Visual Pathways to Health: The Impact of Color and Label Information Format on Nutrition Label Processing

Babette Jacobs
5164931

TU Delft

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by

B.M.M. Jacobs

Student number: 5164931

TU Delft

Preface

I would like to express my most sincere gratitude towards everyone who helped me throughout this thesis. Many obstacles presented themselves throughout the project, however the people around me helped greatly in overcoming each of these.

First and foremost, I would like to thank my supervisor, Laurens Rook, who helped me tremendously throughout this project. Whether it was brainstorming ideas or providing critical feedback on my work, I am very grateful for all his help. Not only did I learn from him on the academic front, but on the social front I also learned a lot about adopting different working styles in different situations. His unconditional support throughout the project made it all the more enjoyable.

Iulia Lefter also played an instrumental role in my thesis journey. With her scientific insights and thoughtful questions, she was able to challenge me, and drive me towards improving the quality of my work. Her positive attitude and willingness to help made our meetings something to look forward to.

Furthermore, I would like to thank all of the other people at the TU Delft who helped along the way. Whether this be through helping me attain apparatus for my experiment, or tackling problems that I ran into. The friendly and helpful attitude of these individuals made it so that I could overcome obstacles.

I am also grateful for all of the people that participated in my eye-tracking experiment. I was able to conduct a lot of experiments in a very short time, which would not have been possible without so many enthusiastic participants.

Lastly, I would like to thank my thesis buddies, family, and friends. Whether it be in terms of discussing thesis struggles, brainstorming ideas, or just hearing me out, they made this journey extremely rewarding and memorable.

B.M.M. Jacobs
Delft, January 2026

Abstract

This study focuses on investigating the relationship between label information format, color, and consumer visual attention in nutritional label design. The aim of this research is to determine whether each of these variables individually influences attention, and to infer whether there is an interaction effect. A meta-analysis was conducted to delve into the role of color on consumer attention. This yielded inconclusive results due to a small sample size and significant variation in experimental designs among the studies. In order to verify whether these results truly indicate that color had little effect on consumer attention, or if this was a result of a confounding variable differing between the studies, an eye tracking experiment was performed. This experiment investigated both label information format and color as separate variables, and also examined their interaction effect on consumer attention. Results from the experiment suggest that the effect of color is dependent on the label information format. In argument based labels, color significantly influences attention, while in heuristic based labels this effect is insignificant. The study furthermore discusses the relevance and limitations of this research, and offers suggestions for future research.

Contents

1
Introduction

Whether to pick up a bag of apples or chips is influenced by many variables. Not only do nutritional knowledge and cultural and socioeconomic settings play a role in this choice, but marketing strategies are argued to be just as, if not more, relevant [57]. Bad nutrition heavily burdens the health care sector by increasing the chances of illness in individuals, boosting the spending of the health care industry, and furthermore, hampering global productivity [9]. To steer consumers towards making better informed and healthier food choices many approaches can be taken. interventions to nudge consumers towards a healthier diet include altering nutritional and health claims as well as visual design [85].

Consumers often are unaware that they are being persuaded when buying food products. Food products are often low involvement products because the decision to buy them is usually made quickly and subconsciously, and the financial burden of a wrong purchase is relatively minimal [62]. Understanding subconscious influences on consumer behavior is crucial to better predict purchase decisions.

1.1. Research Gap

Food marketing is a heavily researched field of study, however there remain aspects of the field that haven't yet been dissected. Visual communication, particularly color design of nutrition labels is such a topic. In the following section, this topic will be discussed in greater detail.

1.1.1. Importance of Nutrition Labels

Nutrition labels are typically used to convey the nutritional composition of a food. Such a label provides crucial information about the contents of numerous micro and macro ingredients in the product. With this information, consumers are provided with the necessary information to substantiate decisions to purchase or consume a product or not, based on whether they deem it healthy. A significant flaw in the typical nutritional label is that it appears very complex to consumers, significantly influencing the degree to which they are effective [59]. In a nutshell, the nutritional label typically includes all the relevant and required information, but a bottleneck arises when the consumer needs to process this information.

To make it easier for consumers to understand the nutritional intricacies of a product, new nutrition labels have been designed that better synthesize the information. Presenting the information in a manner that is more intuitive for the consumer, by means of analogies such as bar graphs and colors, potentially makes it easier for them to understand this information.

Besides nutrition labels being framed to synthesize information in a comprehensive way, they must also be optically appealing to stand out. Typically food packaging is very full, and thus such a label must contain unique features such as color to intrigue a consumer.

1.1.2. Color in Visual Communication

Previous studies suggest that using color in food nutrition labels makes it easier to break down complex information [47]. Due to signals associated with colors, consumers can typically make intuitive and quick decision about a product [96, 15].

1.1.3. Neuromarketing as a Means to Measure Attention

Neuromarketing is an interdisciplinary field that focuses on combining marketing and neuroscience to sketch consumer response on a subconscious level. There are many different tools used within the field of neuromarketing, ranging from biometrics, and fMRI, to eye-tracking, each of which is designed to capture participant responses that may not come to light in self-reporting-based tests [69]. Of these tools, eye-tracking is a non-invasive method whereby visual attention can be quantified, and therefore it has been selected as the central methodological approach for this study.

1.2. Research Objective

A meta analysis has been conducted by Jing Song et al. to make a comprehensive summary of the impact of color-coded and warning nutrition labels [82]. The authors suggest that color coding labels elicits more engagement than using monochrome or colorless labels. Furthermore, the paper suggests that using color simplifies the decision-making process for consumers by making the nutritional information more comprehensible (increased saliency and digestibility) [82]. Although this study delves into the impact of color on consumer behavior, it doesn't focus on consumer attention and eye tracking studies.

The following research objective will be the focus throughout this paper:

This research aims to determine how color influences consumers' visual attention to nutritional information.

With this research aim in mind, the goal is to determine whether color-coded nutritional labels attract more visual attention that non-color-coded labels, as measured through eye-tracking metrics. With this research the gap will be bridged between prior behavioral findings around incorporating color in nutritional labels and directly measuring this effect with quantitative data. This data will be derived from previous studies in the form of a meta-analysis with the hope that the generated knowledge will provide insights into improving consumer awareness and decision-making in the field of making food choices.

1.3. Research Questions

1.3.1. Main Research Question

Considering the research objective of this study, investigating the effect of color on consumer attention, the following is the main research question of this study:

RQ:*What is the effect of color on consumer attention to nutritional labels?*

In the context of this study, consumer attention refers to allocating visual resources towards the nutritional labels on food packaging. To convey visual attention eye-tracking metrics are used, these provide objective indicators of attention engagement [78]. Although previous research has highlighted the effect of incorporating color in nutritional labels, less is known about the underlying attention mechanisms that precede this behavioral outcome [82]. Through placing a focus on eye-tracking data, this research strives to capture the effect of color on an early stage of the decision making process, namely attention allocation.

1.3.2. Sub-Research Questions

The following sub-research questions are formulated to systematically address the main research question and to ensure that the effect of color on visual attention to nutritional labels is examined in a structured manner. In line with the research objective, these questions move from a descriptive overview toward an analytical investigation of visual attention.

SRQ1:*What types of nutritional labels are currently used in the market, and what is their intended purpose?*

Addressing this question provides an overview of the existing nutritional labeling schemes and their underlying objectives. Establishing this context is necessary to situate color-coded labels within current market practices and to justify their relevance in influencing consumer attention.

SRQ2:*How does the use of color, compared to black-and-white presentation, affect consumers' visual attention to nutritional information?*

This question directly targets the core objective of the study by examining whether color influences visual attention allocation to nutritional labels. Visual attention is assessed through eye-tracking measures, allowing for an objective evaluation of engagement with nutritional information.

Together, these sub-research questions enable a comprehensive assessment of both the contextual background of nutritional labeling and the specific attentional effects of color, thereby supporting a clear and focused answer to the main research question.

1.4. Research Approach

To answer the proposed research questions a research approach was developed that consisted of 2 main parts. First, theory was collected, to gain insights into the existing nutritional label landscape. Subsequently, a meta-analysis was performed, to uncover the effect of color on consumer attention in the context of food marketing. This approach is further illustrated in Table 1.1.

Table 1.1: Research approach to determine how color influences consumers' visual attention to nutritional information.

#	Research Question	Research Approach	Output
1	What types of nutritional labels are currently used in the market, and what is their intended purpose?	Background research	Research summary
2	How does the use of color, compared to black-and-white presentation, affect consumers' visual attention to nutritional information?	Meta-analysis	Statistical results

1.5. Reporting Structure

This thesis follows an organized structure. Chapter 1 introduces the context and scope of the research, later delving into this by stating the relevant research questions and research approach. Chapter 2 gives context about the relevant scientific background required to carry out and understand the research. The third chapter explains what a meta-analysis is, how it was performed, and what its results were in the context of this study. Chapter 4 reflects on the results of the meta-analysis (study 1) and discusses the need for a subsequent analysis, eye-tracking experiment (study 2). Chapter 5 then tackles the eye tracking experiment in a similar manner to the meta-analysis chapter. It begins by explaining the design of the experiment and how it was performed, after which its results are presented. Chapter 6 provides a discussion of the obtained results and highlights the relevance of these results, along with a number of limitations and opportunities for future research. In this last chapter, a conclusion is also presented, summarizing the findings of the thesis.

1.6. Hypothesis

This study investigates how information design influences consumer attention to nutritional labels, with a specific focus on the role of color in enhancing visual attention. Prior research suggests that the use of color in label design facilitates information processing [47]. Therefore, consumers may require less cognitive effort and time to process the information, reducing the visual attention devoted to the label [15, 96, 47]. Building on this theoretical foundation, the first hypothesis (H1) of this research is formulated as follows:

H1: *Consumers will fixate longer on black-and-white nutritional labels than on color-coded nutritional labels.*

Accordingly, this thesis focuses on isolating the role of color on consumers' visual attention to nutrition labels. This narrows down the scope of this research, providing a foundation for theoretical background to be discussed in the following chapter.

2

Background

2.1. Nutrition Labels in Food Marketing

This chapter describes the role of nutrition labels in food marketing. Nutrition labels have been used for a long time to aid consumers in deciphering the complexities of what is and what isn't healthy. Their role however has changed over the years, which will be further explained in the following section.

2.1.1. Historical Development and Policy Context

Figure 2.1 shows a timeline of how front of pack (FOP) labels have changed, and what regulations have been introduced from 1989 until 2020 in Europe. The timeline shows that recently there have been many developments in the field of designing these labels.

Since the end of 2016, Food Information to Consumer (FIC) Regulations have been developed and endorsed that require nearly all pre-packaged foods to include a nutritional label, typically on the back of the package [26]. The idea behind setting this legislation is to promote consumers to make healthier choices when purchasing foods, in the hope that better informing consumers would be the way to achieve this. Since 2016, obesity rates have been increasing, leading EU member states to consider additional actions that would drive down these numbers [26]. One of such approaches focuses on FOP labels. Currently these labels exist, but there is not yet legislation making them mandatory or universal across Europe. Policies around these labels typically focus on two primary objectives. Firstly, the goal is to make consumers better informed so that they can use this knowledge to make conscious effort towards choosing healthier products. Secondly, FOP labels are theorized to prod producers to adapt the formulation of their foods to make them healthier [49].

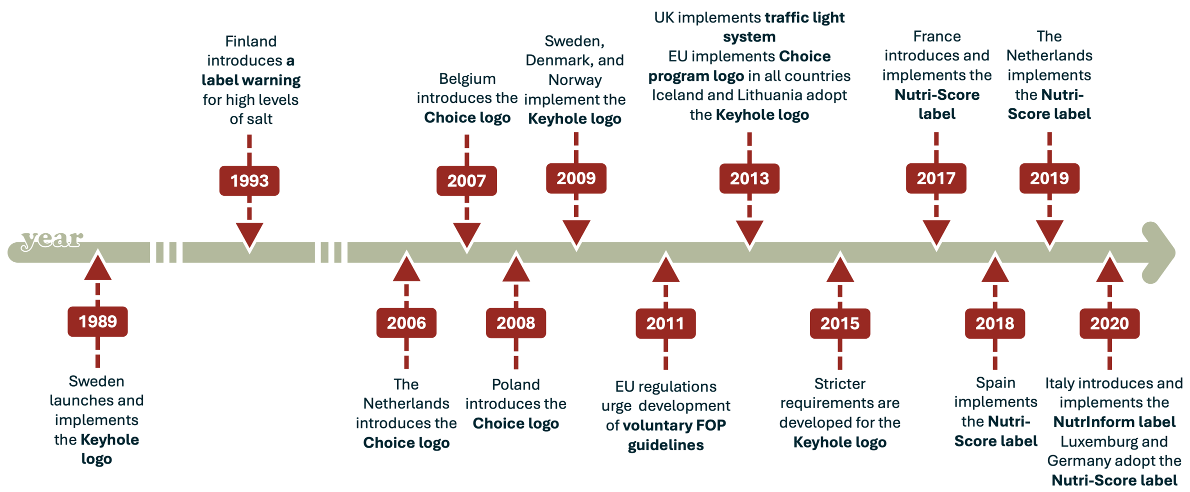


Figure 2.1: Timeline illustrating how FOP labels have developed over time in Europe. This timeline is adapted based on the one presented in the paper by Rebecca Kanter, et al. [49].

As part of the Farm-to-Fork Strategy, the European Commission has taken actions towards revising existing EU rules so as to better inform consumers. The goal of better informing them is to improve the healthiness and sustainability of their diets [27]. One of the fundamental suggestions towards adapting the existing FIC Regulations would focus on making FOP labeling obligatory and by setting universal criteria for calculating and claiming nutrient profiles [27].

Many international organizations have also focused their attention towards the health crisis that the world is currently facing. With child obesity rates increasing drastically the World Health Organization (WHO) Europe has urged countries to put more emphasis on developing and using food labels that are ”consumer-friendly” to promote identifying healthy foods. Additionally, the Organization of Economic Cooperation and Development (OECD) also supports that FOP labels have the potential to increase healthier food choices among citizens [26].

2.1.2. Types of Nutrition Label Formats

This section provides an overview of the nutritional label formats currently used in the market and their intended purpose.

