Associative Patterns of Eye Fixations Process Decision Making during Scene Perception

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Abstract

Tremendous outgrowth of eye movement studies for scene perceptions have revealed a number of unique findings recently. Foundation of improved knowledge-bases as well as understandings about the inherent mechanisms of human visual perceptions and the dynamics of human cognition have become a reality. Above and beyond, business applications of eye tracking have surpassed through a phase of complete success in multidimensional business arenas. In this study, we led a number of eye tracking experiments to ascertain our hypothesis that the eye fixations based on the associative patterns located within the contexts of scenes during scene perception significantly processed the decision making activity. The collected eye movement data from participants who regarded artistic scenes showed that the fixation patterns of eye movements navigated along the existing association among the elements of scenes for decision making. These experimental confirmations established our hypothesis that the associative patterns of eye fixations processed decision making during scene perception.

Keywords: *Associative patterns, Eye fixations, Decision making, Scene perception*

1. Introduction and background

The studies on eye movements are advancing from the very beginning of human visual attention to the recent highly developed knowledge about human visual perception and the dynamics of human cognition. Various emerging and existing interdisciplinary fields are surging for the eye movement researches to avail of opportunities in conceptualizations and implementations. Trends in researches like, human and developmental psychology, psycholinguistic and readings, neuroscience, vision research, usability studies, business marketing and advertising research, ophthalmology, human computer interaction have obvious inclinations for eye movement studies to advance and put into practice the newly discovered ideas of human cognition based on visual perception.

Additionally, these studies have improved research visions and insights, tools and techniques, and extensive applications. Tracking of eye movements leads to noteworthy comprehensions of human mind, in terms of human intentions that are the strategic concerns for businesses because businesses can make acquainted with human conducts, and attitudes to make business plans and policies accordingly. Further, customers' opinions and purposes are necessities for better business and market behavior that mainly depends on their behaviors. Currently, a number of online and offline businesses, like marketing, advertisement, shopping, search engine optimization, and web designing are converting and revolutionizing their business strategies and objectives in accordance with the innovative outcomes of eye movements for business growths [1-7].

Usually, 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 that are common practices among professionals and individuals, including artists and scientists. In reality, this complex mechanism of neurocognition is a combination of numerous underlying processes existing in human mind. The human mind incites and causes cognitive processes, like human's sensation, consciousness, visual attention, perception, meta-cognition, reasoning, analogical thoughts, information processing, and other concerned processes [6-12].

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: movements (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. Therefore, the underlying mechanism of visual viewing is sequential and coordinated phenomena of cognitive as well as correlated processes [6-16].

The study of relationships of movement sequences of eye movements to the behavior of usual human activities has its origin. In fact, inherent salience of objects is not accountable for focal shifts in eye movements, but by their importance to the task or context in hand. In contradiction of free viewing, the movements of eyes and contextual actions are associative in nature and have a chain of linking. Moreover, contextual actions compose of a number of perspectives including an act of associativity within the contexts, elements, or intents. Such associativity has built upon the sense of relevancy among the contexts of the object [13-18].

In addition, a focused visual appearance, i.e. spotlight metaphor, enables and constructs the visual focus of attention in eye movements during artistic scene viewing. The center of focused attention in visual area is considered as having more brightness than areas to which attention is not focused or areas from which attention has been detached. The spotlight of attention switches off at one location and then switches on at other. Besides, as human's capabilities for attention and processing for information has restraints cognitively, so it is rather challenging to consider about focusing everything at a time. Cognitively, human gives attention to small part of visual object, one at a time and likewise, human can focus on only small piece of information at a time. This is why the human processing of information is reasonably gradual as it works on the mechanism of human cognition [10-22].

As a further matter, there occur numerous impact factors, which engender reasoning, notion of analogy, flow of thoughts, meta-cognition, and other pertinent cognitive processes during the eye movements. We regard in a location of scene that is partly determined by the scene's constraints and region's informative description, partly by the task, intent, context, or interest. Viewers can arrange diverse visual paths through the same scene, since they extract information from those parts of the scene to describe particularly. Therefore, the evolved flow of thoughts cognitively, motivates the conscious focus of attention to change to the next contextual part of the scene. By doing so, these impacting factors propel human visual focus of attention dynamically in the phenomena of eye movements [10-38].

