

Eye Fixation curves along Analogical Thinking in Scene Viewing

Gufran Ahmad

Global IT Consultancy for Innovation, India
gufran.researcher@gmail.com

Abstract

Advances in eye movement research and applications of eye movements are shaping and stretching new dimensions day-by-day. In this study, we investigated existing correlation between the eye movement tracks and the flow of analogical thinking. We experimented a series of eye tracking tests to demonstrate our hypothesis that the generated track of eye fixations during scene viewing were predominantly moved and curved along the flow of analogical thinking. Eye movement data were collected from participants who viewed artistic portraits. The eye tracks from eye tracking system traced sequence of eye fixations based on existing flow of analogical thinking. These experimental phenomena verified the hypothesis that the eye fixations curved along analogical thinking in scene viewing.

Keywords: Eye movements, Analogical thinking, Eye fixation, Scene viewing

1. Introduction and background

Studies on eye movements and usages of eye movements are growing exponentially day-by-day. One of the core studies about eye movements gets focus on the influential factors that cause such movements of eyes. These works, which are noteworthy for scientific, social, technological, business applications, appeal considerable motivations among Researchers, Professionals, and Social Practitioners in recent years. So, intense endeavors are engaged in the study the influential factors of human eye movements. Unquestionably, by controlling the influential factors that move human eyes during scene viewing, we may control the eye movements as well.

Human eyes and brain are firmly linked biological units of every human being. So, the system, consisting of human eyes and brain, facilitates several neurological, perceptual, and cognitive phenomena. In the middle of these activities, there lies an essential and mandatory process; the process of eye movements that helps a human in visual viewing and understanding of surrounding objects. The movements of eyes initiate a series of cognitive functions, 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 [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 [5-9].

Typically, an art is defined as a human way of cognitive activities, 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 [10-18].

The thought of analogy is significant in cognitive processes and is key mechanism in creativity which is also a part of the subject, like Visual Art. On the whole, there are two prime ideological viewpoints regarding the concept of analogy [11-15][19-23].

One of the groups of experts considers analogy as high-level perception. There is no clear division between perception, including high-level perception, and analogical thought. As a matter of fact, analogy happens not only at the end, but also in the beginning and during the same time as high-level perception. In high-level perception, humans make representations by selecting relevant information from low-level stimuli. As perception is compulsory for analogy, likewise, analogy is also compulsory for high-level perception [19].

However, the other group of experts considers the shared structure mapping theory. According to this consideration, analogy depends on mapping or alignment of the elements of source and target. The mapping takes place not only between objects, but also between relations of objects and between relations of relations. Mapping is basically process of aligning the representational structures of the two cases and projecting inferences. The main focus of such research is on the mapping process by which people understand one state or pattern in terms of another [20-23].

As a conclusive remark about the analogy and analogical thought, it is important to unveil the facts about these concepts. It is considered that though both groups of experts have different aspects about analogy and analogical thoughts, yet it seems that they are different aspects of the same thing, i.e. two perspectives which are identically equal.

Analogical thoughts are progressive and coexisting cognitive functions which are emanated from thoughts of analogy and continue to flow during entire timespan of visual scene viewing. These generated thoughts which are passing through analogically during scene viewing, take part in focal shifts of eyes during active scene viewing.

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 [3-9][11-15][24-26].

The main motive of this study in artistic scene viewing is to validate analogical thinking curvature as core decisive and controlling factors that shaped the track of eye fixations and to visualize the sequential traces of eye gazes due to eye movements 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.

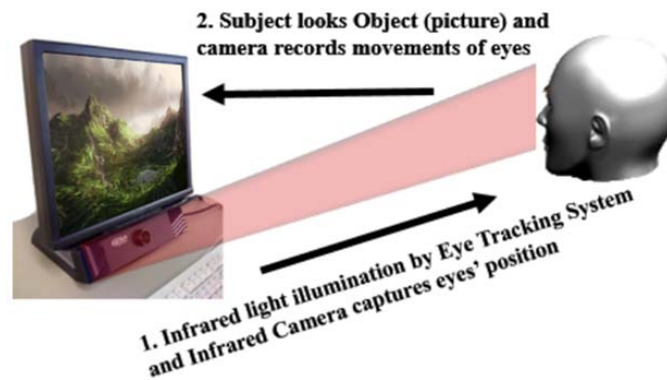


Figure 1. Eye tracking system with operational processes.