There are many different types of label formats for communicating nutritional information about foods. In the EU, it is mandatory for foods sold in member states to have back of package (BOP) nutritional information: the nutritional facts panel [26]. This panel is typically located on the back of the packaging of a food, and includes information pertaining to fats, sugars, carbohydrates, salt, and proteins. All of these nutrients must be listed on the BOP label as per 100g or 100mL of the food product. The companies producing the food can choose whether they would like to list these values per serving size as well [72].

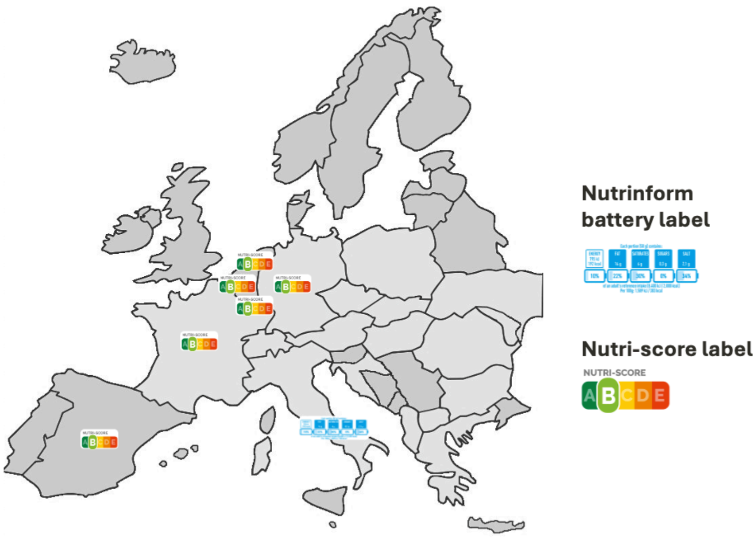


Figure 2.2: Depiction of what countries use Nutri-score labels and NutrInform battery labels across the EU. Image is adapted from the review article written by Margarita Peonides, et al [72].

Due to so many nutrients being obligatory to include on the BOP label, this makes the label challenging to interpret for a large portion of the EU population. With a low level of literacy, or food knowledge, it can quickly become impossible for consumers to infer whether or not they are making a healthy choice. To solve this problem, FOP labels have been designed to make nutritional information more comprehensive. Two popular design formats used in the EU for these labels are the Nutri-Score label and the Nutrinform battery label [35]. Figure 2.2 depicts each of these FOP labels, and provides the distribution of label formats used across a number of EU countries [72].

Although nutritional labels offer many benefits, they are often misunderstood and misused. For example, producers may over-dramatically highlight a positive health aspect of a product, such as a low salt content, in an attempt to hide an unhealthy feature such as a very high sugar content. In this way, consumers can be tricked into perceiving a product as being much healthier than it is reality. Furthermore, misinterpretation of the label may also lead to incorrect estimates of nutrient intake, resulting in a bad overall diet for an individual. The effectiveness of labels is also dependent on the context in which it is present. Individuals can interpret a label differently if their profiles differ significantly in nationality, culture, literacy, and socioeconomic status [21]. In this way, each FOP label comes with its own benefits and shortcomings, all while nudging consumers in unique ways.

Taken together, the current landscape of nutritional labeling consists primarily of mandatory BOP labels and a variety of voluntary FOP labeling schemes. While BOP labels aim to provide comprehensive nutritional information, their complexity often limits accessibility for a broad consumer audience. In contrast, FOP labels are designed to simplify nutritional information and support faster, more intuitive evaluations of product healthiness. These labels therefore serve a dual purpose: informing consumers at the point of purchase and nudging them toward healthier choices, while simultaneously encouraging producers to improve product formulations. This overview of nutritional label formats and their intended purpose directly addresses Sub-Research Question 1 (SRQ1).

2.1.3. Nutrition Labels as Marketing and Behavioral Nudges

Food marketing is a topic that encompasses a set of strategies and activities carried out to influence consumer perceptions of a product, and ultimately their decision to buy said product. The term is an umbrella for many marketing actions that are done related to product promotion including branding, packaging, advertising, pricing, and other promotional endeavors. Each of these activities is conducted with an end goal in mind: creating a feeling of confidence and commitment between the producer/product and consumer. Marketing is a powerful tool, whereby organizations excerpt influence on consumers, tapping into their instincts and beliefs, thereby drastically shaping their purchasing decisions. Large companies are often ahead of the pack when it comes to food marketing. Due to their vast size and extensive resources, they are often able to capture a dominant position in these markets, which makes them potentially powerful in persuading consumer health and well-being [57].

Food packaging is often affiliated with food marketing, but it serves multiple purposes. With appropriate packaging, producers can preserve foods for much longer than if the products were left on a shelf. Beyond this function, packing is also crucial in how it influences product perception. The packaging of a product has a drastic influence on product sales due to its aesthetic and communicative functionalities. Product packaging is a canvas that producers can paint on however they want, to build brand reputation and recognition. Packaging is also a means whereby companies inform and persuade customers to buy their product. In the case of food products (which are deemed low-involvement), the nutritional label is one of the packaging features that can have a tremendous impact on the purchasing decision of the consumer [86].

Food marketing frequently focuses on influencing consumer behavior through ”choice architecture”. A prevalent type of ”choice architecture” is nudging. Nudging entails manipulating a part of the choice context in order to steer people towards making a particular choice [76]. Priming is the most popular form of nudging [51]. Priming typically suggests that cues are given to nudge consumers towards a particular choice [51, 87]. Nutrition labels are a packaging feature whereby priming is performed. These labels are placed on food packages to communicate the nutritional content of the product. Potentially nudging consumers not only toward healthier choices, but also toward purchasing the product itself.

In sum, nutritional labeling has become a standard feature of food packaging, so much so that its absence seems nearly unthinkable. Besides aiding consumers in better understanding nutritional information, the use of intriguing colors will grasp consumer’s attention, kick-starting their decision making. Furthermore, the labels facilitate comparisons between similar products, giving consumers the opportunity to choose the healthier options [21].

2.1.4. The Role of Color as a Signal

Color can be used in marketing messages for attention purposes to increase label interpretation and decision speed [15, 96]. The function of color in nutrition labels is largely as evaluative cue, signaling how healthy a product is, so that consumers can make a split second decision about purchasing it. Traffic-light colors are commonly used to communicate intuitive messages: red is often used to portray that something is unhealthy and should be consumed with caution, while green represents a healthy choice. These associations aren’t emotional for the customer, but rather overlapping with knowledge of traffic signage. Plenty of research on this topic has been done, indicating that consumers are able to make much quicker and more accurate decision between unhealthy and healthy food purchases [47]. All in all, color aids in breaking down complex quantitative information in a simple way whereby consumers are able to better interpret nutritional information.

Color also enhances perceptual salience of nutrition labels [3]. Using color increases the likelihood that consumer notice nutrition labels and that they engage in them. This is useful in the setting of food packaging, since on cluttered packaging, the nutritional label with color will likely have high visibility, drawing consumer engagement [23]. Although increased salience ensures that labels are spotted quicker, not all nutrition labels are equally comprehensive for customers [18]. Therefore, whether or not color-coding is effective depends on how it improves nutritional label salience, and the efficiency with which customers extract nutritional information from the label.

2.2. Visual Attention and Decision Making

2.2.1. Theoretical Basis: Visual Attention and Decision Making

Capturing a consumer's attention is essential in influencing a purchase decision according to a cognitive framework titled the Information Processing Theory (IPT). This framework suggests that information, which is picked up on in one's environment goes through many stages before being translated into an action [61].

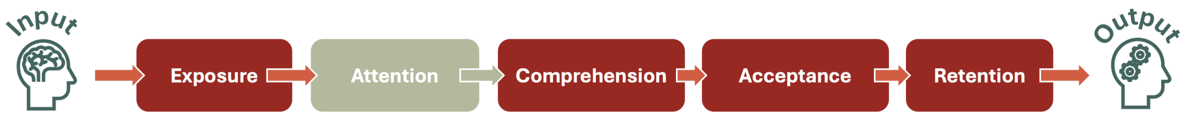


Figure 2.3: Schematic depiction of the information processing theory, with green highlighting the stage of this process relevant for this research topic.

Figure 2.3 presents an illustration of IPT. Between the input of information and an output, a series of steps occur whereby the information is processed. The first step in this process is exposure, referring to when a consumer first encounters a stimuli (advertisement or packaging). Secondly, the consumer's attention is drawn to an aspect of this stimuli. In this research, the consumer's attention is drawn to the nutritional label. If properly designed, the nutritional label should aid the consumer in being able to make sense of nutritional information. After which they begin to develop a judgment about what they have seen. Next, the consumer decides whether or not to believe the information. Lastly, the consumer will choose whether or not to retain this information for future use and possibly perform an action as a response to the newly attained information [61].

In research on food marketing, FOP labels have been shown to draw more consumer attention than BOP labels. In a study done with Belgian consumers, 60% of consumers looked at FOP labels when purchasing a product [65]. That being said, people often claim to do things that are perceived as 'good' (like making a conscious healthy decision by reading FOP labels) more than they actually do this [39]. Therefore, alternative methods to surveys need to be employed which uncover a true behavioral response.

Within the IPT framework, visual attention is a critical early-stage step in the decision making process without which higher order processes cannot occur. Without attention; comprehension, acceptance, and retention all cannot occur, therefore making it a central focus to truly understand the effect of nutritional label design.

2.3. Neuromarketing

As discussed, consumers don't always respond truthfully to surveys. Neuromarketing has been developed to gain an insight into the subconscious responses of consumers to marketing, truly uncovering how decisions are made [75].

2.3.1. Definition and Scope of Neuromarketing

In order to make a decision, a consumer must allocate their attention to the available options and assess these options before they can make a decision [69]. Neuromarketing is a field of study whereby neurology and marketing overlap, so as to gain an insight into consumer behavior based on their neurological response. In order to tackle the fact that traditional self-reported measures aren't always able to capture these instinctive responses, neuromarketing has emerged, which is able to better predict behavior than when only basing it on stated preferences [75].

Neuromarketing techniques provide insight into how the brain responds to stimuli, unveiling what a customer truly thinks of a product, rather than what they claim to prefer [69]. This insight then opens the door to predicting behavioral responses to certain stimuli. With these tools, scientists are therefore able to test exactly what the effect of adapting design features (color, format, etc.) in food packaging is on purchase intentions of customers [5]. In the context of food marketing neuromarketing methods allow researchers to capture fast subconscious decisions, as will be illustrated next.

2.3.2. Overview of Neuroscientific and Physiological Tools

Within the field of neuroscience many tools have been developed. These tools range from biometrics, electroencephalography (EEG) and functional magnetic resonance imaging (fMRI), to eye-tracking [30, 12]. Biometric methods like galvanic skin response (GVR) assess physiological arousal by looking at skin conductance [12]. EEG on the other hand measures neural activity associated with attention and engagement [38]. fMRI studies the brain, and is able to recognize activity in the brain that is associated with emotions [75]. Lastly, eye-tracking is a tool whereby data is collected to quantify visual attention in terms of gaze behavior [66].

Although fMRI and EEG tools are instrumental in neuromarketing, their use is not common. This is largely attributable to the steep costs associated with these tools, and limited availability. Apparatus such as EEG and fMRI are typically bulky instruments, and therefore challenging to use [30]. Moreover, participants need to sit in a noisy tube while their brain gets scanned, all while being in a laboratory environment rather than a real life setting [30].

fMRI provides an insightful window into how the brain responds to certain marketing triggers. In a fMRI study, it was assessed whether participants were able to taste the difference between Coca Cola and Pepsi either when informed they were drinking different beverages or when not informed. People who claim to always drink Coca Cola were informed of what they were drinking, and their brain signals differed as opposed to when they did so blindly [58]. Another study, assessed whether there was a difference between wine perception when the price of wine was known. Participants classified wine as tasting better, when the bottle's price was higher [75].

A non-invasive method whereby consumer response is measured is through eye tracking. Eye tracking entails that a participant's eye movements are tracked in response to being prompted with a marketing message or other form of a prompt, see Figure 2.4. Eye movements provide a window into visual cognition, revealing what information a consumer is likely to be gathering, and therefore help predict what decisions they might make. Eye-tracking data reveal what a consumer instinctively looks at, rather than yielding a rehearsed answer.

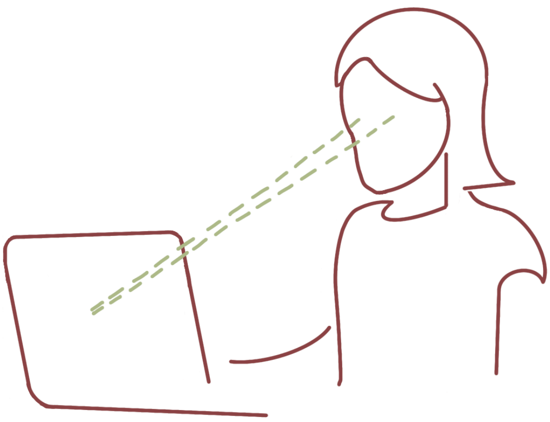


Figure 2.4: Illustration showing how pupil data can be used to find gaze points.

2.4. The Present Study

Many labels have been developed over the years to aid consumers in making food choices. There is a lot of theory that goes into how the label is designed, however research lacks in the field of what features most influence its impact on consumer attention. The goal of this study is therefore to investigate the influence of incorporating color in such labels (colored and black-and-white). This thesis will investigate how previous studies have investigated the relationship between color and consumer attention in nutrition labels, striving to find a common effect between these studies. In order to quantify this effect, the selected studies will focus on using eye-tracking. To do this, a meta-analysis will be performed based on existing studies.

3

Study 1: Meta-Analysis

As proposed in the introduction of this paper, a meta-analysis will be conducted to quantify the overall effect of color in nutritional labels in food packaging on consumer visual attention as reported in previous studies. The first section discusses the methodology followed throughout this research related to conducting a meta-analysis. Initially, the research topic was scoped and identified. This scoping consisted of a number of steps, each of which are elaborately described in the first subsection of this section. The section then reveals how a meta-analysis is conducted in the context of this study. Later, the meta-analysis is performed to get insights into the research topic.

3.1. Meta-Analysis Defined

A meta-analysis provides a way to synthesize quantitative data from a number of studies to arrive at a robust conclusion. Unlike other common review methodologies, it not only summarizes key findings, but gives meaning to them by providing quantitative evidence (with statistical backing) supporting an interaction between variables [42].

