the following five sections: (1) identification of sources and data search, (2) inclusion and exclusion criteria, (3) extraction procedure, (4) coding of main and moderating variables, and (5) meta-analytic calculations.

#### 3.1 | Identification of Sources and Data Search

The search strategy adopted citation databases using a comprehensive array of academic search engines, including Google Scholar, Scopus, and Web of Science, and cross-checking against academic databases like EBSCO, JSTOR, ProQuest, and ScienceDirect, as well as publisher websites such as Emerald, Sage, Springer, Taylor and Francis, and Wiley. This stage involved the careful selection of peer-reviewed journal articles to uphold the integrity of the meta-analysis. These databases are essential because they contain multidisciplinary research from indexed scholarly outlets in social sciences. In the search for data, special care was taken with journals that frequently publish research on food judgments, preferences, or choices, such as *Appetite*, *British Food Journal*, *European Journal of Marketing*, *Food Policy*, *Food Quality and Preference*, *International Journal of Consumer Studies*, *Journal of Business Research*, *Journal of Consumer Behavior*, *Journal of Consumer Marketing*, *Journal of Consumer Psychology*, *Journal of Consumer Research*, *Journal of Marketing*, *Journal of Marketing Research*, *Journal of the Academy of Marketing Science*, *Marketing Science*, and *Psychology & Marketing*. Following the recommendations of essential works on meta-analysis (Hunter and Schmidt 2004; Rosenthal and DiMatteo 2001), this study included unpublished (e.g., dissertations and working papers) scientific works, including from conferences, in the meta-analysis.

This meta-analysis employed keywords such as “vice food choices” (including synonyms “indulgence food choices” and “unhealthy food choices”), “virtue food choices” (including synonyms “healthy food choices” and “self-control food choices”), and “binary food choices” during the data search. These

keywords were defined based on previous studies that used the terms virtue, vice, and binary for food judgments, preferences, or choices (e.g., Chernev and Gal 2010; Huyghe et al. 2017; Ikonen et al. 2020; Ketron and Naletelich 2022; Rudi and Çakır 2017). This initial phase captured the essence of food and eye-tracking applications within consumer and food science journals. The scope was deliberately narrowed to studies that featured AOIs depicting food images. The AOIs presented food under the following conditions: certification labels, dishes, display packages, guideline daily amounts (GDAs), health claims, labels, menus, nutrient claims, package sides, packages, and traffic light labels. The search leveraged “AND” and “OR” Boolean operators to examine the “article title, abstract, and keywords,” narrowing the scope to the “consumer, food, and business.”

#### 3.2 | Inclusion and Exclusion Criteria

The inclusion criteria followed existing literature reviews and meta-analysis guidelines (Grewal et al. 2018; Jackson and Turner 2017; Moher et al. 2009). The inclusion criteria were as follows: (1) articles published in conference proceedings or journals; (2) dissertations and theses; (3) academic works available in full text; and (4) a time window for the search extending until September 2024; all which to allow for a comprehensive understanding of the terms virtue, vice, and binary foods and for complete data analysis. After analyzing these inclusion criteria, 497 articles were selected for the subsequent screening phase. Of the total, 457 were journal articles, 23 were conference papers, and 17 were dissertations. Subsequently, this study adopted backward and forward tracing, wherein a backward tracing began with the key concepts of “virtue, vice, and binary,” resulting in an initial set of research articles using this term, followed by a forward search, resulting in a further set of articles that cited the initial articles.

The exclusion criteria are as follows. Literature reviews and qualitative research (23) were removed because they do not provide the statistical information required for the meta-analysis. In addition, quantitative research with statistical data derived from statistical interdependence analysis (e.g., cluster analysis and factor analysis) (96), with correlations or standardized and non-standardized coefficients (120), with descriptive statistics without using an experiment (105), and with an experimental design using mean difference tests such as ANOVA, chi-square, and *t*-tests (99), were removed, as per Hedges and Olkin (1985). In total, 443 articles were removed and a final sample of 54 articles was used to analyze Cohen's *d* (Cohen 2013). These 54 studies contained the difference between two means (e.g., experimental vs. control condition) divided by the combined standard deviations. Figure 2 describes the number of articles included and excluded in this study.

#### 3.3 | Extraction Procedure

This study used a coding scheme to extract data related to all the relevant variables (Wilson and Lipsey 2000), including images that could represent virtue, vice, and binary food choices, as well as moderators. Virtue foods involved foods perceived as healthy, nutritious, and beneficial for long-term wellbeing,

