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Human Visual Intelligence and the New Territory of Educational Technology Research*

Ilju RHA**
Seoul National University
Korea

The general aim of this article is to explicate what can be researched in our field based on the new understanding on the ability of human visual intelligence. To follow this aim, three key discussions were followed. The first is to explain why the human visual intelligence research is so important in our field and how it was neglected. The basic orientations of the research questions used in its framing and in answering are reviewed. After reviewing traditional research orientations, as the second discussion, alternative, more useful perspective for thinking about human visual intelligence is suggested. And the possibility of contribution for the future research in general is discussed. In doing so, human visual intelligence was defined in rather practically oriented ways rather than theoretically oriented ones. More practical perspectives were suggested. The third discussion is to show how to use the alternative perspectives of human visual intelligence in the areas of educational technology research. It was hoped that the article lays out conceptual groundwork for generation of educational technology research frameworks which can be used for the research conduct, reproduction and sharing by adopting practically oriented views on human visual intelligence as a new territory of educational technology research.

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* Currently participate in the 『Brain Korea 21 Division of Competency-based Education Innovation』 Project
** Department of Education, Seoul National University
iljurha@snu.ac.kr

INTRODUCTION

…Consider the nature of signs the mind makes use of for the understanding of things, or conveying its knowledge to others. For since the things the mind contemplates are none of them, besides itself, present to the understanding, it is necessary that something else, as a sign or representation of the thing it considers, should be present to it. (Locke, 1690)

Human vision, coupled with human brain, generates human visual intelligence. Our environment consists of plethora of visual objects. Throughout the long history of human evolution, the human beings are repetitively exposed to the optical objects and must have reacted to the given situations. Since the vision is the prime mechanism to acquire outside information, human brain, superior to any other animal brain in nature and its prime mechanism being learning, must have evolved greatly through its vision. The potential power of human brain and its mechanism are yet to be studied. However, it is obvious that with the function of human vision, the brain must have accumulated something useful throughout the long history of human evolution.

It is the general aim of this article to explicate what can be researched in our field based on the new understanding on the ability of human visual intelligence. I intend to show that there exist plenty of researchable areas based on the concept of the visual intelligence.

The article has three key objectives stemming from this aim. The first is to explain why, if coming to terms with the human visual intelligence is so important, it is so seldom reviewed in the educational technology field. Stated succinctly, my answer is, first, because the question is seldom asked that there are plenty of yet-to-be-answered problems attached to this issue that it is impossible to answer any of the questions is simply assumed. Second, when the question is asked, it is not answered well because of the basic orientations of the research questions used in its framing and in the answers to it.

The second objective of the article is to develop alternative, more useful perspective for thinking about human visual intelligence and its possibility of contribution for the future research. Such perspective acknowledges that human visual intelligence has to be defined in rather practically oriented ways as well as theoretically oriented ways. A second is to switch from approaching human visual intelligence as scientific construct, as "things to be studied scientifically rigorous ways," to thinking about human visual intelligence as a practical object; that is, to try to focus not on human visual intelligence itself but instead on "the utilization of the functioning of the human visual intelligence." More practical perspectives like these are necessary if we, as educational technologists, want to investigate empirically what actually happens concerning the human visual intelligence as well as how can we utilize this intelligence to the complex, computer dominated educational environments such as today. Better empirical knowledge about human visual intelligence, in turn, opens space for the design of kinds of instructional infrastructures that really do have profitable learning outcomes.

The third objective of the article is to show how to use the alternative perspectives of human visual intelligence in the areas of educational technology research. The article lays out conceptual groundwork for generation of educational technology research frameworks which can be used for the research conduct, reproduction and sharing in our field.

ALTERNATIVE APPROACH TO HUMAN VISUAL INTELLIGENCE RESEARCH

Many famous scientists have described how mental imagery contributed in an essential way to a key discovery or insight (Koestler, 1964; Miller, 1984; Shepard, 1988). Perhaps the best known is Einstein's description of having imagined the consequences of traveling at the speed of light, which led him to the concept of special relativity. There are many other examples as well. Kekule made his fundamental discovery in organic chemistry after having had a dream image in which a snake was coiled in such a way as to represent the molecular structure of benzene. Faraday claimed to have visualized lines of force that emanated from electric and magnetic sources, resulting in the modern conception of electromagnetic fields. Tesla reported that he could determine how well a machine would work by mentally "running" it in his mind. More recently, the physicist Feynman claimed to have used visual images in thinking about interactions among elementary particles, which led to the development of "Feynman diagrams" (Finke, R. A., et al. 1992).