A meta-analysis has two primary functions, namely reaching conclusions with statistical backing, and providing a framework that allows for the assessment of the heterogeneity of previous studies. The first of these functions entails that the data which is accumulated through the analysis is combined in such a way that the average effect of a variable of interest can be quantified. The studies that are compared in a meta-analysis will have a similar experimental set up, thereby making their results comparable. These data points will therefore be compared to one another to attain an average. The average value that is calculated will allow for conclusions to be drawn. Rather than only leading to a conclusion, meta-analyses also take into account the statistical significance of said data points by considering the standard deviation and mean. Incorporating these statistical measures into the data processing gives an insight into the certainty of the conclusion that is drawn [89].

The latter function of a meta-analysis, namely creating a framework to assess heterogeneity of previous studies, focuses on identifying discrepancies among the studies. Heterogeneity looks at how similar or different studies are, therefore a meta-analysis gives insights into what the primary differences between studies are. The differences could be experimental design, context, sampling methodologies, or other factors, that influence the outcome of the study. Such insights are referred to as the effects of moderating variables [89].

The instrumental insights that meta-analyses provide give researchers starting points to conduct further research, develop policies tackling the investigated problems, and overall gain a better understanding of existing problems and topics at hand.

The benefits of conducting a meta-analysis include that it cumulates knowledge, gathering a lot of information in one place, making it more accessible and clear. Another benefit is its focus on statistical relevance. By focusing on statical significance of the data points, their statistical power is accurately translated into sound conclusions. Rather than performing numerous experiments one's self, a meta-analysis allows for researchers to test theories by assessing existing data, instead of having to invest many resources into conducting the same amount of trials. Lastly, by combining many studies, the meta-analysis is able to identify moderating variables across studies, providing insightful findings in the field of study [42].

Topic Scoping

The present study focuses on investigating the relationship between the use of color on consumer attention.

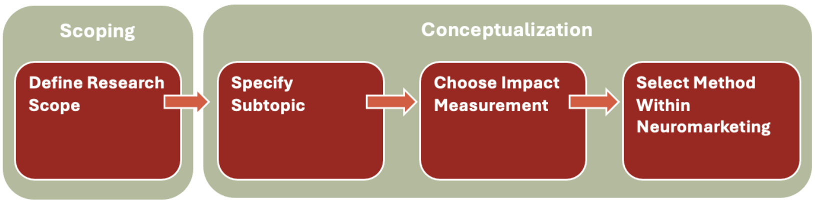


Figure 3.1: Process flow diagram illustrating how initial research topic was determined.

The research objective was formulated by performing an initial research scoping as proposed in Figure 3.1. The first step taken was selecting a research domain. A general idea was first created by focusing on the intersection between the food industry and marketing, resulting in the domain food marketing being established. Secondly, within food marketing a narrower focus was chosen towards food labeling and consumer perception. Specifically, the relationship between food labels and consumer perception and behavior was selected. Once the topic was narrowed down, it was important to determine how an effect of the food label on consumer perception could be singled out and investigated. To evaluate the effectiveness of food marketing strategies a number of assessment methods were considered, ranging from surveys to neuromarketing. Neuromarketing was eventually selected due to its scientific formatting and therefore dependable results [69]. Furthermore, neuromarketing focuses on a consumer's subconscious response which greatly influences the final purchase decision [69]. Within the field of neuromarketing many techniques are used to measure consumer response, ranging from biometric analyses, to brain scanning, and even eye tracking [30, 12]. A preliminary literature review was conducted to identify which method was best documented and therefore most feasible to be used in the meta-analysis. Eye tracking had been greatly used in relation to food labels and consumer response, therefore this technique became part of the focus of this research.

Meta-Analysis Steps

Once the topic is properly scoped, a meta-analysis can be conducted to answer the relevant sub research question, in this case: *How does the use of color, compared to black-and-white presentation, affect consumers' visual attention to nutritional information?*

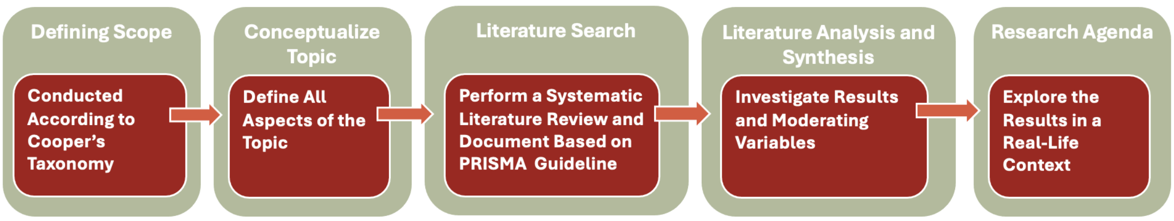


Figure 3.2: Process flow diagram illustrating how the meta-analysis was performed is correspondence with the framework proposed by vom Brocke, et al. [94].

Figure 3.2 shows an adapted flowchart of the framework developed by vom Brocke et al. to perform a meta-analysis [94]. The first step is to define the scope and research topic. To clearly define the purpose, scope, and methodology of this research Cooper's taxonomy was used, a framework to classify and structure literature reviews [17]. Subsequently, the topic is further conceptualized by defining relevant definitions and finalizing the scope. Then, a literature search is performed. This literature search is done following instructions by vom Brocke et al. whereby databases and journals are scoured, all while searching for keywords in a backward and forward search manner [94]. Using software, JASP, a meta-analysis is performed, out of which a range of data is collected. Results include the creation of a forest plot to visualize the effect size. The formulas associated with calculation to generate this plot are provided in Appendix C.

3.2. Performing the Meta-Analysis

A meta-analysis requires heaps of data to synthesize and attain a conclusion based on numeric data and statistics. To collect sufficient data it is important to follow a structured approach to find relevant articles. Such an approach was explained in the methodology section of this report, Figure 3.2. This method begins with clearly defining the scope of the research, followed by further conceptualizing the topic. Next, a literature search is performed, after which the selected literature is analyzed and synthesized. Lastly, the results are interpreted and conclusions are drawn.

3.2.1. Defining the Scope

<table>
<tr><th>Characteristic</th><th colspan="12">Categories</th></tr>
<tr><td>Focus</td><td colspan="3">Research Outcomes</td><td colspan="3">Research Methods</td><td colspan="3">Theories</td><td colspan="3">Applications</td></tr>
<tr><td>Goal</td><td colspan="4">Integration</td><td colspan="4">Criticisms</td><td colspan="4">Central Issues</td></tr>
<tr><td>Perspective</td><td colspan="6">Neutral Representation</td><td colspan="6">Espousal of Position</td></tr>
<tr><td>Coverage</td><td colspan="3">Exhaustive</td><td colspan="3">Exhaustive and Selective</td><td colspan="3">Representative</td><td colspan="3">Central</td></tr>
<tr><td>Organization</td><td colspan="4">Historical</td><td colspan="4">Conceptual</td><td colspan="4">Methodological</td></tr>
<tr><td>Audience</td><td colspan="3">Specialized Scholars</td><td colspan="3">General Scholars</td><td colspan="3">Practitioners</td><td colspan="3">General Public</td></tr>
</table>

Figure 3.3: Taxonomy of literature reviews following Cooper, with categories relevant to this research highlighted in red.

Figure 3.3 illustrates the applicability of Cooper's taxonomy. Cooper's taxonomy frames literature research in six dimensions, whereby it classifies each dimension into a number of different categories, some of which can be selected as being applicable to the research in question. For this research there are categories within each dimension which are applicable to the literature study.

Determining which aspect of previous work should be focused on is essential to narrow down the research that will be included. As such, it was quickly determined that the focus should lie on research outcomes, specifically eye-tracking metrics. This focus makes it so that studies which don't yield research outcomes aren't relevant for this research.

The goal of this paper is to combine existing data (integration) by means of a meta-analysis, to draw conclusions which could help identify what the central issue is. Current studies indicate that healthy nutrition is a globally relevant issue, therefore, it is important to determine whether graphical labels (including colors) attract more attention than traditionally black-and-white ones.

The perspective from which the articles are selected is neutral. That is, articles are not selected as good or bad, rather they are selected based on a number of inclusion and exclusion criteria, as elaborated in Appendix A.

The search strategy lent itself to collecting a representative collection of relevant articles about the topics (nutrition, psychology, consumer behavior). To find articles, several databases were employed, namely Web of Science, PubMed, PsycInfo, and EBSCOhost. On these platforms, all English articles were included in the literature research.

The review is organized methodologically. This entails that the studies are grouped based on whether or not they hone in on label types (traditional versus color coded) and experiment type (eye tracking versus other means of data collection). PRISMA guidelines were used to carry out this research in an organized, reproducible manner, and everything was meticulously noted in a data-extraction spreadsheet.

Lastly, it was important to determine who the audience of this research would be. The primary audience of this paper is researchers and policy makers. These groups can gain insights from the data collected and summarized in this paper, so as to adjust rules and regulation (and perform additional research) to promote healthiness in our society. The secondary audience is label designers. Upon regulation adaptations, label designers will have to adjust existing labels in order to adhere to new regulations.

3.2.2. Conceptualize Topic

A Boolean search strategy was employed. A Boolean search includes a number of key concepts and combines them using operators like AND, and OR. The connector AND was used to combine concepts, and OR was used to group synonyms. The search includes synonyms of the key concepts so that a comprehensive search can be conducted that yields a focused collection of the papers, while ensuring that relevant articles aren't missed because of having used different phrasing.

Table 3.1: Table illustrating the PICO elements translated into concepts which are applicable to this research.

PICO element	Concept
Population	Consumers exposed to food packaging
Intervention	Nutrition labels
Comparator	Black-and-white labels
Outcome	Attention

Table 3.1 illustrates the concepts associated with the individual PICO elements of this research. The table dictates the four most important concepts of this research. These concepts were central in developing a Boolean search string. A systematic search on several databases was done using the following search string:

Boolean Search String

(”food label*” OR ”nutrition label*” OR ”nutri-score” OR ”front-of-pack label*”) AND (”eye tracking” OR ”visual attention” OR gaze OR AOI OR area of interest OR dwell) AND (attention OR engagement OR ctr OR click-through rates OR purchase OR behavior OR perception OR information OR response) AND (color OR colour)

The search didn't include any date restrictions and was filtered to only deliver english studies.

3.2.3. Literature Search

To collect and select relevant articles for the meta-analysis a series of steps were conducted. The process began with an initial article collection, followed by an initial screening, then filtering, and finally the making of a final selection.

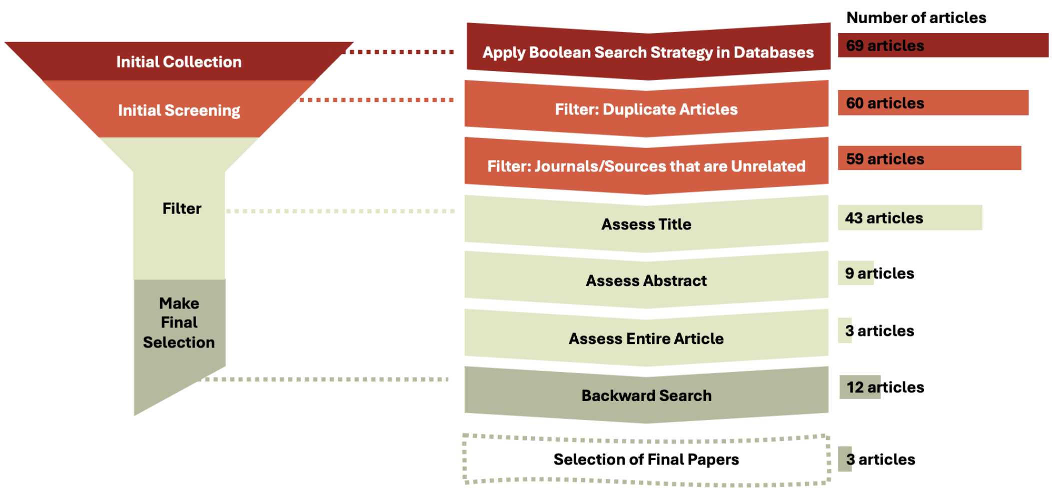


Figure 3.4: Illustration of how PRISMA guidelines were used to filter the articles in preparation for a meta-analysis.

Figure 3.4 schematically depicts the steps that were taken to go from the initially collected range of articles to a final paper selection. It shows that an initial range of papers was collected by searching with the Boolean search string in the 4 databases. This initial search yielded 69 results. All of these results were documented in an Excel document, whereby the article's title, DOI, and abstract were noted.

Once an initial collection was assembled the articles were screened. First off, the articles were screened for duplicates since many databases yielded the same results. Secondly, the origin of the articles was investigated. Specifically, a closer evaluation was done regarding what journal/source the article was retrieved from, so as to exclude unrelated articles. After having conducted an initial screening, a filtering step took place. This step consisted of three sub-steps: title assessment, abstract assessment, and entire article assessment. If the article passed the first sub-step it would continue on to the next sub-step and so on. This filtered out a large chunk of the articles, thereby leaving a comprehensive selection of papers. Lastly, the remaining papers were read in detail and all relevant information was extracted (see Appendix A for a detailed description). A backward search was then conducted, which entails that the articles referenced in the articles were screened and filtered to assess whether these could be included in the study's meta-analysis.

3.2.4. Literature Analysis and Synthesis

Data was extracted from the final paper selection. The variables that were initially deemed of interest were dwell time, fixation count, time to first fixation, and average fixation duration. However, not all articles included data points for the same measurements in their results, therefore the authors of the papers had to be contacted to request the missing data points. Upon assessing the extracted data, it was deduced that most articles had data on dwell time, therefore this was the variable most interesting to collect since a complete set was attainable. All authors were emailed with an email in which dwell time (and corresponding standard deviation and sample size) data was requested as high priority, and the other data was requested with a secondary priority. This was done in correspondence with the ethics committee, who granted approval to contact these authors and store the collected data. Of the emailed authors, 6 responded. Not all authors were able to provide the requested data, resulting in a final article selection of 3 papers. The articles are presented in Table 3.2.

Table 3.2: Final selection of studies and authors used in meta-analysis.