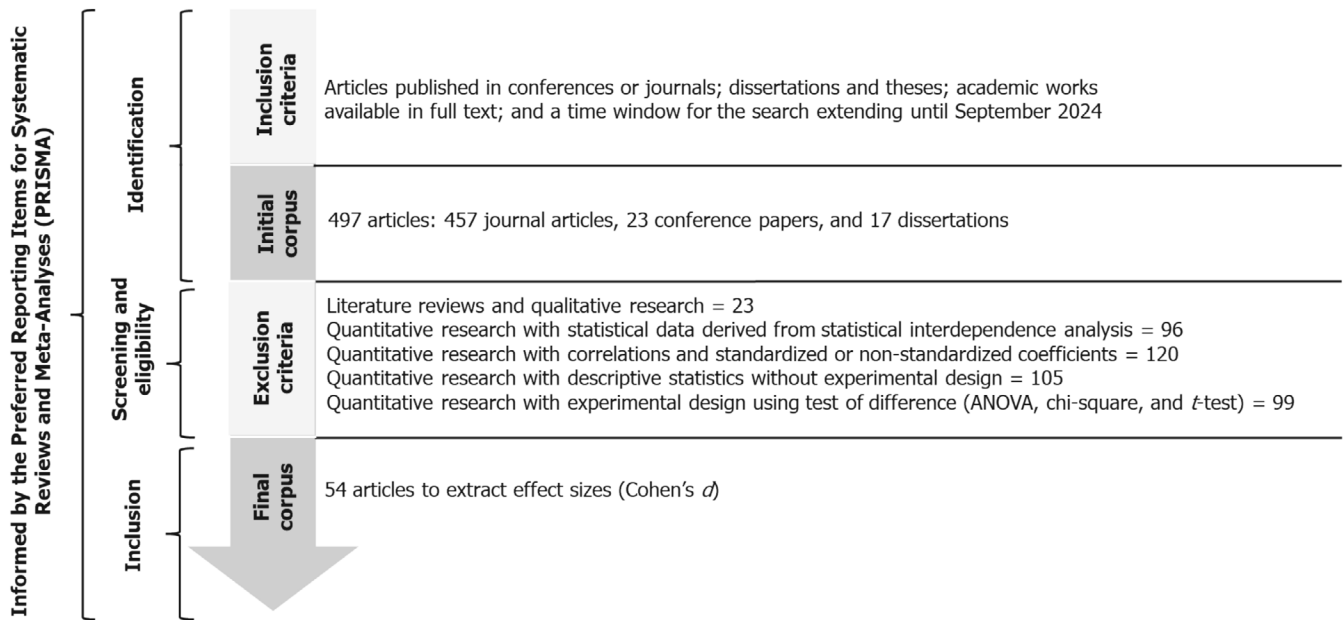


FIGURE 2 | Inclusion and exclusion criteria informed by PRISMA (Moher et al. 2009; Page et al. 2021).

such as fruits and vegetables, grilled chicken, smoothies with no added sugar, and whole grains (e.g., brown rice and quinoa). They are often lower in calories, fat, and/or sugar and are associated with self-control and positive health outcomes. Vice foods involved foods perceived as unhealthy, indulgent, or high in calories, fat, and/or sugar, such as chocolate cake, fast food (e.g., burgers and fries), ice cream, potato chips, and soft drinks. They often provide immediate pleasure but are associated with long-term negative health consequences. Binary food choices involved a forced choice of a virtue and a vice food through the dichotomy health-conscious (virtue) and temptation (vice) decisions, such as choosing between a fruit salad (virtue) and a chocolate cake (vice) as dessert, deciding between a side of steamed vegetables (virtue) and french fries (vice) at a restaurant, or selecting between sparkling water (virtue) and a sugary soda (vice) at a vending machine. The information coded was measures of visual attention (fixation count or number of fixations for attention allocation and fixation duration or dwell time for fixation duration) tracked in the AOIs of the images of the three types of food that were manipulated in the studies. AOI is a specific region within a visual stimulus that is delimited for analysis in eye-tracking studies. The study conducted by Kim et al. (2020), for instance, used fixation count and duration on the AOIs of yogurt packaging to perform visual attention measurements.

This study, which conducted a detailed extraction and coding process for each selected article, compiled information from 54 articles, encompassing 21,756 participants and 153 effect sizes (Cohen's *d*). Two co-authors achieved a 94% inter-rater agreement rate for the coding procedure, well above the 80% standard (Belur et al. 2021). The data extracted included article authorship, title, year, source, keywords, theories employed, research methods, sample countries, contexts of study, limitations, future research directions, sample type, application context, mean, standard deviation, experimental sample versus control condition, and constructs associated with dependent variables, namely attention allocation (fixation count) and cognitive processing (fixation duration). This information was organized in a

database to be used in the “metafor” package in the R software to analyze and visualize data.

### 3.4 | Coding of Main and Moderating Variables

The variables for our meta-analytic model were derived from information contained in the 54 articles included in the data analysis. The independent variables were established based on the characteristics of the images that triggered food bottom-up processes—namely, saliency, surface size, visual clustering, and position—as detailed in the experiments from these studies. Bottom-up processes are stimulus-driven, occurring automatically in response to distinctive features within the environment (Ladeira et al. 2019, 2025). These processes guide visual attention according to the inherent properties of the stimuli, independently of the observer's goals or intentions, as visual cues automatically capture attention (Katsuki and Constantinidis 2014).

Through food bottom-up processes, exposure to food images was classified into three distinct types of independent variables: (1) virtue choice context, represented by healthy food options such as cereals, fruits, and salads; (2) vice choice context, represented by indulgent food options such as cakes, chocolates, and ice cream; and (3) binary choice context, where images simultaneously presented virtue and vice food choices within the same visual frame.

The dependent variables were derived from visual attention measures obtained through AOIs, depicted in figures containing images representing virtue, vice, and binary food contexts. AOIs refer to specific regions within a visual stimulus, such as an image, identified by researchers to analyze where participants direct their gaze (Hessels et al. 2018). The dependent variables measured the psychology—via its physiology—of visual attention, classified into two primary groups: attention allocation (psychology), indicated by fixation count or the number of fixations (physiology), and cognitive processing (psychology),

including measures like fixation duration or dwell time (physiology). Consequently, the direct relationships examined how images associated with bottom-up food processes in virtue, vice, and binary choice contexts influenced visual attention concerning both the attention allocation to and cognitive processing of the stimuli.

The inclusion of moderators was guided by literature addressing potential sources of heterogeneity in meta-analytic effects (Borenstein 2019; Grewal et al. 2018; Jackson and Turner 2017; Lim 2025; Rust and Cooil 1994; Viechtbauer and Cheung 2010). Heterogeneity refers to the variability or differences in effect sizes observed across studies (Borenstein 2019; Rust and Cooil 1994). Given that heterogeneity critically influences the reliability, validity, and interpretability of meta-analytic findings, our meta-analytic model incorporates three distinct categories of moderators: those related to the marketing (derived from images used in experiments), socio-economic indicators (based on the sampled countries), and traditional methodological moderators (derived from study characteristics).

