Analogy Influences Eye Movements during Scene Viewing

Gufran Ahmad
College of Computer Sciences and Information Systems, Jazan University, Jazan, K.S.A.
gufran.researcher@gmail.com

Abstract

Research studies on eye movements for comprehending essential mechanism of visual attention and perception have always been challenging. These studies are mandatory to understand the dynamics of humans' cognitive processes. We carried out eye tracking experiments to examine the hypothesis that the movements of eyes during scene viewing were mainly affected by the thoughts of analogy which are integral part of cognitive processes. Eye movement data, in terms of heat maps, were collected from participants who viewed artistic portraits during active viewing. The map produced from eye tracking system during scene viewing traced a sequence of similar elements of the scene based on analogical thinking. These evidences proved the hypothesis that analogy influenced eye movements during scene viewing.

Keywords: *Eye movements, Analogy, Cognitive processes, Scene viewing*

1. Introduction and background

Eye movements have always been of great interest to the people who intend to study human behavior and activities. People are flourishing this field of study with their valuable contributions for scientific, social, economic and business purposes. Our previous work also complemented remarkable resource to the communities [1].

Eyes are one of crucial senses of a human and involve in visual understanding of all objects biologically. They facilitate also in visual attention and cognitive processes because of biological connection to the human brain. Thus, eyes engage in all the processes including visual attention, perception, cognition, and metacognition [2-4].

Generally, eyes also include in the verbal and nonverbal communications and express the needed information among the participants of communication. Eyes also dynamically participate in the processing of data for information and the visualization of information which are usual customs among professionals and individuals, including artists and scientists [2][4-6].

During eye movements, eyes move to fetch a specific fraction of the visible region in viewing because of having tendency to perceive the degree of detail visible in the central direction of gaze. In the movements, they pass through two temporal phases: fixations (the stops or periods of time when point of gaze or significant look is relatively slow) and saccades (the hops between stopping points). Saccades are often information-seeking and directed to specific objects or regions by the requirements of ongoing behavior. This also concludes the existence of cognitive processes of eye movements in viewing [1][5-9].

Art is characteristically human way of cognitive activity that is aimed at influencing the minds of viewers. Being constructivist in nature, it aims at the deliberate refinement and elaboration of worldviews. Most of the arts are metacognitive in its role as it engages in self-reflection, both individually and socially. The varieties and modes of art are technology-driven. Art is always aimed at realizing the cognitive consequence [10-12].

Analogy is basically similarity in which the same relations or likeness hold between different domains or systems. Analogy is significant in cognitive processes and is key mechanism in creativity which is also a part of the subject, like Visual Art. The main focus of analogical research is on the mapping process by which people understand one state or pattern in terms of another. Mapping is basically process of aligning the representational structures of the two cases and projecting inferences [13-16].

During artistic portrait observation, we move our eyes rapidly in irregular manner to change focus from one fixation to another fixation. This process, saccade, is one of the most common behavior of eyes. Pattern is obtained only during the periods of relative gaze constancy, known as fixations. The process of directing the eyes to view picture in real time is known as gazing of eyes [6-9][17-19].

The main motive of this study in artistic scene viewing is to identify and illustrate the idea of analogy and the generated patterns based on this core idea which is evolved by the cognitive and metacognitive processes that are observed by the shifts of gaze during the eye movements.

2. Eye tracking system

In eye tracking system, the system illuminates infrared light for tracking the eye movements. The camera, connected to the system, captures the location of viewer's eyes in terms of fixation during experimentation time. As the viewer moves his/her eyes to look a new location of the scene, the camera records new fixation also. This process of recording continues subsequently. The system generates eye tracks and heat maps using the captured data which is utilized for further analysis.

The schematic diagram of eye tracking system and basic processes involved during eye tracking experimentation is represented in Figure 1.

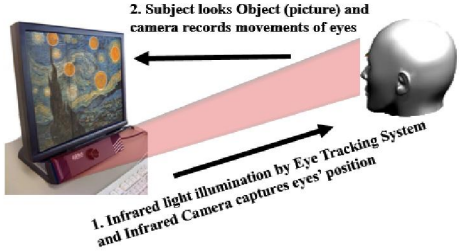

Figure 1. Eye tracking system with operational processes.

