Associative Relevancy facilitates Process of Decision Making during Eye Movements

Gufran Ahmad
Global IT Consultancy for Innovations, India
gufran.researcher@gmail.com

Abstract

Research studies on the influencing factors of eye movements for decision-making processes have intensively advanced towards comprehending core mechanism of visual perception and human cognitive dynamics. In this study, we carried out a number of eye tracking experiments to prove our hypothesis that the eye movements based on the associative relevancy attained within the elements of scenes during scene perception considerably eased the processes of decision-making. The collected eye movement data from participants who viewed artistic scenes discovered that the tracks of eye movements traversed along the subsisting associative relevancy among the portions of scenes for decision-making processes. These experimental proofs validated our hypothesis that the associative relevancy facilitated the process of decision making during eye movements.

Keywords: *Decision-making, Eye movements, Associative relevancy, Scene perception*

1. Introduction and background

Studies on eye movements are undergoing in the advanced level of pioneering tactics and sightings. Numerous interdisciplinary requirements and considerations have broadened eye movement researches into several viewpoints of social, commercial, professional, and scientific scenarios. Research areas like, human and developmental psychology, psycholinguistic and readings, neuroscience, vision research, usability studies, business marketing and advertising research, ophthalmology, human computer interaction are trending for more insightful interests than ever before and eye movement studies are taking part in these areas. Additionally, these studies have upgraded research visions and comprehensions, tackles and practices, and widespread applications. Tracking of eye movements leads to remarkable understandings of human mind, in terms of human intents that are the deliberate concerns for businesses because businesses can make accustomed with human behaviors and approaches to make business strategies and rules accordingly [1-6].

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. Therefore, the underlying mechanism of visual viewing is sequential and coordinated phenomena of cognitive as well as correlated processes [7-20].

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 [10-22].

The study of relationships of locational 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 [23-27].

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 [11-20].

As a further matter of fact, 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 [28-38].

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 [39-42].

During artistic scene observation, we move our eyes rapidly in irregular manner to change focus from one location to another location. 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. 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 [28-42].

There comes the process of associative relevancy that is a progressive and coexisting cognitive process emanated from thoughts of analogy and continues 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, and 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 [23-27] [33-38].

Sited literatures suggest that human eye saccades are information seeking in nature and are engaged in the job of retrieving information. However, the fixations play significant role, as they get involved in decision making, so that new information based on the previous decision might be sought. Further, the decision might be verified for future purposes as well. Besides, the eye fixations act as junctions that undergo through the processes of decision-making under the associated cognitive processes of influential nature [7-20] [43-51].

The movements of eyes consisting of fixations 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 suggests 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 [10-20] [43-51].

We propose the hypothesis that associative relevancy facilitates the process of decision making during the during eye movements. This proposed hypothesis is completely based on cognitively generated underlying mechanism consisting of indivisible flow of thoughts that produces the process of associative relevancy profoundly. An activity consisting of actions initiated by eye movements has a clearly defined objective and may be organized in several alternative ways, in terms of, eye gazes (fixations) by making a decision based upon choosing from a set of possible alternatives produced by series of fixations. 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 facilitates in making decision within the contexts of visual state.

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.
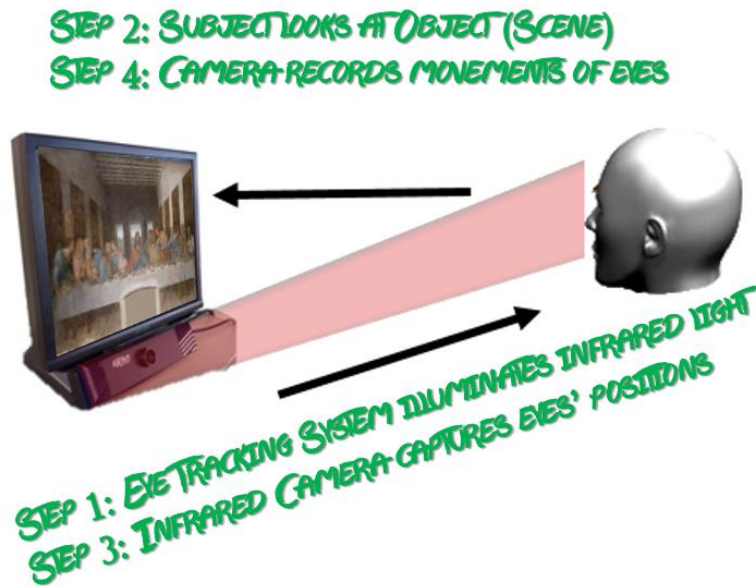
Figure 1. Eye tracking system with operational processes.

