W 1282

AN INTRODUCTION TO EYE-TRACKING RESEARCH: USES AND APPLICATIONS TO IMPROVE THE UNDERSTANDING OF HUMAN BEHAVIOR AND DECISION MAKING

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Introduction – What Is Eye-tracking? How Is It Useful?

The Research, Education and Marketing Lab (R.E.M. Lab or the lab henceforth) was founded in 2021 to improve understanding of factors influencing behavior using visual attention data. This connection is important given that 83 percent of information people use when making decisions is visually gathered, but only 1 percent to 2 percent of the visual field is viewed at any given point in time (Orquin & Mueller Loose, 2013). This research indicates that vision is a primary means of information acquisition, but not a lot of information is viewed and processed at a certain time. The lab uses state-of-the-art technologies to record what participants view as they complete tasks (e.g., purchasing decisions, livestock selection, risk management strategies, information search) and then connects what was viewed with actions taken. These insights can be used to direct future research on demand, buyer behavior, marketing and related issues.

There are several benefits of using eye-tracking research. Eye-tracking research helps address how information breaks through information overload, i.e., when people are inundated with too much information and if they employ mental shortcuts to selectively view relevant information and ignore other information. Information overload decreases the effectiveness of communications, promotions and understanding due to inattention to all available information. From the business perspective, financial and labor resources are spent on designing content that will resonate with clientele (e.g., advertisements, promotions, point-of-sale, infographics) in the hope that the content captures attention, accurately conveys information and attracts the customer. Visual attention metrics can be used to address how people view and use information, which has practical implications for retailers, marketers and others trying to resonate with different customer groups.

Several examples demonstrate how these data can aid in capturing visual attention and influence behavior. Rihn et al. (2019) investigated different point-of-sale formats in garden centers in Florida. They identified logo representations of information as more effective than text information in terms of quickly capturing customers' visual attention, retaining more visual attention (i.e., more fixations) and encouraging purchasing behavior for ornamental plants. In the beef cattle industry, impacts of bull appearance and expected progeny differences (EPD's) have been investigated in breeders' price estimation of what those bulls are worth. Additional examples with practical implications are in Table 1.

Table 1. Practical Implications from Research Incorporating Eye-tracking Technologies

Category	Source	Practical Insights
Purchasing Behavior & Point-of-sale Information	Kleih & Sparke (2021)	When buying **fresh fruit**: 1. The presence of well-known brands increases visual attention and decision making. 2. Optimal branding includes the brand and a visually attractive product.
	Orquin et al. (2020)	**Dairy packaging** design characteristics: 1. Brand-related elements are highly noticed due to being visually distinct, surface size and distance to product center. 2. Nutrition information and sustainability attributes are noticed less by customers. 3. Need to improve saliency of valuable information to encourage visual attention.
	Rihn et al. (2016)	In **garden centers**, visual attention to: 1. Organic logos on food-producing plants encourage purchasing behavior. 2. Food-producing or foliage plants increases purchasing intent, meaning displaying high quality plants and minimizing imperfections is important.
	Xu et al. (2023)	When buying **meat**: 1. Price attracts the most visual attention and strongly impacts choice. 2. Animal welfare information did not attract a lot of visual attention and had limited impact on choice. 3. Shopping habits for meats influenced choice (e.g., buying frequency).

Eye-tracking technology also can be used to assess how customers respond to different stimuli. For instance, experts (individuals who are knowledgeable and familiar with a topic) may respond differently than novices when presented with the same information or images (Jessup et al., 2021; Wong & Ito, 2018). Visual attention data from both sets of people could lead to a deeper understanding of how to communicate across the two groups. Expert visual attention data could be used to help guide and educate a beginner through their decision process (i.e., learn through the eyes of experts) (Jessup et al., 2021). Conversely, the novices' visual attention data could inform businesses on how information acquisition occurs by "newbies" and provide guidance on how to use information the most effectively.

Overall, the information gathered with eye-tracking technology can be applied in the lab or in real-world situations, creating a more holistic view of the market and its response to different stimuli. Eye-tracking technology and software can be easily applied to complement various research, Extension and business goals, which makes it a great asset to researchers and businesses interested in using eye-tracking data to inform their clientele and devise business strategies.

Equipment & Applications

Eye-tracking technologies allow researchers to view products, promotions and other stimuli through the eyes of the participant. There are two main types of cameras used to collect visual attention data: glasses and stationary cameras. The glasses are worn by participants while viewing something (e.g., shopping environments, retail shelves, livestock shows, menus), allowing researchers to understand how they view and use information in a real-world environment (Figure 1a). The glasses capture visual attention metrics using three small cameras. One camera is forward facing and records the interaction, while the remaining two cameras are recording where the eye is looking. The software triangulates the information from the cameras to highlight where people fixate and how their gaze moves (Figure 2). Conversely, the stationary cameras are attached to the base of a computer monitor, and the participant views still images, video clips, websites or other content while sitting at the computer (Figure 1b). The stationary cameras use infrared light to reflect off the back of the cornea to identify where the eye is looking on the monitor. Stationary cameras allow for more control over what the participant is exposed to and hence provide enhanced data capture.

