NATIONAL INSTITUTE OF ADVANCED STUDIES

INDIAN INSTITUTE OF SCIENCE CAMPUS, BANGALORE 560 012, INDIA

NIAS DOCTORAL PROGRAMME

COURSE CERTIFICATE

This is to certify that Mr. Animikh Roy has attended the Course on "**An Introduction to Consciousness Studies**" conducted by Prof. Sangeetha Menon on behalf of the **NIAS Consciousness Studies Programme** at the National Institute of Advanced Studies(NIAS) during the period from August to December 2015. He has scored **A+** grade and **two** credits subsequent to the successful completion of the Course.

(SANGEETHA MENON)

NATIONAL INSTITUTE OF ADVANCED STUDIES

Place: Bangalore
Date: 15 June 2016

Telephone: +91-80-2218 5024/5000 Fax: +91-80-22185028 Email: niasphd@gmail.com

I see therefore I know? : A Paper on Factors Affecting Visual Perception and Contextual Interpretation

By

Animikh Roy

ABSTRACT

Throughout the evolutionary timescale, our ability to interpret and interact efficiently with our surroundings and our subjective reality has been primarily based on visual perception. However, it is the interpretation of what we see (and not the visual image) that really matters for every choice and decision we make. And the neuroscience of visual processing actually tells us that this interpretation, which can be attributed to the phenomenon of perception, has more to do with our brain than our eyes. But, perception and its contextual interpretation is a notion which is prevalent beyond science and can also be explored via the avenues of philosophy, literature, visual art, illusions and photography. This has been largely neglected thus far in the realm of scientific research and we shall aim to reconcile these schools of thought with a holistic approach to discuss how visual perceptions are simply more than meets the eye. How, everyday decisions, are directly or indirectly linked to survival. How visual processing has evolved in ways to facilitate survival, threat elimination and efficient interaction with our surroundings. Moreover, despite everything, sometimes we are baffled when there is no apparent link between what our eyes perceive and what the actual reality looks like. This raises questions regarding the very basis of visual perception and the factors that influence it. In the first part of this paper on vision we endeavour to explore those factors that may influence contextual interpretation at the general objective level such as ambient illumination, visual system of chromatic discounting and factors posing threats to survival along the evolutionary chain. In the second part, we endeavour to explore the "context" itself in greater detail from multiple disciplines at the subjective level of individuals with respect to their memory, past experiences and mental framework in the light of Existentialism. In doing so we shall finally endeavour to analyse the essence of qualia as a correlation between Existential influences and human perception.

Introduction

"When we see the brain we realize that we are, at one level, no more than meat; and, on another, no more than fiction."

— Paul Brooks

It is often argued in the realms of Neuroscience and Psychology that, **"Perception is Interpretation"**. Now imagine a world without the perception of 10 million different colours, the intensity of different saturations and contrasts, the diverse play of light and dark and the sharp distinctions of edges and boundaries. Not only is such a world devoid of the beauty and wonder that our vision enables us to perceive, it is also a dark world where the chances of survival and evolution are very slim. In other words, according to poet John Milton, such a world is indeed "Paradise Lost"!

One can safely argue along these lines that visual perception is most important for the interpretation and understanding of our reality. No wonder thus, research estimates that eighty to eighty five percent of our perception, learning, cognition and activities are mediated through vision. Our brain also allocates maximum neuronal volume to the visual cortex compared to all the other senses. According to the Scientific American, vision be regarded as the primary sensory ability, the accuracy and sensitivity of which have placed humans at the top of the evolutionary chain to become the most dominant species in the planet.

Thus our ability to interpret and interact efficiently with our surroundings and our reality is primarily based on visual perception. Most importantly, it is the interpretation of what we see that really matters for every choice and decision we make. And the neuroscience of visual processing actually tells us that this interpretation which can be attributed to perception has more to do with our brain than with our eyes. As we have already said visual perception is a part and parcel of our day to day lives, helping us make every decision directly or indirectly related to survival or evolution. However, more often than not we are baffled when there is a disconnect between what our eyes perceive and what the actual reality looks like. This in turn raises questions regarding the very basis of visual perception and the factors that influence it. For example: Why do things look as they do? Why does our mind play tricks into making us believe things that are not? Is it our eye or our brain that really determines what we see? The purpose of this paper is to explore why the brain perceives and interprets the way it does, sometimes differently from what the eye sees. We shall explore contextual influences from a scientific understanding of illusions, visual processing of light, evolutionary factors, an individual's memory and finally the very frame work of one's mind in relation to existentialism that creates the very foundation of subjective perception.

Context, Perception and Interpretation

Before we begin our thorough evaluation of the Neuronal Correlates of vision along with discussions on evolution of vision and various philosophies dealing with it, let us first define and explain the three most important components of this review: ***Context, Perception*** and ***Interpretation.***

Let us now begin with "***Context"***. The Oxford English Dictionary defines "context" as: "the parts which immediately precede or follow any particular passage or 'text' and determine its meaning." More generally, context is the "whole situation, background, or environment relevant to a particular event, etc.," which reveals its meaning. These definitions, of course, beg the question of "meaning," to which there are no simple or all-encompassing answers. For our purposes, the definition of meaning is implicit in the central problems of vision, which are identifying the environmental causes of the patterns of light falling on the retinae, and the behavioural significance of those causes for the observer. Accordingly, the meaning of a contour of light on the retina includes, among other things, the particular object in the scene that reflected that pattern and the information that the object conveys about the world.

Context, in turn, includes sensory cues that enable the image feature to be assigned to an object, the observer's history with the object, his motivational state, and the reward value of the object to the observer. As a practical matter, extraction of meaning can be identified with perception, and context is the sensory/behavioural/cognitive milieu that influences the way each sensory feature is perceived. Contextual influences on perception are necessarily manifested as interactions, rather than passive associations, between sensory, behavioural, or cognitive elements.