The first group of moderators pertains to marketing factors. These moderators help to explain whether heterogeneity in effects is influenced by the specific characteristics of the images used in experimental manipulations. Ladeira et al. (2019) similarly employed image-related moderators to examine effect variability within visual attention meta-analyses. In our meta-analytic model, three variables were considered to evaluate the moderating role of marketing factors: First, the potential to cause allergies or intolerances was examined, specifically evaluating the presence or absence of cautionary labels indicating allergen or intolerance information (product). Such labeling could notably influence consumer attention due to health-related concerns (Muthukumar et al. 2020). Second, the shopping channel, representing the retail environment in which the products were presented, was analyzed (place). Differences in consumer interactions and product presentations between online and offline retail environments were considered to assess their distinct impacts on visual attention (Milosavljevic et al. 2012; Wang and Somogyi 2018). Third, the vividness of product presentation, defined by the clarity, detail, and sensory richness of product imagery (promotion), was assessed regarding its ability to attract consumer attention and promote cognitive processing (de Vries et al. 2018; Meersseman et al. 2021).

The second group comprises moderators based on socioeconomic indicators. Ashaduzzaman et al. (2022) identified socioeconomic attributes as potential sources of heterogeneity. Five variables, drawn from comprehensive data provided by Euromonitor International, encapsulate the context in which consumers interact with food products: average daily supply of fat, average daily supply of food calories, body mass index, expenditure on food and non-alcoholic beverages, and reading PISA scores. Economic context was represented by consumer expenditure on food and non-alcoholic beverages, reflecting economic conditions and household spending patterns. This economic indicator was expected to influence purchasing decisions, and consequently, visual attention to available food products. Education context was captured using reading PISA

scores, hypothesized to affect consumers' abilities to process and interpret product information, thereby potentially influencing their visual attention. Health context, such as the average daily supply of fat and food calories, along with body mass index, were incorporated to evaluate how health consciousness and nutritional environments might influence consumers' visual attention toward virtue versus vice product choices. According to the Food and Agriculture Organization (FAO), the average daily supply of fat reflects the total amount of fat available for human consumption, expressed in grams per person per day, while the average daily supply of food calories reflects the total energy available for human consumption, expressed in kilocalories (kcal) per person per day. Whereas the body mass index reflects body fat based on height and weight of adults in different countries.

The third group of moderators comprises traditional controls selected based on their established usage in previous meta-analytic studies (Blut et al. 2021; Ladeira et al. 2023; Santini et al. 2023). Four variables represent this moderator group: geographic region, examining whether effect sizes differ based on the geographical context in which the studies were conducted (Bitencourt et al. 2020); publication ranking, which assesses whether the quality or prestige of journals publishing the studies affects the overall effect sizes (Hedges and Olkin 1985); sample size, indicating the variability in participant numbers across individual studies and its impact on the overall meta-analytic results (Jadil et al. 2021; Jeyaraj 2022); and sample type, referring to the characteristics of participants or observations included in the analyzed studies (Jeyaraj 2022; Mehta et al. 2022). Relevant details were systematically extracted from the theoretical and methodological sections of the included articles. Table 2 summarizes these groupings along with their conceptual and operational definitions, thereby providing a structured framework for subsequent analysis.

### 3.5 | Meta-Analytic Calculations

This meta-analysis employed Cohen's *d* (Cohen 2013), a widely used measure in meta-analytic studies for calculating main effect sizes derived from experimental research (e.g., Santini et al. 2023). Cohen's *d* was selected due to its versatility, accommodating various experimental contexts such as comparisons between two independent groups (e.g., experimental vs. control), within-subject designs, and complex mixed designs. The flexibility of this metric allows consistent analysis of effect sizes across diverse research designs (Hedges and Olkin 1985). Cohen's *d* is essentially a standardized effect size measure that quantifies the difference between two means, commonly applied to assess the magnitude of intervention effects or differences between experimental and control conditions (Borenstein 2019; Cohen 2013). This metric enables us to evaluate the treatment effects across studies so as to offer a clear and intuitive understanding of the strength and magnitude of differences between groups (Hedges and Olkin 1985).

The random effects model was utilized to interpret all analyses conducted in this meta-analysis (Hunter and Schmidt 2004). This model assumes that observed effect sizes across different

studies vary due to both actual differences and sampling error among studies (Borenstein 2019). Accounting for between-study heterogeneity, the random effects model treats each study's effect size as an estimate drawn from a distribution of true effect sizes. This approach provides a generalized summary of the effects, making it particularly suitable when substantial variability exists among studies (Hunter and Schmidt 2004). Consequently, the random effects model offers a more comprehensive estimate that accommodates variability between studies and is well suited for drawing inferences beyond the specific studies included in the meta-analysis (Borenstein 2019).

To conduct the moderation analysis, this meta-analysis employed the “metafor” package in the R software for meta-regression analysis (Viechtbauer and Cheung 2010). Specifically, the “rma” function within this package enables a hierarchical meta-regression approach, which accommodates both continuous and categorical moderators and covariates simultaneously (Harrer et al. 2021). The hierarchical meta-regression technique is an advanced statistical method commonly used in meta-analytic studies to examine the influence of multiple moderators on effect sizes (Card 2015). This method enhances traditional meta-regression methods by structuring data across multiple hierarchical levels, such as study-level and subgroup-level moderators, which allows for more accurate modeling of complex interactions among variables. Incorporating moderators systematically, this hierarchical structure better accounts for variability in effect sizes and provides a framework for integrating fixed and random effects, thereby improving precision when analyzing heterogeneous datasets (Collier et al. 2024).