Study	Author(s)
Effect of different nutrition labels on visual attention and accuracy of nutritional quality perception: Results of an experimental eye-tracking study [32]	Andrijana Musura Gabor, Bojan Stojnic, David Ban Ostic
Advantages of graphical nutrition facts label: faster attention capture and improved healthiness judgment [33]	Zhibing Gao, Ziang Li, Xiangling Zhuang, Guojie Ma
Salient nutrition labels shift peoples' attention to healthy foods and exert more influence on their choice [78]	Qendresa Rramani, Ian Krajbich, Laura Enax, Lisa Brustkern, Bernd Weber

3.3. Results

The 3 articles were analyzed by means of a meta-analysis to draw conclusions about the correlation between the incorporation of color into nutritional label packaging and the visual attention of consumers. The data from these articles can be found in Appendix B. Two of the articles focused on guided daily amount labels presented in black-and-white versus traffic light colors. The other article focused on translating a nutritional facts panel into a bar graph, whereby this was presented either in black and white or color.

Table 3.3: Meta-Analytic Tests

	Test	p
Heterogeneity	$Q_e(2) = 2.81$	.245
Pooled effect	$t(2) = -1.87$	.203

Table 3.3 depicts data associated with meta-analytic tests that were carried out analyzing the data. The table shows data associated with two effects, heterogeneity and the pooled effect. Heterogeneity refers to how much study results differ from one another, beyond that which would be expected through random choice using Cohan's Q. This measure is a sum of the squared difference between the effect size and pooled effect divided by the variance for each of the studies (see formula in Appendix C). Cohan's Q for this meta analysis is 2.81. This would suggest that the studies don't differ tremendously [2]. However, the high p-value (p=.245) associated with this calculation suggests that the value is not statistically significant.

The pooled effect (t-statistic) refers to the overall combined effect size of all three studies in the analysis, basically the average effect size of color in labels on dwell time across all studies. As depicted in Table 3.3 the pooled effect has a high p-value (p=.203), suggesting that it is not statistically significant. Since the test is based on three studies, the fact that the measured effect is not statistically significant is reasonable. The effect of color on dwell time would have had to be very prevalent for only 3 studies to be enough to sufficiently justify it. The sample size for the meta-analysis may have been too small to draw conclusions.

Table 3.4: Meta-Analytic Estimates

		95% CI		95% PI	
	Estimate	Lower	Upper	Lower	Upper
Pooled effect	−0.236	−0.778	0.307	−0.930	0.459
τ	0.101	0.000	1.439		
τ^2	0.010	0.000	2.071		
I^2	23.494	0.000	98.424		

Table 3.4 present the estimates retrieved from the meta-analysis. The table identifies four categories of values, the pooled effect, the standard deviation (τ), variance (τ^2), and the heterogeneity statistic (I^2). The pooled effect here illustrates the weighted average of the effect size for all studies, taking into consideration the sample size and variance. The pooled effect is -0.236, with a broad confidence interval. The 95% confidence interval associated with this pooled effect size crosses over 0, implying that there is no clear effect. The predicted interval (PI) is even broader than the confidence interval, suggesting that in a new study any effect (either positive or negative) could happen. Furthermore, the standard deviation and variance values presented in the table fall within such wide confidence intervals that no certain conclusion can be made about them. If the value were to fall towards the lower end of the confidence interval then there would be little heterogeneity, while if it falls towards the upper boundary, the studies would be very heterogeneous. No precise statement about this can be made though because of the large range. The I^2 estimate suggests a low level of heterogeneity (23.49%). However, the associated confidence interval is very wide (ranging from 0 to 98.42%), indicating a high level of uncertainty in this value's estimation. The true heterogeneity could plausibly be negligible (0%) or very high (98%), therefore its value cannot be interpreted reliably. This uncertainty is likely due to the small number of studies included in the analysis.

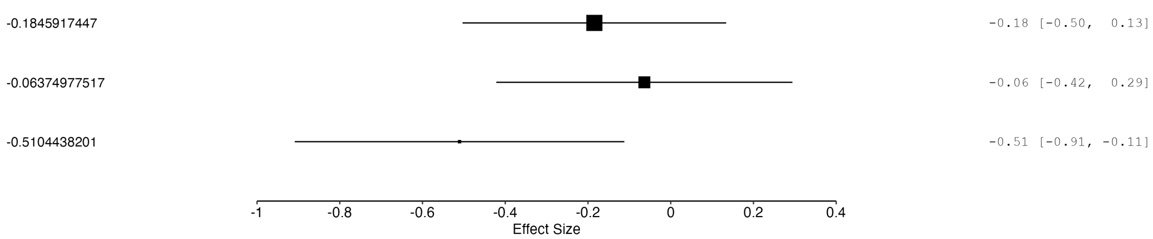


Figure 3.5: Graph illustrating the forest plot derived from performing a meta analysis on the collected data.

Figure 3.5 plots the effect size calculated for each study with its corresponding confidence interval. The graph clearly indicates that the studies have an effect size of nearly 0. This plot demonstrates that although an effect size is calculated for each of the studies, its size is so minimal, that it can be deduced that the effect doesn't exist. The wide intervals indicate low precision, meaning the effect could be positive, negative, or null.

3.4. Implications

Due to the inconclusive results from the meta-analysis, further studies need to be performed to gain clear answers to the previously proposed research question. The meta-analysis suggests that there is no significant effect of color on consumer dwell time, however, it is unclear whether this effect is not significant because of the studies differing too much in terms of experimental design, or because the results actually show this phenomena. To gain more clarity on this topic, an eye-tracking experiment was designed and carried out.

4

Discussion and Study Rationale

4.1. Reflection

The inconclusive results from the meta-analysis highlight that the effect of color in nutritional labels on visual attention cannot be studied in isolation, but rather, that it should be considered in a broader context of information design. Since no consistent effect was found among the studies under investigation, this suggests that color may not be a universal attention cue but rather a conditional one. This entails that its effect would depend on a confounding variable, such as how nutritional information is presented [83]. These findings suggest that surface-level design features like color are not solely responsible for visual attention, rather, that their impact depends on whether they are combined with changes in cognitive demand imposed by label information format [29].

The meta-analysis results revealed that there could be some heterogeneity in experimental designs of the included studies. The studies varied in terms of stimuli complexity, eye tracking metrics, and methodological set-up, likely obscuring the systematic effect of color on dwell time [32, 78, 33]. Since there were differences in label information format among the studies, these differences may have acted as an uncontrolled moderator, limiting the data interpretability [83]. In the articles used for the meta-analysis, the authors examine these factors in combination with color, making it challenging to determine their independent and interactive effects. Therefore, the present study separates the two factors to assess whether an interaction effect occurs [40].

To address the limitations of the meta-analysis, an eye-tracking experiment was designed to systematically isolate the effect of color on visual attention when controlling label information format. By manipulating color and label information format, the experiment addresses the ambiguity that arises from the meta-analysis and allows for a more targeted examination of their interaction [40].

Transitioning from a meta-analysis to an experiment reflects a shift from investigating *whether* an effect arises to understanding specifically *under what conditions* an effect presents itself. This shift aligns with theories of information processing and visual attention, emphasizing that attention allocation is context dependent and funded on principles of both perception and cognitive load [50].

Combining two research methods demonstrates the application of an iterative research strategy, where the analysis of secondary data catalyzes primary data collection [95]. Instead of considering the inconclusive results as a limitation of the study, this thesis uses them in an informative manner to further refine the research objective and gain a deeper understanding of the topic at hand. This methodological triangulation improves the quality of the research and enhances the confidence with which conclusions can be claimed [6].

4.2. Eye Tracking Experiment Introduction

The studies investigated in the meta-analysis vary in multiple ways, however, one of the central ways in which they vary is through employed label information format. The different studies each utilize differently designed nutritional labels, whether this be in the format of a NutriScore, a guided daily amounts (GDA) label, or a bar graph. To uncover whether label information format is a variable that influences the effect of color on visual attention, this variable is divided into two categories; heuristic and argument based design.

4.2.1. Heuristics versus Argument Based Processing

Nutrition labels can be designed in various ways, portraying information in various manners (thus also referred to as label information formats). When labels are designed with intuitive features that a consumer can easily interpret, this is said to promote heuristic processing [13]. Thereby allowing consumers to make rapid decisions. Color in this context enables heuristic processing of information. For example, the color red can suggest that something is bad, while green might suggest something more positive [67]. Another means of portraying information in label design is through arguments. This plays into systematic processing, whereby consumers rationalize the decisions they make [13]. Nutrition labels can be designed in either manner, or even as a merger of both.

4.2.2. Research Objective

Building on the preceding discussion of nutrition label formats, this study aims to understand how design characteristics influence consumer visual attention. Previous research suggests that color and label format play crucial, yet inconsistent, roles in shaping consumer responses to said labels. The results of the meta-analysis suggest that the effect of color on attention is not uniform, therefore suggesting that there is a moderating factor at play.

A potential moderating factor that could explain the inconsistency in these results is label information format. Nutritional labels vary in how they incorporate heuristic cues to kickstart rapid and intuitive judgments versus using argument based claims that require more cognitive processing. These differences in label format might influence how visual attention is allocated, and how other design elements like color are processed.

The primary objective of this research is therefore to investigate how label information format moderates the effect of color on consumers' visual attention to nutritional information. By focusing on heuristic and argument based label formats this study strives to uncover whether the influence of color on visual attention depends on the cognitive demand imposed by the label format. This translates to the following research objective:

To determine how different combinations of label information format and color influence consumers' visual attention to nutritional information.

To address this objective, the study combines insights from a meta-analysis of existing eye-tracking studies with those of a uniquely designed eye-tracking experiment conducted for this thesis. This integrated approach allows for a nuanced assessment of exactly what conditions promote the most visual attention to nutritional labels among consumers.

4.2.3. Main Research Question

Considering the research objective of this study the following is the refined main research question of this study:

RQ:*How do nutrition label information format (heuristic versus argument based) and color use influence consumers' visual attention to nutritional information?*

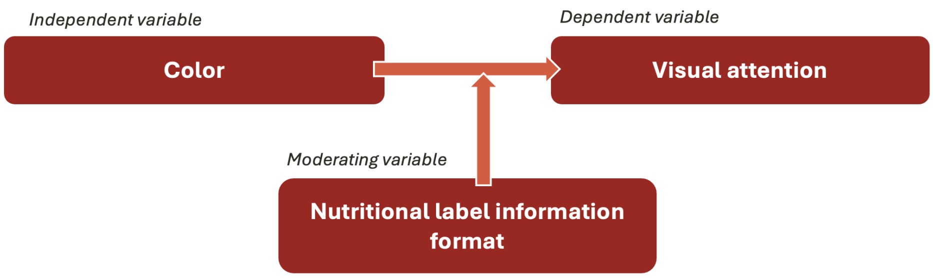


Figure 4.1: Depiction of the research question as portrayed via a causal diagram which illustrates the relationships between the different variables.

Figure 4.1 dissects the research question previously mentioned into a causal diagram, whereby each of the individual variables are highlighted. This dissection provides an overview of the separate components of the research to delve into, so as to finally develop a uniform answer to the overall question.

4.3. Eye Tracking Experiment Theory

The following section introduces theoretical frameworks on heuristic and systematic processing to clarify how variations in nutritional label design might influence consumer attention.

4.3.1. Heuristic and Systematic Processing in Attention Allocation

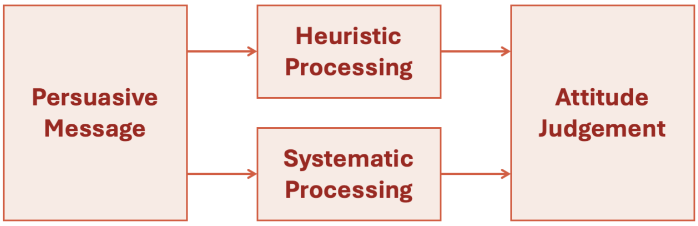


Figure 4.2: Heuristic-Systematic Model as developed by Shelly Chaiken [13].

Consumers tend to make decision according to a dual-process theory. Similar to Kahneman's System 1 and System 2 model, Shelly Chaiken developed a dual-process theory as portrayed in Figure 4.2 [19, 13]. Her heuristic-systematic model (HSM), was developed in 1980. The model focuses on how people process persuasive messages. There are two paths that can be followed to process persuasive information. Systematic processing focuses on individuals soaking up all available information, and evaluating this to make an extensively informed and often factually supported decision. To process information in such a way, the individual must be highly motivated and have a sufficient cognitive capacity to process all of the information. This means of processing often results in a stable and well grounded judgment [13].

Heuristic processing focuses on intuition, and processing information with as little effort as possible. This method relies on heuristic cues (typically learned association) that help make quick judgments. Typically, in stressful situations, when decisions need to be made quickly, or in settings where there is information choice overload; heuristic processing occurs. Decisions are made quickly, but sometimes less accurately than when done in a systematic manner [13]. For heuristic processing it is important that there is not too much information present, layering up heuristics therefore might work counter intuitively, since it results in information overload [36].

The two processing streams are not mutually exclusive [13]. Although a nutrition label may initially grab a consumer's attention due to its use of colors or other heuristic features, a motivated consumer may switch to systematic processing to analyze more detailed nutritional information (if they aspire to make a well supported healthy decision).

4.3.2. HSM and Food Label Design

Different label designs exist, each designed for different purposes. Two common streams of label design exist; analytical and interpretive labels. Each of these label designs differs in terms of the processing pathway it evokes. Analytical labels evoke systematic processing, while interpretive labels rely on heuristic processing [13].

Analytical Labels

Analytical labels are those whereby the label demands cognitive function from the consumer reading it, also referred to as systematic processing [13]. This label is classified as using arguments in how it portrays information, provoking customers to think about the information that is being shared, and using this to inform their purchasing decision. This label form presents information in a non-interpretive fashion, to inform factually [20]. The NutrInform battery and guided daily amounts (GDA) labels are examples.

The NutrInform battery label was created by the Italian Ministry of Economics. The label indicates the content of specific nutrients in the food product [72]. It was first used in 2020. It informs consumers about 5 categories of nutrients: calories, fats, saturates, sugars, and salt. The quantity of these nutrients per portion of the food are listed on the label [60]. The NutrInform battery label allows for assessment of individual products based on reference intakes and portion sizes, bringing about a better impression of these products [72]. The central drawback of this label, however, is that portion sizes aren't standardized. Companies decide themselves what they deem to be a portion of their product, therefore, they can make the recommended portion substantially small, so that the item is perceived as being healthier than if a 'true' portion were to be consumed [64].