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 gazing in those areas respectively [6-7] [11].

In our experiments, we study tracks 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.

3. Present study

We investigate the gazing of eye movements 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 is essential step 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 eye movement tracks of the same scene, which is generated from eye tracking system.
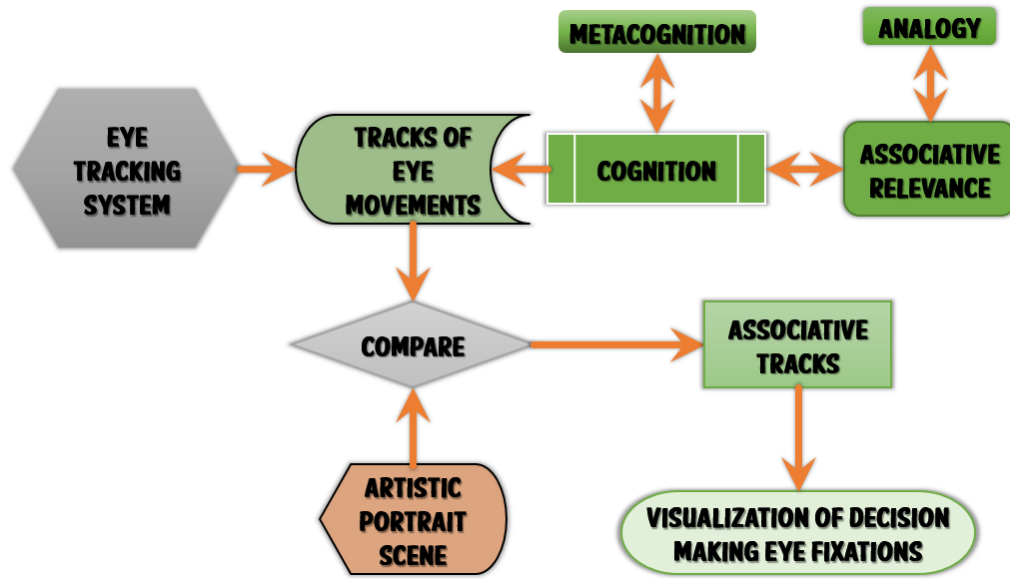
Figure 2. Flow chart of research study.

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 are comparable to the original artistic scene. This comparative analysis infers visualization and interpretation of the outcome. Therefore, 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 maps. By analyzing, we come up with concluding remarks about the dependency of eye movements on the associative relevancy that controls and facilitates the process of decision making in human mind.

4. Method

We selected 81 participants from a number of fields randomly, aging from 19 years to 45 years. Further, we assigned these participants (Subjects) to view two randomly selected famous artistic scenes (Objects) as shown below in figure 3.

The artistic scenes were "The last supper with Jesus and companions", "Artistic expressions with living Creatures".

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 these two 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. Analysis 1: Study of artistic portrait 'The last supper with Jesus and companions'
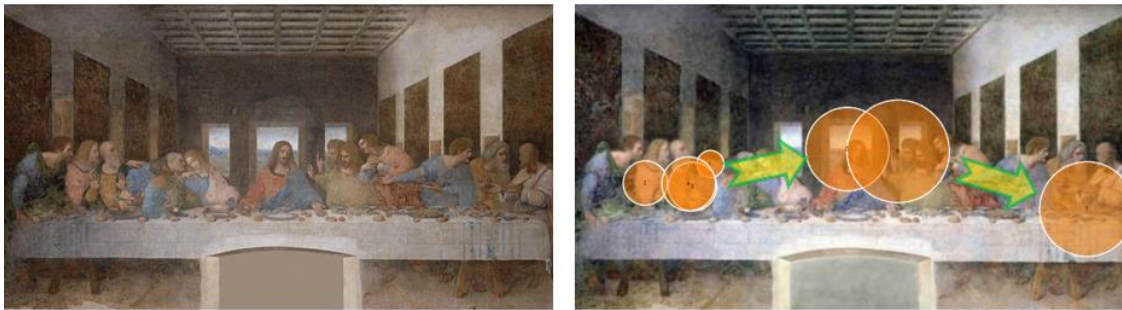