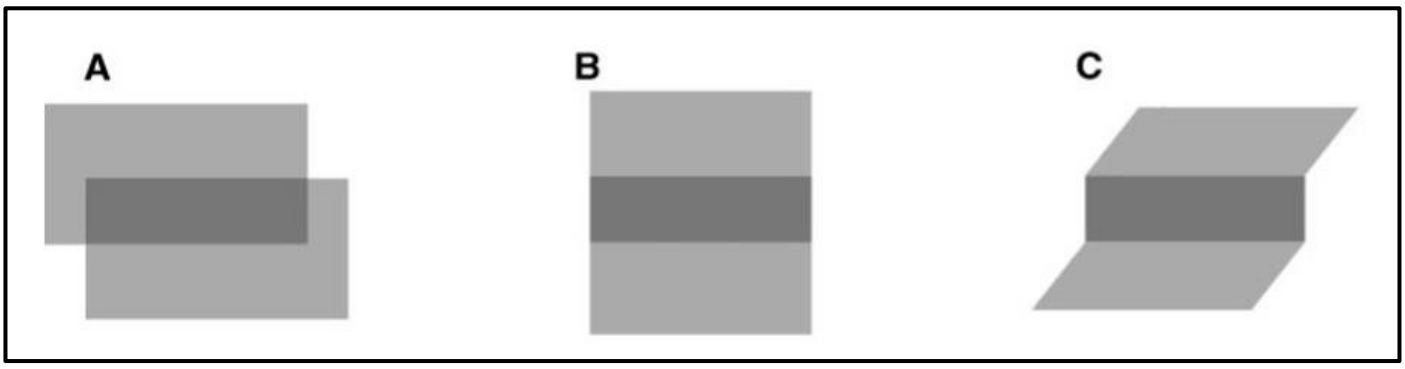


Figure (1)*: Illustration of the influence of local sensory context on visual perception. Each image contains a horizontal dark-grey rectangle. Although the rectangles are physically identical, the surrounding features differ in the three images. As a result, the rectangle is perceptually attributed to different environmental causes in the three instances, i.e., it conveys different meanings. (A) The rectangle appears to result from overlap of two surfaces, one of which is transparent (e.g., a piece of tinted glass). (B) The rectangle appears to result from a variation in surface reflectance (e.g., a stripe painted across a flat canvas). (C) The rectangle appears to result from variation in the angle of the surface with respect to the illumination source. These markedly different perceptual interpretations argue for the existence of different neuronal representations.*

For example, the precepts elicited by the images in the above image (Figure (1) A, B, and C) are not merely of three different sets of features. On the contrary, the meaning of the dark grey bar is changed dramatically through its interactions with surrounding features. The perceptual whole is more than the sum of the sensory parts. With these definitions as a foundation, we begin our review with a brief historical account of views on the role of context in vision. This history originates with philosophical doctrine and empirical psychology and is offered with the belief that past controversies, misunderstandings, and insights on this topic can guide and inform modern-day visual neuroscience. Indeed, the growing bond between psychology and neuroscience has led to remarkable new discoveries regarding the role of context in the neuronal bases of perception, as well as paradigmatic changes in the way neuronal representations are viewed and approached experimentally.

The second important subject of our discussion is ***"Perception"***. Perception in the visual context refers to the organization, identification, and interpretation of sensory information in order to represent and understand the environment. All perception involves signals in the nervous system, which in turn result from physical or chemical stimulation of the sense organs. For example, vision involves light striking the retina of the eye, smell is mediated by odour molecules, and hearing involves pressure waves. Perception is not the passive receipt of these signals, but is shaped by learning, memory, expectation and attention.

Perception however can be categorized in two different ways: one is called ***"Low-Level"*** interpretation while the other one is called ***"High-Level"*** interpretation. We will address the first one from the Gestalt Psychological point of view and the second one using Adelson's illusions. Both of these cases will be demonstrated with examples in the following chapters. However, that does not cover all the aspects which influence perception on the whole. There are other subtle aspects to consider while addressing the processing of perception. As we shall explore further, these aspects are connected with a person's concept and expectations, inherent choices, knowledge and selective mechanisms like attention that ultimately influence perception. Perception depends on complex functions of the nervous system, but subjectively seems mostly effortless because this processing happens outside conscious awareness. Nevertheless, it is this processing that is responsible for the subtle but remarkable difference of interpretation of the same visual data striking the retina, from person to person.

Thirdly, ***"Interpretation"*** in our context of this paper will be discussed in its philosophical sense, which implies the assignment of meanings to various concepts, symbols, or objects under consideration. Moreover, we can clearly see, it is not the eye that gives the final interpretation of the stimulus which hits the retina, it is the brain that does. Therefore, in this context it is tantamount to saying that whatever we see and however we do so is only because of the visual center in the brain - the eye is hardly responsible for painting the reality in front of us. Therefore, within this framework, we can logically conclude that the final ***"Interpretation"*** of what hits the retina is somewhat dependent on context and the kind of perception that is active at the level of the brain. But is that the entire picture? Recent studies show us that this picture is not complete and we will discuss how the brain interprets differently for the same context based on evolutionary factors and existential choices that induce unconscious learning and association.

Clash of the Titans: Gestalt *vs* Adelson

Looking at history and the developments in science, we find that the visual perception problem of how and why we see what we see was in fact first addressed by the Gestalt Theorists in Germany in the 1920s. The Gestalts were the first group of psychologists to clearly articulate this problem and systematically study perceptual organisation with respect to visual processing. Johann Wolfgang von Goethe, Ernst Mach, Max Wertheimer, Wolfgang Köhler, Kurt Koffka, and Kurt Lewin were luminaries that comprised this group, who revolutionized the concepts of vision by renouncing some of the tenets of late 19th century pragmatism and mind-brain materialism. 19th century perceptual psychology believed that the constancy of visual sensations could be attributed to the local interactions within the retinal image. This was refuted accurately by something the Gestalt's coined the "Closure Principle" which basically states that on the contrary; no local stimulation can determine the corresponding sensation by itself. We only perceive and interpret visual sensations in connection with totality of the stimulation. This in turn tells us that we have genetically evolved to extract and perceive forms, shapes and boundaries from the visual stimulation that we receive.

The closure principle can be verified with the simple example of a water colour painting of a face evaporating on a hot stone. In this case, as depicted in the painting in Figure (2), the boundaries and contours of the image gradually disappear as the water colour evaporates on the hot stone but the persistent perception of the human face remains in connection to the total stimulation received by the eyes.

Figure (2)

Figure (3)

The brain in this case gives us a persistent sense of completeness or "closure" despite the missing information in parts. Another example of closure that helps understand how the brain trumps the eye is when we consider a white page with black spots and patches in different sizes arranged in a way that gives us an illusion of shape. In Figure (3) we see a collection of such patches that give us the image of a Dalmatian according to the "Closure Principle". However this the Gestalt theory also shows us how the mind is wired to grasp visual concepts that are well organized and facilitate the extraction of meaning via the closure principle or other principles of grouping and proximity that are

Figure (4)

a part of the theory. For example, in **Figure (4)** it is harder to extract information related to a particular description of form, shape and identity which conveys meaning to the brain as compared to the previous one. However, both the images have the same subject - one Dalmatian. This in turn tells highlights that the brains ability to discount the background and obtain the essential information which conveys meaning, increases with higher levels of organization as viewed in the visual stimulus. In the second image the background and the subject cannot be separated clearly in terms of visual processing of perception unless ones associative memory of a dog or Dalmatian is activated.

According to Neuroscience, the brain usually classifies images by: which object surrounds which thereby establishing depth and distinction. If one object surrounds another object, the surrounded object is seen as figure, and presumably the object farther away is the interpreted as the ground, and vice versa. The second image remains a blurry confusion as no such distinctions can be made before viewing the first one which gives the brain some context to choose what it is looking for. Moreover, remarkably after the choice has been made consciously to extract information regarding a Dalmatian just once, every time one looks at the image which had no meaning before seems to contain the image of a Dalmatian despite it still lacking the boundaries and contours of its body.