Interpretive Labels
Interpretive labels are those that require heuristic processing [13]. They typically include heuristic elements so that consumers can infer things presented by the label based on the associations they make [13]. For example, color coding in such labels depicts whether a food is healthy and good for you (green) or being unhealthy and bad for you (red) [73]. Interpretive labels require less cognitive load than analytical labels, thereby allowing consumers to make quicker decisions. A commonly used interpretive label in the EU is the Nutri-Score label. This label relies on the aforementioned color and a grading system to assess the healthiness of a product, reducing the need for a high level of food literacy [23].

The Nutri-Score label was developed by the French government, and used since 2017 [88]. It works by assigning a score to food products based on a balance between beneficial nutrients (such as fiber and protein) and less healthy components (such as sugars, saturated fats, and sodium). The result is summarized into a letter and color grade from A (healthiest) to E (least healthy) [23]. This allows consumers to quickly assess and compare the overall nutritional quality of foods within the same category. In this way, consumers are able to pick up a product, and by quickly looking at the Nutri-Score, infer whether the bag of chips they have picked up is relatively healthy or not [88]. One of the primary drawbacks of this labeling system is that some companies and countries oppose its use because it grades products per 100g or 100mL amounts, regardless of typical portion sizes. Consequently, products like olive oil or cheese (which are healthy in moderation) might receive low grades due to their high caloric and fat content, resulting in concerns about this labeling system not working accurately in representing traditional or single-ingredient foods [72].

4.3.3. Label Format and Visual Attention

Many features of an FOP label can influence how much attention it attracts from consumers. Among these features are its size, whereby, when it is bigger, consumers will be drawn to it quicker. Furthermore, if the label includes color it has been shown to draw more attention, as is the case when the information it includes is presented comprehensively and in the same location on the package as for other similar products [84].

Studies show that different label designs generate different consumer attentions. Nutri-score and traffic light labels are heuristic based, thereby using interpretive cues to portray information [82]. Studies have shown that a focus on interpretability of these labels is effective, since consumers tend to most accurately understand the nutritional content of foods when fitted with such a label [23]. In line with this train of thought, salience (prominence) is a feature of the label that has proven to increase consumer engagement in other situations too. When communicating nutritional information through a warning label (a very salient packaging feature), consumers seem to pay a lot of attention to this label. Studies have shown that in the presence of warning labels, more engagement is evoked by these warnings than to other nutritional panels; likely attributable to the high degree of salience [90].

All in all analytical labels are the toughest for consumer to understand, such as the NutrInform label and a guided daily amounts label. These labels include lots of textual information, requiring consumers to recall knowledge in order to interpret what this information means [55]. All of these results suggest that a trade off needs to be found between the heuristic and analytical nature of nutritional labels. Enough information needs to be included in the label to communicate the relevant information, but the information should not be so overwhelming that it takes away from the label's salience and comprehensibility.

Different types of consumers have different preferences regarding what they would like to see in a FOP label. Research shows that consumers with a low socio-economic status desires labels that aren't overloaded with data, but rather translate complex information into graphical and pictographic elements that are easier to understand [11]. Besides this, there is also a nuance to be found between how intuitive a label is, and how much information it includes. Some consumers prefer that nutritional information be made extremely comprehensive by presenting solely icons or other simplified elements. However, other consumers become weary of a claim's credibility without sufficient nutritional data being present on the package to support the 'health' claim [46]. Furthermore, the food category in which a product is placed also influences how effective a label is in attracting attention. When consumers make the choice to indulge in an unhealthy product, like chips or chocolate, they are often already aware that the product is unhealthy. Therefore, they typically make an effort not to read the nutritional label, to avoid feeling guilty about buying it [26].

4.4. Research Approach

To answer the proposed research questions a research approach was developed tackling three sub-research questions. By means of designing and performing an eye tracking study, results are obtained to substantiate answers to each of these questions. Table 4.1 clearly lists the approach taken to answer each of the sub-research questions.

Table 4.1: Research approach to determine how different combinations of label information format and color influence consumers' visual attention to nutritional information.

#	Research Question	Research Approach	Output
2	How does the use of color, compared to black-and-white presentation, affect consumers' visual attention to nutritional information?	Eye-tracking experiment	Statistical results
3	How does nutrition label information format, comparing heuristic and argument based designs, affect consumers' visual attention to nutritional information?	Eye-tracking experiment	Statistical results
4	What is the interaction effect between label information format and color on consumer attention?	Eye-tracking experiment	Statistical results

4.5. Hypothesis

This study investigates how information design influences consumer attention to nutritional labels, extending the initial focus on color to include differences in label information format. In addition to color, information design theory suggests that the structure of information presentation influences cognitive processing [52, 80]. Specifically, heuristic based designs are argued to facilitate faster and more intuitive interpretation compared to argument based formats, which require more deliberate processing [13]. Consequently, the effect of color on attention is expected to depend on the information format in which it is embedded. Building on this theoretical perspective, a second hypothesis is formulated:

H2: *The effect of color-coded nutrition labels on attention is moderated by label information format.*

This hypothesis allows for the examination of both color and label information format as determinants of visual attention to nutritional labels.

5
Study 2: Eye-Tracking Experiment

5.1. Methodology

Because the meta-analysis produced inconclusive results regarding the relationship between color and consumer visual attention, an eye-tracking experiment was designed and conducted. The experiment tests how variations in label information format and color influence dwell time. The intended results will aid in inferring why the results were inconsistent.

5.1.1. Ethics Approval

The Human Research and Ethics Committee (HREC) at Delft University of Technology officially approved the experiment and protocol.

5.1.2. Study Design and Participants

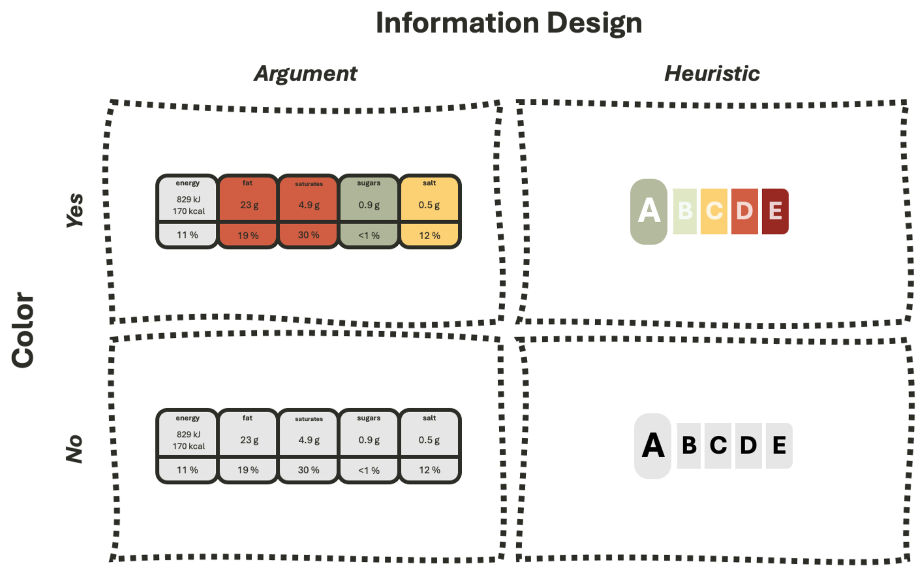


Figure 5.1: This matrix indicates the manipulated variables, color and label information format, investigated during this experiment.

The experiment was a 2 (color: yes, no) x 2 (argument versus heuristic) between-subject design on the perception of food nutrition as presented in Figure 5.1 [14]. The independent variables in this study is color, with as moderating variable the presence heuristic or argumentative features in label information format. Attention, the dependent variable, was measured in this experiment by analyzing gaze data. The primary eye-tracking metric was dwell time.

Participants for this study were recruited primarily at the TU Delft, with an emphasis on equal spread of male and female participants. Candidates needed to be: 18 years of age or older, have normal or corrected to normal vision, and be able to maintain one steady head position for the eye-tracking calibration. Also, they should not blink excessively to avoid disturbing the measurement.

Throughout the experiment participants were exposed to 11 food products; oatmeal cookies, chocolate, banana chips, soda, protein bar, oats, paprika chips, yogurt, coconut drink, candy, and nuts.

To make sure that participants were familiar with the experimental procedure, one product (candy) was included as a practice stimulus. By including a practice products, participants were able to acclimate to the experiment's demands and setup, reducing the risk of learning effects throughout the actual trials.

The other ten products were selected to represent five tiers of healthiness, with two products assigned to each tier. The tiers were designed to closely resemble the grading system of the NutriScore system (A to E). This made it so that the stimulus reflected realistic variations in nutritional quality. By choosing products that were classified differently in terms of healthiness this balanced the product exposure, preventing any tier from disproportionately influencing attention patterns.

When selecting the products, both familiar (eg. oats and soda) and unfamiliar (eg. banana chips and coconut drink) products were selected. This combination was intended to minimize predictability in consumer expectations. By including familiar and unfamiliar products the likelihood of habitual responses was minimized, and so consumers were nudged to pay more attention to label design features.

To further avoid pre-exising brand associations and preferences, all product packages were designed specifically for the purpose of this study. By not using common brands and packages, the experiment aims to isolate the effect of label design features from prior knowledge or affectiveness towards existing brands.

Together, these product choices ensure that the observed effect is attributable to label design features rather than product familiarity, branding, learning effects, or nutritional extremity.

5.1.3. Descriptive Statistics

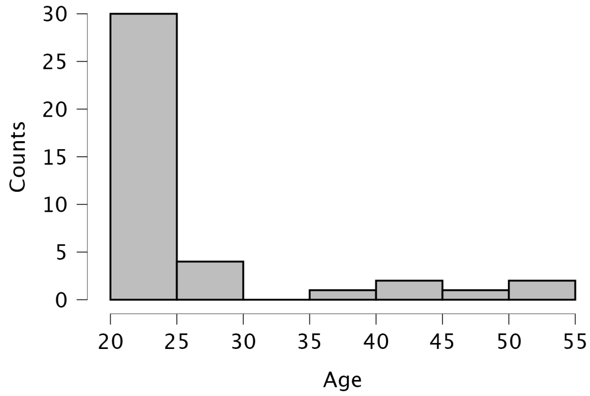
The original sample consisted of 43 participants, of which 3 were omitted due software and equipment malfunctions (N=3, 6.97%). After removing these participants, the final sample size was 40 participants. Figure 5.2 highlights the descriptive statistics for this sample.

	Weight (kg)	Height (cm)	BMI
Mean	71.05	178.50	22.24
Std. Deviation	10.14	8.49	2.21
Minimum	56.00	162.00	17.87
Maximum	93.00	198.00	25.91

(a) Descriptive statistics for weight, height, and BMI

	Age
Mean	26.68
Std. Deviation	8.89
Range	34.00
Minimum	20.00
Maximum	54.00

(b) Descriptive statistics for age



(c) Age frequency distribution

Gender	Frequency	Percent
Female	25	62.5
Male	15	37.5
Missing	0	0.0
Total	40	100.0

(d) Frequencies for gender

Nationality	Frequency	Percent
Dutch	39	97.5
Dutch/Italian	1	2.5
Missing	0	0.0
Total	40	100.0

(e) Frequencies for nationality

Dietary preference	Frequency	Percent
Pescatarian (no meat, but eat fish and/or shellfish)	1	2.5
Vegan	1	2.5
Vegetarian	5	12.5
Missing	33	82.5
Total	40	100.0

(f) Frequencies for dietary preference

Allergies	Frequency	Percent
Dairy	1	2.5
No allergy	33	82.5
Parsley	1	2.5
Shellfish	2	5.0
Soya	1	2.5
Tree nuts	1	2.5
Wheat/gluten	1	2.5
Missing	0	0.0
Total	40	100.0

(g) Frequencies for allergies

Figure 5.2: Sample characteristics of participants in the eye-tracking experiment.

5.1.4. Procedure

Figure 5.3 illustrates how the eye tracking experiment was conducted. The experiment was conducted in person. Participants were given an introduction to the experiment whereby they were told that the experiment consisted of 3 phases. In the first phase, the participants were asked to answer a pre-survey. In this survey a number of demographic questions were asked.

The second phase of the procedure was the actual eye-tracking experiment. Participants were first fitted with the eye-tracker (a Pupil Core headset), after which followed a calibration procedure. In the software that accompanies the headset (Pupil Capture) a 5-point calibration procedure exists, and this

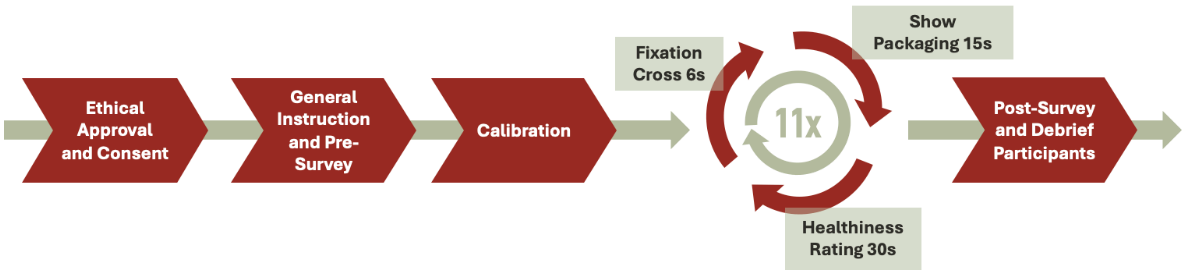


Figure 5.3: Process flow diagram depicting the experimental procedure that was followed throughout the eye tracking experiment.

was followed to the tee. Once the headset was calibrated the recording began, and products were displayed. A timed PowerPoint presentation was developed that included 1 practice product and a subsequent 10 products. During the presentation a sequence of three steps repeated as each product came into view. First, the participant was urged to focus on a fixation cross for 6 seconds. Afterwards, a food product (of which the packaging was specifically designed for this experiment using Canva templates) was displayed on the same screen. This product was shown for 15 seconds, giving the participant ample time to digest all of the information from the package. Once the package disappeared, a white frame came into view, giving the participant 30 seconds to answer survey questions related to the product they had just been shown. These questions were retrieved from the research papers that were used in the meta-analysis to enhance the comparability of the results [32, 78].