Normally, an art is a human way of cognitive activities and the art has the purpose to influence the minds of people who looked at them. Art is productive activity that focuses on the thoughtful modification and embellishment of worldviews. Mostly, 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. In addition, as science is laying its foundation to understand our knowledge about art, likewise, the art offers us a view of mind that understands the art. Undoubtedly, we identify that all types of art are one of the fabulous representations in our lifetimes. It can calm down our distressed heart and motivate our mental states and spirits. Further, artistic perceptions stimulate profound thoughts as well as all types of sensations. Along with other sensations and perceptions, an art stimulates the human emotions as well. That is an integral part of human intelligence, so that the onlookers of artworks may sense and perceive a novel lookout [10-20] [23-32] [39-42].

During artistic scene observation, we move our eyes rapidly in irregular manner to change focus from one movement to another movement. 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 movements. The process of directing the eyes to view picture in real time is known as gazing of eyes. The processes of eye movements bring about and propagate a series of streaming thoughts successively to obtain information about the scene or object of interest. These streams of thoughts predominantly originate the notion of analogy. Although there are a number of standpoints about analogy itself, yet analogical impression is constantly accessible in visual perceptions. Based on existing research works, it gives the consideration that the standpoint of mapping and the standpoint of higher level of perception are two dissimilar looks of the same thing, i.e., analogy. Analogy is one of the inherent concepts that persist during the phenomena of eye movements, although it is not the complete reason to believe as this does not explain the whole scenario [10] [11] [13-15] [17-20] [23-32].

The associative patterns generated by eye fixations during scene perception are based on the associative relevancy that are progressive and coexisting cognitive processes and are emanated from thoughts of analogy and continue to flow during entire timespan of visual scene viewing. These generated processes of associative relevancy bring about the process of associations among the relevant entities or

contexts. These associative relevancy phenomena pass through human cognitive process as an aid during scene viewing, take part in focal shifts of eyes during active scene viewing as well as facilitate in decision making process by choosing the optimal route of alternative. Associative relevancy is developmental and interrelated notion, which originates from thoughts of analogy during the process of human viewing. The influence of associative relevancy predominantly remains during cognitive phenomena of eye movements. It is an underlying mechanism for creativity and annihilation of complexity during information processing and information retrieval for better interpretation of the object of interests. Besides, it resembles as an associative chain that links contexts, intents, portions, elements, shapes, sizes, colors, contrasts, or relations based on similarity or sameness. Further, associative relevancy manipulates and generates an incitement cognitively to associate relative contexts, intents, elements, etc. The process of associative relevancy initiates during the shifts in visual focus of attention as the movements of eyes establish associations among analogical contexts or portions of interest during the active scene viewing [10] [11] [23-38].

Sited literatures suggest that human eye saccades go along different locations to seek information and have tendencies for information retrieval from the visited locations. Such kind of saccadic movements contributes a significant part in the process of decision making. Though in the initial stage of saccadic movements, the eye movements are absolutely random, yet in the subsequent stages of saccadic movements, the eye movements tend for directed movements after attaining the state of decisiveness in human minds cognitively. During this transitional phase and afterward, latest information is sought on the basis of earlier information retrieval. The process continues until a well-established and meaningful objectives are achieved in compliance with the preliminary intentions [10-20] [23-32] [43-51].

The movements of eyes consisting of movements and saccades have a clearly defined objective that may be organized in several alternative ways of movements by making a decision based upon choosing from a set of possible alternatives under the guidance of the cognitive processes and analogical thoughts. Each choice offers its own advantages and disadvantages, so that in a complex situation, the decision maker might not be able to make a preferable option at once and quickly decide why he or she should prefer one alternative and not another. To clarify the situation and compare the alternatives in several aspects, inherent human information processing along with associative relevancy phenomena suggest a series of cognitive operations. Their aims are to analyze the situation critically and thus prepare a decision to move ahead during active scene viewing phenomena.

We propose the hypothesis that associative patterns of eye fixations process decision making during scene perception. This proposed hypothesis is completely based on cognitively generated underlying mechanism consisting of indivisible flow of thoughts that produces the process of associative patterns profoundly.

An undertaking (a system of actions initiated by eye movements) having a clearly defined objective may be organized in several alternative ways (eye gazes) of movements by making a decision based upon choosing from a set of possible alternatives produced by series of movements. Each choice offers its own advantages and disadvantages, so that in a complex situation, the decision maker might not be able to make a preferable option at once and quickly decide why human should prefer one alternative and not another. To clarify the situation and compare the alternatives in several aspects, eye movements suggest a series of operations based on cognitively evolved associative relevancy process. Their aim is to analyze the situation critically and thus prepare a decision for those bearing the responsibility for a final choice by decisive path of movements based on associative relevancy that ultimately assists in making decision within the contexts of visual scenario.

