Rythm of the Eyes: Enhancing Visual Communication through Eye-Tracking Technology

Shamsul Abu Bakar & Patrick A. Miller

Introduction

Visual is the main form of communication used by designers to convey unique and creative messages to the viewers. Whether the communication processes took place in basic forms such as in 2D sketches, paintings or through rendered 3D animated models, the ultimatum of using visual communication is to enhance the viewers experience with the tangible creative products and subsequently improve the quality of their decision-making. The platforms for visual communication within the creative environment also include advanced visualization technologies such as virtual reality and augmented reality, which provide real-time and real-world experience to the viewers. Nevertheless questions were raised whether the designers were fully aware of the viewers perception towards the visual information embedded in their creative products. Without these understanding, the products and their valuable information would be less meaningful to the viewers.

Although communication ineffectiveness can be improved by enhancing the visual quality, it is also important to identify appropriate scientific methodology that can be used to understand viewers physiological responses associated to what they perceived. This phenomenon has triggered inquiries towards the idea of recording human eye movements since the late 19th century. It is the nature of humans to bring their eyes into a particular field of view and focusing on the fine details towards an area that captured their attention (Duchowski, 2007). Even though it takes only a brief moment, understanding the eye's attention path may provide insight into what the observers found interesting, what drew their attention, and perhaps even provide a clue as to how a person perceived whatever scene she or he was viewing (Duchowski, 2007, p. 3). Substantial number of existing scientific research in the field of Human Visual system (HVS) has demonstrated that the use of eye-tracking technology and methodology can be significant and may provide meaningful outcome that will enhance visual interaction and communication between the designers and viewers in a creative environment.

Eye-Tracking Technology and Methodology: A Brief Review

Research in eye-tracking was first initiated in the late 19th century with early interest in understanding eye movements that occurs in reading process (Jacob and Karn (2003. This early research was initiated through direct observation and intrusive mechanical devices that required contact with the cornea and was followed by non-intrusive approaches in the early 20th century (Jacob & Karn, 2003). Then, in the second quarter of the 20th century, researchers began to explore eye-movements associated with still images. For instance, in 1935, Buswell attempted to identify people's eye-movement patterns and perceptions when they look at color pictures.

Since the 1950s, eye-tracking technologies have been heavily focused on usability studies that ranges from pilot training (Flemisch & Onken, 2000; Harris & Christhilf, 1980) to computer interface (Byrne et al., 1999; Goldberg & Kotval, 1998) and web design (Abel, 2010; Albert, 2002). Furthermore, eye-tracking studies on scene perception and visual attention towards pictorial media such as paintings (Massaro et al., 2012; Wallraven et al., 2009) and photographic images (Rayner, 1998; Bakar, 2013) provides possible understanding of how eye-tracking can be used for research in creative environment.

The increase of interest in eye-tracking research can be associated with the advancement of the easy access to different types of tracking equipment. For example, in 1960s, head-mounted was introduced but only allowed a certain level of head movement in comparison with today's eye-tracking apparatus that is becoming less intrusive, less obtrusive, more mobile and easier to use (Figure 1). These qualities in particular can be associated with the advancement of imaging sensors, video cameras and image processing systems that are considered important for human computer interaction (HCI) (Oyekoya, 2007).

Figure 1: Desktop based eye-tracking equipment where Shuttle-1 was used by researchers to monitor eye-tracking experiment and Shuttle 2 was equipped with an eye-tracking infrared sensor to track the participants eye movements.

Generally, research in eye-tracking focuses on several types of gaze data, including saccades, fixations, dwelling time, and scanpath (Figure 2). Eye movements (gaze) are not a continuous process when viewing pictures or a static scene (Pomplun, 1998). Eye movements that tend to leap from one inspected location to another are identified as saccades, and the motionless positions between those leaps are fixations (ibid). Dwelling time is defined as time durations for individual fixations, while scanpath refers to eye movement patterns that emerge from a sequence of fixations (Jacob & Karn, 2003). Results from other experiments have suggested that the gist of a scene can be comprehended by a viewer with the first few fixations (Duchowski, 2007).