There is considerable evidence that much of our everyday thinking is based on the formation and transformation of visual images. Moreover, there are many accounts of the role that visualization plays in the learning and conceptualization process.

There are also numerous accounts of the role that imagery plays in creative literary and artistic achievement. One artist who became blind as an adult claimed to use visualization to paint landscapes by imagining how the overall painting would look (Finke 1986). Skilled writers often comment on the role that imagery plays in giving rise to new ideas for stories(Ghiselin, 1952; Koestler, 1964). Architects have frequently reported using imagery to explore new ideas for designing buildings and other structures.

Such accounts are suggestive of the importance of human visual intelligence in thinking and discovery. Despite the fact that the role of visual intelligence is obvious in our daily lives, those phenomena are treated as anecdotal incidences which lack the scientific approach to the study of creative cognition. Scholars who advocate the scientific procedures to the issue argue that research needs to be based on more than anecdotes or introspective reports and empirical methods are needed for studying creative acts induced by visual intelligence under controlled laboratory conditions(Finke, R. A., et al. 1992).

In this regards, Pylyshyn (2003) had to say as follows:

The problem with trying to understand vision and visual imagery is that on the one hand these phenomena are intimately familiar to us from the inside so it is difficult to objectify them, even though the processes involved are also too fast and too ephemeral to be observed introspectively. On the other hand, what we do observe is misleading because it is always the world as it appears to us that we see, not the real work that is being done by the mind in going from the proximal stimuli, generally optical patterns on the retina, to the familiar experience of seeing (or imagining) the world.

I argue that any form of reasoning, including reasoning by visualizing, must meet the constraints of productivity and systematicity (Pylyshyn, Z., 2003).

These scientifically oriented views are logically sound and some of the laboratory driven research results showed the possibility of the scientific methods.

I do not intend to argue against the scientific approach nor marginalizing the productivity of the logics of the scientific methods. However, for the practically oriented societies such as educational technology society, it would not be productive to wait until the scientists fully discover the functional mechanisms of human visual intelligence. The scientific discovery on human visual intelligence is at its infancy. For the practical purposes, intermediate theoretical framework for human visual intelligence which can guide the sound utilization and research orientation is a necessity.

TOWARD THE THEORY OF HUMAN VISUAL INTELLIGENCE

Brain and Vision

The human brain is known to contain about 100 billion neurons and each neuron has up to 10 thousand connections, of which less than ten are to the same neuron, such that each neuron is connected with a thousand other neurons (Spitzer, 2006). So there are, approximately, 100 trillion connections. Neurons work by representing something, and this means that there must be 100 trillion finely-tuned synapses in our brains. From a neurobiological point of view, the intelligent functions such as learning, thinking, and feeling occur via changes in the strength of such neuronal connections at synapses. As synapses change when they transmit signals, the intelligent function occurs whenever the brain processes information.

It is known that optical information from the eyes is transmitted to the primary visual cortex in the occipital lobe at the back of the head. This information is then sent to many other visual centers located in the posterior temporal and parietal cortex. Some estimates put the percentage of the cortex involved with visual function at more than 50% in the macaque monkey, although it is probably slightly lower in humans (Palmer, 2003). The complete visual system thus includes much of the brain as well as the eyes, and the whole eye-brain system must function properly for the organism to extract reliable information about the environment from the ambient optic array (Gibson, 1979).

Since the current vision science is at its beginning stage, only limited information on limited field is available. Even though the spectrum of visual phenomena includes interpretation, operation, and creation of visual objects (Rha, 2004), the scientific studies are mainly concentrating on explaining 'how we see'. The full spectrum of human visual intelligence is not even defined yet.