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 movement during experimentation time. As the viewer moves his/her eyes to look a new location of the scene, the camera records new movement 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.

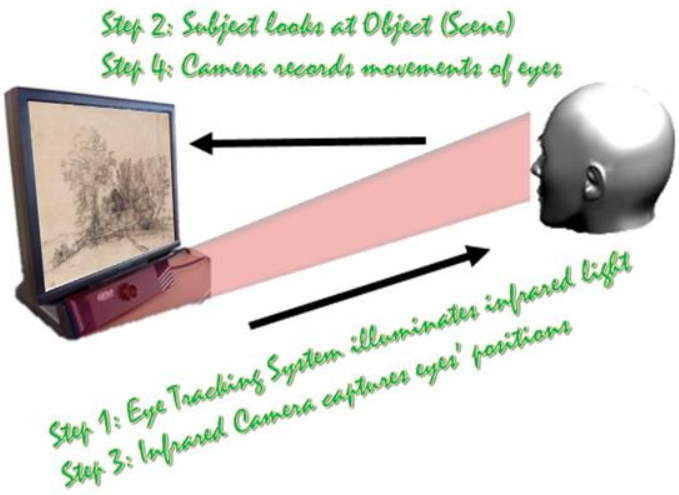

Figure 1. Eye tracking system with operational processes.

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 [6] [7] [11-14].

In our experiments, we study track of eye movements as 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. By these eye fixations, an eye tracking pattern is generated by eye tracking system that records the human eye movements.

3. Present study

We investigate the generated patterns of eye fixations from cognitive perspective, including the associative relevancy process, 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 scene and other item is the generated pattern of eye movement tracks of the same scene, which is generated from eye tracking system.

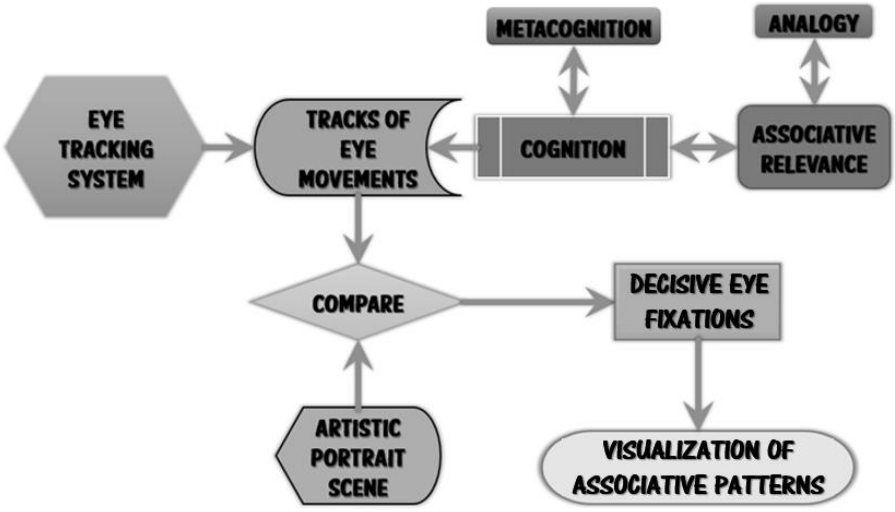

Figure 2. Flow chart of research study.

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

During comparison stage, we make use of cognitive process including metacognitive process, in addition to analogy based associative relevancy mechanism that is happening consistently. These underlying processes generate crucial correlation that creates resultant patterns of eye fixations. By analyzing, we come up with concluding remarks about the dependency of eye movements on the associative relevancy that controls and processes decision making in human mind.

4. Method

We selected 91 participants from a number of fields randomly, aging from 19 years to 45 years. Further, we assigned these participants (Subjects) to view three randomly selected famous artistic scenes (Objects) as shown below in figure 3.

The artistic scenes were “The fishing boat at sea”, “The cottage among trees”, and “The marsh with water lilies”.

Figure 3. Selected Artistic Scenes for research study

Their eye movements were closely monitored as they viewed 32 bits full-color artistic scenes. The Objects, the scenes were displayed on a computer monitor. The scenes 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 sequenced gazing with circles of concentration.

The Subjects' heads were 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 scenes freely.

