Dynamics of Eye Gazing rely on Associative Relevance in Scene Viewing

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Abstract

Researches on eye movements are gaining significant momentum for understanding underlying mechanism of visual high-level perception and dynamics of humans' cognitive processes. We conducted a series of eye tracking experiments to testify our hypothesis that the dynamic shifts of active eye gaze in scene viewing were predominantly depended on correlated contexts of scene's elements. Eye movement data were gathered from participants who regarded artistic portraits during active viewing. The map produced from eye tracking system in scene viewing tracked an association of analogical gazes on contextual basis. These experimental phenomena evidenced the hypothesis that dynamics of eye gazing relied on associative relevance in scene viewing.

Keywords: *Eye gazing, Cognitive process, Associative relevance, Scene viewing*

1. Introduction and background

Studies on eye movements are getting serious attention among Researchers, Professionals, and Social Practitioners in recent years. Fortunately, the eye tracking technologies have surpassed through innovative advancements during the same time span. Now, people are making strong efforts to study human behavior and activities as per their intentions, which are significant for understanding human minds and in turn, human interactions comprehensively.

Movements of eyes facilitate a human in visual understanding of surrounding objects because of the existence of biological link between eyes and human brain. The entire process of cognition is carried out by a number of consecutive sub-processes, including visual attention, perception, analogical thoughts, cognitive reasoning and metacognition [1-5].

Normally, eye movements involve in the verbal and nonverbal communications and assist in providing the desired information among the participants of communication. In addition to these, eye movements actively contribute in the processing of data for information and the visualization of information which are common practices among professionals and individuals, including artists and scientists [4][5].

In eye movement processes, eyes change their gazes to spot a specific portion 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 infers the existence of cognitive processes of eye movements in viewing as well [4-13].

Typically, a human way of cognitive activities is defined as the art which is expected to influence the minds of people who looked at them. Art is productive activity that focuses on the thoughtful modification and embellishment of worldviews. By and large, all known pieces of art are creative and metacognitive as per their roles because they are self-explanatory. The types and styles of art are technology-driven as innovative technologies bring renaissance to the artworks. The most essential part of art is its motive to become conscious about itself and in turn, firing up the cognitive processes in human mind [9][14][15].

Associative relevance is evolutionary and cohesive notion which is emanated from thoughts of analogy. Analogy is significant in cognitive processes and is key mechanism in creativity which is also a part of the subject, like Visual Art. Analogy is basically similarity in which the same relations or likeness hold between different domains or systems. 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 [16-19].

In analogical mapping, a familiar condition is used as a model for making inferences about an unfamiliar condition. The mapping process includes a structural alignment between two represented conditions and the projection of inferences from one to the other. The alignment must be structurally consistent, i.e. there must be a one-to-one correspondence between the mapped elements in the base and target, and the arguments of corresponding predicates must also correspond. This generates an association of relative visual contexts which originate in the middle of dynamic shifts of eye gaze during eye movements [16-19].

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 [3-8][10-13][20-22].

The main motive of this study in artistic scene viewing is to identify associative relevance and to visualize the associative eye movement patterns 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 movement 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.

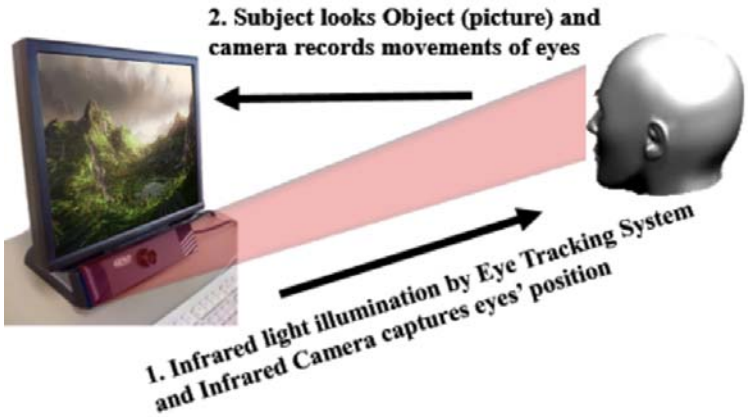

Figure 1. Eye tracking system with operational processes.

The traces of eye movements are taken in diverse layouts as per analyst's suitability. Among them, there are two most common formats are 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][4].

In our experiments, we study the sequenced gazing of viewer's eye movements, which is generated by the system, during scene viewing. These are the dynamic shifts of eye gaze in scene viewing.

