



# Is an Eye Tracker Really Useful in Usability Testing?

## Introduction

Eye trackers have come a long way in their ability to track eye movement. Many units are passive devices that no longer require the wearing of awkward headpieces. They are getting almost affordable for many smaller labs. People can be training on set up and use in a short period of time. And technical issues in actual tracking are improving all the time. Yet, some users—particularly those with bifocal and trifocal eyeglasses—are still hard still to track through their glasses. Some eye trackers cannot pick up quick glances and the targeted position on screen is only an approximation of the actual position being viewed. And even with the best eye trackers, the most reliable tracking occurs when the participant refrains from head or body movement even though it is not uncommon for a participant to lean into the monitor when they are particularly engaged with an interactive product.<sup>1</sup>

Despite these limitation issues, eye trackers are increasingly finding their way into the usability lab. Vendors of eye trackers claim they provide “clearer results” and that they “unveil information normally missed” [1]. They claim that the eye tracker will tell you “in what order information is absorbed and processed” [2]. User of eye trackers often create “heat maps” (a type of visual summary of the places where the participants looked), that are shown to eager clients despite working with sample sizes too small to be generalized. But do eye trackers really provide the insight claimed? Unfortunately, the answer is mostly “no.”

Humans, like machines, can be conceptualized as having three elements input, processing, and output [3]. Assuming that an eye tracker is fully capable of monitoring human eye movement, and sensitive enough to detect even quick glances at an object, what the eye tracker is actually showing us is the input to the participant at the sensor level. What the eye tracker

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<sup>1</sup> Tracking eye movement when it is combined with head and body movement is particularly difficult for some units, but asking participants to try to not move their head or body so the eye tracker can keep track of their eye movement should be considered an unacceptable constraint on the participant’s natural behavior by anyone performing a usability evaluation as.

fails to take into account is the processing that occurs to this input. This processing determines what happens to this input—if it results in any change to us cognitively or behaviorally. And this processing is rather sophisticated in the case of humans. This lack of accounting for how visual information is processed results in both false positive and false negative assumptions.

## **Issue 1: We See What We Look At**

Eye tracking data assumes that the data that is placed in front of this is something that we actually look at. This is, in fact, false to a large extent. Our perceptual system is not like a camera—it does not dutifully record what is in front of us. And the translation of what is in front of us to what we perceive is influenced at every step in the process from initial signal detection, through initial perception, filtered by limits in attention, and then modified prior by being evaluated and processed by our emotional and cognitive systems.

Consider some of the facts about basic detection on what we “see.” The human visual system is a complex combination of signal detection sensors, pre-processing of information that occurs within the eye, and processing of information that occurs at several locations within the human brain. The human visual system attempts to make logic and order out of what is put in front of us. The pre-processing of information and is reasonably easy to demonstrate. Occurs outside of our awareness and outside of our control.

Consider the two pairs of objects in Figure 1 below. The first figure is a combination of a plus sign and dot. Close your left eye and look directly at the plus sign. Then slowly move closer to the image (or print the page out and moved closer to your face). At a point a few inches away from your face, the dot on the right-hand side will disappear. Note that this will only work if you keep your main focus on the plus sign.



Figure 1: The Demonstration of Visual Data “Fill In”

This phenomenon occurs because this procedure places the dot within the optic nerve of the eye—an area without any photoreceptors. But our visual processing system does not allow us to “see” a hole in our vision so we perceive the visual information that our processing systems assumes is there—in this case a white field and not a lone dot floating in space [4]. Now repeat the same experiment with the image on the right. In this case, at the same distance away as in the first experiment, the two lines will suddenly become joined. In this case, our visual processing system will insert data—the segment of line that would connect the two line segments. In addition to either removing or adding information compared to what is actually in front of us, the relationship of other objects in the area in which we look has a profound effect on how we perceive these objects. This phenomena was studied as far back as 1889 by Müller-Lyer [5]. Consider Figure 2 below [6]. The figure shows a pair of blocks either side-by-side on top of each other. One block is light in color and the other block is dark in color—or so it would appear. You may be surprised to learn that the two blocks on top of each other in the image below are actually the same shade of grey. To prove this to yourself, place a finger across the edge where the 2 blocks meet.