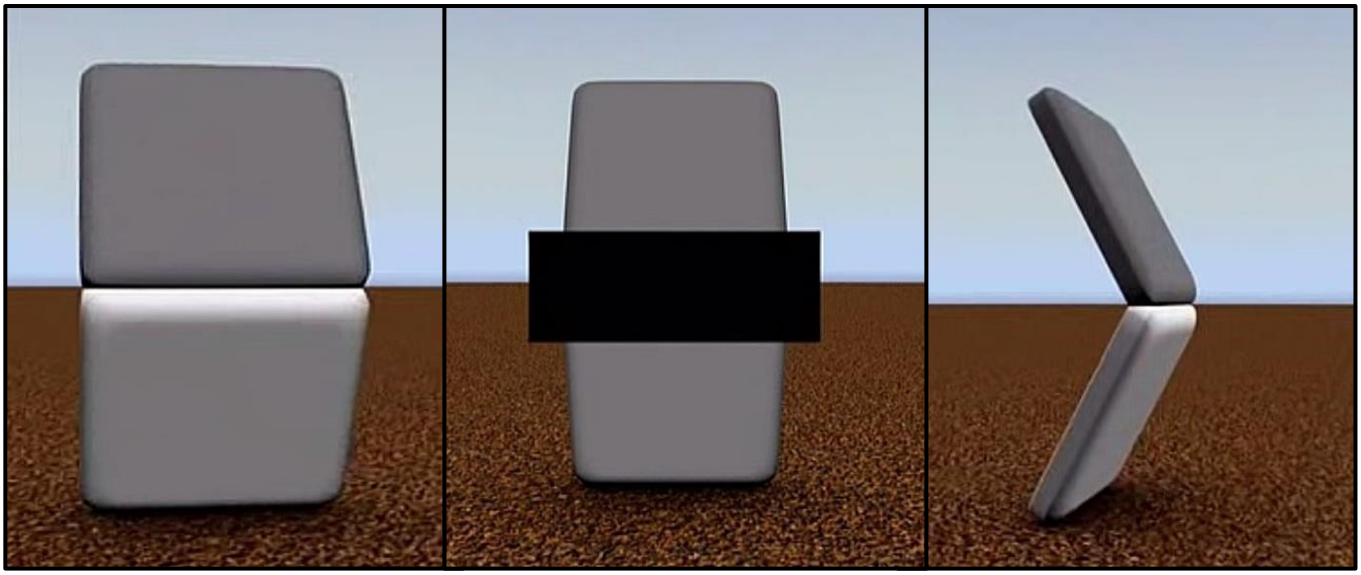
Therefore in this context perception can be understood as a phenomenon associated to the brain more than the eye. It is in fact a conscious choice made by the brain that creates a description extracting specific essentials out of the entire sensory stimulus that hits the retina. An illusion on the other hand remains a description of descriptions, till the context necessary for perceptual interpretation becomes clear and the brain abstracts meaning to create a specific description with respect to a specific context. Alternating contexts can lead to different perceptions of the same illusion.

The two-faces and vase (also known as Rubin's figure) is a popular example which serves as an excellent and intuitive demonstration of the figure–ground distinction the brain makes during visual perception. Rubin's figure–ground distinction also influenced the Gestalt psychologists since it involved higher-level cognitive pattern matching, in which the overall picture determines its mental interpretation, rather than the net effect of the individual pieces. In this case the brain can interpret the visual stimulus differently by alternating between the foreground and background of the image in two distinct colours. This is understanding depth through contrast; brightness etc. is what enables the brain to make an interpretation of what the eye sees. These images demonstrate the central tenet of Gestalt theory: that the whole has global properties different from those derived from the sum of its parts.

However, the modern approach to understanding visual perception in Neuroscience does not completely agree with the theory of mental processes influencing perception as proposed by the Gestalt school of thought. It takes the path of a *rigorous reductionist approach* to raise questions regarding the adequacy of low-level explanations provided by Gestalt Psychologists, by giving illusory examples which demand a rigorous high level explanation associated to a fixed neural basis and its key role with respect to certain kinds of visual data that defy the influence of global properties as highlighted by the Gestalt Psychologists. This school of thought is markedly

different because it challenges the long standing Gestalt Theory and states that an image has vital local properties with respect to brightness and depth that influence its overall interpretation rendering the global properties meaningless in such cases.

This can be demonstrated best with an image from Adelson's collection of illusions which show us the sharp influence of brightness, contrast and depth perception, demanding a high level explanation of visual processing.



Figures: 5(A), 5(B) and5(C)

Figures 5 (A, B & C) demonstrate a classical Adelson illusion. In the first figure it seems that the shade of grey on the top half is much darker compared to that of the bottom half. However, figure 5 (B) clearly demonstrates that both the top and bottom half are exactly the same shade of grey. In doing so Adelson has shown that an observer's interpretation of the spatial organization of surfaces in a visual scene has a marked association with the apparent brightness of those surfaces. This illusion relies upon the use of pictorial cues to render a percept of a 3D tilted surface as shown in Figure 5 (C).

The two sub-regions of this surface appear of very different brightness, despite the fact that their intensities are verifiably identical. A subtle change in the stimulus, which alters the 3D perceptual interpretation but leaves the local luminance corresponding regions of surface; it is, in fact, reversed. Since the probable shadow cannot account for such a contrast reversal, it is likely that region underneath has a lower surface reflectance than its counterpart. Hence it is perceived as dimmer. Such visual tests designed by Adelson provide fresh insight into the role of global vs local properties that influence the perception of a given image and demand a high-level explanation.

Although high-level explanations of this sort have considerable value, history has seen their impact diluted by failure to suggest a specific mechanism or to identify a neural basis. Adelson tells us that the mechanistic solution lies in propagation of constraints [on brightness] from grey-level junctions' that determine perceptual organization (such as the corrugated boundary contour in Fig 5 (A)) and decomposition of the image into a set of intrinsic images representing

reflectance, illumination, and transparency. While the former is sufficiently vague as to be tautological, and the latter sounds like Helmholtz, modellers have indeed made progress along these lines. However, given the diversity of cues and the range of possible perceptual interpretations, it is not an easy problem to solve. Neurophysiologists have traditionally focused on relatively low-level sensory phenomena that can be explained by local Interactions; as an experimental parameter, spatial context has often been explicitly shunned. While there have been some demonstrations of broader contextual interactions in most cases these appear to be merely scaled versions of the local contrast effects.

Not surprisingly, the neural elements and events underlying Adelson's new brightness illusions are entirely unknown. It is useful, however, to view these illusions as part of a larger class of phenomena in which the way a stimulus parameter is perceived is dependent upon perceptual interpretation as manipulated by other stimulus parameters. This perspective suggests an experimental paradigm that is poised to revolutionize (albeit complicate) the conduct and interpretation of neurophysiologies experiments. Adopting this paradigm, recent experiments have shown that both neuronal selectivity for and perception of one stimulus parameter can be markedly influenced by other image factors that govern the observer's interpretation of the arrangement of elements in a visual scene. The new brightness illusions are among many phenomena that could be examined in the same manner.