The Functional Structure of Human Visual Intelligence

Webster defines the human intelligence as follows: the ability to learn or understand or to deal with new or trying situations; the skilled use of reason; and the ability to apply knowledge to manipulate one's environment or to think abstractly. And Hoffman (1998) defined visual intelligence from the perspective of visual communication. He defined that visual intelligence may be described as a quality of mind developed to the point of critical perceptual awareness in visual communication. It implies not only the skilled use of visual reasoning to read and to communicate, but also a holistic integration of skilled verbal and visual reasoning, from an understanding of how the elements that compose meaning in images can be manipulated to distort reality, to the utilization of the visual in abstract thought.

In order to pursue the practical use of human visual abilities, I like to define the human visual intelligence as follows: "Human visual intelligence is the ability to utilize the direct or indirect products or by-products of human vision."

Based on the definition, various practical approach toward the utilization of the products of the human vision and human brain can be devised. The following figure 1 illustrates a simple framework for the functional structure of human visual intelligence.

The illustration suggests followings.

1. at the beginning stage of human development, the visual intelligence develops by processing visual entities in primitive forms. Later the visual entities are

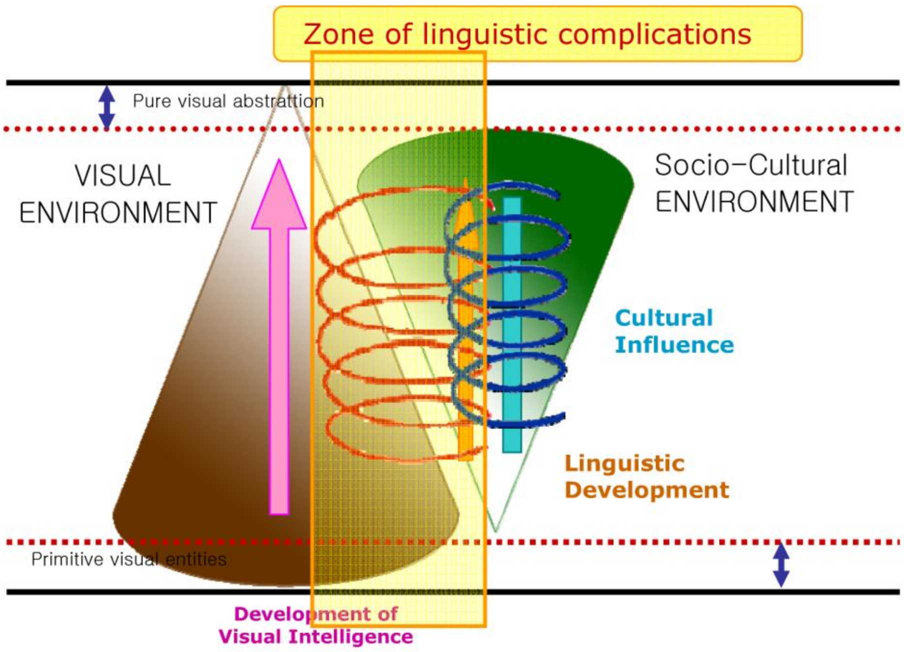

Figure 1. A hypothetical framework on the functional structure of human visual intelligence

'polluted' by the language.

2. the visual intelligence develops in two different ways; it develops by itself or by interacting with (or influenced by) language.
3. visual intelligence also plays important role for linguistic development.
4. there exists a zone of complicated interactions between visual intelligence and language throughout their development.
5. there could be different types of visual entities such as concrete, abstract, and linguistically-bound visual entities.

Vygotsky (1962) believed that concepts are acquired by a three stage process: syncretic responses that involve mainly events or objects contiguously associated with the word or sign, complexes that are class ideas based on identify of attributes and that have several types and levels, and abstract concepts that subsume, in a progressively broad and complex way, more and more objects, events, and actions that share a common relevance. In this view, the word is an indispensable index that makes exploratory and inferential thought possible. The inner speech of adults is cryptic, truncated, fragmentary, and incomplete. A topical interest selects out of the ongoing thought process one word that may represent a whole sentence. These words may be concrete or abstract terms, but in any case they serve as dispositional foci for the thought process that may be moving rapidly on to other relevant inferences.

Thus he adopted socio-cultural factors as the most important interacting factors which can serve for the thought process. The intricacy of language, to him, stems from the culture and society.