The scenes were presented to the Subjects for maximum duration of 60 seconds. During this time span, the Subjects viewed the scenes with their normal eyes and focused attention on the Object, the scene.

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

5. Analysis

During the phase of analysis, we analyzed all two sceneries respectively with the purpose to expound our findings methodically in the most generalized perspective.

5.1. Study of "The fishing boat at sea" artistic scene

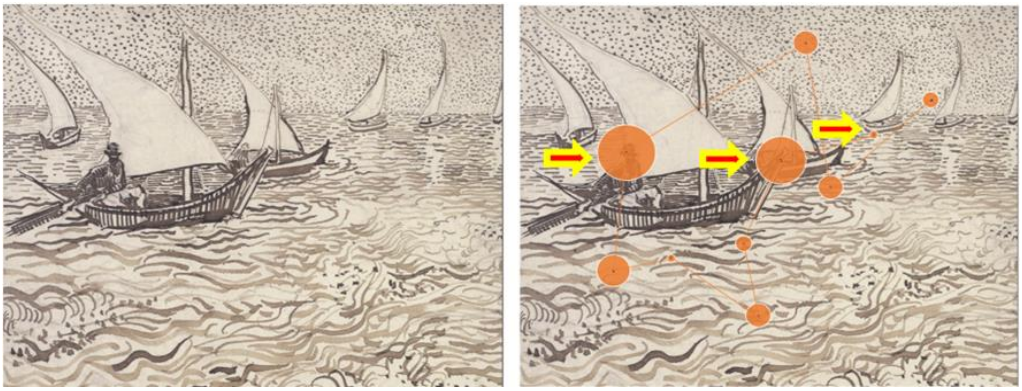

Figure 4. The fishing boat at sea scene and eye movement track of the same artistic scene

In experimentations of the above artistic scene (figure 4), the left side scene is the original scene of the fishing boat at sea showing a number of boats being sailed across the sea. The right side scene is the track of eye movements by eye tracking system during the scene viewing by the Subject.

In beginning of the experimentation, as the Subjects started to move the eyes randomly, they looked at the upper central part of the scene. Subsequently, as the visual attentions and consciousness of the Subjects were gained due to happening of cognitive processes, they started to look at the upper central boat sailed by a fisherman and focused over the fishing boat at sea. At this point, the eye fixation pattern generated by gazing at the boat was carried along with inherently intrinsic processes of cognitive flow of thoughts and evolved perception in terms of associative relevancy. Further, the obtained information could be forwarded in the next successive move of eye tracks. An analogous and associative element of scene was encountered in terms of another fishing boat sailed by another fisherman at sea. The associative correlation between these two fixations had established a significant process of decision making based on these associative patterns for further moves of eye tracks.

Later, Subjects gazed their eyes towards the lower portions of the scene. It happened due to the establishment of scanpath nature of eye movement for information seeking purpose. In addition to these, these subsequent moves during eye tracking indicated the biased flow of thoughts that happened due to cognitively developed awareness and attentiveness for implementation of coexisting flow of thoughts.

However, the established flow of thoughts in terms of associative patterns based on sailing boats along with fishermen continued further and directed eye tracks that were in need for a decisive move forward.

This decision making process was carried along with inherently intrinsic processes of cognitively evolved associative relevancy which was based on analogical thoughts that are flowing within cognitive minds.

Subsequently, by the coexisting phenomena of associative patterns evolved from associative thoughts, the Subjects shifted their eye gazes towards the nearest fishing boat at sea in the scene; the central left portion of the scene. At this state, the Subjects attained the process of chaining the relevant contexts of the scene in accordance with the existing process of associative relevancy and perceived the inherent process that consistently directed and controlled the track of eye movements. The process of associative relevancy in the Subjects' minds caused them to move along with their eye movements and recognized associative patterns. The procedure continued till the track of eye movements reached to the right-side of the scene for seeking further information based on established knowledge and associative patterns.

Therefore, we concluded that the associative patterns generated during the eye movements processed decision making activity. The visualization of associative patterns during scene perception revealed the process of decision making by human mind under the influence of underlying mechanism of cognitively evolved process of associative relevancy.

Further, later interview of Subjects confirmed the generated patterns of associative relevancy and the influential factor that led them to move their eyes decisively. In the beginning, they were gazing at the upper and central portions of the fishing boats at sea due to analogous objects of interest within the scene, later got interest in analogous contexts of the nearest fishing boat within the elements of scene. These factors helped and guided in making decision for the next move within various portions of the scene. The process of such viewing continued further and ended after allocated timespan. So, we concluded that in these experimentations, the generated associative patterns of eye fixations processed decision making during scene perception.