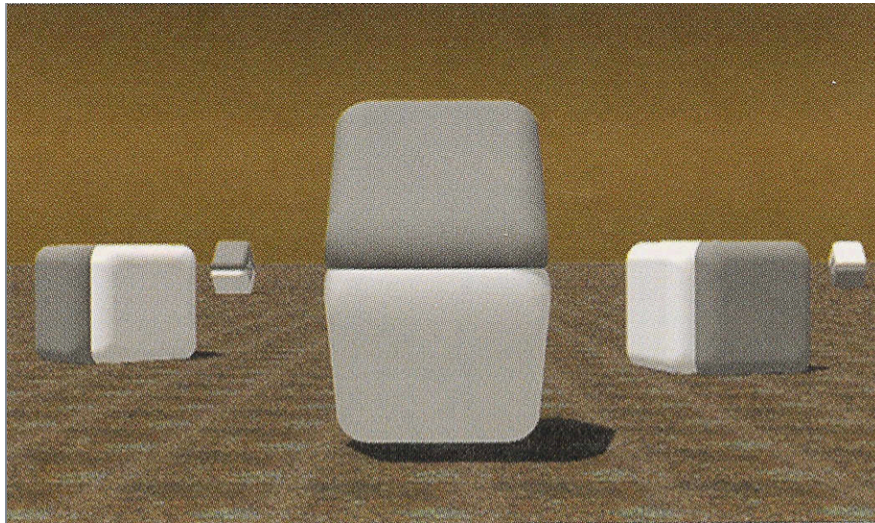


Figure 2: An Demonstration of Relative Perception

Another example of our inability to accurately perceive the information right in front of us is shown in Figure 3 below, originally developed by Roger Shepherd [8, 9]. This figure shows two apparently different coffee tables. In actuality, the two tabletops are exactly the same size, just rotated by ninety degrees. (You'll probably need a ruler to prove this to yourself since just knowing this information will not change your visual perception.)

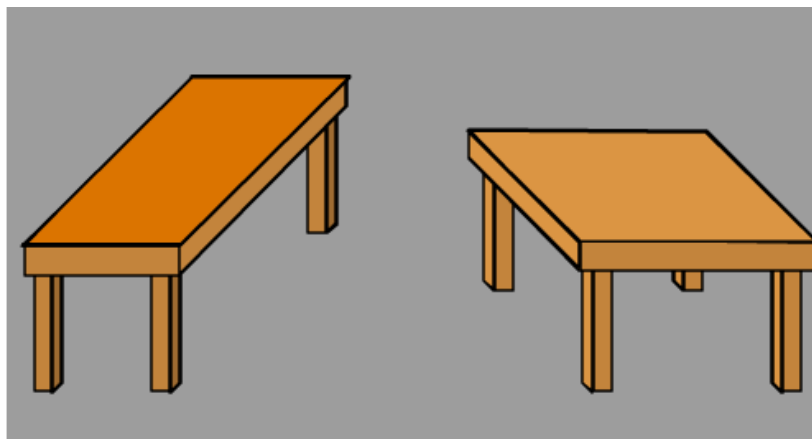


Figure 3: Roger Shepherd's "Turning the Tables"

Another effect that needs to be considered is attentional filtering. At any given moment, our visual field is being bombarded with a vast amount of information. Except in very limited cases, the amount of information presented to us is more than our visual processing system could possibly handle [10]. As a result, the human mind makes rapid decisions about what information within our visual field should be attended to and what should be ignored. This effect has been researched for many years by researchers Charblis and Simons [11]. Multiple experiments have been conducted to demonstrate that we cannot process all of the visual information presented to us, particularly when we are trying to think (a condition inherent in a usability study). Charblis and Simons coined the term “attentional blindness” to describe this phenomenon. One of the versions of original experiments showing this effect is available on YouTube (<http://www.youtube.com/watch?v=Ahg6qcgoay4>), though many other examples can be easily found on the web.

