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Review

Eye tracking and nutrition label use: A review of the literature and recommendations for label enhancement

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ABSTRACT

Nutrition labels on food packages are among the most prominent and far-reaching policy measures related to diet and have the capacity to promote healthy eating. Unfortunately, certain nutrition label characteristics may impede consumer detection and comprehension of labels. Research using precise cameras monitoring consumer visual attention (i.e., eye tracking) has begun to identify ways in which label design could be modified to improve consumers' ability to locate and effectively utilize nutrition information. The present paper reviews all published studies of nutrition label use that have utilized eye tracking methodology, identifies directions for further research in this growing field, and makes research-based recommendations for ways in which labels could be modified to improve consumers' ability to use nutrition labels to select healthful foods.

Introduction

Most consumers report being motivated, at least in part, by health considerations when making food choices (Glanz et al., 1998). These health-motivated consumers are more likely to seek information to help them assess the healthfulness of various food options (Hess et al., 2012). Unfortunately, even consumers motivated to select healthful foods are sometimes unsuccessful in accurately assessing food healthfulness due to barriers in comprehending nutrition information (Grunert et al., 2010). In addition to barriers related to consumer characteristics, such as low nutritional knowledge (Hendrix et al., 2008), other barriers exist that are directly linked to product characteristics. These barriers relate to the manner in which the nutrition information is presented: label location, size, color, and format can all influence whether the label is viewed by a consumer, and how readily it is understood.

The degree to which these product characteristics serve as impediments to consumer acquisition of health information depends upon the presentation format of the nutrition label; thus, label formatting represents an important opportunity for improving consumer ability to acquire and comprehend nutrition information. A large body of research has examined consumers' self-reported use of nutrition labels (see Cowburn and Stockley (2005) and Grunert and Wills (2007) for reviews), but self-reporting of nutrition label use is limited in several important ways: individuals may overestimate their use of labels in order to appear more health-conscious, they may misremember their usual level of attention to labels, and they may not be aware of the parts of the label they tend to look at versus the parts they ignore, making it difficult to report attention to specific nutrients.

Eye-tracking research is becoming more common in this field as an objective way of monitoring consumer attention to nutrition labels; indeed, eye tracking is a key component of the EU-funded massive assessment of nutrition labeling, Food Labeling to Advance Better Education for Life project (FLABEL; Storcksdieck genannt Bonsmann et al., 2010). In eye tracking, high-speed cameras precisely record a participant's gaze to assess visual attention. These cameras are mounted either on a flat, stable surface like a desk or are worn by the participant (e.g., using cameras mounted on a pair of glasses).

Recently, researchers have begun investigating nutrition label use with eye-tracking cameras to monitor consumers' visual attention to nutrition information. Although simply viewing nutrition information does not guarantee understanding the information or using it to guide food selection, viewing the information is a necessary precursor to utilizing it. This eye tracking research is still in its early stages, but already consistent themes are emerging which indicate steps that can be taken to enhance nutrition labels

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such that consumers would be better able to locate and interpret nutrition labels.

The present review synthesizes the existing research findings from, to the best of our knowledge, all published, peer-reviewed research using eye-tracking methodology to assess consumer attention to nutrition labels. The studies' collective implications for design of nutrition labels and food packages is discussed, as well as relevance of this body of research to current food labeling policy in the EU and US, and attention is given to areas in particular need of additional research.

Strengths and limitations of eye-tracking research

Traditionally, research on nutrition label use has involved self-report methodology: consumers indicate whether they read nutrition labels when making choices related to food purchase and/or consumption and also whether they understand the content of these labels (for review, see Cowburn and Stockley, 2005). This methodology provided important early insights about consumer use and understanding of nutrition labels; however, researchers have recently reported that such self-report measures may significantly overestimate actual rates of label use and comprehension (Cowburn and Stockley, 2005; Grunert et al., 2010). To arrive at more accurate estimates of label use, eye-tracking technology precisely tracks the location and duration of visual attention using high-resolution, high-speed cameras that record, up to 1000 times per second, exactly where an individual is looking (Duchowski, 2007; SR Research, 2010).