3. Present study

We investigate the gazing of eye movements from cognitive perspective, including the associative nature of analogical mapping, during scene viewing and analyze the patterns of sequenced gazing to visualize the information. Here, visualization of sequenced gazing patterns to extract information for interpretation are essential steps of this study.

Initially, eye movements, in terms of sequenced gaze, are collected from participants who view full-color scenes while engaging in a visual search task in which they are freely viewing different fields of each scene. Finally, we compare and analyze the sequenced gazing against the artistic scene. The interpretation is carried out with the help of cognitive and analogical processes in current research.

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 chart diagram (figure 2). This is a comparative study of two items; one item is artistic portrait and other item is the eye movement tracks of the same portrait, which is generated from eye tracking system.

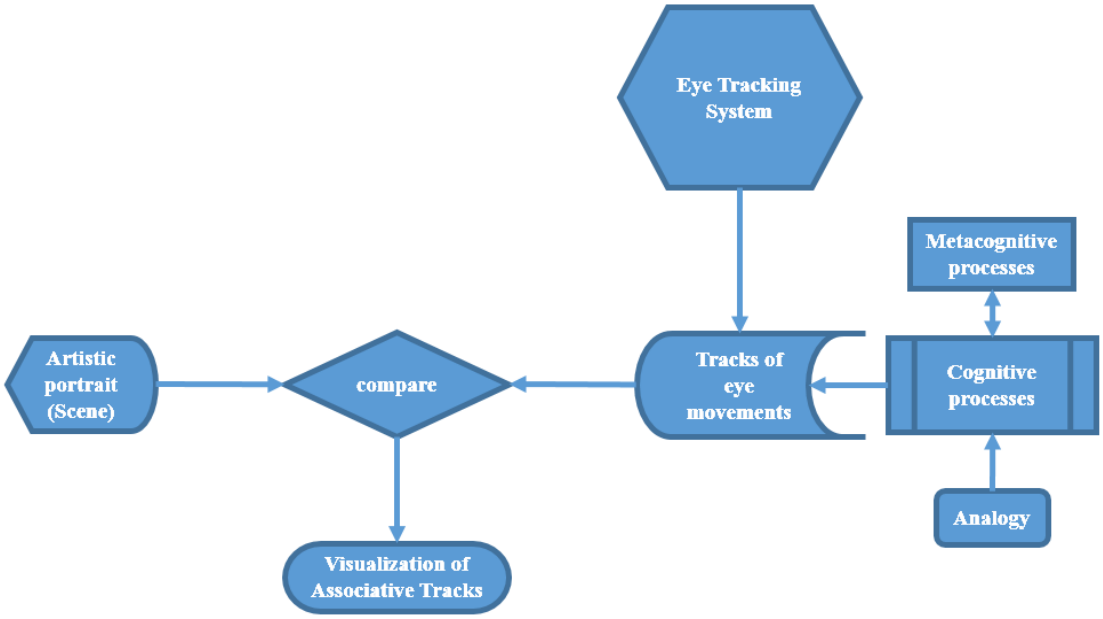

Figure 2. Flow chart of research study.

It begins with recording of eye movement tracks for a Subject; a viewer on eye tracking system for an Object; artistic portrait. The generated eye movement tracks of the same artistic portrait is comparable to the original artistic portrait. This comparative analysis infers visualization and interpretation of the outcome. So, these two items gets compared side by side.

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

4. 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 were “Autumnal scenery in the evening by Van Gogh”, “Artistic Lonely Human by an unknown artist”, “Green Hills”.

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 (circles with gazed time-period in areas) and saccades (sequenced gazes with linear edges).

The Subject's 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 a short duration of 25 seconds to limit perceivable attentiveness. During this time span, the Subjects viewed the pictures with their normal eyes and focused attention on the Object, the portrait.

Here, we analyzed all 3 portraits respectively with the intention to elaborate our findings in the most common and generalized perspective.

4.1. Analysis 1: Study of artistic portrait of Autumnal scenery in the evening

Figure 4. Portrait of Autumnal scenery in the evening and sequenced gaze of the same portrait

In these eye tracking experiments of figure 4, the Subjects were assigned to gaze at artistic scene of Autumnal scenery in the evening which was filled with shiny background of riverbank, glossy trees, sunlit fields, and gleaming clouds, etc. In the beginning, the Subjects' consciousness directed them towards visual attention over the central field of brightness contrast due to the existence of a riverbank which was at rear-end of the portrait and shined by the sunlight. This eye gazing phenomena was caused by contextual biasing of the visual field of the portrait as the portion of the portrait was comparatively brighter than the remaining portions of the portrait. At this stage, the Subjects perceived knowledge about the field of the portrait, which helped them to move to the next step.