The traces of eye movements are taken in diverse layouts as per analyst's suitability. Among them, there are two most common formats; Heat Map and Sequenced Gazing with circle of concentration. In Heat Map, the track of eye is recorded as illumination and intensity of infrared light rays. This is based on Energy Therapy Technique (ETT). In Sequenced Gazing, the eye tracks are entered as numbered circles with their areas indicating the time duration of eye's gazing in those areas respectively [3][5].

In our experiments, we study the heat maps of viewer's eye movements, which is generated by the system, during scene viewing. These are assured evidences of eye movements.

3. Present study

We investigate the eye movements from cognitive perspective during scene viewing and analyze the patterns of heat map to visualize the information. Here, visualization of heat map patterns to extract information for interpretation is an essential step of this study.

Initially, eye movement heat map was collected from participants who viewed full-color scenes while engaged in a visual search task in which they are freely viewing different regions appeared in each picture. Finally, we compared and analyzed the heat map against the artistic portrait. The interpretation is carried out with the help of cognitive and metacognitive processes in current research.

4. Flow chart of study

The study on eye movements during scene viewing consists of a number of steps to be performed. These steps are represented as shown in the adjacent flow diagram (figure 2). This is a comparative study of two items; artistic portrait and the heat map of the same portrait, which is generated by eye tracking system.

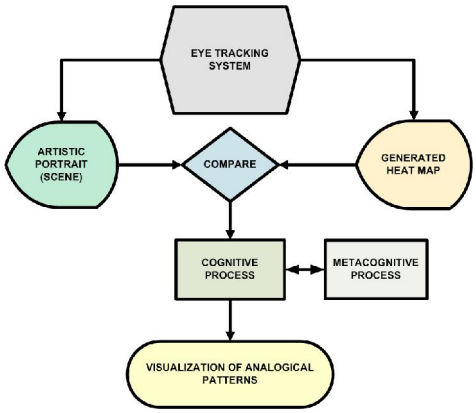

Figure 2. Flow chart of research study.

It begins with recording of heat map of a viewer's, i.e. Subject's eye movements on eye tracking system for an Object; artistic portrait. The generated heat map of the same artistic portrait is comparable to the original artistic portrait. This comparative analysis brings visualization and interpretation of the outcome.

During comparison stage, we utilize cognitive process, and metacognitive process, in addition to analogical perspective, to understand the hidden mechanism that creates resultant maps. By analyzing, we come up with concluding remarks on evolving phenomena.

5. Method

We selected 38 participants from a number of fields within university, aging from 22 years to 32 years. These Subjects, the participants were assigned to view 3 randomly selected famous artistic portraits as shown below in figure 3.

The artistic portraits are "Garden of Presbytery with Lake and Figures by Van Gogh", "Artistic Lonely Human by an unknown artist", "Pier with Ships in Antwerp by Van Gogh".

Figure 3. Selected Artistic Portraits for research study

Subjects' eye movements were closely monitored as they viewed 32-bits full-color artistic sceneries. The Objects; the portraits were displayed on a computer monitor. The portraits were shown at a resolution of 1280 × 1024 pixels and subtended 15 deg. horizontally by 10 deg. vertically at a viewing distance of 75 cm. Eye position was sampled from

an Eye Tech Digital Systems TM3 16 mm Eye Tracker, and eye tracking data was parsed into fixations, in terms of heat maps illuminated with light intensities.

The Subjects' head was held steady in advance prior to experimentation. Prior to the first trial, Subjects completed a procedure to calibrate the output of the eye tracker against spatial positions on the display screen. This procedure was repeated regularly throughout the experiment to maintain high level of accuracy. Subjects were initiated to view the pictures freely.

The pictures were presented to the Subjects for maximum duration of 100 seconds. During this time span, the Subjects viewed the pictures with their normal eyes and focused attentions on the Objects, i.e. the portraits.