5.2. Analysis 2: Study of "The cottage among trees" artistic scene

Figure 5. The cottage among trees scene and eye movement track of the same scene

In this experimentations of artistic scene (figure 5), the left side scene is a famous painting named as 'the cottage among trees'. In this scene, there is a central fenced cottage and surrounded by trees. On the right side, the same scene along with eye tracks is shown.

In the beginning of experimentations, the Subjects looked at the lower-central region of the scene where they gazed at the central cottage and later, they looked at lower portion of the cottage in the scene due to the attainment of the visual attention and scene perception. At this stage, the attainment of cognitive correlation was built up by the flow of thoughts that propagated in between the associative patterns of eye fixations cognitively. Ultimately, these established flow of a thoughts sparked cognitively generated process of associative relevancy and established a thought of associative patterns. Based on these processes of associative relevancy and seeking for patterns of associative nature, the eye gaze decisively moved towards lower-left side of the scene. Subsequently, the track of eye movements moved to the lower portion of the central cottage and circulated the established thoughts of associativity among the elements of scene based on cottage.

Later, due to the origination of in-between novel flow of thought and the breaking of the contextual factor of human cognition, associative relevancy process could not further direct eye movements on the

same basis of central cottage based associative pattern rather the process emerged with a novel contextual factor of scene background. Subsequently, due to the dominating and coexisting phenomena of associativity, the flow of associative thinking emanated associative relevancy that assisted eye movements in making decision to move forward from lower-left portion to central portion of the scene where the flow of thought based on associative correlation among the elements of scene was reconstructed. Hence, the eye movements decisively followed along the guidance of associative relevancy process based on contextual elements of scene. Further, these happenings of phenomenal sequences concluded that the generation of associative patterns directed and guided the Subjects' eye movements for making decisions which is evident form the visualization of associative patterns of eye fixations.

In successive interview, the concerned Subjects revealed that they were strongly influenced by the analogous objects and excited to know about the interrelation within the scene. Mostly, they were interested to understand the relevant meaning of objects within scene. By doing so, they shifted their eye gazes as directed expressively by existing influential portions within the scene. Therefore, we concluded that the associative patterns of eye fixations processed decision making during scene perception.

5.3. Analysis 3: Study of "The marsh with water lilies" artistic scene

Figure 6. Scene of the marsh with water lilies and eye movement track of the same scene

In these eye tracking experiments for the marsh with water lilies scene (figure 6), the scenery represents the muddy marsh filled with water lilies. The scene at the left side is the original artistic scene, whereas the scene at the right side is the eye movement track of the same scene.

In the beginning, due to the initiation of visual attention and consciousness by viewing artistic scene, the Subjects focused eye movements at the center portion of scene. It was due to sensational difference in color contrast of context (water color and dark grass in the center of marsh along with flying bird) that compelled the focus of eye gazes to perceive the underlying cognizance. At this stage, the formation of cognitively evolved associative relevancy among contextual background by the flow of analogical thoughts played a significant role and made to move the eye gazes decisively. The process for the foundation of associative correlation was progressed cognitively in human mind. Hence, the eye fixation shifted to the upper portions of the scene where the soil was in same color contrast of context (the dark grass of ground). The associative correlation was established between these elements of scene and the process of associative pattern formation continued. Further, this process induced the eye fixation to go ahead along the existing flow of associative thought cognitively.

Next, eye fixation shifted temporarily for information seeking mode as it could not find associative relevancy based context within the elements of scene. In the next move, the process of associativity was reestablished and the eye gazes came across the right portion of the scene. The visual attention and sensation of the Subjects perceived cognitively evolved associative relevancy and formation of associative patterns consecutively. The eye fixations moved towards left side of the scene where eye fixations found associative relevancy with the existing contextual basis and the associative flow of thoughts. Further, the generated associative patterns by eye fixations based on associativity revealed that

the decision to move along existing associativity among the elements of scene was made by influential flow of associative thoughts.

Hence, these experimentations showed the existence of cognitively created associative patterns and directional shifts in accordance with these associative relevancy processes during the scene viewing.

Later interviews of the Subjects concluded that they got interest in bright and dark color contrast within various portions of the scene due to contextual objects of the scene. These similar portions of the scene were attractive to them as these were viewing the scene. These related influencing factors were very peculiar to them. So, they decided to move their eyes accordingly.