Figure 4. Scenery of 'The last supper with Jesus and companions' and eye track of the same scenery

In these eye-tracking experiments of figure 4, the Subject attentively looked at artistic scenery of 'the last supper with Jesus and companions' having holy Jesus sitting in the central portion of the scene and other companions talking and expressing gesticulations.

In the beginning, the Subjects' started to move their eyes towards the left side of the scenery where the Subjects' looked at the companions with their facial expressions and hand gestures. The Subjects' sensation and visual attention brought the eye gazes to come across these elements, i.e. the companions on the left side of the scenery that brought forward human consciousness and visual perception.

At this moment, the Subjects' minds were cognitively withstood in the middle of flow of thoughts that evolved cognitively generated associative relevancy process. Therefore, the eye gazes dynamically shifted towards the central portion of the scenery and found holy Jesus and companions of analogical nature, i.e. their facial expressions and gestures. The process of association among these contexts of relevancy came into existence and started the process of chaining these relevancies. At this stage, the Subjects perceived knowledge about the field of the scenery, which helped them to move to the next step. Moreover, due to the existence of cognitive process during the shifts in visual focus of attention, the Subject sensed the flows of analogical thoughts and started to realize the idea of analogy. These cognitive phenomena compelled the Subjects to shift further within the scenery due to existing relevancy among them in terms of being the Objects of sameness. This evolved thought and association of relevancy continued in the next move as visual focus of attention shifted towards the central portion of the scenery where the Subject put the visual focus of attention.

In addition to these, there existed one more perspective of decision-making process that consistently remained there in Subjects' minds and was supported and coordinated by the process of associative relevancy. Even before the shifting of the eye gazes, the underlying mechanism of associative relevancy cognitively helped in the process of decision making for the next move of the eye gazes. Therefore, under the guidance of associative relevancy, the subjects' eyes moved along the guided track.

Next, the eye gazes dynamically moved towards the right side of the scene and associated again the facial expressions and hand gestures in the subsequent moves. Cognitively, the process of chaining carried out by the influential factor of associative relevancy. Such directed moves of eye gazes were decisively performed by the human mind where the processes of decision making under the command of cognitively generated associative relevancy were established. The process of the decision-making was heavily relied on the process of associative relevancy because of the involvement of human cognition in human centered information processing and decision-making. Within these stages, the visual focus of attention came across cognitively generated incentives that evolved flows of analogical thoughts. These thoughts derived a sense of associativity among the focused houses in subsequent movements of eyes. These types of associative chaining among relevant elements (facial expressions and hand gestures) in the artistic scenery arose from cognitively induced factor of analogy and associative relevancy. Hence, associative relevancy was the driving force that provided a significant mechanism for the happening of the process of decision-making in human minds. Without this important mechanism, human eye gazes would be unable to move decisively.

Later conversations to the Subjects suggested that the ongoing conversation and dialogues among the companions and the holy Jesus were the objects of interest in the beginning. Subsequently, the facial expressions and hand gestures of the artistic scenery became a matter of interest to the Subjects, as these objects were wonderful and interesting entities of the artistic scenery that Subjects started to pay attention. The related fields of similarity compelled them to shift their visual focuses of attention dynamically and decided to focus over those facial expressions and hand gestures subsequently.

Hence, by undergoing cognitive processes of Subjects' minds in artistic scenery viewing, we concluded that associative relevancy facilitated the process of decision making during eye movements. Hence, we got concrete confirmation in this analysis about our hypothesis.