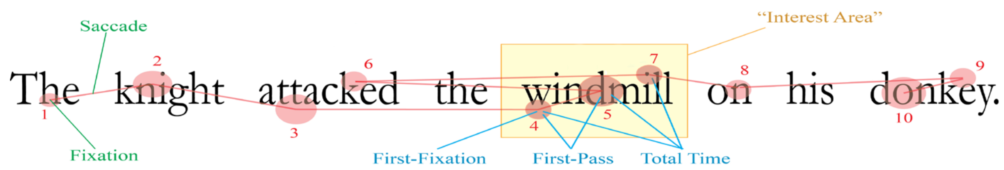

Figure 2: An example of scanpath and composite gaze data recorded in reading experiment using eye-tracking. Different circle sizes represent dwelling time for individual fixations. (Image adapted and revised from Cusimano, 2012)

For the eye-tracking survey, the number of participants varied according to types of eye-tracking study. For instance, the minimum sample size for usability studies is typically five participants. In addition, a study by Jacob (2003) on tweenty usability experiments conducted in the last fifty years recorded that the number of samples were between three and fourty. Meanwhile, for some preference and perception studies, the number included in a sample for an eye-tracking experiment ranged from eight (Glaholt, et al., 2009) to thirty six (Djamasbi et al., 2007) and 103 (Lee, Tang & Tsai, 2005). Although most of the eye-tracking research relatively involves low number of participants, it was proven in many studies that fewer numbers of participants could still yield meaningful results (e.g.Kim, Kang & Bakar, 2013).

Eye tracking analysis: Meaningful findings and the obstacles

Results from numerous eye-tracking research suggested that eye movements are not random and the analyses could be vital in identifying the underlying reasons for human responses. Instead of relying solely onto rigor statistical analyses, eye-tracking analysis provides tangible visual-based evidence that enhance researcher understanding towards a particular phenomenon from different perspectives. Eye-tracking analysis was found to be useful in identifying characteristics of visual media that can draw viewers' attention or exposed content that received unexpectedly higher visual attention. A study using historic photographic images as stimuli for instance, found that eye-tracking analysis helps to identify and validate the pertinent content of the images, sometimes differently than what have been anticipated (Bakar, 2013). The finding is in agreement with Josephson and Holmes (2002, p. 6), who suggested content that contains unique details also dramatically influences the pattern of fixations and saccade as such detail draws more attentions than common or expected visual information.

It is also important to highlight that human figures consistently attract viewers visual attention (Figure 3), even when they are not the dominant content portrayed in an image (Bakar, 2013). An argument by Wallraven et. al. (2009, p. 6) stated that human figures or clear human faces are considered to have a high degree of salience, however, the viewers are more selective of what they examine when there are more people in the same image (Bakar, 2013).

Under this condition, participants typically choose to give longer visual attention to human figures with unique traits. This statement supports Antes and Josephsons (2002, p. 6) findings: viewers tend to fixate on unique regions of visual scenes sooner and more frequently and for longer durations if that scene has unique characteristics. Further to this, viewers may also have high salience for human faces due to their innate reaction in knowing more about the human identities, status, health, behavior and emotions (Fridlund, 1994).