So, these associative patterns led towards the observable confirmation that the existence of associative relevancy process that streamed in between the human cognitive processes during scene viewing, guided and processed decision making for the eye fixations to move along. Therefore, we established that the associative patterns of eye fixations processed decision making during scene perception.

6. Discussion

In this research work, we select some of the finest pieces of art deliberately. The artistic scenes involve in their demonstration with the foremost intent of artistic artworks in the shape of human cognition mechanism in viewing these artistic scenes. These creative pieces of art display inherent human interaction to perceive knowledge and elucidation of realistic world in human mind. Further, these emotional assessments are rather too convoluted to comprehend from visual analytics and analytical reasoning. Consequently, these cognitive perspectives, i.e. thinking of analogy and process of associative relevancy are discovered by the associative patterns of eye fixations in scene viewing.

Decision making is a wide open topic to be explored in various reference frames. In each and every domains of management, technology, and sciences, the significance of decision making and the studies on decision making processes have revealed an integrated and complementary part of all scenarios. In a number of cited literatures, the decision making process is closely connected with the human cognition as there is a significant amount of contribution and control carried out by the human interaction. Moreover, most of the times, the decisions are made by the human within human-centric processes and scenarios that are nurtured by human interactions [43-51].

Generated associative patterns from the associativity and the flow of associative thoughts during scene viewing are significant stages for appropriate retrieval of task-relevant visual information which are essential for visualization of final patterns. In this study, we notice that the generated associative patterns by eye movement tracks are intensely trailing the identical path as guided and decided by the associative relevancy processes. These associative patterns indicate a vibrant inclination for the processing of decision making and getting initiation from the associative correlation among contexts during eye movements. Therefore, the eye movements are manipulated procedure under the guidance of associative relevancy transmission. As a result, without taking into account the influential factor; associative relevancy propagation, it is impossible to link the entire scenario of human cognition in the sequential patterns within eye movement tracks.

However, there are plenty of situations during which the presence of uncertainty factors places the saccades into a new position where decisions are to be made under uncertainty. Although the uncertainty that sticks with the movements of eyes, has no advantage, yet the conditions of operations are not known and we cannot optimize the decision with their degree of success. There is a fair possibility of improvement and optimization of the decision by adding counterfeit information in hand. Therefore, the decision making under certain level of uncertainty is worse than the decision making with known conditions, i.e. the conditions beforehand. Further, the directed and cognitively associated decision making processes bound for and lead towards accurate and appropriate decision. Thus, the fixations among saccades during eye movements act as junctions that undergo through the processes of decision making under the associated cognitive processes of influential nature.

The visualization of streaming associative relevancy process in terms of followed eye movement tracks is a tactical and decisive part of whole activities. The visualization of decisive and controlled eye movement tracks, in terms of associative relevancy, is unarguably innovative perspective of each and every analyst who examine them for definite intents of decision making processes. This, in turn, causes a number of associative relevancy scenarios in scene viewing by various perspectives of analysts.

The directional shifts in eye movements have correlated consequences along with the decision making processes that is happening cognitively within human mind and is consistently processing information

together with the associative relevancy processes in terms of associative patterns. The visualization of relevant eye movement tracks reinforces again the existence of dominating associative relevancy factor; the controller of entire phenomena in between the inherent cognitive and metacognitive processes during scene viewing.

In addition to these arguments, the experimental evidence of associative traversal path and in turn, generated associative patterns by eye tracks as the happening of decision making processes during active scene viewing hold our hypothesis for which we conducted a series of experimentations. The hypothesis that the associative patterns of eye fixations process decision making during scene perception, is convincing and inventive development related to eye movement research.