In addition to the precision and objectivity of measurement, eye tracking provides other benefits to the study of nutrition label use. For example, this type of research is less susceptible to social desirability among research participants – whereas individuals being directly questioned about their nutrition label use may provide inflated responses to align with what they perceive to be more acceptable or popular behaviors, the demand characteristics present in an eye tracking study may be less salient, and the behavior being monitored may be more instinctive. In an eye tracking study, participants can view foods while their eye movements are monitored – and, importantly, they can do so before ever responding to a question about health or nutrition; thus, any attention to the nutrition label during the viewing task is more likely to have been driven by habit than by demand characteristics involved in subsequent questions regarding health and nutrition. It is important to note that some participants may suspect the researcher is interested in nutrition label use, rather than purchasing behavior, product marketing, or whatever the ostensible purpose of the research may be. In addition, nutrition label use, like any behavior observed in a laboratory, may be affected by simply being observed; merely participating in a research study can influence an individual to behave differently from how she would behave outside of the study context (the so-called subject bias).

Along with the benefits of eye tracking, it should be mentioned, of course, that eye tracking also has limitations. One limitation is that research utilizing eye-tracking methodology may lack realism for study participants. One or more factors involved in eye-tracking research will typically be unrepresentative of the manner in which actual food choices are made (i.e., studies may occur in a laboratory with participants seated at a computer where a desk-mounted eye tracker monitors their gaze, or participants may traverse a more naturalistic setting, but may do so while wearing an eye-tracking apparatus that they would not typically wear). In addition, knowing that eye gaze is being monitored could influence one to behave differently from how he/she might behave when not being monitored. Nevertheless, eye tracking is less obtrusive compared to other methods employed to understand consumer use of nutrition information (e.g. supermarket observations or think-aloud methods). Moreover, it provides the most detailed information on consumers' visual attention.

Another limitation is that eye tracking does not tell us about the cognitions underlying eye movements (i.e., researchers can see *what* people are looking at, but not *why* they are looking at these things). If an individual does not look at a nutrition label when viewing a product, the non-attending may be because he or she is uninterested in nutrition information; on the other hand, if this is a familiar product, it is also plausible that a person who does not view the label may be extremely interested in nutrition information and may have previously viewed this label extensively and learned it sufficiently well to feel that further examination is unnecessary. Indeed, eye tracking is sensitive to a participant's familiarity with the visual display (Pieters et al., 1996, 1999) because familiarity allows the participant to retrieve relevant, previously-viewed information from memory. This concern regarding familiarity with products could be addressed in research by using products stripped of brand names (as in Graham and Jeffery (2011, 2012)) or by presenting unfamiliar products (e.g., foreign brands or specially-designed packages, as in van Herpen and van Trijp (2011)). Moreover, to improve the interpretation of data acquired via eye-tracker, it is useful to interview the participants after the eye-tracking task and inquire what they were thinking during the task. This can be done while showing the participants their eye-tracking recordings, for instance in a retrospective think-aloud task. Finally, it should be noted that using eye tracking technology can be relatively expensive and time-consuming.

Methods

Literature search

To identify all published studies that utilized eye tracking methodology to study nutrition label use, we first searched for publications in the databases PubMed, PsycINFO, and Google Scholar using search terms such as eye track* and nutrition label. Search terms used, number of hits per search, and number of suitable publications retrieved can be found in Table 1. The suitability of the publications for inclusion in this review was based on reading the abstract and, when necessary, portions of the publication. In addition to the search engines used to locate relevant publications, one study was identified through personal contacts with the authors. This resulted in a total of nine publications of which the primary results are detailed in the "Results and Discussion" section below and outlined in Table 2. Moreover, results of these nine studies are discussed in the light of findings from other studies and theoretical frameworks.

Results and discussion

Eye-tracking research on nutrition label use has identified several nutrition label characteristics which make it more difficult than necessary for consumers to locate and comprehend nutrition information. Label location is one such factor. Graham and Jeffery (2011) reported that consumers spend over 30% more time viewing nutrition labels located in the center, compared with the sides, of a visual plane (i.e., their study employed a computer screen as the visual plane, but the results may translate well to the rectangular visual plane characteristic of many food packages). In addition to location *of* the label, location *on* the label also relates to consumer viewing of nutrition information (Graham and Jeffery, 2011). Nutrients located nearer to the label's top receive more visual attention from consumers, a pattern which is inconsistent with consumers' self-reports of the nutrients they believe merit

Table 1
Literature search terms, databases used, and results returned.