Figure 1a. Eye-tracking Glasses

Figure 1b. Stationary Eye-tracking Camera on Computer Monitor

Figure 1. *Images of the Eye-tracking Cameras Used to Capture Visual Attention*

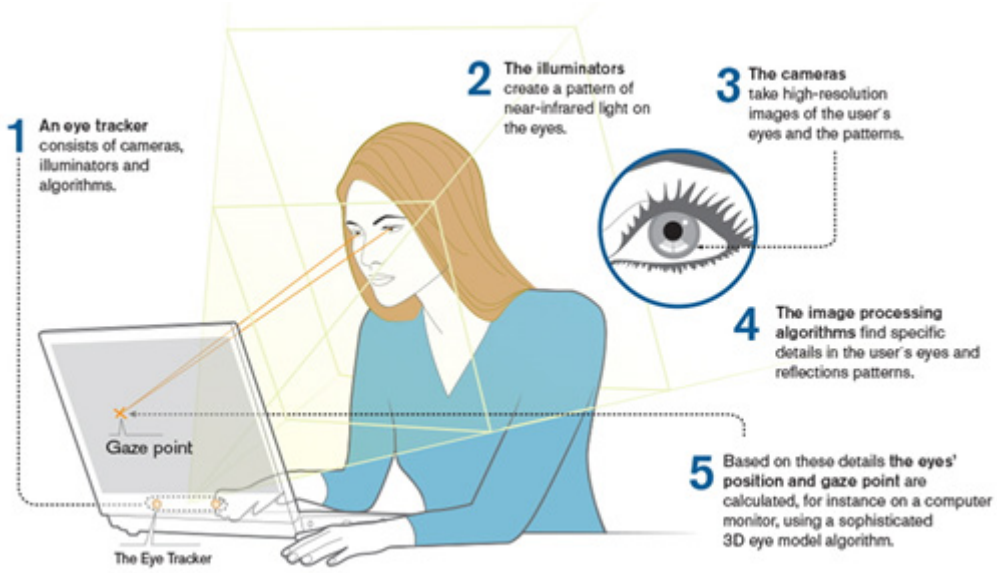

Figure 2. *Triangulation of Eye-tracking cameras. Source: iMotions (2024)*

Eye-tracking technologies collect a variety of visual attention data (Table 2). They can record how long a participant views the stimuli (total visit duration) or how long the participant fixates on a specific area of the stimuli (fixation duration). The total number of fixations (fixation count) on different areas of the stimuli also can be recorded. Fixations are of interest to researchers and business professionals because when the eye fixates on information, the most information acquisition occurs, meaning people are processing and using that information while making decisions (Orquin & Mueller Loose, 2013). Lastly, how quickly the participant fixated or visited the specific area of interest on the stimuli can be noted (time to first fixation). The visual attention metrics are then paired with research questions (e.g., How likely are you to purchase this product?) to identify correlations between visual attention and behavior.

Table 2. Visual Attention Metrics

Metric	Definition	Indicates
Time to first fixation (TTFF)	The duration of time before participants visually attend a defined area of interest.	How quickly people view the area of interest.
Fixation counts (FC)	Number of fixations on each area of interest.	Cognitive processing, decision making, relative importance
Fixation duration (FD)	Total amount of time fixated on the area of interest.	Does the attribute or area keep attention?
Total visit duration (TVD)	Total amount of time viewing the area of interest (includes fixations and gaze movements).	Does the attribute or area keep attention?

There are several potential opportunities to use eye-tracking technologies in academia and industry settings (Table 3). Applications include design, marketing and a wide variety of other topics. Essentially, anytime information related to the ability of stimuli to capture and keep attention and how that impacts behavior is of interest, these technologies can be used. Depending upon the objective, different eye-tracking technologies (e.g., stationary cameras or mobile glasses) are more appropriate. Incorporating eye-tracking technology to address related research questions gives academics, Extension personnel and industry leaders additional insights into their clientele, which can potentially improve market penetration and effectiveness of promotions.

Table 3. Potential Applications and Opportunities

Topics	Potential Indicators
Design – product, websites, packaging	Ease of use, ease of understanding, consumer preferences, purchasing behavior (Orquin et al., 2020)
Marketing – promotions, advertising, displays, branding, signage, labels, etc.	Consumer preferences, behavioral change, visual attendance (see review by Orquin & Mueller Loose, 2013)
Layout – stores, shelving, menus	Ease of use & understanding, consumer preferences (Huddleston et al., 2018)
Pricing strategies	Purchasing behavior (Ye et al., 2020)
Instructions/tutorials	"How to" videos featuring visual attention, information acquisition behavior (Wong & Ito, 2018)
Judging / strategy – livestock, plants, other	Expert vs. novice visual attention behavior (Lohmeyer et al., 2023)
Visual search behavior	Ease of use and understanding (see review by Orquin & Mueller Loose, 2013)

Ongoing Projects

The R.E.M. Lab (remlab.tennessee.edu) is currently involved with three research projects incorporating eye-tracking technologies. The first project addresses bull selection by breeders and is investigating correlations between information viewed and the price estimation (Figure 3). Results can provide key insights on breeders' use of indices and animal imagery when deciding on bulls. In turn, this information can improve ease of use and education, information acquisition, and marketing and promotional efforts.