Adelson's new illusions provide striking and self-evident cause to question the sufficiency of low-level explanations for brightness perception. They tell us what is not an adequate mechanism, and they inspire us to search for one that is. Although this debate over mechanism is not new, Adelson has rekindled it at a propitious time. However, delving deeper into the evolutionary reasons behind the development of vision over millennia might help explain this apparent misinterpretation of greys in Fig 5 (A, B and C). This will be covered in the next portion with other similar examples explained in this new context.

Back To Evolution

The human visual system is an amazing mechanism that has been arguably most effective in helping mankind in becoming the most dominant species on Earth. No wonder the visual cortex is the largest and most developed of all sensory cortices in the human brain. Our visual system is in fact so complex, diverse and precise at the same time, that in 1802, philosopher William Paley called it a miracle of "design". Charles Darwin himself wrote in his Origin of Species, that the evolution of the eye by natural selection at first glance seemed "absurd in the highest possible degree". However, he went on to explain that despite the difficulty in imagining it, this was perfectly feasible as a part of the evolutionary process:

"...if numerous gradations from a simple and imperfect eye to one complex and perfect can be shown to exist, each grade being useful to its possessor, as is certainly the case; if further, the eye ever varies and the variations be inherited, as is likewise certainly the case and if such variations should be useful to any animal under changing conditions of life, then the difficulty of believing that a perfect and complex eye could be formed by natural selection, though insuperable by our imagination, should not be considered as subversive of the theory"

- **Charles Darwin**

Thereby, he suggested a gradation from "an optic nerve merely coated with pigment, and without any other mechanism" to "a moderately high stage of perfection", giving examples of extant intermediate grades of evolution. Darwin's suggestions were soon shown to be correct, and current research is investigating the genetic mechanisms responsible for eye development and evolution.

Thereafter, D.E. Nilsson has independently put forth four theorized general stages in the evolution of a vertebrate eye from a patch of photoreceptors. Nilsson and S. Pelger published a classical paper theorizing how many generations are needed to evolve a complex eye in vertebrates. Another researcher, G.C. Young, has used fossil evidence to infer evolutionary conclusions, based on the structure of eye orbits and openings in fossilized skulls for blood vessels and nerves to go through. All this evidence adds to the growing amount of evidence that supports Darwin's theory.

The very first fossils of eyes that have been found to date are from the lower Cambrian period (about 540 million years ago). This period saw a burst of apparently rapid evolution, and is referred to as the the "Cambrian explosion". One of the many hypothetical causes of this diversification is the "Light Switch" theory of Andrew Parker. According to him, *"evolution of eyes initiated an arms race that led to a rapid spate of evolution"*. Earlier than this, organisms may have had use for light sensitivity, but not for fast locomotion and navigation by vision.

The evolution of a circular patch of photoreceptor cells into a fully functional vertebrate eye has been approximated based on **rates of mutation, relative advantage to the organism, and natural selection**. Based on calculations, it has been proposed that it would take less than

364,000 years for the vertebrate eye to evolve from a patch of photoreceptors. Thus we clearly see that the development of vision has had a major role in propelling evolution. Especially in homo-sapiens, vision has been vital for their dominance, threat elimination and survival throughout history.

However, we must clearly keep in mind that vision with respect to primate evolution has more to do with the developed brain than to do with the eyes. And it is especially with respect to the Bayesian model of the human brain that we can explain how visual evolution has occurred to facilitate maximum efficiency and maximum evolutionary advantage for humans in any scenario with respect to survival and prosperous growth. The very evolution of the eye in single celled organisms was for the purpose of looking for food. In humans the complex development of the visual cortex is as a result of hunting, gathering and organizing tendencies that ensured the betterment and survival of the race from its early days of evolution. The other key aspect to consider here is "Threat Elimination" for protection against natural threats and predator threats. Most visual processing and interpretations happen throughout or lives because of the experience we gather but this might not be as important as we thought.

Recent evolutionary studies on new born babies and other new born animals have clearly shown strong evolutionary and genetic factors influencing how we interpret and perceive visual data. This is most evident when it comes to the issue of survival. A particular species acquires certain visual traits depending on the genes passed on from their ancestors. A new born buffalo has been recorded to run away from an approaching lioness without any form of prior learning or experience acquired during its first few seconds of birth. Furthermore, a study using a human baby and a mountain goat done on a high glass table with a thin boundary show remarkable results. None of the human babies are able to recognize the edge of the table and show prominent tendencies of falling off, while the new born mountain goats clearly identified the boundary of the table and showed no tendencies of falling off the edge. Thus it was concluded that through this evolutionary instinct that was ingrained in the gene of the mountain goats enabled them to do clear depth perception without learning, contrary to that of human babies. This is analogous to how dogs are genetically wired to swim in water where as humans are not. Due to natural selection, baby mountain goats not born with depth perception would be worse off and probably die, leading to a genetic and biological adaption to their environment - high precision depth perception. So it is evident from such examples that although the same data is hitting the retina of the eyes in both the cases, due to the difference in the genetic code of humans and mountain goats, their brains interpret the same visual data in different ways based on the context of depth perception that is innate in their genes. Similarly there are lots of unique ways in which the human mind is also wired to perceive visual data in specific ways due to natural selection and we shall discuss some of these aspects below. Therefore let us now discuss some of the factors involving the Bayesian model of the human brain, visual perception and evolution along with their inter-dependence and inter-relations:

1) The Bayesian approach as revealed from works of Randy L. Diehl of the University of Texas at Austin has been successful in perceptual studies and extends elegantly to the domain of evolution by natural selection.

2) Bayesian natural selection is a formalization of Darwinian natural selection that specifies explicitly how the natural scene statistics and other properties of the environment interact with genes to determine the design of visual perception and cognitive systems.

3) The proposed Bayesian framework consists of two complementary components: maximum evolutionary advantage with respect to decision making and Bayesian natural selection.

4) In his works, fairly complicated simulations of Bayesian natural selection were found to be tractable. Simulations of evolutionary scenarios considerably more complex than those described here are also feasible.

5) Even the relatively simple simulations described here reveal some surprising predictions (concerning likely patterns of co-evolutionary trajectory, and trade-offs between reproductive efficiency and placement of perceptual decision criteria), which should be testable in the field.

6) The Bayesian framework facilitates efficient decision making with respect to the information that is fed into the visual system of humans and the brain has developed through natural selection in ways to autonomously choose pathways to arrive at the quickest possible solution with respect to a given environmental input for reasons of efficiency, reproduction and survival.

Let us now list the ways in which the neuronal networks of our brain enable us to perform complex visual tasks and conduct our lives in the most efficient manner. This will also highlight certain unique aspects of the human brain that contribute to specific interpretations of visual data.