Chomsky and Miller (1963) introduced into a discussion of natural languages the concept of comprehension operator, a system of implicit responses that maps language input into cognitive representations of the implications of meanings that the input contains. They point out that this process is not a literal one, because the resulting representations are often not isomorphic to the message. Here we encounter the problem of language as experience; the stream of experience bears little similarity to the stream of language. How language and experience are brought together? A stream of nonverbal perceptual inputs may result in the implicit reconstruction by a hearer of the stream of experience that gave rise to it. In this case, the basic comprehension system would be nonverbal.

If we follow this line of thought, there must exist some perceptual nonverbal "entities" in order to the sharing of the experience through linguistic exchanges.

The suggestions made by Vygotsky and Chomsky set the ground rule of the relationship between visual intelligence and language: the language develops under the influence of socio-cultural factors and the language requires some kind of 'nonverbal' entities to be communicable.

The Contents of Human Visual Intelligence

Since there are various kinds of product or byproduct of human vision, the human visual intelligence encompasses multiple dimensions. Following table 1 shows an example of categorizing the various human visual intelligence phenomena suggested by Rha (2007).

Table 1. Three Dimensional Category of Human Visual Intelligence

- Dimension 1: Interpretation
  - Physical vision
  - Elemental judgment
  - Holistic interpretation
- Dimension 2: Operation
  - Visual operation of physical entities
  - Visual operation of conceptual entities
  - Visual operation of holistic relationships
- Dimension 3: Creation
  - Future vision
  - Visual fantasy
  - Dreaming

Rha (2004) explains that the various visual phenomena are differentiated by the dimensions with practical reasons. The interpretation dimension is mainly concerned with interpreting the physical world outside of the visual system. In ordinary terms, visual intelligence at this dimension indicates 'parsing the environment' type of intellectual functioning. The operation dimension describes intellectual functions occurring inside the brain. This dimension describes the phenomena of operating the entities in our mind. Human beings always operate physical and conceptual entities visually. And yet at this dimension, the entities operated inside the mind is closely related to the reality. In other words, the operations are based on the reality even though the operations occur inside the mind. The creation dimension also occurs inside the mind. However, it is not directly related to the reality. Future vision, fantasy, dreams are definitely visual phenomena.

The suggested functional structure and the categorization of content areas of visual intelligence are by no means complete nor fully scientifically based. It is hypothetical in nature. The framework should be taken as only a basic theoretical endeavor for the study on human visual intelligence from the new perspectives.

TYPES OF RESEARCH ON VISUAL INTELLIGENCE

The new perspective provides a launching ground toward the research on the newly formulated conception of human visual intelligence. In this regards, there seem to be three different types of research in the field of visual intelligence; the theory and principle type, practical application type, and measurement type. For the convenience of sharing ideas, they are named simply Type 1, 2, 3 research.

Type I Research

The central interest of Type I research is on the theory and principles concerning the visual intelligence itself. It poses 'why' questions. In this type of research, main questions appear to be two directions: What are the mechanisms of visual intelligence? What are the relationships among the visual intelligence events such as interpretation, operation, and creation? Here included following topics: 1) the mechanisms of visual abstraction, individual, sexual, and cultural differences of visual intelligence, 2) the mechanism of the development of visual intelligence throughout the lifetime 3) language influence, interrelationships between language and visual intelligence, and the functions in between language and visual intelligence, and 4) the difference of visual intelligence between adult and children, acceptance, usage, attitude toward visual intelligence

Type II Research

The central interest of Type II research is on the practical application of the visual intelligence in the interested field. It poses 'how' questions. In this type of research, all sort of applications questions for extensive areas are possible. Followings are some examples: What are the applicable functions of human visual intelligence? What are the applicable areas of human visual intelligence? How can visual intelligence and language, or symbol systems efficiently function for adjustment? How can we pursue learning efficacy utilizing visual intelligence? How can we improve learning environment with utilizing visual intelligence? Further more, the research topic includes fascinating areas such as followings: 1) switching between visual and verbal modality, 2) abstracting, concentrating, adjusting visuals, 3) adjusting abstraction levels of visuals, 4) juxtaposing knowledge objects, 5) efficient functional division of language and visuals.