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 track of eye fixations 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, including the flow of analogical thinking, 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.

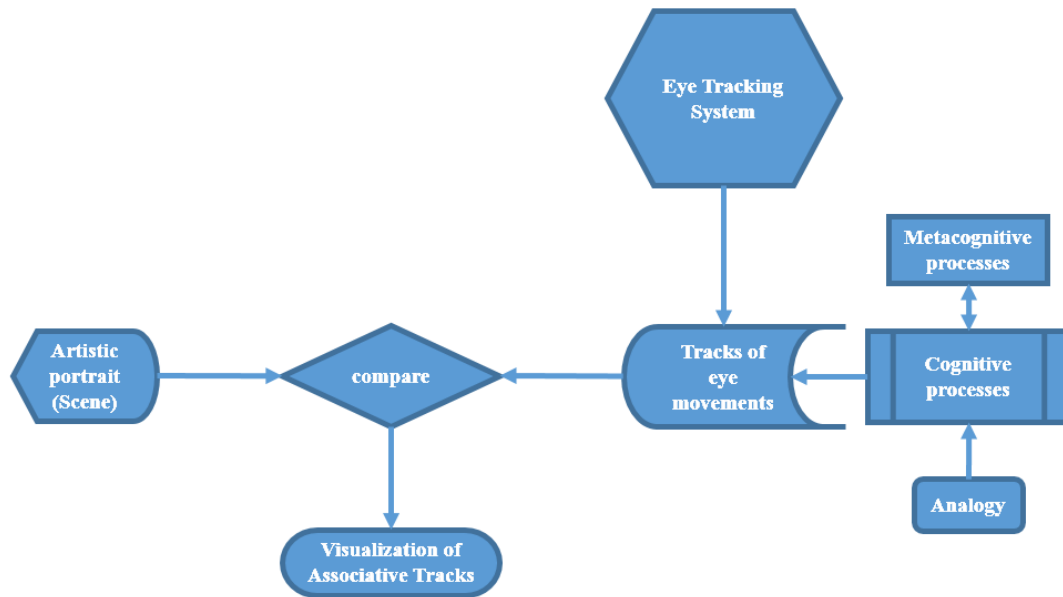


Figure 2. Flow chart of research study.

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 analogical thinking that is happening consistently, to understand the crucial correlation that creates

resultant maps. By analyzing, we come up with concluding remarks about the dependency of eye movements on the analogical thinking that controls the phenomena of dynamic shifts of eye gazes. Further, the directed curvature of analogical thinking leads the track of eye fixations as well.

4. Method

We selected 58 participants from a number of fields randomly, 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 “Green Hills with Lake, Waterfalls, Palm trees”, “Garden of Presbytery with Lake and Figures by Van Gogh”, “Mona Lisa in mysterious smile and backgrounds by Leonardo Da Vinci”.



Figure 3. Selected Artistic Portraits 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 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 “Green Hills with Lake, Waterfalls, and Palm trees” artistic portrait



Figure 4. Green Hills portrait and eye movement track of the same artistic portrait

In the above artistic portrait of figure 4, the left side portrait is the original portrait. The right side portrait is the track of eye fixations by eye tracking system during the scene viewing by the Subject.