Visual Motor Abilities

1. **Fixation** - The ability to steadily and accurately gaze at an object of regard. This is most dysfunctional in nystagmus which is an uncontrollable shaking of the eyes.
2. **Pursuits** - The ability to smoothly and accurately track, or follow, a moving object.
3. **Saccades** - The ability to quickly and accurately look, or scan, from one object to another.
4. **Accommodation** - The ability to accurately focus on an object of regard, sustain that focusing of the eyes, and to change focusing when looking at different distances.
5. **Convergence** - The ability to accurately aim the eyes at an object of regard and to track an object as it moves towards and away from the person.
6. **Binocularity** - The integration of accommodation and convergence.
7. **Stereopsis** - Depth perception.

Visual Perception

1. **Visual-Motor Integration -** Eye-hand, eye-foot, and eye-body coordination.
2. **Visual-Auditory Integration -** The ability to relate and associate what is seen and heard.
3. **Visual Memory -** The ability to remember and recall information that is seen.
4. **Visual Closure -** The ability "to fill in the gaps," or complete a visual picture based on seeing only some of the parts.
5. **Spatial Relationships -** The ability to know "where I am" in relation to objects and space around me and to know where objects are in relation to one another.
6. **Figure-Ground Discrimination -** The ability to discern form and object from background.

Furthermore, some unique capabilities of human vision concern the following:

1. **The Field of View –** The human eye has a total field of view of approximately 200 degrees horizontally — about 120 degrees of which are shared by both eyes, giving rise to what's known as binocular vision — and 135 degrees vertically, (though these values tend to decrease with age). This is due to the fact that both of our eyes are positioned more or less on the front of our heads, as opposed to the sides. Animals with monocular vision have a much wider range but it trades of for the precision of binocular vision in humans. This gives us focus as predators and hunters as opposed to monocular vision common in preys who tend to avoid being eaten. This vision in humans is also 3 dimensional with depth perception which matters a lot in terms of interacting with the environment in which we are born and survive. As homo-sapiens evolved to become hunters and gatherers using various tools for the primary reason of acquiring food, it was important to have high focus on what lies in front as the desired target instead of worrying about being eaten by other species in the process.

2. **Angular Resolution-** Angular resolution is one of the terms used to describe an optical device's ability to distinguish very small details. If you want to talk about the smallest thing perceivable by the human eye, it makes sense to do so in terms of angular resolution. Angular resolution is commonly measured in units known as arc minutes and arc seconds, which correspond to 1/60th and 1/3600th of a single degree in your field of view, respectively. The typical set of human eyes has an angular resolution on the order of one arc minute, give or take a few arc seconds. If you were to draw a line measuring a third of a millimetre wide on a piece of paper and hold it at arm's length, the line would cover about 1 arc minute of your vision. This shows us that we have a greater eye for details and the capacity to look at minute features and differences than any other species.

3. **The Blind Spot -** The human eye is lined with photoreceptor cells that it uses to perceive light. Visual information received by these photoreceptor cells is relayed to the brain via the optic nerve. The only problem is that the optic nerve actually passes through part of photoreceptors lining the inside of the eye, creating a small, receptor-less patch where it's impossible to detect light. Normally this isn't an issue. We've got two eyes, and our brains are incredibly good at using the visual information gathered from each eye to fill in the gaps left by the other's blind spot. Therefore the human brain has the capacity and tendency to fill up missing gaps in visual data which explains the tendency for closure as highlighted by the Gestalt psychologists.

4. **The "Visible" Spectrum -** Probably the most well-known of human sensory limitations, the typical human eye is only capable of perceiving light at wavelengths between 390 and 750 nanometres. Of course, calling it the "visible" spectrum is a bit of a misnomer, as plenty of animals are capable of perceiving light with frequencies outside this relatively narrow band of electromagnetic radiation. One of the main reasons behind this is that humans are not nocturnal in nature like some animals which perceive light beyond the human visible spectrum for nocturnal hunting and other survival related factors.

Having highlighted these factors, both from the point of view of Evolutionary Biology and the Bayesian Model of the brain, let us carefully reinvestigate the Gestalt and Adelson illusions to look for an explanation in the light of this knowledge. Due to evolutionary factors, it is evident that the human brain processes colour contrast and depth in greater detail and precision. In each of these cases the human brain prioritizes in identifying shapes and forms and especially faces which are very important for interacting and surviving in the environment we live. So we have an innate tendency to associate the context of forms and faces even to the incomplete data that hits the retina thereby giving rise to the importance of global properties as per the Gestalt point of view.

On the other hand in case of figure 5(A), the brain registers the top and bottom surfaces as two different shades of grey despite the fact that they are exactly the same. Now, let us see the reason for this anomaly. In this case the Bayesian brain is wired to give more importance to 3D vision and light perception in a 3D world as opposed to that of a 2D world. In case of a 3D world the Bayesian brain takes immediate decisions on how to most efficiently orient, configure and conform with respect to the 3D object in front, hence in such cases the apparent perception of the importance of colour takes a back seat as it has no significance with respect to threat elimination and survival of the species. Thus we can conclude that the Bayesian brain takes global and local decisions to interpret the same visual data differently based on evolutionary factors to maximize advantage for the survival of the species.

Cultural Influences on Vision

In the early days of civilization, when homo-sapiens social structure evolved into larger settled units from being cave-dwelling small packs, a lot of visual perception and contextual interpretation started getting influenced by society and culture as well. By the sixth and fifth centuries BC the faculty of vision and the attributes of knowledge had run together in the Greek word "*theorin"*, meaning both 'to see' and 'to know'. Knowledge was henceforth a register of vision. Ignorance therefore becomes a lack of knowledge predicated on objects not being visible, so darkness equals ignorance. In turn, the dark becomes a source of fear as if knowledge of visible objects were the only defense against terror and anxiety. This again has strong connections to the evolutionary instincts of survival and threat elimination.

These philosophical questions of vision and knowledge and a related fear in the absence of sight are clearly highlighted in studies related to cross-cultural investigations into aspects of sleeping. This study was approached firstly through Warlpiri socio-cultural practices of sleep and care, and Warlpiri ideas of the night and sight. Yasmine Musharbash conducted a long term study and presented the ethnography and analysis of the Warlpiri material in dialogue with aspects of the cultural history of sleep in Europe. The very sense of security and safety in society imparts different kinds of knowledge and experience based contextual interpretations in different human societies. The Warlpiri, for example, are habituated to identify predator related threats in pitch

darkness where as a person from a secure western society experimentally fail to identify the same under the very same conditions.

Another example is from the society of Eskimos in the Arctic region. In a land of stark white snow everywhere, the polar bears are almost impossible to distinguish because of the similarity of their coat colour with that of the background snow. Tourists and others visiting the Artic for the first time always fail to make this distinction and often fail to identify this threat. However, Eskimos have that acquired training to make clear distinctions through experience and past knowledge, thereby automatically associating context and distinction between the bear and the snowy background as the visual feed hits the retina.

So broadly speaking at the societal and cultural level we find experimentally that there are certain mental constructs innate to a society or a tribe at particular geographical locations of the world which attach a particular meaning to visual data in our daily lives. This kind of contextual interpretation is broadly acquired through cultural knowledge and learning to adapt and survive in a particular environment under particular circumstances innate to that location that is not generally prevalent everywhere in the world.