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8. References

[1] Monica Koller, Thomas Salzberger, Gerhard Brenner and Peter Walla, "Broadening the range of applications of eye-tracking in business research," Analise, Porto Alegre, vol. 23, no. 1, pp. 71-77, 2012.
[2] Bing Pan, Helene A. Hembrooke, Geri K. Gay, Laura A. Granka, Matthew K. Feusner and Jill K. Newman, "The Determinants of Web Page Viewing Behavior: An Eye-Tracking Study," Association for Computing Machinery, pp. 147-154, 2004.
[3] Bing Pan, Helene Hembrooke, Thorsten Joachims, Lori Lorigo, Geri Gay and Laura Granka, "In Google We Trust: Users' Decisions on Rank, Position, and Relevance," Journal of Computer Mediated Communication, vol. 12, pp. 801-823, 2007.
[4] Laura A. Granka, Thorsten Joachims and Geri Gay, "Eye-Tracking Analysis of User Behavior in WWW Search," in SIGIR 04, Sheffield, South Yorkshire, UK, 2004.
[5] Olav Hermansen, "Implementing eye movements in business applications," Brage Bibsys, Hogskolen i Ostfold, 2015.
[6] Aga Bojko, Eye Tracking: The User Experience, a practical guide to research, New York: Rosenfeld Media, 2013.
[7] Andrew Duchowski, Eye Tracking Methodology: Theory and Practice, London: Springer Verlag, 2003.
[8] Luca Tommasi, Mary A. Peterson and Lynn Nadel, Eds., Cognitive Biology: Evolutionary and Developmental Perspectives on Mind, Brain and Behavior, London: MIT Press, 2009.
[9] Tom Brown, the Science and Art of Tracking, New York: NY: Berkley Books, 1999.
[10] Gufran Ahmad, Yukio Ohsawa and Nishihara Yoko, "Cognitive Impact of Eye Movements in Picture Viewing," International Journal of Intelligent Information Processing, vol. 2, no. 1, pp. 18, 2011.
[11] Jana Holsanova, Discourse, Vision, and Cognition, New York: John Benjamins Publishing Company, 2008.
[12] John K. Tsotsos, A Computational Perspective on Visual Attention, London: MIT Press, 2011.
[13] Lawrence Stark and Stephen R. Ellis, "Scanpaths Revisited: Cognitive Models Direct Active Looking," in Eye Movements: Cognition and Visual Perception, R. A. M. J. W. S. Dennis F. Fisher, Ed., Hillsdale: Lawrence Erlbaum Associates, 1981, pp. 193-226.
[14] Robert Snowden, Peter Thompson and Tom Troscianko, Basic Vision: An introduction to visual perception, Oxford University Press, 2012.
[15] Keith Rayner, Eye movements and visual cognition: scene perception and reading, New York: Springer Verlag, 1992.