The second research project addresses e-commerce sales of ornamental plants (Figure 4). The use of e-commerce platforms to directly sell products to consumers has increased recently. There is a lot of potential to sell plants using e-commerce, but consumers' use of online information is not well understood when considering plants. In this study, participants view an online website displaying plants with different attributes and select their preferred item. Ultimately, understanding consumers' perceived risk and use of online information while making choices can be used to improve usability of online platforms when selling plants direct to consumers.

The third study addresses in-store purchasing behavior for Tennessee value-added dairy products (Figure 5). Participants view targeted promotions, then value-added dairy products (i.e., cheese) and select the item they want to purchase. A second stage of the project includes participants wearing eye-tracking glasses as they visit a farm shop selling dairy products. The results will provide insights on how people visually process the retail environment in an agritourism setting. Actionable recommendations will be developed and may address improving retail displays, store layout and the customer experience.

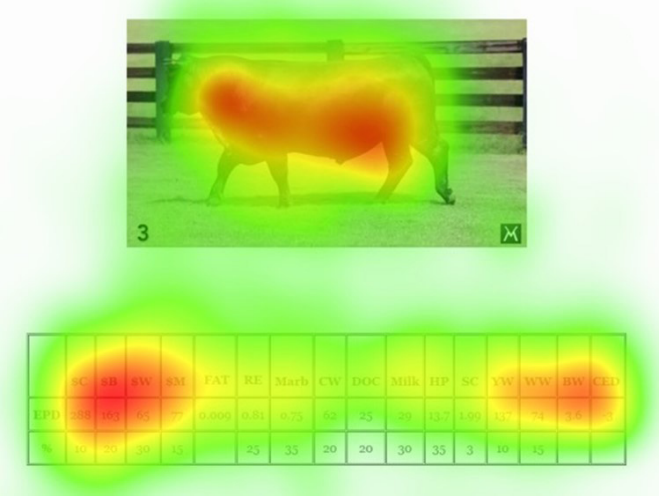

Figure 3. *Example of a Heatmap of Factors Influencing Bull Buying in the Southeast U.S.*

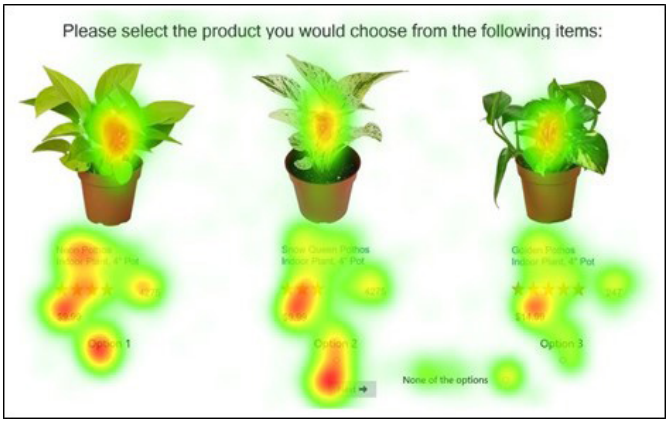

Figure 4. *Heatmap of Plant Purchasing Behavior Using an Online Platform (n=94)*

Figure 5. *Example Heatmap of Value-added Dairy Study*

Note: Heatmaps demonstrate visual attention concentration with red indicating areas of higher concentration, followed by yellow, and green.

Conclusion

Eye-tracking technology opens the door to view information through the eyes of others. Through these insights, there is an opportunity to improve effectiveness of communication and marketing efforts with different groups of people. When firms are considering several options, data from eye-tracking can aid in generating actionable marketing and product design insights to help businesses attract and engage their target audiences. For example, if a firm is considering redesigning its logo, eye-tracking can demonstrate which design attracts the most attention and the relationship between participants' visual attention and their liking of the design. As a result, the superior design or specific elements of that design (e.g., color, font, image) can be identified. This can reduce the risk of having a logo that does not align with customers by identifying what visually attracts them prior to reprinting promotional materials with the new design.

Another opportunity is related to information exchange. For instance, in the bull buying study, eye-tracking technologies are used to determine what the buyer is looking at when evaluating the bulls. This allows for researchers to assess if they visually attend to important information, and, if they do not look at that information, should the information be repositioned to capture more attention or possibly not used at all. This real-world application allows for improved decision making by bull buyers through presenting information in a format that is easier to comprehend, while simultaneously indicating what information should be highlighted by sellers from a marketing perspective. Generally, there are many other uses for eye-tracking technologies to improve information flow or product design, but it depends upon the firm's goals or researchers' question or inquiry.

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