Thus, so far we have discussed how evolution, the Bayesian brain, cultural association and learning may have a prominent impact on contextual interpretation of visual perception. This has been a progressive discussion which started in a broad sense and was narrowed down to geography and culture as we progressed. In the next sections we shall narrow it down further to the individual level and see how memory acquired during one's lifetime can play an important role in contextual interpretation of visual perception.

Vision and Memory

Vision with reference to the aspects of memory will primarily be discussed in two parts. One part will deal with temporal and factual memory with respect to the Hippocampus while the next will deal with emotional memory with respect to the Amygdala.

Psychologists and neuroscientists generally agree that the hippocampus plays an important role in the formation of new memories about experienced events (episodic or autobiographical memory).Part of this function is hippocampal involvement in the detection of novel events, places and stimuli. Some researchers regard the hippocampus as part of a larger medial temporal lobe memory system responsible for general declarative memory (memories that can be explicitly verbalized—these would include, for example, memory for facts in addition to episodic memory). Therefore as we keep gathering more experience and memory down the ages in a life-span our we acquire the capability of assigning new meaning and context to things we see in our day to day lives. This is significant both in terms of short term memory and long term memories.

Let us explore this idea with the following visual illusion:

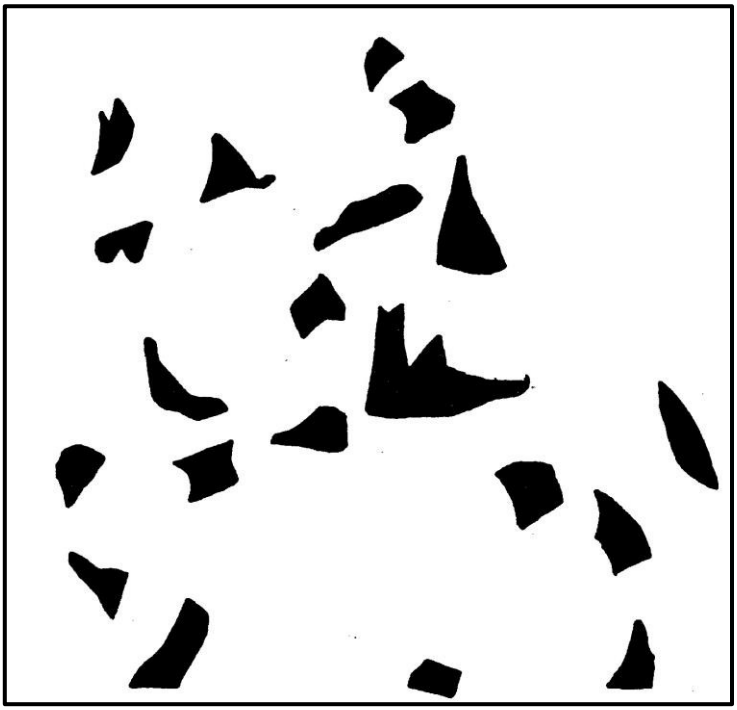


Figure (6)

Can you guess what the illusion in Figure (6) depicts? Don't be surprised if you can't because contextual interpretation of such abstract visual data can be well accounted for in terms of short term and long term memories. It has been experimentally seen in various universities that a statistical majority of people who correctly identified this illusion as a horse with a rider on its back had a greater association to wild animals, nature, and farm-life or to the sports of horse riding and polo compared to those who could not contextually identify it.

Interestingly, another set of experiments were done where the subjects were divided into two groups. The first group was shown a set of pictures related to life in the city, consisting of buildings, cars etc. in rapid succession before asking them to interpret this illusion. On the other hand, the second group was shown a set of pictures related to wildlife and animals before interpreting the same illusion. It was evidently observed that almost everyone in the second group were able to identify the horse and the rider, while the subjects in the first group failed to do so.

This experiment shows the influence of both short term and long term associative memory with respect to contextual interpretations. It is clear that visual perception is indeed influenced to a great deal by what we are used to seeing and associating as a part of our immediate experience as well as throughout our lives.

Emotional Memory on the other hand also has a major influence on visual perception. This is related to the things that we acquire a strong affinity for or resentment towards, through our life experiences. Emotional memory in both cases has strong association to the Amygdala of the brain and it is important to understand how that imparts meaning and context. For example people who have a strong affinity towards dogs identify the Dalmatian in Figure (4) much faster and better than those who don't. This will be further discussed in the final section of this paper.

Furthermore, contextual interpretation also has a very strong connection to fear memory and trauma with respect to Post Traumatic Visual Disorders and other visual phobia. People with intense memories of phobias of spiders and snakes in the past have failed to distinguish a plastic spider or a rope lying on the ground from the actual subject of their trauma. Similar cases have been reported with rape victims and war victims who have been traumatized to such an extent that they always misinterpret their visual perceptions with anything remotely or even vaguely associated to the cause of their trauma.

The remarkable aspect of these disorders is that the visual center of these victims; that is all the features related to their eyes have been tested to be absolutely normal. Yet they end up seeing the wrong things and misinterpreting their perception based on the preconceived context in their brain. Furthermore, neuroscience studies have revealed that all the firing of cue specific neurons with respect to a particular event is overcome by the firing of generalized neurons that signal for fear randomly for any visual stimulus and this leads to the contextual misinterpretations.

Another remarkable aspect of these disorders are that they are completely curable through methods of Neuro-linguistic programming and rehabilitation. In other words, just by reprogramming the contextual associations of the mind, visual phobias and post traumatic visual disorders can be cured and the patient's vision can be brought back to its normal state.

This study has provided insights that we must take into consideration while studying the contextual interpretation of vision. However, how a specific context would influence an observer at the very subjective level, in the first place to choose one specific description of perception

from another is even more intriguing. So, we shall try to resolve this with the theory of Existentialism that has been discussed in the final portion as a philosophical resolution of perception and interpretation.

The Existential Resolution

William James popularly said that mental constructs influence our vision every day and what finally influences mental constructs at the individual subjective level can be explained to some extend through the philosophy of Existentialism.

Existentialism is a term applied to the work of certain late 19th- and 20th-century European philosophers such as Søren Kierkegaard, Fyodor Dostoyevsky, Friedrich Nietzsche, Jean Paul Sartre and Albert Camus who collectively shared the belief that the philosophy of perception begins with the human subject—not merely the thinking subject, but the acting, feeling, living human individual. While the supreme value of existentialist thought is commonly acknowledged to be freedom, its primary virtue is authenticity. In the view of the existentialist, the individual's starting point is characterized by what has been called "the existential attitude" or a sense of disorientation and confusion in the face of an apparently meaningless or absurd world.

Søren Kierkegaard is generally considered to have been the first existentialist philosopher, though he did not use the term existentialism. He proposed that each individual—not society or religion—is solely responsible for giving meaning to life and living it passionately and sincerely ("authentically"). The fundamental tenets of existential philosophy as proposed by Nietzsche, Sartre and others are vitally important in understanding the contextual interpretation of all perception.