Next, the Subjects dynamically shifted their eye gazes over the top portion of the portrait because of another contextual biasing of the visual field in the portrait that influenced the Subjects to shift their eye gazes. Further, the human cognitive processes evolved in the middle of its flow in the human mind initiated significant analogical mapping process between the first gazed visual field and the second gazed visual field on the basis of analogy. This mapping process associated the related fields of brightness on the basis of analogy. Therefore, the dynamic shift of eye gazes heavily relied on associative relevance of analogical mapping.

Thereafter, eye gaze dynamically shifted towards central and subsequent fields of the portrait. During the entire span of time, the processes of analogical mapping and in turn, the formation of associative visual fields were continuously propagated in dynamic eye gazing shifts.

Later interview of the Subjects suggested that the visual fields of brightness contrast were the subject of interest to the Subjects. Further, related fields of similarity compelled them to shift their eye gazes dynamically. Hence, the conclusion came from undergoing cognitive processes of Subjects' minds in scene viewing that evolved the central idea of analogical mapping, and in turn, associative relevance.

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

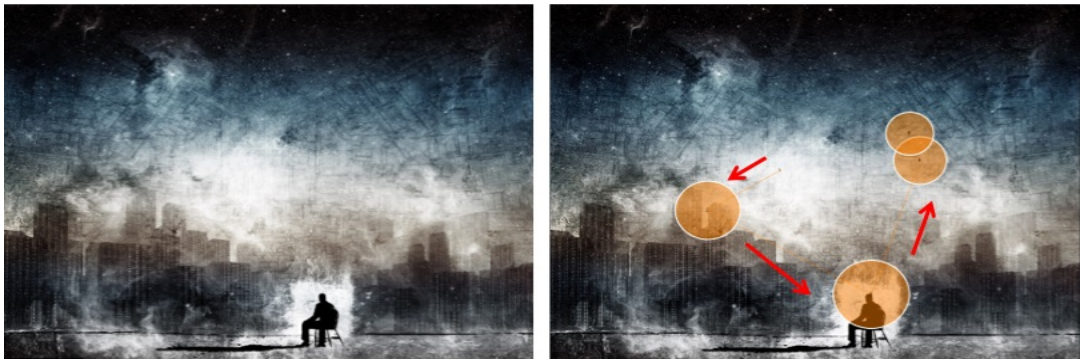

Figure 5. Artistic portrait of Lonely Human and generated sequenced gaze of the same portrait

In these eye tracking experiments of figure 5, the Subjects started gazing at central brightness contrast field because of contextual biasing of the field in the portrait. This brings visual attention and perception to the Subjects for the knowledge of context and relevant fields. The existing cognitive process in the human minds enlightened the other coexisting processes, i.e., the process of analogical mapping and the process of metacognition, which assisted eye gazes to dynamically proceed further.

The Subjects' eye gazes moved towards next contextually biased field which was a field of brightness contrast. Subsequently, Subjects' eye gazes moved again to the central human due to the influence of brightness contrast biasing in the visual fields of the portrait. The process of analogical mapping guided the Subjects' eye gazes to map and represent the associative context of visual fields in the portrait. These associative relevance was reflected in the existing cognitive process as the eye gaze changed to other positions of the artistic portrait dynamically.

Later interview of the Subjects realized this fact as well. They narrated that they were actively looking at similar bright regions of the scene because they were excited to know about these

immensely lightened fields and the man in the middle of intense light. This inferred again the presence of associative relevance in the visual fields of artistic portrait.

4.3. Analysis 3: Study of artistic portrait of Green Hills

Figure 6. Artistic portrait of Green Hills and the sequenced gaze of the same portrait

In these eye tracking experiments of figure 6, the Subjects were involved in active viewing of Green-Hills artistic portrait which was painted with the hills, central lake, dark clouds, palm trees, and waterfalls. In the beginning, Subjects' visual attention came across a waterfall in the left-side of the portrait. Subjects' eye gazes perceived consciousness and perceived knowledge about the visual field of the portrait.