As the Subjects started to move the eyes randomly, they looked at the center 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 extreme left and focused over the portions of waterfall. Later, by the coexisting phenomena of analogical thinking, they shifted their focuses towards another waterfall; just top right-side of the previous waterfall. At this state, the Subjects attained the higher level of perception and perceived the inherent analogical thinking that consistently directed and controlled the track of eye fixations. Again, the concurrent flowing, the wavy analogical thinking caused them to gaze their eyes across the next waterfall. The process continued till the track of eye fixations reached to the top right-side of the scene analogically. In this case, the existing flow of analogical thinking compelled eye gazes to propagate further and directed the focus of eyes to move along in the same direction of analogical thought transmission. So, the eye movements were closely operated and controlled by the flow of analogical thinking that existed consistently and concurrently during the entire span of time of scene viewing.

With these controlling analogical flow of thinking, the eyes of Subjects moved subsequently to other similar regions of the portrait, which was obvious from the eye movement links of the portrait. Therefore, the floating thinking of analogical perspectives which were mainly happening in between the established cognitive process of visual attention, regulated the eye movements during scene viewing.

Further, later interview of Subjects confirmed the influential factor of analogical thinking that led them to track their eyes as directed. In the beginning, they were gazing at waterfall and later got interest in similar region consisting of waterfall that was adjacent to the current portion of portrait. The process of such viewing continued further and ended after allocated timespan. So, these interests due to analogy in adjacent regions of the scene, led human eyes to move towards a directed path based on floating analogical thinking.

4.2. Analysis 2: Study of “Garden of Presbytery with Lake and Figures” artistic portrait



Figure 5. Garden of Presbytery portrait and eye movement track of the same portrait

In this artistic portrait; the garden of Presbytery with Lake and Figures, there were tall, wooden trees and the people around the central lake, walking and passing by the lake.

In the beginning of experimentations, the Subjects looked at the central region of the portrait. Then, they looked at a walking person the bottom right-side of the portrait due to attainment of the visual perception. Though this visual attention was built up on by undergoing cognitive processes, yet the track of eye fixations fell into the generalized theory of scan-path of eye movements [26]. This brought the track of eye fixations towards bottom left-side of the portrait. Subsequently, due to the dominating and coexisting phenomena of analogy, the flow of analogical thinking blended the track of eye fixations towards another walking person near to the previous walking person. Further, the curvature of analogical thinking guided the rest of the track of eye fixations. Finally, the Subjects got deviated track of eye fixations as the flow of analogical thinking received jolt because of the biased color contexts of the portions of the portrait.

However, these happenings of phenomenal sequences concluded that the flow of analogical thinking directed and guided the Subjects' eyes towards the same direction as the direction of the flow. Further, these observations led towards another remark that the track of eye fixations were totally controlled by the prominent factor, i.e. Subjects' analogical thinking during this scene viewing.

In successive interview, the concerned Subjects revealed that they were strongly influenced by the figures; the walking people during scene viewing. Mostly, they were interested to understand the activities of these people in the portrait. Nonetheless, this was a combination of several complex mechanisms that were happening during the scene viewing. Definitely, we identified that the flow of analogical thinking was an essential and integrated part of these.

4.3. Analysis 3: Study of “Mona Lisa in mysterious smile and backgrounds” artistic portrait

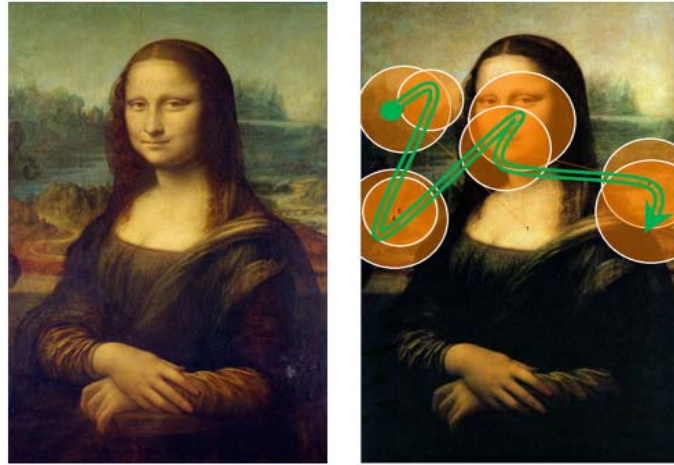


Figure 6. Portrait of Mona Lisa and eye movement track of the same portrait

In this eye tracking experiment, Leonardo De Vinci’s artistic portrait; Mona Lisa with mysterious smile and numerous backgrounds was placed as Object to be viewed by all Subjects.