## 4 | Results

The analysis of the collected data was conducted utilizing the “metafor” package in the R software, a choice driven by R's strong capabilities for statistical computation and graphical representation, particularly suited for meta-analytical reviews.

A random-effects model was employed to calculate the overall mean effect size across a diverse set of direct relationships identified in the included studies. These relationships involved food products categorized into three distinct contexts: virtue food products, vice food products, and their binary combinations. This approach acknowledges the inherent variability among study effect sizes, attributing it to real differences in study populations, settings, and interventions rather than sampling error, thus providing a more generalized understanding of the effects under investigation.

After establishing the overall mean effect size, the analysis focused on understanding how the presentation of food products impacts visual attention. A meta-regression analysis was conducted, incorporating marketing-, socioeconomic-, and methodological-related moderators. This analysis allowed for the identification of both the direction and magnitude of the moderating effects, thus clarifying how specific moderators influenced the relationship between food products and visual attention.

**TABLE 3** | Main effects of food bottom-up processes.

| Choice context                       | <i>k</i> | <i>d</i> | CI (95%) |       | <i>Z</i> | <i>p</i> |
|--------------------------------------|----------|----------|----------|-------|----------|----------|
| <b>Panel A. Attention allocation</b> |          |          |          |       |          |          |
| Virtue                               | 27       | 0.690    | 0.389    | 0.990 | 4.50     | 0.001    |
| Vice                                 | 25       | 0.745    | 0.433    | 1.057 | 4.68     | 0.001    |
| Binary                               | 7        | 0.803    | -0.282   | 1.888 | 1.45     | 0.147    |
| <b>Panel B. Cognitive processing</b> |          |          |          |       |          |          |
| Virtue                               | 44       | 0.843    | 0.429    | 1.257 | 3.99     | 0.001    |
| Vice                                 | 31       | 0.123    | -0.513   | 0.760 | 0.38     | 0.703    |
| Binary                               | 19       | 2.048    | 1.385    | 2.712 | 6.05     | 0.001    |

Abbreviations: CI = confidence interval; *d* = Cohen's effect size; *k* = number of effect sizes; *p* = *p* value; *Z* = *Z* statistic.

### 4.1 | Effects of Food Bottom-Up Processes on Visual Attention

This meta-analysis examined the physiological measures (fixation count and fixation duration) of psychological constructs (attention allocation and cognitive processing) of visual attention to evaluate the effects of the drivers of attention generated in food bottom-up processes (virtue, vice, and binary choice contexts).

Regarding attention allocation to stimuli, two of the three relationships were significant: virtue ( $d = 0.690$ ; CI [0.389, 0.990],  $Z = 4.50$ ,  $p < 0.001$ ) and vice ( $d = 0.745$ ; CI [0.433, 1.057],  $Z = 4.68$ ,  $p < 0.001$ ) choice contexts. Regarding cognitive processing of stimuli, two of the three relationships were significant: virtue ( $d = 0.843$ ; CI [0.429, 1.257],  $Z = 3.99$ ,  $p < 0.001$ ) and binary ( $d = 2.048$ ; CI [1.385, 2.712],  $Z = 6.05$ ,  $p < 0.001$ ) choice contexts. A summary of all the relationships investigated can be found in Table 3.

Subsequently, the meta-analysis evaluated potential publication bias using Egger's test and funnel plot (Egger et al. 1997; Sterne and Egger 2005; Thornton and Lee 2000). This test investigated whether the distribution sample was asymmetric. The Egger regression measures the degree of funnel plot asymmetry using the intercept from the regression of standard average deviations against precision (Egger et al. 1997). In this study, the publication bias did not affect our findings in the following relationships since they presented no significance: binary choice context and attention allocation ( $t = 0.271$ ;  $p = 0.797$ ) and vice choice context and cognitive processing ( $t = -0.463$ ;  $p = 0.646$ ). The other relationships presented asymmetry problems: virtue choice context and attention allocation ( $t = 3.35$ ;  $p < 0.005$ ), vice choice context and attention allocation ( $t = 6.99$ ;  $p < 0.001$ ), virtue choice context and cognitive processing ( $t = 2.48$ ;  $p < 0.05$ ), and binary choice context and cognitive processing ( $t = 4.27$ ;  $p < 0.001$ ).

To correct the asymmetry of the mentioned main effect sizes, this meta-analysis applied the bias correction of the trim and fill process (Duval and Tweedie 2000a, 2000b). We repeated publication bias tests as a sensitivity analysis after removing

extensive studies. When the unusually large samples were removed, Egger's test was not statistically significant for all relationships: vice choice context and attention allocation ( $t=0.562$ ;  $p=0.578$ ), virtue choice context and cognitive processing ( $t=-0.351$ ;  $p=0.726$ ), and binary choice context and cognitive processing ( $t=0.261$ ;  $p=0.796$ ). In the case of the relationship between virtue choice context and attention allocation, the trim and fill process did not remove any extensive studies; thus, it did not consider the asymmetry problem to be present.

## 4.2 | Effects of Moderators on Visual Attention

This meta-analysis investigated potential moderators that could influence the main relationships, focusing on the four significant ones shown in Table 3: virtue choice context and attention allocation, vice choice context and attention allocation, virtue choice context and cognitive processing, and binary choice context and cognitive processing.

Tables 4 and 5 present the results for the relationships involving attention allocation to and cognitive processing of stimuli, respectively. Model 1 includes only the covariates (methodological moderators: geographic region, publication ranking, sample size, and sample type) while Model 2 incorporates potential moderators related to marketing factors (externally-driven moderators: cause of allergy or intolerance, shopping channel, and vividness of product presentation) and socioeconomic indicators (internally-driven moderators: average supply of fat per day, average supply of food calories per day, body mass index, expenditure on food and non-alcoholic beverages, and reading PISA score).