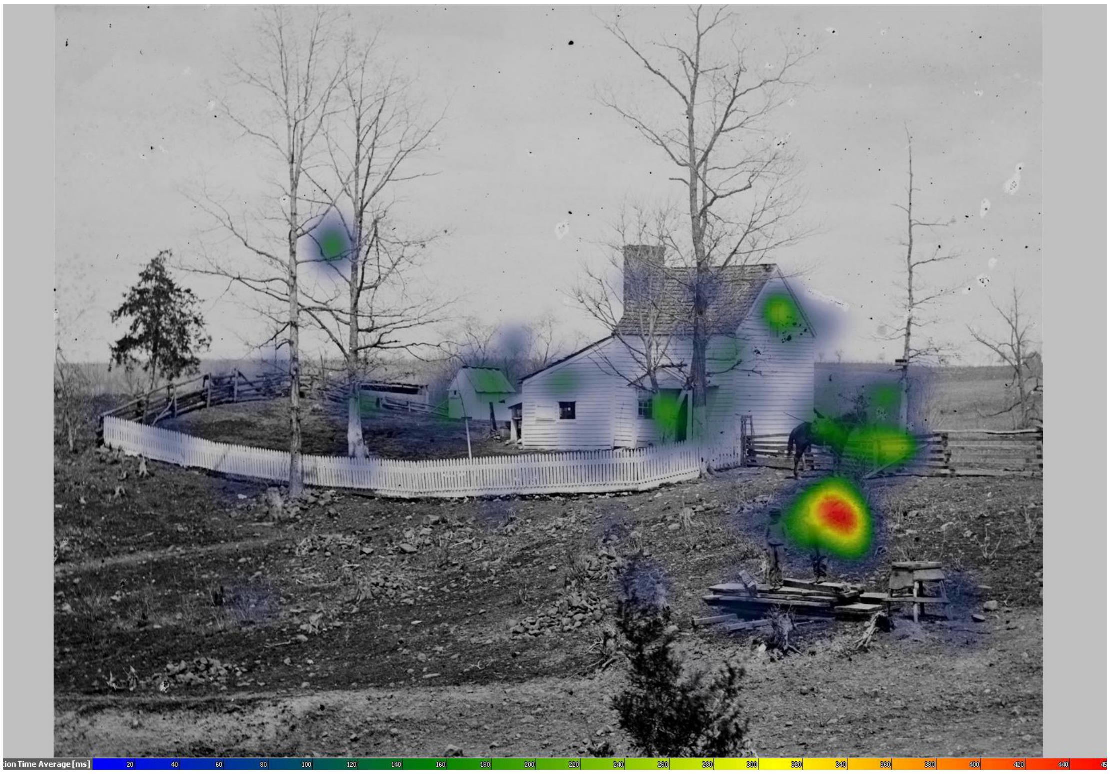

Figure 3: Although the house is the dominant content in this historic image, the human presences attracts more visual attention from the viewers based on the eye-tracking heatmap analysis (Source: Original image from US Library of Congress, accessed on Jan 19th 2012 and Bakar, 2013).

Nevertheless, several obstacles that currently limit the use of eye tracking research should also be highlighted. Eye-tracking participants know that their eye movements are being recorded: they might react or behave in ways that anticipate the researchers expectations, or try to please the researcher rather than experience the stimuli (either for still images or video) for their own purposes. This may reduces the internal validity of the study. It is highly crucial to analyze only initial patterns of eye fixations to obtain the gist of a stimuli used in eye-tracking study (Rayner, 1998). He emphasized the needs to limit time duration for eye-tracking analysis in order to avoid the possibility of participants filling the images (stimuli) with unnecessary details. Besides, Rayner further argues that detailed analysis of eye movement can be a high-cost and low-yield effort and highlighted the need to be cautious when interpreting gaze data. This is because some of the eye-tracking analysis (e.g heatmap) shows only participants visual attention but does not reveal if elements in the images are preferred based on their attention. Furthermore, many models of the eye-tracking equipment are confined in laboratory environments (desktop based), thus limiting the possibility to conduct research in specific type of real-world environment such as at public parks. To allow such possibility, higher investment is needed for mobile eye-tracking equipment such as the ultra lightweight eye tracker glasses.

Conclusion

Although the technology has been introduced for more than a century, eye-tracking research can still be considered exclusive for certain field of research. Currently eye-tracking is widely used in research related to usability study, human computer interface (HCI), psychology, and neuroscience. This information reveals the vast potential of future research that is still lacking and could be further explored by researcher particularly those in creative environments. Even in developed countries, eye-tracking technology is rarely used particularly in research related to landscape architecture (Kim et al., 2013). In Malaysia, the lack of eye-tracking research is even more evident and can still be considered at an infant stage. This includes other field of research in built environments such as architecture, interior architecture, and urban planning. The opportunity to use eye-tracking to enhance visual communication in creative environment is limitless and ready to be exploited.

Finally, understanding viewer's perception may help designers to plan, avoid and, eliminate unnecessary details that may distract viewers attention towards information delivered through their visual product. The understanding will significantly reduce information overload and lead to increase communication effectiveness between designers and the viewers.

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