In the beginning, due to the initiation of visual attention by viewing artistic portrait, the Subjects focused eye fixations at the top left-side background of the lady. It was due to difference in color contrast of context that compelled the focus of eye gazes to perceive the underlying cognizance. Later, the focus shifted to the down left-side of the background because of the same brightness contrast of the context, in addition to the strange hill-side road of the scene. Further, the track of eye fixations moved at the central part; the face of the lady due to the color contrast factor again. Finally, the track of the eye fixations moved towards the right-side of the scene’s background due to color contrast factor and hill-side road of the scene.

Hence, these experimentations showed the existence of cognitive processes and occurrence of stimulated thoughts based on the idea of analogy. So, we observed the concurrent and persuasive phenomena of the curvature of analogical thinking that derived and bended the track of eye fixations during the scene viewing.

Later interviews of the Subjects concluded that they got interest in shiny facial expression of Mona Lisa, strange and glossy portrait backgrounds as were keen to know about the backgrounds portrayed mountains, roads, bridges.

So, these sequential activities led towards the observable confirmation that the existence of analogical thinking that flowed in between the processes of scene viewing, guided and controlled the track of eye fixations. The track of eye fixations were clearly followed along the curvature of analogical thinking.

5. 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 [5][6][8-18]. 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, analogy and flow of analogical thinking are discovered by the tracks of eye fixations in scene viewing.

Coexisting flow of analogical thinking during scene viewing is significant step for appropriate retrieval of task-relevant visual information which are essential for visualization of final maps [11-15]. In this study, we observe that the generated eye movement tracks of sequenced gazes are strongly

following the same path as the flow of analogical thinking. These are major evidences to verify our objective, i.e. the eye movements get manipulated operation under the guidance of analogical thinking broadcast. As a result, without taking into account the influential factor; analogical thought propagation, it is impossible to link the entire scenario of human cognition in the sequential eye gazing of eye movement tracks.

The visualization of streaming analogical thinking in terms of followed eye movement tracks is a tactical and decisive part of whole activities. The visualization of controlled eye movement tracks, in terms of analogical thinking, is unarguably innovative perspective of each and every analyst who examine them for definite intents. This, in turn, causes a number of analogical thinking in scene viewing by various perspectives of analysts. Though the existence of analogical thinking is available in the literature [19-23], yet its presence and clarification varies drastically. In this regard, the visualization of relevant eye movement tracks reinforce again the existence of dominating analogical 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 analogous traversal path generated by eye tracks as the flow of analogical thinking during active scene viewing holds our hypothesis for which we conducted a series of experimentations. The hypothesis that the track of eye fixations curves along analogical thinking, is persuasive and pioneering breakthrough related to eye movements study.

6. Future plan

We plan to propose a generalized model of eye movements based on analogical thinking and elaborate the model for other areas of human interactions as well. We are working out for the same and it is in progress.

One more proposal is about human-centric processes association in context to the underlying mechanism of eLearning. We have undergone through the conceptual phase as well as the layout of the research plan. We hope this novel work may bring a number of new insights for future research works.

7. Conclusion

We bring to a close our outcomes with the inference that the factor of analogical thinking that is curving within the visual fields of artistic portraits during scene viewing, controls and moves along the eye fixations track of human eyes during visual scene viewing.

The steered shifts in eye fixations depend on the directed curvature of analogical thinking during scene viewing. These curvy analogical thinking, in terms of cognitive outcomes, operate humans' eye movements, in terms of the track of eye fixations during scene viewing.