Regarding the relationships between virtue choice context and attention allocation and between vice choice context and attention allocation, the meta-analysis found a significant effect of covariates on both relationships. In both cases, the results suggest that smaller sample sizes ( $\beta=-0.757$  and  $-1.23$ ) amplify the relationships compared to larger samples. However, we found that a higher reading PISA score led to more substantial effects ( $\beta=2.92$ ) than a lower PISA reading score between virtue choice context and attention allocation. Whereas, we observe that a lower average supply of fat per day resulted in stronger effects ( $\beta=-1.72$ ) compared to a higher average supply of fat per day, a lower average supply of food calories per day was linked to stronger effects ( $\beta=-3.80$ ) than a higher average supply of calories per day, and a higher consumer expenditure on food and non-alcoholic beverages was associated with stronger effects ( $\beta=6.44$ ) compared to lower expenditure between vice choice context and attention allocation.

Regarding the relationship between virtue choice context and cognitive processing, the results demonstrated that studies conducted in Eastern countries ( $\beta=-3.59$ ) among consumers ( $\beta=5.74$ ) and published in high-ranking journals ( $\beta=3.28$ ) produced more potent effects than those in Western countries among non-consumers in lower-ranking journals. The marketing factors indicated more substantial effects in studies in the absence of allergies or intolerances ( $\beta=-1.56$ ), when involving online store channels ( $\beta=-6.12$ ), and with lower levels of

vividness ( $\beta=-2.11$ ). Whereas the results showed stronger effects in socioeconomic indicators in countries with a higher body mass index ( $\beta=2.01$ ) and with greater consumer expenditures on food and non-alcoholic beverages ( $\beta=3.75$ ).

Regarding the relationship between binary choice context and cognitive processing, the results established that studies conducted in Western countries ( $\beta=49.49$ ) with larger samples ( $\beta=2.98$ ) and published in high-ranking journals ( $\beta=4.52$ ) produced stronger effects than those in Eastern countries with smaller samples in lower-ranking journals. The marketing factors also revealed more potent effects in the absence of allergies or intolerances ( $\beta=-3.92$ ), when involving offline store channels ( $\beta=9.24$ ), and with lower levels of vividness ( $\beta=-5.76$ ). The socioeconomic indicators further suggested stronger effects in countries with a higher average fat supply per day ( $\beta=2.18$ ), a lower average supply of food calories per day ( $\beta=-3.80$ ), a lower body mass index ( $\beta=-3.41$ ), a higher consumer expenditure on food and non-alcoholic beverages ( $\beta=7.33$ ), and a higher reading PISA score ( $\beta=4.78$ ).

## 5 | Conclusion

### 5.1 | General Discussion

The findings from this meta-analysis offer valuable insights into the ongoing discourse within the food industry regarding the virtue-vice dichotomy of product choices. This dichotomy, encompassing the spectrum from health-oriented to more indulgent food options, carries significant implications for consumer attitudes and behaviors toward food products. The analysis contributes to a deeper understanding of this dynamic by elucidating the differential impact of virtue, vice, and combined food choice presentations on visual attention.

One of the key findings is that virtue, vice, or binary product presentations positively influence visual attention. However, these influences vary according to the psychological constructs (physiological measures) of visual attention. Virtue choice context influences both attention allocation (fixation count) and cognitive processing (fixation duration), whereas vice choice context and binary choice context influence only attention allocation and cognitive processing, respectively.

Our results do not invalidate previous findings, such as those of Motoki et al. (2018), who demonstrated that viewing marketing stimuli can affect viewing time, or those of Gere et al. (2020), who demonstrated that viewing such stimuli can influence visual attention. These meta-analytic findings only show that, with the number of effect sizes in previous studies, some relationships did not appear significant. Four possible reasons may explain this non-significance. First and foremost, high heterogeneity among the studies analyzed—stemming from contextual, sampling, or methodological differences—can dilute the effects (Borenstein 2019). This possibility justifies the use of moderators through hierarchical meta-regression. Besides that, publication bias may be relevant, where studies with non-significant or negative results are less frequently published (Sterne and Egger 2005). This highlights the importance of publishing counterintuitive or