Subsequently, by the process of analogical mapping, Subjects shifted gazes to adjacent visual field of related context, i.e., another waterfall. Thus, the process of associative relevance of visual field context within the portions of artistic portrait began. The human cognitive process that included the process of analogical mapping and metacognitive state, continued till the end of active artistic scene viewing.

Thereafter, the eye gaze changed dynamically towards contextual biasing due to darkness contrast of the visual field (from surrounding regions) in the central right-side of the portrait. This contextual biasing interrupted the process of analogical mapping in human cognitive process temporarily. Thereafter, the process of analogical mapping and in turn, the process of associative relevance in the context of visual fields regained dynamically. Subsequently, the eye gazes attained attention again and looked for associative relevance built on the basis of previous analogical context. This study demonstrated the existence of analogical mapping with associative relevance and its temporal collapse as well, in addition to its dynamic recovery during scene viewing.

Later interview of the Subject confirmed their interest in looking for waterfalls after understanding their live activities. Though they missed in the middle of active seek, yet they were keen to have. Hence, these cognitive processes brought a conclusive outcome from the portrait with associative mapping over visual fields contextually.

5. Discussion

In this study, the artistic portraits cover their reflection with the main objective of artistic artworks in the shape of human cognition mechanism in viewing these artistic sceneries [4-9]. These creative pieces of art reflect inherent human interaction to perceive knowledge and interpretation of realistic world in human mind. These emotional views are rather too complicated to understand from visual analytics and analytical reasoning. Consequently, these cognitive perspectives and natural analogical mapping for associative relevance are discovered by eye movements in scene viewing.

Dynamic eye gaze shifts during scene viewing are significant steps for appropriate retrieval of task-relevant visual information which are essential for visualization of final maps [4-9][20-22]. In this study, we observe that the generated eye movement tracks of sequenced gazes are remarkably associative in nature. These are major evidences to verify an association of analogical mapping based on contexts. Further, even a short-term failure of these associative mapping process of analogical

contexts as in the last above-mentioned analysis conveys a completely different outcome for that instant. As a result, without taking account of associative relevance of analogical mapping, it is impossible to link the entire scenario of human cognition in the sequential eye gazing of eye movement tracks.

Furthermore, the repossession of associative mapping (from its deviated stage due to temporary loss of sight or contextual biasing of visual fields) of analogical contexts of visual fields during dynamic eye gaze shifts is outstanding from the perspective of its competence. This capability of repossession is a definite indicator of consistent associative mapping formed in between human cognitive processes. These repossessions of associative relevance are efficient of getting irreplaceable and unaffected overall outcomes despite abrupt disruption during scene viewing.

During last stages of experiments, the visualization of associative relevance of contexts in terms of associative eye movement tracks is a tactical and decisive part of whole activities. The visualization of associative eye movement tracks, in terms of analogical mapping based on contexts, is unarguably innovative perspective of each and every analyst who examine them for definite intents. This, in turn, causes a number of associative mapping in scene viewing by various perspectives of analysts. Though the existence of analogical mapping is available in the literature [16-19], yet its presence and clarification varies drastically. In this regard, the visualization of associative eye movement tracks reinforce again the existence of associative context relevance of analogical mapping in between the inherent cognitive and metacognitive processes during scene viewing.

In addition to these arguments, the experimental evidence of associative relevance during active scene viewing holds our hypothesis for which we conducted a series of experimentations. The hypothesis that dynamics of eye gazing rely on associative relevance in scene viewing, is persuasive and pioneering breakthrough related to eye movements study.

Finally, these experimental results have practical application aspects as well. One of the application areas is the development of smart screens with user-centric multimedia systems. These eye tracking methodologies and hypothetical idea of associative relevance can serve as core principles on top of which sophisticated and intelligent systems can be built. These principles can be utilized practically in designing user-centric, eye-gaze controlled smart screens and monitors of commercial products to manage the visual portions or objects of screen in smart environments. In these smart environments, smart screens or displays may keep an eye on users' eye-gazes dynamically and response as per users' objects of interest due to the existence of associative relevance hypothesis.

6. Conclusion

We conclude that the factor of associative relevance that is evolved from the undergoing process of analogical mapping on the basis of contexts within the visual fields of artistic portraits, is an integrated, dynamic, and coexisting phenomena during human cognition.

The dynamic shifts in eye gaze depend on the associative relevance during scene viewing. This key notion transmits all analogical mapping to result in cognitive outcomes as visualization of associative eye movement tracks in scene viewing.

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