Let us revisit William James, before proceeding further on the doctrine of existentialism. James notably said the following regarding the contextual interpretation of vision.

"Some such process as this must go on in all our experience. Beef and mutton, strawberries and raspberries, odor of rose and odor of violet, contract different adhesions which reinforce the differences already felt in the terms. The reader may say that this has nothing to do with making us feel the difference between the two terms. It is merely fixing, identifying, and so to speak substantializing, the terms. But what we feel as their difference, we should feel, even though we were unable to name or otherwise identify the terms.

To which I reply that I believe that the difference is always concreted and made to seem more substantial by recognizing the terms. I went out for instance the other day and found that the snow just fallen had a very odd look, different from the common appearance of snow. I presently called it a 'micaceous' look; and it seemed to me as if, the moment I did so, the difference grew more distinct and fixed than it was before. The other connotations of the word 'micaceous' dragged the snow farther away from ordinary snow and seemed even to aggravate the peculiar look in question."

These paragraphs highlight the fundamental core principle of Existentialism that will be described below along with its relevance to this work on visual perception.

Key-concept under consideration:

Existence Precedes Essence: A central proposition of Existentialism is that existence precedes essence, which means that the most important consideration for individuals is their individual subjectivity which makes them independently acting and responsible, conscious beings ("existence")—rather than what labels, roles, stereotypes, definitions, or other preconceived categories the individuals fit ("essence").

Let us reanalyse this in the context of vision. From the very beginning of this paper we have taken a converging approach. We started at the very broad level considering human psychology and mechanisms of vision at large, followed by genetic, cultural, geographical and memory-related factors which have some significant influence on visual perception. But beyond all of these factors we still find outliers who cannot be structured into this stereotypical method of approach of psychological analysis.

In other words, with reference to figure (6), we still find one or two people in both the groups who fail to verify the statistical outcome of the experiment. This individuality has strong implications on one final frontier that determines the mental construct of humans at the individual subjective level. This is also valid for the acquisition and cure of phobias and traumatic stress disorders. A lot of people exposed to the same conditions of fear and trauma do not develop these disorders at all, while some are able to cure themselves via methods discussed above, while the rest find it impossible to get a proper cure.

Therefore, all of these are linked to and can be explained by existential choices at the subjective level. The actual life of the individuals is what constitutes what could be called their "true essence" instead of there being an arbitrarily attributed essence others use to define them. It is often claimed in this context that people define themselves because of how they choose to lead their lives and guide their preferences. **This is as opposed to their genes, or human nature, or evolution or culture or geography bearing the blame,** which basically indicates the essence in this context.

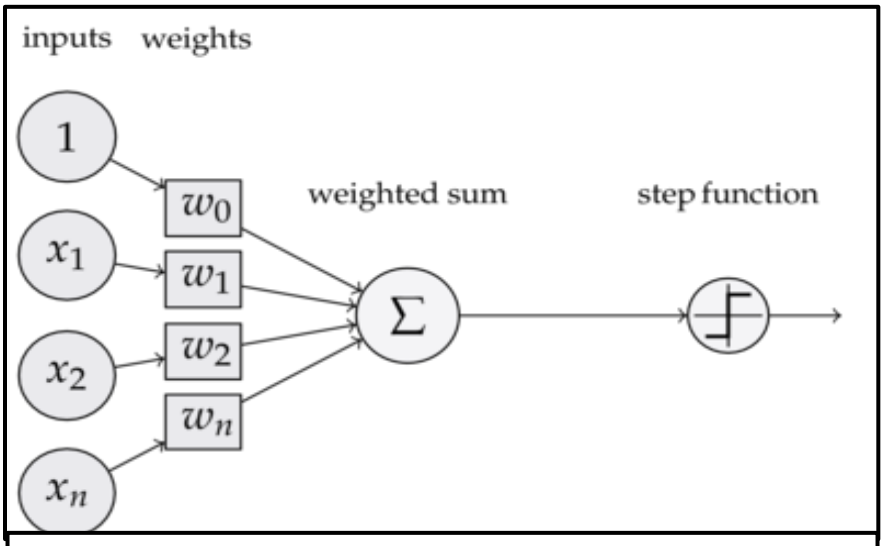


Figure (7)

The Neuronal Perceptron Model

Thus, human beings, through their own consciousness, create their own values, which in turn determine their affinities and aversions which subconsciously have a strong influence on contextual interpretation of visual data. This can be best explained through the perceptron model applied to the study of neurons. In figure (7) we see the perceptron model of a neuron that can be applied to the study of visual perception. Within the premise of our work, let us correlate and simplify this model. In the given diagram, the inputs are analogous to the visual data that reaches the retina of the eye and is transmitted to the brain via the optic nerve. The weights are what give the context to the visual data and the step function of output is the specific interpretation that the brain projects based on the visual data and the context. Therefore how an individual's brain associates context and meaning to a particular visual data has a lot to do with existential philosophy which provides significant insight into this matter.

Being intrigued in this philosophy, we wanted to conduct an experiment to study the significance of existential influence alone on visual perception by controlling all other factors related to contextual interpretations. We chose a group of 25 students of the exact same age (13) from the exact same school (La Martiniere for Boys, Kolkata) and with the same socio-economic & cultural background (all Bengali's) who have grown up together in the same geographical location and conducted a visual experiment with a self-designed illusion.

The illusion is a modification of the original Dalmatian illusion in figure (4) with two other identifiable objects (an assault rifle and a comic book superhero) embedded and blended into its background. A personal interview was conducted for each individual subject after the test and the illusion along with the results are shown below.

Figure (8)

Serial Number and Initials of Student	Identified The Dalmatian	Identified the Assault Rifle	Identified the Superhero	Loves Dogs	Scared of Dogs	Reads DC comics/ watches DC cartoons regularly	Plays 1st person shooter games
1) AB	YES	NO	YES	YES	NO	YES	NO
2) ABY	YES	YES	NO	YES	NO	YES	YES
3) IS	NO	YES	YES	NO	NO	YES	YES
4) JP	NO	YES	YES	NO	NO	YES	YES
5) AG	YES	NO	NO	NO	YES	NO	NO
6) JM	YES	NO	YES	NO	YES	YES	NO
7) AR	NO	NO	NO	NO	NO	YES	YES
8) RG	YES	NO	YES	NO	YES	NO	YES
9) RB	YES	NO	YES	YES	NO	YES	NO
10) ABS	NO	NO	NO	YES	NO	NO	YES
11) ABJ	YES	NO	YES	NO	YES	NO	YES
12) CD	YES	NO	YES	NO	YES	YES	NO
13) NS	YES	YES	NO	NO	YES	NO	YES
14) RC	YES	YES	NO	YES	NO	NO	YES
15) SC	NO	YES	NO	NO	NO	NO	YES
16) AG	YES	NO	YES	YES	NO	YES	NO
17) SP	NO	NO	YES	NO	NO	YES	YES
18) SM	YES	NO	YES	YES	NO	NO	NO