**TABLE 4** | Moderation effects on attention allocation.

| Variables  | Model 1                | Model 2                 |
|--|------------------------|-------------------------|
| <b>Panel A. Virtue choice context and attention allocation</b> |                        |                         |
| Controls   |                        |                         |
| Geographic region  | −1.50 [−3.17; 0.171]   | −4.74 [−10.18; 0.069]   |
| Publication ranking  | 0.399 [−0.230; 1.02]   | −0.355 [−2.95; 1.44]    |
| Sample size  | −0.757[−1.39; −0.117]* | −0.973 [−2.95; 1.00]    |
| Sample type  | 0.080 [−784; 0.171]    | 0.859 [−0.733; 2.45]    |
| Marketing factors  |                        |                         |
| Cause of allergy or intolerance                                |                        | 0.133 [−0.854; 1.12]    |
| Shopping channel   |                        | −0.404 [−1.83; 1.02]    |
| Vividness of product presentation                              |                        | −0.415 [−2.46; 1.63]    |
| Socioeconomic indicators                                       |                        |                         |
| Average supply of fat per day                                  |                        | 1.40 [−2.58; 5.39]      |
| Average supply of food calories per day                        |                        | −4.51 [−2.58; 5.39]     |
| Body mass index  |                        | 1.43 [−1.57; 4.45]      |
| Expenditure on food and non-alcoholic beverages                |                        | 0.683 [−4.10; 5.47]     |
| Reading PISA score   |                        | 2.92 [0.267; 5.58]*     |
| <b>Panel B. Vice choice context and attention allocation</b>   |                        |                         |
| Controls   |                        |                         |
| Geographic region  | 0.040 [−1.96; 5.21]    | 0.424 [−2.34; 3.19]     |
| Publication ranking  | 0.558 [−0.098; 1.21]   | 0.150 [−1.58; 1.88]     |
| Sample size  | −1.23 [−1.91; −0.550]* | −1.85 [−3.58; −0.172]*  |
| Sample type  | 0.140 [−0.984; 1.26]   | −1.14 [−3.03; 0.739]    |
| Marketing factors  |                        |                         |
| Cause of allergy or intolerance                                |                        | 0.389 [−0.276; 1.05]    |
| Shopping channel   |                        | 0.671 [−0.089; 2.24]    |
| Vividness of product presentation                              |                        | −0.049 [−1.39; 1.29]    |
| Socioeconomic indicators                                       |                        |                         |
| Average supply of fat per day                                  |                        | −1.72 [−3.33; −0.118]*  |
| Average supply of food calories per day                        |                        | −3.80 [−5.24; −2.36]*** |
| Body mass index  |                        | 1.91 [−0.847; 4.68]     |
| Expenditure on food and non-alcoholic beverages                |                        | 6.44 [3.76; 9.11]***    |
| Reading PISA score   |                        | −1.09 [−2.73; 0.546]    |

Note: Confidence intervals in brackets. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

unconventional results. In addition, the variables' definitions and measures may differ across studies, which leads to inconsistent findings. This suggests a need for theoretical consensus or methodological standardization. Last but not least, the effect between the independent and dependent variables could be genuinely small or absent in certain contexts. This highlights the multifaceted nature of consumer attention, which

raises the imperative of engaging in granular scrutiny of the distinct constructs within visual attention.

Indeed, the physiological measures of psychological constructs of visual attention demonstrate a distinction between attention allocation and cognitive processing. The results indicate that the impact on cognitive processing, measured by

**TABLE 5** | Moderation effects on cognitive processing.

| Variables  | Model 1                 | Model 2                 |
|--|-------------------------|-------------------------|
| <b>Panel A. Virtue choice context and cognitive processing</b> |                         |                         |
| Controls   |                         |                         |
| Geographic region  | -1.66 [-3.35; 0.001]    | -3.59 [-6.35; -0.825]*  |
| Publication ranking  | 1.82 [0.784; 2.87]***   | 3.28 [2.00; 4.55]***    |
| Sample size  | -0.017 [-1.05; 1.02]    | 0.401 [-1.41; 2.21]     |
| Sample type  | 2.41 [1.00; 3.83]***    | 5.74 [3.50; 7.97]***    |
| Marketing factors  |                         |                         |
| Cause of allergy or intolerance                                |                         | -1.56 [-2.82; -0.304]*  |
| Shopping channel   |                         | -6.12 [-8.50; -3.73]*** |
| Vividness of product presentation                              |                         | -2.11 [-3.69; -0.533]** |
| Socioeconomic indicators                                       |                         |                         |
| Average supply of fat per day                                  |                         | -0.452 [-1.80; 0.898]   |
| Average supply of food calories per day                        |                         | -5.46 [-8.11; 2.81]     |
| Body mass index  |                         | 2.01 [0.273; 3.76]*     |
| Expenditure on food and non-alcoholic beverages                |                         | 3.75 [1.16; 6.34]**     |
| Reading PISA score   |                         | -1.82 [-4.10; 0.455]    |
| <b>Panel B. Binary choice context and cognitive processing</b> |                         |                         |
| Controls   |                         |                         |
| Geographic region  | 31.88 [25.16; 38.60]*** | 49.49 [41.66; 57.33]*** |
| Publication ranking  | 0.494 [-2.65; 3.64]     | 4.52 [2.72; 6.31]***    |
| Sample size  | 1.12 [-0.403; 2.65]     | 2.98 [1.61; 4.35]***    |
| Sample type  | 0.621 [-0.768; 2.01]    | 0.582 [-0.443; 0.16]    |
| Marketing factors  |                         |                         |
| Cause of allergy or intolerance                                |                         | -3.92 [-5.06; -2.79]*** |
| Shopping channel   |                         | 9.24 [6.27; 12.11]***   |
| Vividness of product presentation                              |                         | -5.76 [-7.60; -3.92]*** |
| Socioeconomic indicators                                       |                         |                         |
| Average supply of fat per day                                  |                         | 2.18 [0.481; 3.88]*     |
| Average supply of food calories per day                        |                         | -3.80 [-5.24; -2.36]*** |
| Body mass index  |                         | -3.41 [-6.24; -0.578]*  |
| Expenditure on food and non-alcoholic beverages                |                         | 7.33 [3.46; 11.21]***   |
| Reading PISA score   |                         | 4.78 [2.56; 6.99]***    |

Note: Confidence intervals in brackets. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

fixation durations, is more pronounced than that of attention allocation, measured by fixation counts, especially in binary choice contexts. This finding highlights the complexity of visual attention and suggests that initial attention capture might precede in-depth cognitive processing in decision-making, especially in more complex scenarios, as seen in the case of binary choice contexts.