Once the 10th and final product was presented and the corresponding questions had been answered, participants move on to the final phase of the procedure, namely the post-survey. In the post-survey participants were asked 6 manipulation check questions. Furthermore, additional questions were also asked to infer how participants had experienced the experiment, and whether they had any further observations or things to share. The participants were then debriefed.

5.1.5. Data Processing

A series of steps were followed to go from collecting raw eye tracking data to drawing conclusions about consumer attention to nutrition labels. The data processing associated with this translation is demonstrated in Figure 5.4, and further elaborated on in the following sections.

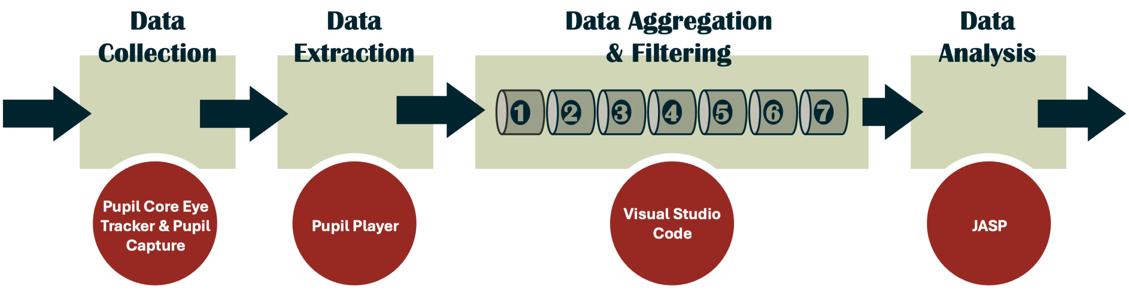


Figure 5.4: Visual depiction of how the eye tracking data was processed in a series of steps, and what apparatus and program was used accordingly.

Data Collection and Apparatus

To collect the eye tracking data two main pieces of apparatus were essential, namely an eye-tracking and a computer. The eye-tracker that was used was the Pupil Core Eye-Tracker, having an appearance similar to a regular pair of glasses. The eye-tracker headset is fitted with three cameras and a wire that allows it to be plugged into a computer. Two cameras are angled towards the participant's pupils around the outside of the face, and one captures what a participant looks at in a fish-eye like manner. Since the eye-tracker is in the form a headset it lends itself to generating an experimental setting that resembles how a consumer would act in real life (freedom to move one's head and posture). Once the participant is fitted with the headset the Pupil Capture software is launched to calibrate the device and begin the recording. This software collects footage from all three cameras throughout the experiment, thereby creating videos of each pupil and of the participant's ”world view”.

Data Extraction

Once the recordings are generated and exported by the Pupil Capture software the Pupil Player software is used to initiate data extraction. The recording folder including the footage generated by Pupil Capture is imported into Pupil Player. This latter software is used to run the gaze recordings and ”world view” recording alongside each other to track the participant's gaze. Once the gaze is tracked, its movement is converted to gaze positions (coordinates) which are then exported by the software in the form of a csv file along with an mp4 file of the ”world view”.

Data Aggregation and Filtering

To go from the csv file with gaze positions to dwell time a Python script was written, Appendix D. The script consists of 7 blocks, Figure 5.5, which are elaborately discussed in the following section.

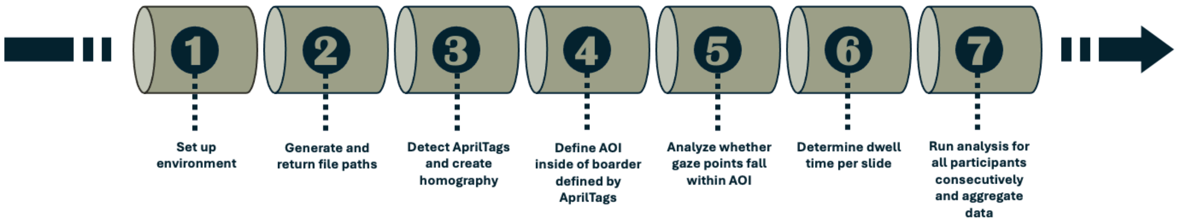


Figure 5.5: Visual depiction of the pipeline followed to process the eye tracking data from raw data to dwell time figures.

The first part of the code focuses on setting up an environment in which the data analysis can run. This entails that a number of relevant libraries are important, and that all topics that are to be analyzed are introduced. There are a few fundamental things that are done in this section of the code. Firstly, it introduces a dictionary that links a participant number to a time offset (indicating the start time of each experiment). A second crucial part of this code block is the introduction of a gaze confidence threshold. A cut-off confidence level of 0.6 is applied to the gaze data; therefore data whereby the confidence level falls under this value is excluded from further analysis [74].

The second code block generates and returns all file paths that are used throughout the rest of the code. This is possible because all of the data for each participant is stored in a participant folder, each of which have identical structures.

To accurately map gaze points from image coordinates AprilTags were used. AprilTags look similar to QR codes and are typically used in robotics as location markers. An experiment conducted by Yasmin Faraji et al was used as inspiration to utilize the AprilTags to mark the boarders of the screen, so that consistent areas of interest could be identified throughout the recording regardless of head movement [28]. The third block uses the OpenCV library to detect the AprilTags (all from the 36h11 family) in each frame of the video recording. For each video frame where all four AprilTags were visible, a planar homography was estimated and stored for later used in gaze transformations.

In the fourth block of the code, the area of interest (AOI) was manually identified. The first frame for which a valid homography was available (from the first participant) was used as reference frame. Within this reference frame the upper left corner and lower right corner of the AOI were selected by the researcher, and these coordinates were stored as board coordinates so that they could be projected into each video frame.

Subsequently, in the fifth code block, specific homographies and gaze data were put alongside each other. All the coordinates associated with the gaze data points were converted to board coordinates and classified as falling within or outside of the previously defined AOI providing a basis for the dwell time analysis. If a homography was unavailable for a frame, the most recent homography was applied since limited camera motion between successive slides was assumed.

Gaze dwell time within the AOI was aggregated per slide by converting the frame indices (whether the gaze point fell inside or outside of the AOI) into time, and summing these times per slide. For the final gaze point in each slide interval the gaze duration was approximated using the median inter-sample interval. This was all done in the sixth block of the code.

The final block of code presents a pipeline that separates the analysis into separate steps. This pipeline makes it so that the entire analysis can run individually for each participant in modular stages; this saves time and processing power, allowing for the analysis to run in a smooth and iterative manner, extracting information for each participant individually without having to restart between participants. Lastly, the final part of the code aggregates all of the dwell time data. Data whereby no dwell time (0 seconds) within the AOI was observed was excluded from further analysis, since the absence of gaze allocation to the AOI doesn't provide interpretable data about attention processing and is likely a result of technical limitations.

Data Analysis

Upon having converted the raw eye tracking data to dwell times and organizing this appropriately, the data was imported into a software names JASP. This software lends itself to analyzing the data in an intuitive manner, and performing statistical analysis such as determining descriptive statistics and ANOVA analyses. Before performing the statistical analyses, a final cleaning of the data was carried out, specifically removing the dwell time data for the practice product (candy). This resulted in a large table that included the dwell times per product per participant for all products and participants (204 data points in total).

5.1.6. Manipulation

Color and label information format of the nutritional labels were manipulated to test their effect on consumer attention and comprehension.

Figure 5.6: Oat packaging mock-ups used during the eye-tracking with all 4 variations of nutrition labels.

Figure 5.6 presents the 4 versions of an oat package used in the 4 variations of the experiment. Each of the versions is fitted with a unique nutrition label.

Color

Figure 5.7: Palette signifying which colors were used in the colored nutrition labels used in the eye-tracking experiment.

Previous studies, as investigated in the meta-analysis portion of this report, investigate the effect of incorporating color in nutrition labels. In this study, nutrition labels were either black-and-white or colored. The color scheme, Figure 5.7, was chosen since it resembles the colors of a traffic light, colors with which people tend to have associations.

Heuristics versus Arguments

Research has shown that decisions based on persuasive messages are made in one of two ways, through heuristic or systematic processing [13]. To try activate both of these processing mechanisms different nutrition label designs were developed, see Figure 5.1. The Nutri-Score label includes heuristic elements (an A to E grading system) to promote activation of the heuristic processing pathways. The GDA label includes a number of arguments in the form of nutrient contents and what this means in terms of how much of each nutrient should be consumer daily. These factual statements are hypothesized to activate the systematic processing pathway.

Manipulation Check

To ensure that the participants understood the experiment correctly, a manipulation check was carried out in the post-survey. 6 questions were posed whereby the participants had to recall what they had seen during the eye-tracking experiment. Of these 6 questions, 3 focused on whether the labels they saw were colored or black-and-white. The other 3 questions focused on whether the labels had been heuristic or argument based according to the participant. The manipulation check was designed to really test the participant's recall by formulating each question in a slightly different manner, and by using both pictures and descriptive texts to describe the manipulated variables.

5.1.7. Measures

Dwell Time

Data collected from the eye tracker was used to determine participant's overall dwell time within the area of interest (region around the nutrition label). To find the gaze points within this region, so-called AprilTags were fitted to the borders of the computer screen [28]. These tags were used to indicate what the frame was within which the data analysis occurred. Once the outer edges of the frame were fixed (as was done with the static AprilTags), the coordinates of the area of interest (AOI) were specified. For each product, the gaze points within this AOI were translated to dwell times. With this data answers to the sub research questions SRQ2, SRQ3, and SRQ4 is derived. The experimental setup appeared as in Figure 5.8.

Figure 5.8: Photograph of eye tracking experimental set up with posing participant.

Self-Reported Product Assessment

Throughout the eye tracking experiment 2 questions were posed after each product the participant saw. These questions were copied from two articles that were used in the meta-analysis of this research. The 2 questions were as follows:

Product Assessment Survey Questions

1. How much do you think you would like the taste of this product? (Whereby -4 is not at all, and 4 is very much so)
2. How healthy do you think this product is? (Whereby 1 is unhealthy and 5 is very healthy)

The first of these questions came from a research paper written by Qëndresa Rramani et al, and the latter from a paper written by Andrijana Gabor et al [78, 32]. The first question hones into subjective liking, how much that individual participant likes the product. While the other question prods the participant to process the information they were presented to make a judgment about the product's healthiness.

5.2. Results

The following section delves into the results obtained from the eye-tracking experiment. It first highlights the results of the manipulation check. Then it explains the effect of color and label information format on dwell time. Finally, the focus shifts towards the effect of these factors on survey responses.

5.2.1. Manipulation Check

A manipulation check was performed to infer whether the experiments worked as intended. The questions within the categories of manipulated variables (color and label information format) were tested for correct answers. As presented in Table 5.1 all chi-squared results were significant, implying that participants were able to recall the variable that was tested in their experiment, therefore the experiment worked as intended.

Table 5.1: Chi-Squared Tests for Manipulation Checks

(a) Manipulation check 1 (color)

	Value	df	p
X^2	32.73	1	$< .001$
N	40		

(b) Manipulation check 2 (color)

	Value	df	p
X^2	40.00	1	$< .001$
N	40		

(c) Manipulation check 3 (color)

	Value	df	p
X^2	40.00	1	$< .001$
N	40		

(d) Manipulation check 4 (label information format)

	Value	df	p
X^2	32.73	1	$< .001$
N	40		

(e) Manipulation check 5 (label information format)

	Value	df	p
X^2	40.00	1	$< .001$
N	40		

(f) Manipulation check 6 (label information format)

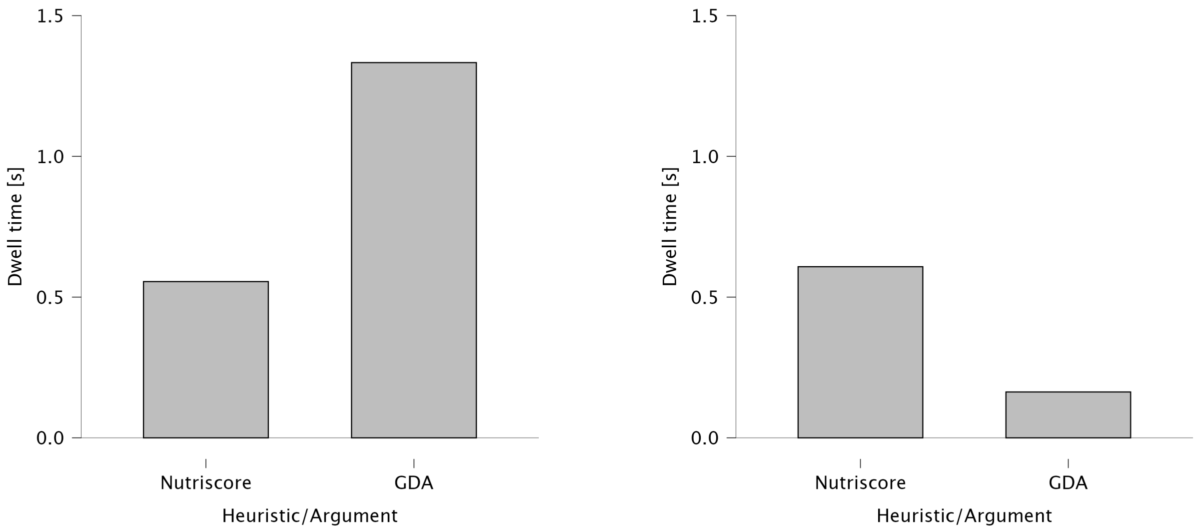
	Value	df	p
X^2	40.00	1	$< .001$
N	40		

5.2.2. Hypothesis Tests

Table 5.2: ANOVA - Dwell Time

							95% CI for η^2	
Cases	Sum of Squares	df	Mean Square	F	p	η^2	Lower	Upper
Heuristic/Argument	1.378	1	1.378	0.976	.324	0.004	0.000	0.040
Color/BW	15.520	1	15.520	10.994	.001	0.049	0.007	0.119
Heuristic/Argument * Color/BW	18.594	1	18.594	13.171	$< .001$	0.059	0.012	0.132
Residuals	282.348	200	1.412					

An ANOVA analysis, depicted in Table 5.2, illustrates the effect sizes of label information format and the use of color, as well as their interaction effect. The analysis suggests that the effect of using arguments versus heuristics in label information format is negligible, F(1,204)=0.976, p=.324, η^2=0.004, 95% CI [0.000, 0.040]. The effect of using color or black-and-white is significant, namely F(1,204)=10.994, p=.001, η^2=0.049, 95% CI [0.007, 0.119]. This suggests that there is a statistically significant impact of the general use of color on consumer dwell time. When looking at the interaction between these two variables, the effect is strong and significant, F(1,204)=13.171, p<.001, η^2=0.059, 95% CI [0.012, 0.132]. This data suggests that depending on the label information format employed (heuristic or argument based) the effect of incorporating color varies.