[16] Simon P. Liversedge, Iain D. Gilchrist and Stefan Everling, The Oxford Handbook of Eye Movements, Oxford University Press, 2011.
[17] John. M. Henderson and Andrew Hollingworth, "Eye movements during Scene Viewing. An Overview," in Eye Guidance in Reading and Scene Perception, G. W. Underwood, Ed., Oxford: Elsevier, 1998, pp. 269-293.
[18] Roger P. G. Van Gompel, Martin H. Fischer, Wayne S. Murray and Robin L. Hill, Eds., Eye Movements: A Window on Mind and Brain, Elsevier, 2007.
[19] Zenzi M. Griffin, "Why look? Reasons for eye movements related to language production," in The integration of language, vision, and action: Eye movements and the visual world, H. a. Ferreira, Ed., New York, Psychology Press, 2004, pp. 213-247.
[20] James E. Hoffman, "Visual Attention and Eye Movements," in Attention, H. Pashler, Ed., London, Psychology Press, 1998, pp. 119-153.
[21] Adrian Wells, Emotional Disorders and Metacognition: Innovative Cognitive Therapy, West Sussex: John Wiley & Sons, 2000.
[22] Benjamin Martin Bly, David E. Rumelhart, Eds., Cognitive Science, Academic Press, 1999.
[23] Gufran Ahmad, "Dynamic Shifts in Visual Focus of Eye Movements Emphasize Associative Relevancy", Research in World Economy, vol. 6, no. 4, pp. 18-28, 2015.
[24] Gufran Ahmad, "Visual Focus of Attention Actively Associates Relevancy in Eye Movements", Journal of Business Theory and Practice, vol. 3, no. 2, pp. 209-223, 2015.
[25] Gufran Ahmad, "Eye Fixation curves along Analogical Thinking in Scene Viewing," International Journal of Engineering and Industries, vol. 6, no. 1, pp. 54-62, 2015.
[26] Gufran Ahmad, "Dynamics of Eye Gazing rely on Associative Relevance in Scene Viewing," Journal of Convergence Information Technology, vol. 9, no. 2, pp. 35-42, 2014.
[27] Gufran Ahmad, "Associative Relevance Based Stimulus Shifts Focus in Eye Movements", International Business Research, vol. 8, no. 10, pp. 25-34, 2015.
[28] John M. Henderson and Andrew Hollingworth, "High-level Scene Perception," Annual Review of Psychology, vol. 50, no. 1, pp. 243-271, 1999.
[29] Gufran Ahmad, "Flow of Analogical Thoughts Controls Eye Movements in Scene Viewing", Journal of Next Generation Information Technology, vol. 5, no. 4, pp. 118-125, 2014.
[30] Gufran Ahmad, "Analogical Thinking Induces Eye Movements in Scene Viewing", International Journal of Machine Learning and Computing, vol. 4, no. 1, pp. 94-98, 2014.
[31] Gufran Ahmad, "Analogical Thoughts Persuade Eye Movements during Scene Viewing", International Journal of Intelligent Information Processing, vol. 4, no. 4, pp. 39-45, 2013.
[32] Gufran Ahmad, "Analogy Influences Eye Movements during Scene Viewing", Proceedings of International Conference on Computing and Convergence Technology, Republic of Korea, pp. 14, 2013.
[33] Douglas Hofstadter and Emmanuel Sander, Surfaces and Essences: Analogy as the Fuel and Fire of Thinking, New York: Basic Books, 2013.
[34] Dedre Gentner, M. J. Rattermann and K. D. Forbus, "The roles of similarity in transfer: Separating retrievability from inferential soundness," Cognitive Psychology, vol. 25, pp. 524-575, 1993.
[35] Dedre Gentner, "Structure-mapping: A theoretical framework for analogy," Cognitive Science, vol. 7, pp. 155-170, 1983.
[36] Gufran Ahmad, "Eye Movements Look for Analogical Patterns during Scene Viewing," Journal of Economics, Business and Management, vol. 2, no. 4, pp. 285-288, 2014.
[37] Dedre Gentner and A. B. Markman, "Structure-mapping in analogy and similarity," American Psychologist, vol. 52, pp. 45-56, 1997.
[38] Dedre Gentner and J. Medina, "Similarity and the development of rules," Cognition, vol. 65, pp. 263-297, 1998.
[39] Fernanda B. Viegas and Martin Wattenberg, "Artistic Data Virtualization: Beyond Visual Analytics," in Second International Conference on Online Communities and Social Computing, 2007.
[40] Mark Turner, The Artful Mind – Cognitive Science and the riddle of human creativity, Oxford University Press, 2006.
[41] Robert L. Solso, The psychology of art and the evolution of the conscious brain, MIT Press, 2003.
[42] Robert L. Solso, Cognition and Visual Arts, London: MIT Press, 1994.
[43] John Adair, Decision Making and Problem Solving Strategies, London: KoganPage Press, 2010.

[44] Gary D. Bird, Johan Lauwereyns, Matthew T. Crawford, "The role of eye movements in decision making and the prospect of exposure effects", Vision Research, vol. 60, pp. 16-21, 2012.
[45] Andrey R. Nikolaev, Sebastian Pannasch, Junji Ito, Artem V. Belopolsky, (Eds.), Eye movement related brain activity during perceptual and cognitive processing, Frontiers Research Topics, Frontiers E-books, 2014.
[46] Gufran Ahmad, "Associative Relevance based Eye Fixations enhance Decision Making Processes in Scene Perception", Journal of Management Research, vol. 8, no. 2, pp. 1-17, 2016.
[47] Jacob L. Orquin, Simone Mueller Loose, "Attention and choice: A review on eye movements in decision making", Acta Psychologica, vol. 144, no. 1, pp. 190-206, 2013.
[48] Rufin VanRullen, Simon J. Thorpe, "The time course of visual processing: from early perception to decision-making", Journal of Cognitive Neuroscience, vol. 13, no. 4, pp. 454-461, 2001.
[49] Agnes Scholz, Bettina von Helversen, Jörg Rieskam, "Eye movements reveal memory processes during similarity- and rule-based decision making", Cognition, vol. 136, pp. 228-246, 2015.
[50] Thi Minh Hang Vu, Viet Phu Tu, Klaus Duerrschmid, "Design factors influence consumers' gazing behavior and decision time in an eye-tracking test: A study on food images", Food Quality and Performance, vol. 47, Part B, pp. 130-138, 2016.
[51] Sung Jun Joo, Leor N. Katz, Alexander C. Huk, "Decision-related perturbations of decision irrelevant eye movements", PNAS, Proceedings of National Academy of Sciences of the United States of America, vol. 113, no. 7, pp. 1925-1930, 2016.