	Source	Search terms	# of hits	# of suitable hits	Publications[a]	# duplicates
1	PubMed	Eye track* and nutrition label	7	5	Goldberg et al. (1999), Graham and Jeffery (2011, 2012), van Herpen and van Trijp (2011) and Visschers et al. (2010)	0
2	PubMed	Eye track* and nutrition table	2	1		1
3	PubMed	Eye track* and nutrition information	5	4		4
4	PubMed	Eye track* and food package	1	1		1
5	PubMed	Eye track* and food information	7	5		5
6	PubMed	Visual attention and nutrition label	19	2		2
7	PsycINFO	Eye track* and nutrition	3	3	Jones and Richardson (2007), Bialkova and van Trijp (2011)	1
8	PsycINFO	Visual attention and nutrition	1	0		0
9	Google Scholar[b]	Eye track and nutrition label	10	3		3
10	Google Scholar[b]	Visual attention and nutrition label	10	3		3
11	Google Scholar[b]	Eye tracking and food package and nutrition label	10	3	Orquin and Scholderer (2011)	2
12	Personal contacts		1	1	Orquin et al., (submitted for publication)	0
Total			77	31		22
Included in current paper (# of suitable publications – # of duplicates)						9

[a] Only new results (i.e., those not retrieved from earlier searches) are presented.
[b] Because Google Scholar retrieves a very large number of results for the tested combinations of search terms, only the most relevant (i.e., the first 10) search results were considered.

greatest attention (i.e., although an individual may report that a nutrient near the top of a nutrition label is equally important to view as another nutrient near the bottom of the label, she is actually more likely to view the nutrient at the top of the label). Similarly, consumers appear to find information located in the center of the label, which is the densest area, more slowly than information at the top or bottom of a label (Goldberg et al., 1999). Thus, modifying both the location of the label itself and the locations of nutrients on the label could lead to consumers spending more time viewing the most health-relevant nutrients.

There are also other ways in which a nutrition label itself could be modified to increase its visual salience and thereby its ability to attract consumer attention. It has recently been demonstrated that increased visual salience of nutrition labels is associated with decreased time to first gaze fixation on the nutrition label (Orquin et al., submitted for publication) and higher attention capture (Orquin et al. (submitted for publication)), meaning that more salient nutrition labels are likely to be seen more quickly and more often than less salient nutrition labels. Visual salience can be manipulated by changing the color, contrast or orientation of the object (Itti et al., 1998), and through the presence of anchor lines on the label (Goldberg et al., 1999). Moreover, the presence of the traffic light system in addition to the nutrition table draws people's attention to the personally relevant nutrients (Jones and Richardson, 2007). Visual salience is measurable using computer algorithms of human vision (Itti and Koch, 2001).

Another way of increasing the salience of nutrition labels is by increasing the surface size of the label. It has been demonstrated that surface size increments are associated with decreases in time to first fixation and increases in attention capture (Orquin et al., submitted for publication). Surface size increments seem to operate independently of visual salience, perhaps by increasing the probability that a given area will be fixated upon, although the effect of size increments varies both between stimulus types and within stimulus areas (Wedel and Pieters, 2006). Increasing the visual salience and surface size of nutrition labels thus represent two different strategies associated with greater attention capture and faster localization of nutrition labels. The speed with which consumers are able to locate nutrition labels could be particularly important considering that eye tracking research focusing on in-store purchase behavior has shown that consumers spend as little as 2 s inspecting each product (Clement, 2007).

Studies of consumer comprehension have suggested similar ways that label design can be modified to improve consumer understanding of the information being communicated by nutrition labels. Consumers report better understanding for labels that are color-coded (i.e., Traffic Light labels which indicate high, medium, and low levels of particular nutrients to limit by coloring them red, amber, and green, respectively) compared with monochromatic labels (Borgmeier and Westenhoefer, 2009; Kelly et al., 2009).

Finally, eye-tracking research indicates that nutrition label use could be improved in at least one way that does not impact the label at all. Consumers devote a very limited amount of time to viewing foods both inside and outside of the laboratory (Clement, 2007; Russo and LeClerc, 1994). This implies that as the number of components included on a food package increases, the amount of time spent looking at any one is likely to decrease. Visual "clutter" surrounding the nutrition label can therefore lower attention to nutrition labels (Visschers et al., 2010). Thus, reducing the number of total features found on food packaging could increase consumer attention to the nutrition label independent of any changes to the label itself. Moreover, specific features of food packages contribute to the amount of perceived clutter and, consequently, consumer attention, such as the variability of colors and the contrast between the target stimulus and its background (Rosenholtz et al., 2007).