Attentional blindness, and its close relative “change blindness” are not a random event. Though they are unconscious, they can be shown to be purposeful in nature. We process the information we see in front of us and make a decision about whether it fits or not into what we are thinking. If it doesn’t fit, we often perceive it differently than it actually is in order to make it fit or seem more acceptable or even ignore it. For example, this author was involved with research into the use of subliminal messages while an undergraduate. Subliminal messages are generally one or two frames within a film intended to send a message to the viewer without their noticing it. However, in one case the subliminal message was a full second of video—enough visual information that it should have been perceived by all observers. However, the video, which happened to be of a naked woman, was placed within a commercial for a bank. Most viewers failed to even notice the woman at all. And those that did notice the woman explained her behavior by stating that she was taking a shower—which was, in fact, not the case. The Charblis and Simons experiment (which used a gorilla instead of a bear) has even been studied with eye tracking. According to Charblis and Simons in their book on the subject:

“Sports scientist Daniel Memmert of Heidelberg University ran our gorilla experiment using his eye tracker and found that subjects who fail to notice the gorilla had spent, on average, a full second looking right at it—the same amount of time as those who did see it!” [12]

In other words, many of the people who fail to “see” the moon walking bear are very likely to have seen it within their visual system but discarded it as not fitting within the context. As a result, they fail to process it.

Therefore, knowing that a person’s eyes were directed at a spot on a screen for a specific period of time (a “fixation”) does not tell us: (1) whether or not they processed what they their eyes fixated on, (2) how accurately they processed it (assuming they did), or (3) how that processed information was stored in memory (if it was).

## **Issue 2: We Need to Look at Something to See It**

This other issue with eye tracking data is the assumption that we only see what we look fixate on. This is also untrue.

The human visual system is made up of two types of vision: foveal vision and peripheral vision. Within the approximate center of each eye is a small (approximate 5mm), yellowish region called the macula. Contained within the macula is the fovea—an area of highly packed photoreceptor cells. This area of packed cells (generally known as our central vision) provides us with high acuity, color information. To “see” an object with our fovea does requires us to look directly at the object. And central vision works provides us with a visual field of approximately 13°. Outside the macula is a much larger area of cells that comprise our peripheral vision. This area of the eye, having far fewer photoreceptors, produces information of significantly lower acuity; however, it is tuned to detect black and white information (which works well even in low lighting conditions) and contains a number of specialized cells for detecting things such as horizontal and vertical structures, edges, and movement. The peripheral vision extends the field of view from approximately 13° to approximately 180°. More importantly, these two “types” of vision work together to determine direct our attention

to allow us to attempt to process the vast amount of information that is present in our visual field at any given moment.

Researcher Hans-Werner Hunziker [14] identified three primary functions of our peripheral vision—(1) the identification of similar forms and movements, (2) recognition of well-known structures, and (3) the delivery of sensations that form the background of our detailed vision. In other words, our peripheral vision provides background information for our central vision and serve a triage function. We use the information obtained from our peripheral vision to determine how much attention (if any) is needed to better classify an object detected in our periphery. In other words, objects detected within our visual field are screened to determine if they are already of an readily identifiable form and structure without requiring direct focus or if we need to direct our focus on them to get more information. If we believe that we know what the object is that is in our peripheral vision, we continue to focus on the objects currently within our central vision.<sup>2</sup> In other words, we detect and process objects in our peripheral field of vision without ever looking directly at them.