5.1. Analysis 1: Study of artistic portrait of Garden of Presbytery with Lake and Figures

Figure 4. Portrait of Garden of Presbytery and heat map of the same portrait

In this eye tracking experiment, the Subject was assigned to gaze at artistic scene of garden with lake and figures. During gazing at upper regions of portrait, the Subject's attention could not perceive noteworthy consciousness but during scene viewing at lower regions, the underlying cognitive and metacognitive processes were taking part during this active scene viewing [6-9][11][12][17][18]. These processes enforced the Subject to go through the analogical thoughts which are parts of cognitive processes. Consequently, the analogical thinking compelled the Subject to track the similar regions or visual fields of the portrait. Here, the analogy was built based on people who were visiting the garden.

Later interview of the Subject suggested that the visually similar figures (people) were the subject of interest to the viewer that compelled the viewer's mind to know the activities of each and every human. Hence, this conclusion came from undergoing cognitive processes of viewer's mind during scene viewing that evolved the central idea of analogy, an integral part of these cognitive processes.

5.2. Analysis 2: Study of artistic portrait of Lonely Human

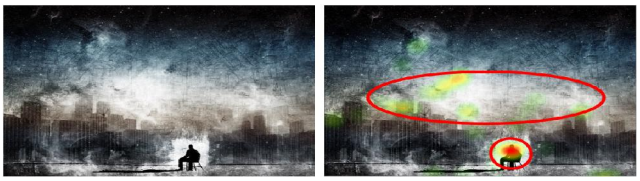

Figure 5. Artistic portrait of Lonely Human and generated heat map of the same portrait

In this eye tracking experiment, the Subject gazed most of the times at visually brighter regions of the portrait where the illumination was excessive. The effect was due to the context of surroundings; the perception of brightness was determined by the contrast between brighter and darker visual fields [6][10-12][18]. This contextual bias in brightness contrast was based on the influential thinking that came into existence due to the thought of analogy, in terms of brightness; the perceived contrasts in visual fields. Consequently, the analogy which was initiated by the Subject's attention and consciousness led to the creation of analogical patterns based on intensity of light.

Later interview of the Subject realized this fact that he was actively looking at similar bright regions of the scene because he was excited to know about these immensely lightened fields and the man in the middle of intense light.

5.3. Analysis 3: Study of artistic portrait of Pier with Ships in Antwerp

Figure 6. Artistic portrait of Pier with Ships and the heat map of the same portrait

In this eye tracking experiment, the Subject's attention came across white stopper and perceived consciousness. Subsequently, by the thoughts of analogy, Subject shifted gaze to adjacent fixation to look for second white stopper. Thereafter, he lost his attention and gazed at a number of regions throughout the portrait. This was due to the complexity and disturbance of visual elements of the portrait, like chaotic ships [6-9][17][18]. Subsequently, he attained his attention again and looked for contextual perception. The subsequent flow of thoughts revealed another analogy for the people who were moving towards the

ships. This study demonstrated the existence of more than one analogical thinking that might happen during scene viewing as well.

Later interview of the Subject confirmed his interest in looking for activities that were going on at pier. He was keen to have simplicity and similarity among complexity to bring a conclusive outcome from the portrait.

6. Discussion

In this study, the artistic portraits extend their impression with the fact that the artists are imagining this realistic world in different perspective, i.e. humanitarian perspective. These emotional views are rather too convoluted to understand from visual analytics and analytical reasoning. These cognitive perspectives and natural analogical thoughts are discovered by eye movements during scene viewing.

During the last stage of experiments, the visualization of analogical thinking is a crucial and central part of whole activity. The visualization of analogical thinking is unarguably innovative standpoint of each and every analyst who scrutinize them for definite intents. This, in turn, causes a number of analogies in scene viewing by various perspectives of analysts. Though the existence of analogical thought is available in the literature [11-16], yet its presence and clarification varies drastically. In this regard, the analogical patterns reinforce again the existence of analogical thoughts in between the inherent cognitive and metacognitive processes.

Saccades and gazes during scene viewing are key factors for proper realization of task-relevant visual information [6][9][17-19]. In this study, we noticed that the generated heat maps by eye movements are noteworthy and are major evidences to verify the analogical thoughts and associated cognitive processes in eye movements. These analogical thoughts are capable to state human's cognitive aspects in terms of brightness contrast observed in the heat maps. Without taking account of analogical thought into the matter, it is problematic to be familiar with the triggering sequential cognitive and metacognitive processes also.