According to attitude models, such as the Elaboration Likelihood Model (ELM; Petty and Cacioppo, 1986), elaboration of information is determined by motivation and ability. Although attention capture does not necessarily lead to elaboration it does indicate information acquisition (Duchowski, 2007) which constitutes a necessary but not sufficient condition for elaboration (Bialkova and van Trijp, 2010). To the extent that attention capture identifies elaboration, research findings on consumer attention to nutrition information seem consistent with ELM predictions; for example, it has been shown that motivation and ability relate independently and interactively to elaboration of nutrition information (measured, for instance, as dwell time – milliseconds spent looking

Table 2
Nutrition label components/characteristics related to label viewing.

Label component/characteristic	References
Label location	Graham and Jeffery (2011)
Position of nutrients on label	Graham and Jeffery (2011) Goldberg et al. (1999)
Visual clutter surrounding label	Visschers et al. (2010)
Label size	Orquin et al., (submitted for publication)
Label saliency	Orquin et al., (submitted for publication) Bialkova and van Trijp (2011)
Anchor lines	Goldberg et al. (1999)
Label simplicity	van Herpen and van Trijp (2011)

at the label). Increases in motivation lead to increased attention to nutrition information (Bialkova and van Trijp, 2011; Orquin and Scholderer, 2011; van Herpen and van Trijp, 2011; Visschers et al., 2010) independent of ability. Similarly, increases in consumer ability to comprehend nutrition labels (operationalized as improvements in ease of label use) lead to increased attention to labels independent of motivation (Bialkova and van Trijp, 2011; Orquin et al., submitted for publication; Visschers et al., 2010). Motivation and ability furthermore seem to interact with greatest attention to nutrition information when both motivation and ability are high (Bialkova and van Trijp, 2011).

According to the ELM and the existing body of eye tracking and nutrition label use research reviewed in this paper, the label enhancements described above are most likely to benefit motivated consumers. Importantly, the reviewed studies also suggest that increasing ability to comprehend nutrition information has an effect on behavior independent of motivation, meaning that enhanced nutrition labels could provide substantial benefit even to consumers lacking a strong health motivation. Label enhancements described here are consistent with theories on persuasive design (Fogg, 2009), which predict that positive changes in lifestyle are best accomplished by increasing ability rather than motivation. Whereas motivation can be difficult to increase meaningfully, ability is relatively easy to manipulate via improvements to situational barriers and distractions (Fogg, 2009). In short, the enhancements detailed here could make nutrition labels easier for consumers to locate and comprehend, providing consumers with the means to make more healthful food choices.

Conclusions

The existing body of eye-tracking research examining nutrition label use is small, but has shown substantial recent growth. Use of this methodology has produced several useful findings related to consumer use of nutrition labels. To review, the eye-tracking evidence to date suggests the following label characteristics can enhance consumer's ability to use labels effectively:

- Labels positioned centrally.
- Nutrients positioned according to health relevance.
- Visual clutter surrounding nutrition labels reduced.
- Visual salience of nutrition labels increased (e.g., using contrast and/or orientation).
- Surface size of nutrition labels increased.
- Simplifying heuristics incorporated.

These features should not be considered an exhaustive list of nutrition label characteristics related to consumer understanding and use of labels. Future research is likely to expand on this list, and there are several areas that merit additional investigation. First, there are undoubtedly additional characteristics of nutrition labels and food packages that influence consumers' attention towards nutrition information beyond those identified in the extant research. It is known that characteristics such as location, nutrient order, and label size can affect visibility, but these characteristics could be explored in greater depth, and there are other characteristics of nutrition labels that may also be relevant, such as type face and pictograms. Moreover, other nutrition information formats (e.g., a logo or front-of-package table) should be compared to nutrition tables (see Jones and Richardson, 2007; van Herpen and van Trijp, 2011) to identify optimal modes of presentation.

In addition, more research is needed investigating label enhancements on various packages, different types of products (e.g., those believed by consumers to be more versus less healthful), and in specific consumer segments (see Graham and Jeffery, 2012). It should, for example, be examined how the relation between clutter and package design can be optimized in order to increase the visibility of the nutrition information, and what kind of nutrition table format will be noticed and understood by children or low-literacy adults. Finally, research is needed which moves beyond consumers' attention to nutrition information by also investigating the relationships between attention to labels, comprehension of nutrition information, and food selection.