Many people are trained to consciously process the objects within their peripheral system. Astronomers are taught to use this area of their vision to detect faint objects more clearly. A dim star, for instance, is best seen when your eyes are not aimed directly at it.<sup>3</sup> Anyone who plays basketball, soccer, hockey, or any other sport involving passing between its team members learns to make a “blind pass” by passing to a player they are not looking directly at. (Otherwise, the pass is known as being “telegraphed.”) But the bulk of peripheral vision processing is done at an unconscious level. An example of this phenomenon is common to most people who have conducted a usability evaluation and is often described as “banner blindness”—the tendency for people to ignore items in their peripheral vision that look like ads or banners [15]. When asked why they did not look at the object, respondents often state that they “recognize” them as an advertisement or some other information that was not pertinent to the task at

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<sup>2</sup> If this function was not performed by our peripheral vision, we could not maintain focus on an object for very long since we would have to continuously look at every object that appears anywhere in our total visual field. We would, in effect, have no ability to fixate.

<sup>3</sup> It is believed that Aristotle detected one of a nebula he discovered using this technique.

hand. This is often a false assumption (since designers often put objects in the peripheral user's vision that are not advertising and not unnecessary information for a task), but it demonstrates that these objects are detected, processed, and do effect the behavior of people without them ever looking directly at them.

Since an eye tracker is associated only with central vision, there is no way to tell from eye tracking data alone when or even if an objects in our peripheral vision are being "viewed" (which, based on visual field size, is approximately 72% of our visual field).

### **Issue 3: As Observers, Seeing is Believing**

Discussions about the limitation, or the value, of eye trackers are not new. Professional forum discussions occur regularly with strong opinions on both sides. Researchers warn about the limitations and about making false inferences, but people who have attended usability sessions where eye trackers are used are quite certain of their value and of the data they are seeing. They have seen them in use and *know* they work. This may be the most concerning issue of the use of eye trackers.

Presented with the information that an eye tracker can produce, limited though it may be, observers are able to provide explanations for what they are seeing. But human are inherently wired to try to determine cause and effect relationships between observations, even when they do not exist. These tendencies constitute a set of faulty reasoning biases that include the post hoc or false cause bias (a tendency to assume cause and effect relationships between two elements even if they do not exist), the confirmation bias (a tendency for people to identify information that confirms preconceptions regardless of whether the information is true), and several others biases [16, 17]. These tendencies form a power basis for creating rationalization—beliefs that are explained in a rational or logical but may not be true. Since rationalization is internal (and therefore internally validated), these beliefs are powerful and difficult to challenge, but not necessarily correct. Given the limitation of the actual data present, coupled with the certainty in which observer believe what they see can be explained, can lead to false but powerful conclusions by observers.

Even if people could avoid these biases (which is highly improbable),

watching the real-time display of eye tracking data during the test (a common way in which eye trackers are being integrated into usability testing), tends to distract the observer and perhaps even the facilitator from “being in the moment” with the participant and therefore able to detect and understand the participant’s reactions and behaviors—events in testing that are vastly better indicators of how “usable” a product is compared to the participants eye movement.

## Conclusion

There are specific cases where an eye tracker can provide some useful information in a usability study. For example, when testing alternate visual layouts (where the participant does not have to engage with it beyond looking at it), viewing eye tracking data can give some insight onto which elements attracts the users eye, though additional investigation is required to determine whether and how any fixations were processed. But, even in this case, it is only possible to investigate fixations that are processed at a conscious level. If the fixation was processed at a subconscious level (where most psychologists believe that approximately 98% of our decision-making occurs), it is, by definition, impossible to determine how it was processed and how it was perceived.<sup>4</sup>

A more directly useful application of an eye tracker is to see how people are reading a specific block of text. In this case, as in the case of a static screen eye tracking data can help reveal specific words or phrases that require repeated reference—an indication that these phrases are either unclear or are modified by subsequent text. In this case, though participants are generally unaware of this repeated reference back to troublesome words and phrases, the repeated reference observable in their eye tracking data is directly observable.

However, the use of an eye tracker in a usability evaluation, where users are performing tasks and their test performance is being monitored, is not warranted. Practitioners would be better served if the use of an eye tracker was associated with evaluating static page layouts and blocks of text than attempting to discern usability or performance data during and interactive section by trying to follow where a person’s eye is going.

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<sup>4</sup> There are numerous research studies that study subconscious influences that could possibly be used in these cases, but the methodology is far beyond the scope of a usability evaluation.

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