Further, the visual gaze and focus of attention shift over time during scene viewing [6][17-19]. Thus, the possibility of more than one analogy within a single scene viewing scenario is frequent. The flow of thoughts alters as per transferal phases of perceptive consciousness and metacognitive processes. Thus, the thoughts of analogy obviously do vary in accordance with all these coherent reasons.

In addition to these arguments, the experimental evidence of analogy and analogical thoughts during active scene viewing holds our hypothesis for which we conducted a series of experimentations. The hypothesis that analogy influences eye movements during scene viewing, is persuasive and innovative breakthrough related to eye movements study.

7. Conclusion

We conclude that the factor of analogy plays a leading role during scene viewing. This core idea propagates all analogical thinking to result in cognitive outcomes. As per the experimental evidences, these thoughts of analogies within the human mind exist in the middle of cognitive and metacognitive processes which are observed during active scene viewing.

Further, these analogies bring the creation of analogical patterns within individual artistic sceneries, which are visualized in scenes' elements respectively. As a result, the influential analogies leave traces of their dominance during scene viewing.

8. References

[1] Ahmad Gufran, Ohsawa Y., Nishihara Y. "Cognitive Impact of Eye Movements in Picture Viewing", *International Journal of Intelligent Information Processing*, vol. 2, no. 1, 1-8. 2011

[2] Rogers, Kara. *The Eye: The Physiology of Human Perception.* NY: Britannica Educational Publishing, 2010.

[3] Brown, Tom. *The Science and Art of Tracking.* NY: Berkley Books, 1999.

[4] Wells, Adrian. *Emotional Disorders and Metacognition: Innovative Cognitive Therapy.* West Sussex: John Wiley & Sons, 2000.

[5] Duchowski, Andrew T. *Eye Tracking Methodology: Theory and Practice.* London: Springer Verlag, 2003.

[6] Holsanova, Jana. *Discourse, Vision, and Cognition.* John Benjamins Publishing Company, 2008.

[7] Griffin, Z. M. "Why look? Reasons for eye movements related to language production." In *The integration of language, vision, and action: Eye movements and the visual world*, by Henderson and Ferreira, 213-247. New York: Psychology Press, 2004.

[8] Henderson, J. M., and A. Hollingworth. "High Level Scene Perception." *Annual Review of Psychology 50*, 1999: 243-271.

[9] Rayner, K. *Eye movements and visual cognition: scene perception and reading.* New York: Springer Verlag, 1992.

[10] Viegas, Fernanda B., and Martin Wattenberg. "Artistic Data Virtualization: Beyond Visual Analytics." *Online Communities and Social Computing, Second International Conference.* Beijing: Springer, 2007. 182-191.

[11] Turner, Mark. *The Artful Mind – Cognitive Science and the riddle of human creativity.* Oxford University Press, 2006.

[12] Solso, R. L. *Cognition and Visual Arts.* Massachusetts London: MIT Press, 1994.

[13] Gentner, D. "Structure-mapping: A theoretical framework for analogy." *Cognitive Science 7*, 1983: 155–170.

[14] Gentner, D., and A. B. Markman. "Structure-mapping in analogy and similarity." *American Psychologist 52*, 1997: 45–56.

[15] Gentner, D., M. J. Rattermann, and K. D. Forbus. "The roles of similarity in transfer: Separating retrievability from inferential soundness." *Cognitive Psychology 25,* 1993: 524–575.

[16] Gentner, D., and J. Medina. "Similarity and the development of rules." *Cognition 65*, 1998: 263–297.

[17] Henderson, J. M., and A. Hollingworth. "Eye movements during Scene Viewing. An Overview." In *Eye Guidance in Reading and Scene Perception*, by G. W. Underwood, 269-293. Oxford: Elsevier, 1998.

[18] Hoffman, J. E. "Visual Attention and Eye Movements." In *Attention*, by H. Pashler, 119-153. London: Psychology Press, 1998.

[19] Stark, Lawrence, and Stephen R. Ellis. "Scanpaths Revisited: Cognitive Models Direct Active Looking." In *Eye Movements: Cognition and Visual Perception*, by Dennis F. Fisher, Richard A. Monty and John W. Senders, 193-226. Hillsdale: Lawrence Erlbaum Associates, 1981.