Policy relevance

The findings reported here could be utilized by policy makers to improve the usability of nutrition labels in nations around the world. As one example, the Nutrition Facts Panels mandated in the US by the Nutrition Education and Labeling Act of 1990 (NLEA, 1990) are located on the rear or side panels of food packages; the present body of research suggests that these labels are likely to receive very little visual attention in their present location, and labels located on package fronts would be viewed more by consumers. In addition, prior to 2011, nutrition labeling was voluntary in the EU unless a health or nutrition claim was made on the food package. This lack of a requirement for nutrition labeling to appear meant that approximately 15% of food products in the EU lack a back-of-pack nutrition panel and 52% lack a front-of-pack label (Storcksdieck genannt Bonsmann et al., 2010).

As of July 2011, the EU Parliament agreed on a new regulation that makes nutrition labeling mandatory for all food products. This regulation was formally adopted in autumn of 2011 and will be implemented during the following 5 years. The regulation includes important aspects like mandatory nutrition facts panels on all prepackaged food products, which must state the amount of calories, fat, saturated fats, carbohydrates, sugars, protein, and salt per 100 g or 100 ml. Moreover, the regulation specifies certain legibility criteria for nutrition labels, i.e., "mandatory food information shall be marked in a conspicuous place in such a way as to be easily visible, [and] clearly legible" (European Parliament, 2011).

The regulation also states that the font size used in nutrition labels must be equal to or greater than 1.2 mm and for packages with a surface size of less than 80 cm^2 the font size must be greater than 0.9 mm. These legibility criteria seem to be in accordance with the directions proposed in this review about how to lower barriers for nutrition label use; however, it could, in fact, *reduce* the readability of nutrition information. On a package with a surface size of exactly 80 cm^2, an eight letter word, like "calories", when printed in the minimum required font size of 0.9 mm, would cover less than 0.001% of the package surface. Although no research has been carried out testing this exact font size specification yet, the studies reported in this review make it clear that size does matter for visual attention. Using the minimum allowable font size could decrease the surface size of the nutrition label and hence the probability that consumers will fixate on it; in addition this font size could lead to consumer difficulty in locating the nutrition label amidst the visual clutter created by food package elements that do not adhere to the 0.9 mm criterion.

Collectively, the body of eye-tracking research suggests the front-of-package nutrition labels are more likely to attract consumers' visual attention and to lead to healthy food purchases. Thus, mandatory front-of-package labeling could be one policy recommendation based on this research. Such a recommendation would also be consistent with other consumer research in which shoppers report liking and understanding front-of-package labels (e.g., Feunekes et al., 2008) and preferring monochromatic labels, like many FOP designs, over black and white labels, like most existing nutrition tables (see Grunert and Wills, 2007). At present, front-of-package nutrition labeling is not mandated by any policy in the United States or in the European Union (EUFIC, 2011). However, this may change in the near future, as several governments, consumer groups, and public health NGOs in Europe and the United States are in favor of introducing the traffic light color coding in their countries. This type of front-of-package system is already quite common in the UK and was recently mandated in Thailand, the first country to require front-of-package nutrition labels.

Recently, the Institute of Medicine (IOM), an independent, nonprofit organization in the United States that provides the public unbiased, authoritative reports on health-related topics released a report on front-of-package nutrition labels (http://www.iom.edu/Reports/2011/Front-of-Package-Nutrition-Rating-Systems-and-Symbols-Promoting-Healthier-Choices.aspx) in which it suggested that four key components should be included on front-of-package nutrition labels due to their particular importance for public health: calories per serving, fat (specifically trans- and saturated-fat), sodium, and added sugars. While these IOM recommendations were made with regard to reduced-content front-of-package labels specifically (and the recommended nutrients for inclusion on front-of-package labels in the US were quite consistent with nutrients typically included on multiple traffic light-style front-of-package labels in the United Kingdom), the identification of key nutrients could be instructive to a policy reformatting long-form nutrition tables as well. Given evidence that consumers are more likely to view nutrients near the tops of nutrition labels, it could potentially benefit public health to move the nutrients identified by the IOM to the top of nutrition labels.

The extant eye tracking research objectively measuring nutrition label use provides several suggestions for modifying food packaging in general and nutrition labels in particular to increase consumers' ability to easily locate and comprehend nutrition information. Theories of persuasion, like the ELM, suggest that enhancing consumers' ability to use nutrition information will result in consumers giving greater consideration to this health-relevant information when making their food choices. Thus, results from eye-tracking research indicate that consumer diet and overall health could benefit considerably from relatively small changes to the presentation of nutrition information on food packaging.

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