## 5.2 | Theoretical Contributions

The theoretical contributions of this meta-analysis extend far beyond empirical findings, offering a rich range of insights into the dynamics of consumers' visual attention, with evidence from the food industry. First, this study's exploration of the virtue-vice dichotomy and the varying levels of visual

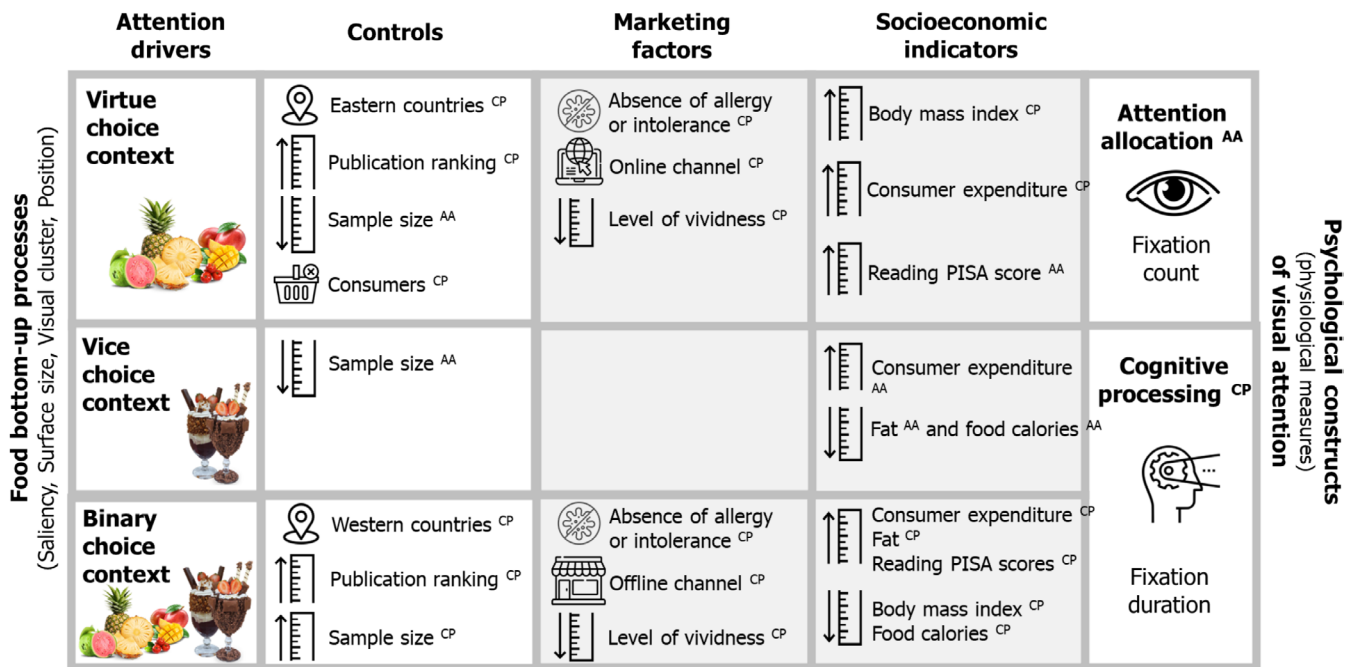


FIGURE 3 | Food bottom-up processes, moderators, and visual attention.

attention elicited by different product presentations adds depth to our understanding of consumer behavior in the face of multiple product choices. Second, this study projects a conceptual map of these relationships and their potential moderators, as illustrated in Figure 3, clarifying when the visualization of food increases or reduces visual attention. Third, this study addresses gaps in extant theoretical understanding by unpacking the complexity of contexts and variables, which often defy linear explanations.

Although previous theories provide an essential framework for understanding the results of a meta-analysis, the complexity of the contexts and variables analyzed often defies linear explanations. The lack of theoretical support for some moderators should not be seen as a limitation but as an opportunity to extend existing conceptual frameworks. As Hagger and Chatzisarantis (2009) suggest, unexpected results in meta-analyses can reveal new research directions and prompt theoretical adjustments to capture the complexities of the phenomena studied. Exploring these results promotes theoretical advancement, consistent with Edmondson and McManus (2007), who note that unexpected insights can be pivotal in the evolution of developing theories.

In addition to outlining possible ideas for future research, this meta-analysis can help to clarify critical issues in scholarly discourse. The differentiation between attention allocation and cognitive processing offers a refined framework for understanding visual attention. Quantifying these constructs through fixation count and duration delineates the stages of consumers' (physiological) visual attention, from initial attention capture to deeper information processing. This distinction contributes to a more precise theoretical understanding of the mechanisms underpinning visual attention, thereby helping to analyze consumer interactions with product presentations in greater detail.

Another key point is the expansion of the virtue-vice dichotomy. This study elucidates the nature between virtue and vice product presentations and their impact on consumers' visual attention. The finding that virtue food product presentations result in higher visual attention than vice food product presentations highlights the importance and relevance of consumers' perception of the food product as a virtue or vice choice in shaping their attitudes and behaviors. This emphasizes the theoretical significance of product framing, especially in the food industry.

Analyzing visual attention in contexts where consumers are presented with both virtue and vice options yields intriguing insights, including how diverse products in the same setting can trigger sequential anchoring, where the evaluation of one item influences perceptions of the next (Chernev 2011a, 2011b), and how temporal factors, such as planned consumption timing, may alter decision-making (Siddiqui et al. 2017). Moreover, the findings highlight that binary choice contexts often deepen cognitive processing, suggesting a more involved decision-making process driven by comparative evaluations. This insight challenges and expands existing theories, indicating that the juxtaposition of contrasting choices may provoke deeper engagement, thereby prompting a reevaluation of models that treat consumer decision-making as linear.