(a) Black-and-white **(b)** Color

Figure 5.9: Differences in dwell time per variable.

Figure 5.9 shows how mean dwell time varies based on the different label information format in colored and black-and-white conditions. Figure 5.9a shows the difference in dwell time in black-and-white conditions, while Figure 5.9b shows the same but in colored conditions. Between Nutriscore and GDA labels the mean dwell times are inverse in the different conditions, signifying the interaction effect, as found in Table 5.2.

Table 5.3: Simple Main Effects - Heuristic/Argument

Level of Color/BW	Sum of Squares	df	Mean Square	F	p
Color	4.420	1	4.420	3.131	.078
BW	16.986	1	16.986	12.032	$< .001$

A simple main effects analysis, Table 5.3, shows that in the black-and-white condition, argument versus heuristic labels produced a significant effect F(1,204)=12.032, p<.001. This suggests that under black-and-white conditions, the label information format influenced participant's responses. In the colored label conditions, the effect was not significant, F(1,204)=3.131, p=.078.

Table 5.4: Simple Main Effects - Color/BW

Level of Heuristic/Argument	Sum of Squares	df	Mean Square	F	p
Nutriscore	0.077	1	0.077	0.055	.815
GDA	30.840	1	30.840	21.846	$< .001$

According to the second simple main effect analysis, Table 5.4, for Nutriscore labels it does not matter whether these are presented in a colored or black-and-white manner, F(1,204)=0.055, p=0.815. In contrast to this, presenting labels in color versus black-and-white format for GDA labels does have a significant effect, F(1,204)=21.846, p<0.001. This indicates that the use of color strongly influenced participants' responses when presented with GDA labels.

5.2.3. Supplementary Analysis

Besides assessing dwell time data, a supplementary analysis of the self reported preferences per displayed product was also done. The answers to these questions were investigated to see if the results are similar to that found in the meta-analysis articles that the questions stem from.

Question 1: Perceived Product Taste
An ANOVA analysis was carried out, Table 5.5, to assess how the question: *How much do you think you would like the taste of this product?* was answered under the varying experimental conditions. The results show that variations in using arguments or heuristics in the label information format had a significant impact on how this question was answered, F(1,40)=4.662, p=.038, η^2=0.104, 95% CI [0.000,0.316]. Whether color or black-and-white was used in the label had no significant effect on how the question was answered, F(1,40)=0.172, p=.681, η^2=0.004, 95% CI [0.000,0.127]. The interaction between these two variables (label information format and color) did however pose a significant effect on the outcome to this question, F(1,40)=4.991, p=.032, η^4=0.111, 95% CI [0.000,0.324].

Table 5.5: ANOVA - Mean Q1

							95% CI for η^2	
Cases	Sum of Squares	df	Mean Square	F	p	η^2	Lower	Upper
Argument/Heuristic	4.456	1	4.456	4.662	.038	0.104	0.000	0.316
Color/BW	0.164	1	0.164	0.172	.681	0.004	0.000	0.127
Argument/Heuristic * Color/BW	4.771	1	4.771	4.991	.032	0.111	0.000	0.324
Residuals	33.453	35	0.956					

Table 5.6 presents the results from a simple main effects analysis of arguments and heuristics in the different color settings. This analysis proved that in the presence of color the answers given to the posed question varied significantly under the influence of using different label information formats, F(1,40)=8.920, p=.005. In a black-and-white setting the effect was not significant, F(1,40)=0.003, p=.956.

Table 5.6: Simple Main Effects - Argument/Heuristic - Q1

Level of Color/BW	Sum of Squares	df	Mean Square	F	p
Color	8.525	1	8.525	8.920	.005
BW	0.003	1	0.003	0.003	.956

Table 5.7 yields the outcome of a simple main effects analysis of using color in different argument/heuristic settings. The analysis shows that in neither a Nutriscore nor GDA setting the effect of color is significant, F(1,40)=3.242, p=.080, and F(1,40)=1.803, p=.188 respectively.

Table 5.7: Simple Main Effects - Color/BW - Q1

Level of Argument/Heuristic	Sum of Squares	df	Mean Square	F	p
Nutriscore	3.099	1	3.099	3.242	.080
GDA	1.724	1	1.724	1.803	.188

The study included in the meta-analysis that proposed this question didn't report a conclusive answer regarding the influence of color and label design on perceived product taste, limiting the opportunity to compare these results with the present findings.

Question 2: Perceived Product Healthiness
To determine the effect of the study variables on the question: *How healthy do you think this product is?*, another ANOVA analysis was carried out. The analysis, Table 5.8, shows that none of the variables had an effect on this measure. Both the presence or absence of color and label information format had no significant effect, F(1,40)=1.250, p=.271, η^2=0.034, 95% CI [0.000, 0.213], and F(1,40)=0.535, p=.469, η^2=0.015, 95% CI [0.000,0.170] respectively. There was also no significant interaction between the variables, F(1,40)=0.011, p=.919, η^2=2.859 × 10^{-4}, 95% CI [0.000,0.062].

Table 5.9 presents the results of a simple main effects analysis, carried out to measure the effect of different levels of using color or black-and-white in an arguments/heuristic setting on the answers to

Table 5.8: ANOVA - Mean Q2

Cases	Sum of Squares	df	Mean Square	F	p	η^2	95% CI for η^2	
							Lower	Upper
Color/BW	0.220	1	0.220	1.250	.271	0.034	0.000	0.213
Argument/Heuristic	0.094	1	0.094	0.535	.469	0.015	0.000	0.170
Color/BW * Argument/Heuristic	0.002	1	0.002	0.011	.919	2.859×10^{-4}	0.000	0.062
Residuals	6.150	35	0.176					

question 2. Neither levels had a significant effect on the outcome of this measure, in the presence of color F(1,40)=0.183, p=.672, and in black-and-white F(1,40)=0.379, p=.542.

Table 5.9: Simple Main Effects - Argument/Heuristic - Q2

Level of Color/BW	Sum of Squares	df	Mean Square	F	p
Color	0.032	1	0.032	0.183	.672
BW	0.067	1	0.067	0.379	.542

This outcome contrasts with that seen in literature, whereby results suggest that the average healthiness scores are significantly higher when viewing (traffic light) colored labels [32]. In Andrijana Gabor et al's study, which focused only on chocolate bars, participants were more likely to look at the nutrition labels because the healthiness differences were nuanced. In contrast, the experiment conducted in this thesis included a wider range of products. Consequentially, this drastic difference in experimental design is likely the reason for the contrasting outcomes.

In Table 5.10 the results of a simple main effects analysis with different levels of argument and heuristic use is carried out in the context of color on the answers given to question 2. The analysis suggests that in the case of both the Nutriscore and GDA label, there was no significant effect on the outcome to this question, F(1,40)=0.689, p=.412, and F(1,40)=0.562, p=.459, respectively.

Table 5.10: Simple Main Effects - Color/BW - Q2

Level of Argument/Heuristic	Sum of Squares	df	Mean Square	F	p
Nutriscore	0.121	1	0.121	0.689	.412
GDA	0.099	1	0.099	0.562	.459

5.3. Discussion

The results from the eye tracking study show that the effect of color on attention is strongly context dependent. Label information format in isolation didn't significantly affect dwell time, although when combined with different color contexts an interaction effect between the variables arose. All in all, color enhances attention when it reduces cognitive load, whereas heuristic labels already guide consumers toward easier processing.

6
General Discussion

The main objective of this study was to investigate how variations in nutrition label information design (color and label information format) effect consumers' visual attention to nutritional information. This research objective was chosen to better understand how specific design choices in nutrition labels shape the way consumers attend to and interpret nutritional information. In the following sections the meaning behind the results obtained will be discussed, the relevance will be highlighted, research limitations tackled, and suggestions for future studies proposed.

6.1. General Discussion

This thesis explores the effect of the use of color in nutritional label design on visual attention, with a moderating variable: label information format. The standalone effects of color on consumer attention was assessed by means of a meta-analysis. The meta-analysis didn't reveal a conclusive effect of color on attention, but rather revealed that there was likely a confounding variable at play, namely, label information format [83]. To investigate whether this acted as confounding variable an eye-tracking experiment was designed and performed. The main finding was that especially in the case of GDA labels, adding color has a significant effect on consumer attention. While in the setting of Nutriscore labels, this effect is not significant. These results suggest that the effect of color on consumer attention is significantly influenced by label information format. Although this research doesn't design an 'optimal' nutrition label, it does uncover which label features affect consumer attention, and specifically what combinations do so best, providing inspiration for future research. The scientific relevance and practical implications of this study will be discussed in the following sections.

6.2. Scientific Relevance

The eye-tracking study hypothesized (H1) that consumers will fixate longer on black-and-white nutritional labels than on color-coded nutritional labels. The second hypothesis (H2) sounded as follows: the effect of color-coded nutrition labels on attention is moderated by label information format. In the following paragraphs these hypotheses will be discussed when held against the obtained results, shedding light on their scientific relevance.

6.2.1. Color Shortens Dwell Time Duration

The meta-analysis doesn't provide support for the hypothesis that consumers spend more time looking at black-and-white nutrition labels than colored ones. The pooled effect of color on dwell time was not statistically significant, and had confidence intervals spanning zero, implying that there was no consistent directional effect among the studies. The included studies varied in label format and experimental design, likely stunting the appearance of a systematic effect of color on attention [32, 78, 33]. This patterns is in line with prior research reporting inconsistent or context-dependent effects of color on consumer attention, rather than a robust main effect of color alone [80]. The heterogeneous nature of the studies in combination with the results suggests that color doesn't universally affect attention, but rather that its effect is contingent on a confounding variable. Consequently, the fact that no significant pooled effect was uncovered doesn't necessarily imply that color is irrelevant in label design, rather that its impact on attention might depend on other variables [22, 68, 80].

6.2.2. Label Information Format Moderates the Effect of Color on Visual Attention

The results from this study reveal that cognitive demand plays a significant role in drawing visual attention to nutritional labels. In line with H2, significant differences in dwell times arose when label information format was considered in combination with color.

Argument-based labels (GDA) showed significantly higher dwell times when presented in black-and-white versus when color was used. This finding aligns with dual-process theories of information processing, proposing that heuristic cues reduce the need for extensive cognitive processing (as is required for systematic processing pathways) by enabling more intuitive and faster judgments [13]. In this context, it seems that color acts as a heuristic cue that shifts processing from systematic to heuristic pathways, thereby reducing dwell time.

For heuristic-based labels (Nutri-Score), the introduction of color posed a much weaker effect on dwell time. This is consistent with the idea that in information communication "less is more" [36]. Once a label already facilitates rapid interpretation, adding further heuristic cues yields diminishing results. Scientifically speaking, this implies that attention isn't governed by the number of design features included in the label, but rather by their interplay, and how adding such features affects the label's cognitive demand.

The combination of these findings contribute to a more refined understanding of how visual attention to nutritional labels emerges from the interaction effects between color and label information format. This interaction between color and label information format has not been explicitly reported in the existing literature reviewed for this thesis.

6.3. Practical Relevance

This study provides actionable insights into how nutritional labels can be designed to optimize consumer attention. The findings offer practical value for both policymakers and practitioners involved in nutritional communication and packaging design.

From a policy perspective, the results suggest that color should be used selectively, depending on the cognitive demand imposed by the label feature, in packaging rather than applying it to all aspects of the package [36]. In particular, the findings reveal that color is most effective when applied to argument-based labels (like GDA labels) where the cognitive demand is otherwise high. Policymakers could use this insight when designing or revising FOP labels to enhance attentional engagement. This insight is useful specifically in situations where there is a high level of information complexity and risk of consumers not being able to take up all the information [93]. By applying color in a targeted manner this aligns with the principles of nudging, whereby subtle design changes can steer consumers towards making healthier choices without restricting their choice freedom [87].

For both designers and practitioners, the insights from this study can provide guidance to develop effective labels. Rather than adding color to already intuitive formats, designers can achieve a greater impact by using color to reduce cognitive load in more complex labels [70]. For example, they could look into redesigning GDA labels with optimized color coding to increase attention to nutritional attributes that might otherwise be overlooked. These insights would shift the role of color from serving an aesthetic purpose to also serving a functional one that supports information processing.

Companies are another party that could also benefit from applying these findings. By strategically applying these insights, consumer attention could be guided towards certain product attributes like health claims or premium qualities. Deliberately combining color and label information design would allow companies to engineering their packaging in such a way that their products could be differentiated more effectively on crowded shelves, potentially increasing consumer engagement and thereby purchase likelihood [3].

Overall, this study provides insights that can be used in an actionable manner to create effective nutritional label design. The results suggest that rather than isolating visual features, it is important to focus on aligning these features (color) with cognitive demands of the information presented. Applying this knowledge could help in achieving public health objectives, as well as informing design decisions in commercial food marketing.

6.4. Research Limitations

6.4.1. Limitations of the Meta-Analysis

A significant limitation of the performed meta-analysis is that it was performed by one individual, therefore although the search strategy was extensively documented, the vocabulary of the researcher and means of researching may have added a bias to the results found [48]. Since a meta-analysis focuses on articles that are found and deemed applicable to the study, this bias could result in missing data that another party might have uncovered [31]. To compensate for this, a future meta-analysis could focus on a compilation of studies found by multiple researchers, and the searches could span over more databases.

This meta-analysis compares a number of different studies all focused on incorporating color in nutritional labels for food packaging, however there are numerous variations among the studies. For example, the product category under investigation differed between the studies, some focused on solely chocolate bars while others focused on crackers [32, 78]. To make the meta-analysis more coherent, and the effects more comparable, studies with similar study designs could be compared [31].