Type III Research

The central interest of Type III research is the measurement of visual intelligence.

Individuals tend to have different portfolios of visual intelligence. Visual interpretation and visual operation, for example, can be treated quite independently among individuals. A person who shows very high sensitivity in visual interpretation may have very poor visual operation ability. If we develop efficient and sound methodology for investigating visual intelligence phenomena, we can not only be applying the individual talent to the appropriate areas and develop appropriate representational methods, but also be possible to plot out the methods of cultivating various areas of visual intelligence for individuals.

CONCLUSION

The writer of a textbook 'visual perception: physiology, psychology and ecology', Bruce et al (2003) starts their view of the relationship between the environment and the vision as follows:

All organisms, whether bacteria, oak trees, or whales, must be adapted to their environments if they are to survive and reproduce. The structure and physiology of organisms are not fixed at the start of life; to some extent, adjustments to changes in the environment can occur so as to fine-tune the organism's adaptation. One way of achieving this is through the regulation of growth processes, as when plants grow so that their leaves face the strongest available light. Another way, which is much more rapid and is only available to animals, is movement of the body by contraction of muscles.

If the movement of an animal's body is to adapt it to its environment, it must be regulated, or guided, by the environment. Thus the swimming movements of a fish's body, tail, and fins are regulated so as to bring it into contact with food and to avoid obstacles; or the movement of a person's throat, tongue, and lips in speaking are regulated by the speech of other people, linguistic rules and so on.

In order for its movement to be regulated by the environment, an animal must be able to detect structures and events in its surroundings. We call this ability perception, and it in turn requires that an animal be sensitive to at least one form of energy that can provide information about the environment. One source of information is provided by chemical substances diffusing through air or water. Another is mechanical energy whether pressure on the body surface, forces on the limbs and muscles, or waves of sound pressure in air or water. Further information sources, to which some animals are sensitive but people probably are not, are electric and magnetic fields.

An animal sensitive to diffusing chemicals can detect the presence of nearby food or predators, but often cannot pinpoint the exact location, and cannot detect the layout of its inanimate surroundings. Pressure on the skin and mechanical forces on the limbs can provide information about the environment in immediate contact with an animal, while sound can provide information about more distant animals but not usually about distant inanimate structures.

Sensitivity to diffusing chemicals and to mechanical energy gives and animal considerable perceptual abilities, but leaves it unable to obtain information rapidly about either its inanimate world or about silent animals at a distance from itself. The form of energy that can provide these kinds of information is light, and consequently most animals have some ability to perceive their surroundings through vision. (Bruce et al., 2003, p 3)

The human vision has been allowing human beings to detect structures and events for a long period of time. I believe that the human beings have been developing their use of vision in a unique way and that the ability to utilize the various products of human vision has also been accumulated throughout the evolution. Human beings have been developing such abilities as interpreting, operating, and creating visual entities. It is the high time to utilize the accumulated visual abilities, the human visual intelligence in the full spectrum of the scholastic fields not to speak of Educational Technology.

Vision and visuals have been familiar and popular themes of research in educational technology field. For a long period of time, pictures were the primary medium for illiterate people to which religious and political contents could be conveyed by means of illustrations only. After the time of Comenius "picture-book", graphical representation has remained a central concept in pedagogy and didactics. Illustrations have become an indispensable component in teaching material and other expository texts. Since then, visuals are one of the necessary components in instructional design. And with the advent of computers and web-based communication, the potential instructional power of visuals grows ever before.

We, as educational technologists, are in the era of knowledge based society searching for effective and efficient methods of knowledge generation, organization, and dissemination. The study on the human visual intelligence has full possibility of providing ideal methods for the mission.

In this regards, I hope that the article lays out conceptual groundwork for the generation of educational technology research frameworks which can be used for the research conduct, reproduction and sharing by adopting practically oriented views on human visual intelligence as a new territory of educational technology research.

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Ilju RHA

Professor, Dept. of Education, College of Education, Seoul National University

Chief Editor of Journal of Lifelong Learning Society (JLLS)

Interests: Educational Technology, Distance Education, and Visual Intelligence

E-mail: iljurha@snu.ac.kr, Homepage: http://iwind.com