Also, this study reinforces Lim's (2025) call for a thorough examination of externally and internally driven moderators as significant influences in meta-analytic studies, in this case, on visual attention, thereby contributing insights that meaningfully enrich extant understanding of consumer behavior. The findings concerning marketing factors and socioeconomic indicators reveal complex interactions between product presentation and visual attention, thus challenging oversimplified assumptions about consumer engagement and its psychological (conceptual) and physiological (operational) manifestations from a visual perspective. The emphasis on economic, education, and health

indicators highlights the crucial role contextual factors play in shaping consumer perceptions and behaviors, advocating for a more integrated perspective that considers societal influences. Moreover, marketing-related moderators underscore essential aspects such as allergy tolerance, the choice of shopping channels, and product presentation vividness, all critical in formulating effective marketing communication strategies.

### 5.3 | Practical implications

The findings of this meta-analysis hold significant managerial relevance for food industry professionals, marketing strategists, and public health policymakers. These insights can guide the development of effective marketing strategies, thoughtful product presentations, and impactful health communication campaigns, all of which contribute to influencing consumer choices toward healthier products.

First, adopt strategic product presentations. The observed effects of virtue, vice, and binary product displays on visual attention highlight the critical role of thoughtful product design and placement. Presenting healthier (virtue) and indulgent (vice) options together can increase consumer awareness, prompting careful evaluation and potentially nudging them toward healthier and more mindful decisions. Clearly distinguishing between product categories is therefore important, arguably even more so in environments prone to impulsive buying or purchasing, as well-structured product displays can counteract impulse-driven decisions by encouraging consumers to engage in deliberate, evaluative thinking that aligns with their long-term wellbeing.

Second, boost implementation of cautionary labels. The reduced cognitive processing observed when products lack clear allergen or intolerance information reinforces the need for prominently displaying health-related labels. Such labeling meets public health objectives and aligns with marketing goals by capturing consumer cognitive engagement and influencing purchase decisions. Including clear disclaimers can build confidence and trust among individuals, especially those with dietary sensitivities, as they signal a brand's commitment to transparency, safety, and inclusivity. This approach can also potentially expand the consumer base and strengthen brand loyalty, especially in markets where health considerations are increasingly pivotal. Labels should therefore be integrated in informative and visually appealing ways, ensuring that critical health information is both noticeable and easily understood without overwhelming consumers.

Third, curate product vividness. The negative effect associated with reduced vividness on cognitive processing reinforces the importance of employing detailed product descriptions and high-quality imagery. These vivid presentations can effectively simulate sensory experiences, leading to deeper or greater engagement in both physical (offline) and digital (online) platforms. This attention to vividness not only enhances immediate visual impact but can also potentially bolster brand perception and encourage (repeat) purchases. Incorporating interactive technologies such as augmented reality should therefore appeal more strongly to consumers or amplify consumer interest while empowering stakeholders to differentiate their offerings.

Fourth, develop retail channels. The finding that online shopping environments foster deeper cognitive processing with virtue choices, whereas offline environments do the same with binary choices, underscores the need for tailored approaches. Brick-and-mortar retail benefits from tangible, sensory-rich displays, prompting consumers to explore products directly and compare vice-virtue options side by side. Online platforms, in contrast, can capitalize on immersive digital experiences and targeted suggestions that highlight the advantages of healthier options and simulate some of the tactile or visual cues found offline. Such differentiated strategies empower stakeholders to more effectively guide consumer decision-making and encourage mindful consumption choices.

Fifth, embrace contextual influences. The significant role of socioeconomic indicators (e.g., average supply of fat and food calories per day, body mass index, consumer expenditure on food and non-alcoholic beverages, and reading PISA score) in shaping visual attention highlights the need for marketing campaigns aligned with local economic, educational, and health conditions. Tailoring product presentations to reflect regional priorities and lifestyles enhances relevance, making consumers more likely to engage with healthier options. For instance, in areas with higher obesity rates, more explicit labeling and visual cues might support mindful consumption, whereas regions with lower reading proficiency may benefit from simpler, image-based messages. Considering these factors helps to address local consumer needs more precisely, thereby bridging the gap between product offerings and societal wellbeing.

Finally, engage in public health campaigns. Insights on binary product contexts, effective cautionary labeling, and vivid product presentations can guide the creation of targeted campaigns, thus enabling public health authorities to communicate nutritional information clearly and persuasively. This approach can encourage mindful consumption practices and empower consumers to make informed dietary decisions.

### 5.4 | Limitations and Future Directions

The findings of this meta-analysis offer valuable insights. However, several limitations should be acknowledged, which present meaningful opportunities for further exploration.

First, although fixation count and duration effectively measured attention allocation and cognitive processing in this study, other potentially informative eye-tracking metrics were not included. Future research could expand on this work by incorporating additional metrics such as time to first fixation (i.e., the elapsed time between stimulus onset and initial fixation on an AOI), scanpaths (i.e., sequences of fixations and saccades across the visual field), saccade length (i.e., the distance traveled by the eye between fixations), pupil size (i.e., an indicator of cognitive load or emotional arousal), and blink rate (i.e., reflecting attentional shifts or fatigue). Integrating these additional metrics could offer a more detailed understanding of visual attention during consumer evaluations of marketing stimuli.

Second, while the current analysis examined marketing factors and socioeconomic indicators as moderators of visual attention,

other potential moderating variables might further clarify the observed variability in outcomes. Expanding the scope of moderators to include technological advancements, such as augmented reality experiences, could be particularly beneficial. Augmented reality provides immersive, interactive experiences capable of significantly altering consumer engagement and attention patterns. Exploring this innovation could yield insights relevant for digital marketing strategies targeted at enhancing consumer engagement and decision-making processes. Similarly, accounting for evolving consumer preferences influenced by global issues and sustainability trends could provide practical insights for both marketers and policymakers. Addressing these emerging trends is crucial for understanding how shifting consumer priorities influence attention and purchasing behaviors, thereby supporting the development of responsive, forward-looking marketing strategies.

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### Conflicts of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

Data can be made available upon reasonable request.

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