19) DG	**NO**	**YES**	**NO**	**YES**	**NO**	**YES**	**YES**
20) MS	**YES**	**NO**	**NO**	**NO**	**YES**	**NO**	**NO**
21) SJ	**YES**	**NO**	**YES**	**YES**	**NO**	**YES**	**NO**
22) AH	**NO**	**YES**	**YES**	**NO**	**NO**	**YES**	**YES**
23) SGH	**YES**	**NO**	**NO**	**YES**	**NO**	**YES**	**NO**
24) RI	**NO**	**YES**	**YES**	**NO**	**NO**	**YES**	**YES**
25) AJB	**YES**	**YES**	**YES**	**NO**	**YES**	**YES**	**YES**

The contextual interpretations of Figure (8) have important and interesting results as shown in the table above. It is seen in most of the cases that the contextual interpretation of the illusion is in direct association to the affinity or aversion of the subject at the individual level without any broad factors involved in the process. It was clear from the interviews, that in almost all cases when the subject did identify a particular embedded object correctly it was due to a specific subjective preference or bias. It is interesting to note that fear was the only other factor that was taken into consideration for contextual identification by the individual subjects, but that was a significant minority in comparison with the existential preferences.

From this experiment it is evident that visual perception and contextual interpretations are more complex than it is classically thought so in Gestalt psychology or in terms of the basic reductionist neurobiological point of view. There are important evolutionary factors to consider and beyond that it further gets moulded by the existential subjective experience. This existential subjectivity accounts for the expectations, innate value attachment and knowledge acquired through experience at a personal level. The study of Neuro-linguistic programming is an example of structuring and categorizing such data at the individual personal level and scientifically analysing the subject on the basis of their individual perception. Similarly visual perception can also be extended through such studies to bring into account the aspects which critically influence visual processing at the subjective level. We can then assign the so called “weights” or “expectation values” and create a new perceptron model for a deeper and holistic understanding of visual processing as executed by the individual’s brain.

Conclusion

We shall now summarize the various factors related to the contextual interpretation of visual perception highlighted throughout this paper.

1) To begin with, we defined *Context, Perception and Interpretation* in the classical sense of the terms along with appropriate explanations of the relevance of each term with respect to our investigation.
2) The issue of *high level* and *low level* explanations of visual perception were then discussed from psychological and neuroscientific points of view based on **Gestalt** and **Adelson** standpoints.
3) Contextual Interpretations were then studied in every chapter in detail adopting a convergent technique, starting from the very broad sense that applies to all humans, to the very specific factors which apply only to specific individuals at the subjective level.
4) These are the various factors which have been studied in detail from a broad to narrow sense to understand the contextual interpretation of all visual perceptions:
    a) Evolutionary Factors and Natural Selection
    b) The Bayesian Brain and efficiency
    c) Distinct abilities and attributes of human vision
    d) Cultural and geographical influences on vision
    e) Memory and Vision (temporal Factual and Emotional)
    f) Vision and Existentialism

Thus this study maps most of the factors that influence contextual interpretation of visual perception in detail to be able to facilitate psychological and neuroscientific study in this field with a fresh perspective. It also brings in existential philosophy as a plausible explanation for mental constructs that influence vision at the individual subjective level. We believe that a more rigorous perceptron like model can be developed collectively taking into consideration all of these factors that have been covered in detail, in this paper. Vision is certainly a complex phenomenon and although there might be consensus regarding the objective reality out there but as we see subjective visual perception on the other hand tells a very different story. So understanding why we see the way we do in the present will certainly determine the further enhancement and evolution of vision in the future as humans prepare to take the next bold step and become an interstellar civilization. This next step of perception in an environment beyond the boundaries of planet Earth might require essential upgrades in the visual centres of our brain through transhumanism to show us a reality far more enhanced, precise and spectacular than we perceive today!

List of References:

1) **Contextual Influences on Visual Processing** -By -Thomas D. Albright and Gene R. Stoner Howard Hughes Medical Institute, Systems Neurobiology Laboratories, The Salk Institute for Biological Studies, La Jolla, California 92037.

2) **'My most true mind thus makes mine eye untrue'**- By- Thomas D. Albright; Salk Institute for Biological Studies, La Jolla, California 92037.

3) **'Why do things look as they do?'** – By - Thomas D. Albright; Salk Institute for Biological Studies, La Jolla, California 92037.

4) **Perceiving**- by-Thomas D. Albright, Salk Institute for Biological Studies, La Jolla, California 92037.

5) **Vision is our Dominant Sense** - http://www.brainline.org/content/2008/11/vision-our-dominant-sense_pageall.html

6) **Animal Eyes-**by- Land, M.F. and Nilsson, D.-E Oxford University Press, Oxford (2002).

7) **Darwin, Charles (1859) On the Origin of Species**. London: -by-John Murray.

8) **"New Perspectives on Eye Development and the Evolution of Eyes and Photoreceptors"** – by- Gehring, W. J. (13 January 2005). (Full text). Journal of Heredity (Oxford Journals) 96 (3): 171–184. doi:10.1093/jhered/esi027. PMID 15653558. Retrieved 2008-04-26.

9) **"The Evolution of Eyes". Annual Review of Neuroscience**- by- M F Land; R D Fernald (1992 15: 1–29. doi:10.1146/annurev.ne.15.030192.000245. PMID 1575438.

10) **Night, sight, and feeling safe: An exploration of aspects of Warlpiri and Western** sleep by-Yasmine Musharbash, University of Sydney.

11) **From low level perception to high level perception, a coherent approach for visual attention modelling** –by- O. Le Meur1,2,*, P. Le Callet2, D. Barba2, D. Thoreau1, E. Francois1 1-THOMSON multimedia R&D France, 1 Avenue de Belle Fontaine, 35511 Cesson-Sévigné cedex, FRANCE. 2-IRCCyN UMR n°6597 CNRS, Ecole Polytechnique de l'Université de Nantes, rue Christian Pauc, La chantrerie, BP50609, 44306 Nantes cedex, FRANCE.

12) **A Bayesian approach to the evolution of perceptual and cognitive systems** –by- Wilson S. Geisler∗, Randy L. Diehl. Department of Psychology, Center for Perceptual Systems, University of Texas at Austin, Austin, TX 78712, USA Received 27 May 2002; received in revised form 13 December 2002; accepted 19 December 2002.

13) **Infants on the Edge: Beyond the Visual Cliff** –by-Karen E. Adolph and Kari S. Kretch New York University.

14) **Hierarchical Perceptron Model of Vision –** by- Sebastian Seung

15) **"Existentialism" –** by- Crowell, Steven (October 2010). Stanford Encyclopaedia of Philosophy.

16) **"Existentialism".** Philosophy 23 (84): 19–37- by- Copleston, F.C. (2009)

17) **Visual Perception in Village Eskimo and Urban Caucasian Children –**by-JUDITH KLEINFELD

18) **Memory, Learning, and Emotion: the Hippocampus-** psycheducation.org.