8. References

- [1] Jose Luis Bermudez, "Cognitive Science: An Introduction to the Science of Mind", Cambridge: Cambridge University Press, UK, 2014.
- [2] Adrian Wells, "Emotional Disorders and Metacognition: Innovative Cognitive Therapy", West Sussex: John Wiley & Sons, 2000.
- [3] Andrew Duchowski, "Eye Tracking Methodology: Theory and Practice", London: Springer Verlag, UK, 2003.
- [4] Tom Brown, "The Science and Art of Tracking", NY: Berkley Books, USA, 1999.
- [5] Jana Holsanova, "Discourse, Vision, and Cognition", John Benjamins Publishing Company, 2008.
- [6] Gufran Ahmad, Yukio Ohsawa, Nishihara Yoko, "Cognitive Impact of Eye Movements in Picture Viewing", "International Journal of Intelligent Information Processing", AICIT, vol. 2, no. 1, pp. 1-8, 2011.
- [7] 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, Henderson and Ferreira (Eds.), pp. 213-247, New York: Psychology Press, 2004.

- [8] John M. Henderson, Andrew Hollingworth, "High-level Scene Perception", "Annual Review of Psychology", vol. 50, no. 1, pp. 243-271, 1999.
- [9] Keith Rayner, "Eye movements and visual cognition: scene perception and reading", New York: Springer Verlag, 1992.
- [10] Fernanda B. Viegas, Martin Wattenberg, "Artistic Data Virtualization: Beyond Visual Analytics", In Proceedings of Second International Conference on Online Communities and Social Computing, pp. 182-191, 2007.
- [11] 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.
- [12] 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.
- [13] 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.
- [14] Gufran Ahmad, "Analogical Thoughts Persuade Eye Movements during Scene Viewing", International Journal of Intelligent Information Processing, vol. 4, no. 4, pp. 39-45, 2013.
- [15] Gufran Ahmad, "Analogy Influences Eye Movements during Scene Viewing", In Proceedings of International Conference on Computing and Convergence Technology, pp. 1-4, 2013.
- [16] Mark Turner, "The Artful Mind – Cognitive Science and the riddle of human creativity", Oxford University Press, 2006.
- [17] Robert L. Solso, "Cognition and Visual Arts", Massachusetts London: MIT Press, 1994.
- [18] Robert L. Solso, "The Psychology of Art and the Evolution of the Conscious Brain", Massachusetts London: MIT Press, 2003.
- [19] Douglas Hofstadter, Emmanuel Sander, "Surfaces and Essences: Analogy as the fuel and fire of thinking", New York: Basic Books, 2013.
- [20] Dedre Gentner, "Structure-mapping: A theoretical framework for analogy", "Cognitive Science", vol. 7, pp. 155-170, 1983.
- [21] Dedre Gentner, A. B. Markman, "Structure-mapping in analogy and similarity", "American Psychologist", vol. 52, pp.45–56, 1997.
- [22] Dedre Gentner, M. J. Rattermann, K. D. Forbus, "The roles of similarity in transfer: Separating retrievability from inferential soundness", "Cognitive Psychology", vol. 25, pp. 524–575, 1993.
- [23] Dedre Gentner, J. Medina, "Similarity and the development of rules", "Cognition", vol. 65, pp. 263–297, 1998.
- [24] John M. Henderson, Andrew Hollingworth, "Eye movements during Scene Viewing. An Overview", In Eye Guidance in Reading and Scene Perception, G. W. Underwood (Ed.), pp. 269-293. Oxford: Elsevier, 1998.
- [25] James E. Hoffman, "Visual Attention and Eye Movements", In Attention, H. Pashler (Ed.), pp. 119-153. London: Psychology Press, 1998.
- [26] Lawrence Stark, Stephen R. Ellis, "Scanpaths Revisited: Cognitive Models Direct Active Looking", In Eye Movements: Cognition and Visual Perception, Dennis F. Fisher, Richard A. Monty, John W. Senders (Eds.), pp. 193-226. Hillsdale: Lawrence Erlbaum Associates, 1981.