6.4.2. Limitations of the Eye-Tracking Experiment

The experiment was conducted in various environments, therefore external factors like lighting, noise, distractions, etc. varied among the trials. Although these settings closely resemble a supermarket in which consumers would typically study food packaging, these varying external factors could have an impact on the results [28]. At the end of the survey a question was posed: *Is there anything you would like to share about this experiment?*. This question was answered by one participant mentioning that the setting was noisy and thereby slightly distracting. This response suggests that some participants may be more affected by the noisy surroundings than others, influencing their responses throughout the experiment [81]. Had the experiment been performed in a laboratory setting, the results would have been more reliable since external factors could be controlled [41].

The survey question revealed that participants found the packages presented in the experiment to look realistic, but that they more closely resembled value brands than leading brands. This affected the product perception that they had [25]. In turn also influencing their judgment and response to the product, since the results also showed that prior knowledge played a significant role in their assessment of products [59]. To avoid this predicament in future research, more packaging designs could be developed, after which a pretest with independent participants could be used to select the most representative designs for application in the experiment [10].

The Pupil Core glasses that were used throughout the experiment were challenging to adjust to the specific facial features of all participants. Consequentially, not all experiments yielded equally accurate gaze data, because sometimes participant's pupils would no longer be in view of the glasses' camera [74]. Low confidence intervals for the gaze data resulted in exclusion of some data points from analyses, shrinking the data sample. The participants were able to move freely once fitted with the eye-tracker. However, this introduced the risk that head movement caused the glasses to shift relative to the eyes, affecting the accuracy of the eye-tracking data [92]. Future studies could personalize the fitting of the glasses more to the participants and provide a chin rest for participants to stabilize their head, improving the accuracy and reliability of the gaze data.

The sampling for this experiment was done through convenience sampling, which resulted in a homogeneous group of participants (as can be seen primarily in nationality of participants), this takes away from the generalizability of the results [1, 37, 56]. The entire survey was in English which made its comprehension difficult for some participants who didn't have English as native language [44]. This could have influenced the answers given to the questions throughout the experiment.

6.5. Future Research

This study is a stepping stone towards better understanding how design influences consumer attention in terms of color under the influence of label information format. Future work may build on these findings in a number of ways.

First, future studies could replicate the experiment performed with a larger and more diverse sample to better validate the results. When accumulating such a sample it would be important to focus on increasing diversity within the sample to make the results more generalizable, especially in terms of nationality and general healthiness (BMI) [8]. In the present study, the sample was attained through convenience sampling. This resulted in the sample not being very diverse in terms of nationality and healthiness, therefore, making it not representative of the general population [1, 56]. Culture and general healthiness are variables that influence food perception and therefore could affect the responses of the participants in the present study [71, 77].

Secondly, the eye-tracking experiment could better resemble a food shopping setting by using more unfamiliar products [45]. The current study focuses on an experimental setting with packages of products that consumers are largely familiar with. In a setting whereby consumers shop for foods, like in a supermarket, they might run into more products they are unfamiliar with and therefore be prompted to infer about the nutritional information of said product before making a purchasing decision [91]. Therefore, this could make the findings of such research more insightful.

Thirdly, the current research suggests that when combining color with information design this affects attention. Future studies could further investigate whether this is the case for all colors, or whether specific color pallettes or hues yield a more significant effect than other [53, 4]. Research in color psychology indicates that colors are associated with distinct emotional responses [34, 24]. Consequently, the use of different colors could evoke different reactions from consumers, which might affect their product perception. For example, blue is typically associated with calmness, which, when incorporated into a food label, might influence how the product is evaluated [34].

Fourthly, it could be insightful to investigate the impact of other heuristic features on consumer attention. Research suggests that there are three heuristic categories that influence a consumer's perception of the product: "affect heuristic", "natural-is-better heuristic", and "trust heuristic" [63]. The first refers to the heuristics that promote an instinctive feeling in the consumer, the second prompts the consumer to believe the product is 'naturally-made', and the latter evokes a sense of trust (like an organic label) [63]. A new eye tracking experiment could be performed, testing a wider array of product packages that include such elements. All three of these heuristics could be tested, and by means of a 3x3 experimental design, it could be determined what the impact of each heuristic is and what their interaction effects are [16].

Lastly, the design of the experiment could be expanded to include additional behavioral outcomes. Currently, the study focuses on attention. However, if participants are instructed, for example, to purchase a healthy product or detect changes in labels, they might make entirely different choices [7]. This might reveal that with a goal in mind rather than just accumulating information, other decision strategies and processing patterns are activated [79].

7 Conclusion

Nutritional labels on food packaging serve a unique purpose of conveying information to educate a consumer about a product's healthiness, typically urging them to choose a healthy option. Whether or not these labels work effectively depends on whether the consumer is able to process the portrayed information to make a purchasing or consumption decision. A crucial step of this decision making process is attracting consumer attention. Within this process, visual attention represents a critical gateway: without attention, further cognitive processing cannot occur. There is therefore a need to understand exactly what design elements play a role in attracting said attention to design effective labels.

Previous studies have investigated whether color is a design feature powerful enough to dictate whether a consumer pays more attention to a label in its presence, however, the existing evidence remains inconclusive. This ambiguity was confirmed by the meta-analysis conducted in this thesis, which subsequently motivated a more focused research objective, namely: *to determine how different combinations of label information format and color influence consumers' visual attention to nutritional information*. To address this objective, an eye-tracking study was conducted in which participants completed a survey and gaze data were collected.

This study generated instrumental results for the moderating effect of label information format and color on consumer attention to nutritional labels. Table 7.1 shows the results per hypothesis. The meta-analysis was unable to uncover an effect of incorporating colors in labels on attention (H1), but did catalyze the search towards a confounding variable.

Hypothesis 2 is accepted, the findings indicate that processing time depends on whether heuristic cues are present to shift consumers from systematic to heuristic processing. The results from the eye-tracking experiment argue that there is a significant interaction effect between color and label information format on visual attention.

Table 7.1: Research result indicating hypothesis acceptance or rejection.

#	Hypothesis	Result
1	Consumers will fixate longer on black-and-white nutritional labels than on color-coded nutritional labels.	Rejected
2	The effect of color-coded nutrition labels on attention is moderated by label information format.	Accepted

This study shows that color doesn't work as a universal attention enhancer, but rather as a contextual heuristic cue whose effectiveness depends on the cognitive demands imposed by label information format. By demonstrating that visual attention comes from the interaction between heuristic and systematic processing, this study advances understanding of why previous research produced inconsistent results. It provides a more precise account for how nutritional label design can influence consumer attention.

A

PRISMA Reporting

A.1. Defining Research Question using PICO Framework

The PICO framework, which stands for population, intervention, comparator, and outcome, is a framework that assists in formulating a research question that is focused and well structured [54].

Table A.1: A table depicting how the research question was defined using the PICO framework.

PICO element	Description
Population	Consumers who have been exposed to food packaging
Intervention	Nutrition labels that incorporate color to improve the perception of the labels (for example, traffic light labels)
Comparator	Black-and-white labels
Outcome	Attention, as measured per eye-tracking methods (dwell time, fixation count, area of fixation, and time to first fixation (TTFF))

By incorporating all of the insights from the PICO framework dissection illustrated in Table A.1 the following research question was developed: What is the effect of color on consumer attention to nutritional labels?

A.2. Defining Inclusion and Exclusion Criteria

To assess what literature should be included in the meta-analysis portion of this research a selection was made based on a number of inclusion and exclusion criteria. The criteria were developed to filter out studies that didn't fit in line with what was intended to be inferred.

Table A.2: A table defining the inclusion and exclusion criteria used to assess whether articles could be used for this study's meta-analysis.

Criterion	Inclusion	Exclusion
Study Design	Experimental studies that use eye tracking	Solely qualitative studies, meta-analyses, conference abstracts, and reviews
Population	Humans with normal vision, exposed to food packaging	Animal studies and studies whereby exposure to non-food items is tested
Intervention	Colored labels	Black and white labels and no labels
Outcome	Eye tracking metrics (dwell time, fixation count, area of fixation, and time to first fixation (TTFF))	Survey data
Language	English	All other languages

Table A.2 defines the criteria that determine whether a study should be included or excluded from the meta-analysis done for this research.

A.3. Systematic Review Protocol

A review protocol was drafted in order to increase the study's reproducibility. The current study was carried out by a single author, therefore, in order to ensure that the same results are obtained if the study were to be carried out a second time, a detailed protocol was developed to depict exactly how the research was done.

A.3.1. Title

The Effect of Color in Nutrition Labels on Consumer Visual Attention

A.3.2. Background and Rationale

Nutrition labels exist to aid consumers in making healthier food choices, but they are often overlooked by consumers, defeating their entire point. Through the incorporation of visual design elements such as color, it is possible to alter consumer attention, which could in turn lead to better processing of the information. Eye-tracking methods present a scientific approach to measure said attention. Though numerous studies in this direction have been conducted, no meta-analysis exists linking eye-tracking metrics to consumer attention in this setting.

A.3.3. Objective

To perform a systematic review and meta-analysis that provide an insight into the effect of color incorporation in nutrition labels on visual attention, as measured by eye-tracking methods.

A.3.4. Eligibility Criteria

See Table A.2 for a detailed depiction of the inclusion and exclusion criteria valid throughout this systematic literature review.

A.3.5. Sources of Studies

Numerous databases were used in order to find studies that could be used in this research's review. The databases that were used are: PubMed, PsycINFO, Web of Science, and EBSCOhost. Searching the reference lists of included studies by hand will also be done.

A.3.6. Search Strategy

A Boolean query was formulated and plotted in each of the databases to accumulate a number of articles for evaluation. No data limits were applied to the search, however, a limit was set in terms of only analyzing English articles.

A.3.7. Study Selection
The manner by which studies were selected is elaborately depicted in subsection 3.2.3.

A.3.8. Data Extraction
To extract the appropriate data a standardized list was created, whereby the same data was extracted each time from each of the articles. The data that was extracted reads as follows:

- Authors, year, country, sample size, publisher
- Participant demographics (age, gender)
- Study set up (what intervention was used and how was the experiment designed)
- Outcome metric (dwell time, fixation count, area of fixation, and time to first fixation (TTFF))
- Statistical data associated with outcome metric (mean, standard deviation, sample size)
- Effect size

A.3.9. Data Synthesis
In this section the main outcome of the data is deduced. Using a meta-analysis the standardized mean difference of attention is quantified, and this data is translated into a statement that answers the previously proposed research question. A heterogeneity assessment is also conducted, to determine deviancy between the data.

B

Final Article Selection and Data Extraction

Table B.1 presents the data that has been extracted from the three articles included in the meta-analysis carried out in this research. It presents article names and corresponding data points that follow from the studies.

Study	Author(s)	Colored label			Non-colored label			Effect size	Variance	SE
		Dwell [ms]	N	SD [ms]	Dwell [ms]	N	SD [ms]			
Effect of different nutrition labels on visual attention and accuracy of nutritional quality perception: Results of an experimental eye-tracking study [32]	Andrijana Musura Gabor, Bojan Stojnic, David Ban Ostic	2,080	76	2,314	2,504	76	2,278	-0.1846	0.0264	0.1626
Advantages of graphical nutrition facts label: faster attention capture and improved healthiness judgement [33]	Zhibing Gao, Ziang Li, Xianging Zhuang, Guojie Ma	5,164	60	1,970	5,292	60	2,045	-0.0637	0.0334	0.1826
Salient nutrition labels shift peoples' attention to healthy foods and exert more influence on their choice [78]	Qendresa Rramani, Ian Krajbich, Laura Enax, Lisa Brustkern, Bernd Weber	412	50	168	506	50	199	-0.5104	0.0413	0.2032

Table B.1: Summary of studies on nutrition labels, dwell times, and effect sizes.

C

Calculating Meta-Analysis Variables

A meta-analysis includes a number of mathematical computation in order to translate collected raw data into values relevant for the comparative literature study. The fundamental variable that needs to be calculated in a meta-analysis is effect size, of which the standard error also needs to be calculated.

In order to go about calculating the effect size a standardized mean difference is calculated, commonly referred to as Cohen's *d*. This variable quantifies effect size, and due to its standardized nature, it makes it easy to assess what the meaning is behind its magnitude. A standard mean difference of 0.2 or smaller means that there is a small effect, while a value of around 0.5 indicates a moderate effect, and 0.8 or larger signifies a large effect [43].

The formula for Cohen's *d* is noted in Equation C.1 [43].

$$d = \frac{\bar{x_1} - \bar{x_2}}{s_{pooled}} \tag{C.1}$$

To calculate s_{pooled} the formula in Equation C.2 is used, whereby s_1 and s_2 resemble the standard deviation for the groups in the trials (colored and non colored label respectively) [43].

$$s_{pooled} = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{(n_1 - 1) + (n_2 - 1)}} \tag{C.2}$$

Once the effect size is quantified, the standard error associated with this variable can be calculated according to Equation C.3 [43].

$$SE_d = \sqrt{\frac{n_1 + n_2}{n_1 \times n_2} + \frac{SMD_{between}^2}{2(n_1 + n_2)}} \tag{C.3}$$

Since all studies measure dwell time in the same direction and on a time scale, the effect size and its magnitude is of importance. This is because all values collected will be positive (in terms of time). Therefore, the value obtained for the effect size will indicate whether there is a positive or negative relationship between the variables dwell time and color of nutrition label (consumer visual attention and label design), and the effect size will give an insight into the magnitude of this effect.

D

Data Analysis Code

The following link can be used to access a copy of the Python code used to perform the data analysis portion of the eye tracking experiment:

https://github.com/babettejacobss/MOT-Thesis

The way that the code functions is explained in detail in subsection 5.1.5. In order to run the code from the link above, the file paths must be adapted accordingly.

E
Reference to AI Usage

Throughout this project AI tools were used. Perplexity and NotebookLM were used to assist in performing the literature search associated with this research. Both of these tools were used to scour the internet for relevant articles and papers, and to help in critically analyzing their contents. These tools were used in a supportive manner, whereby they were used to supplement manual searches as opposed to being the main method of searching.

ChatGPT was used to assist in writing the thesis report. This tool was used to improve the quality of english in some sections of the report and to help in finding synonyms. The tool was also used to brainstorm changes in the thesis' structure and idea generation. Additionally, ChatGPT was used to help in writing the data analysis code for the eye-tracking experiment portion of this thesis.

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