5.2. Analysis 2: Study of Artistic Scenery 'Artistic expressions with living Creatures'

Figure 5. Scenery of 'Artistic expressions with living Creatures' and eye track of the same scenery

In these eye-tracking experiments of figure 5, we showed an artistic scenery "Artistic expressions with living Creatures" that was an artistic expression of joy and pleasure among various humans and animals. In the beginning, the consciousness of the Subjects developed visual attention and the eye gazes started focusing at lower left portion of scenery where human dancing was an activity of joy. At this stage, the eye gazes persisted there for processing information to perceive and retrieve the knowledge. The Subjects attained a definite flow of thought based on contextual portion of the scene and in turn, passed through the process of associative relevancy in the next move. Consequently, the eye gazes dynamically shifted to the adjacent right character of the scene. Again, the eye gazes perceived the sense of joy and pleasure in dancing creature.

Next, as the existing flow of thought relied on the idea of analogy and initiated to associate the contextual fields of creatures' joy and pleasure within the artistic scenery, Subjects' eye gazes moved to the next right creature near central portion of the scene. This brings visual 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 considerations and the process of linking visual elements of scenery based on associative relevancy. By doing so, it became obvious that the driving force of associative relevancy enabled in moving forward the eye gazes from one fixation to the next fixation, and in turn, facilitated the process of decision making within human minds, so that the eye gazes moved accordingly and decisively.

The Subjects' eye gazes moved towards next contextually relevant visual field of the scenery, which was a field of associativity relevant field of joy and pleasure of another creature. The process of associative relevancy directed the Subjects' eye movements to think about the associative contexts (the joy and the pleasure emotions) of visual fields in the scenery. Such associative relevancy under the Object's emotional joy and pleasure originated cognitively generated incentives that exerted drive to facilitate eye movements to proceed further in the direction of associatively relevant elements of the scenery. Further, the shifts in eye gazes during eye movements reflected the associative relevancy that actively linked such relevancy under the influential cognitive processes. Furthermore, the shifts in eye gazes influentially driven by associative relevancy indicated the processes of decision making in human minds that compelled to move further.

Later interviews of the Subjects comprehended these details as well. They reported that they were actively looking at emotional pleasure and joy among creatures of the artistic scenery, as these Objects existing in different portions of the artistic scenery were interesting to them. Such attraction made the decision to continue the process of scene viewing. This settled our hypotheses that the associative relevancy facilitated the process of decision making during eye movements.

6. Discussion

In this research work, we choose some of the finest pieces of art intentionally. The artistic sceneries embrace in their manifestation with the foremost purpose of artistic artworks in the shape of human cognition mechanism in viewing these artistic sceneries. 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, i.e. thinking of analogy and process of associative relevancy are discovered by the tracks of eye movements in scene viewing [6] [10-22] [39-42].

Decision-making has become a science rather than an art. Although in some of the management sectors, people still consider it as an art, yet the studies of decision-making processes have revealed it as a science. 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 [10-22] [43-51].

Coexisting associative relevancy processes from the flow of analogical thoughts during scene viewing is significant step for appropriate retrieval of task-relevant visual information, which are essential for visualization of final maps. In this study, we observe that the generated tracks of eye movements are strongly following the same path as directed and decided by the associative relevancy processes. These facts show a clear tendency for decision-making process to get initiation from the associative relevancy based eye movements. Therefore, the eye movements get manipulated operation under the guidance of associative relevancy broadcast. As a result, without taking into account the influential factor, i.e. associative relevancy propagation; it is impossible to link the entire scenario of human cognition in the sequential eye movements within eye movement tracks.

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 analyst who examines 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 are happening cognitively within human mind and is consistently processing

information together with the associative relevancy processes. The visualization of relevant eye movement tracks reinforces again the existence of dominating associative relevancy factor, i.e. 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 generated by eye tracks as the happening of decision-making processes during active scene viewing holds our hypothesis for which we conducted a series of experimentations. The hypothesis that the associative relevancy facilitates the process of decision making during eye movements, is a persuasive and innovative finding related to eye movements study.

7. Acknowledgement

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. 1-8, 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 and 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. 1-4, 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 behaviour 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.