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ORIGINAL ARTICLE

COGNITIVE NEUROSCIENCE AND ROCK ART: AN ANTHROPOLOGICAL PERSPECTIVE FROM CENTRAL INDIA ROCK-SHELTERS

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***Abstract**: It is well known that hunter-gatherer rock art and aspects of cognitive neuroscience are directly related. In this conceptual research paper, there is an attempt to demonstrate how rock art and the production and consumption of rock art have direct relationships with cognitive neuroscience and analyze the issue from an anthropological perspective. Two central questions have been addressed here. Can artistic experiences in rock art advance our understanding of individuality and individual processes via neural activity and how vision and emotions shape our memory, colour symbolism and overall belief systems? **Methods:** The themes, subject matter, colour composition, style of rock art, techniques, superimposition, time-frames and spatial distribution of the paintings on the canvas of the sandstone rock-shelters have been identified, analysed and interpreted deploying the core concepts from cognitive neuroscience. **Results:** This study reported rock art from a few newly discovered rock-shelter sites by the author from Central India and introduced a few previously discovered sites by various other researchers to interpret the subject matter of rock art implementing the mechanisms of cognitive neuroscience. The study as general principles postulates that the creation of rock art generates discreet cognitive capacities which are directly mediated by the interactions with their surrounding environment constructing social realities. **Conclusions:** Brain activities and vision are directly related to different forms of emotions. People synchronise their brain activities while producing art and/or paintings when they communicate between each other. This patterned communication has certain advantages and disadvantages both in the past and present irrespective of technological advances and socio-cultural differences. Hence, emotions are social reality. Cognitive neuroscience informs us how the brain works and what happened in the ancient times with the ancient minds when they learned to produce rock art.*

Keywords: Rock art, emotion, vision, colour, memory, symbolism.

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1. INTRODUCTION

Cognitive neuroscience is a novel discipline encompassing several different fields of research. Being multidisciplinary and inter-disciplinary this particular realm of knowledge integrates various scientific domains, primarily psychology, neurobiology and mathematics including philosophy, linguistics, computer science and artificial neural network. The applications of cognitive neuroscience are widespread in neuroimaging and neural signal processing [1], however, in recent years the theoretical and conceptual mechanisms of this discipline have found broader and useful applications in prehistoric archaeology and socio-cultural anthropology. While delineating the cognitive background of mental functioning it is important to include the basic tenets of cognitive neuroscience that influences this study. Previously, it was assumed that single neurons perform complex encoding tasks, including for places, faces and diverse locations in space. However, microbes can also impart information related to cognitive frameworks associated with complex animals. Therefore, a single cellular wiring architecture represents more potential behavioral changes than priorly assumed. Hence, the inbuilt, default mode network is not the only spontaneous oscillatory mechanism in the brain. Behavioral changes and emotions are critically related to contexts and each organism's internal state. Various neuromodulators and their smaller derivatives, neuropeptides control and influence context dependent behaviour and internal states, often guided by emotions. The inbuilt mechanism or hardware, let's say the actual default network is responsible for emotional upheavals, when disturbed may lead to psychiatric disorders. This implies that default mode network is crucial for smooth cognitive functioning. The brain therefore, perceives and represents the world. It processes all the vital information, and decides how to respond meaningfully from the observer's point of view and not the observed system's [2]. Therefore, the spontaneously active brain has its own logic and grammar. Implementation of the said mechanisms concurs that the human brain is a cultural artifact. Social reality and emotions as deciphered through rock art is therefore one conduit for transmitting behavioral changes and patterns, preferences, ideologies and meanings from one generation to the next via natural selection [3].

Hunter-gatherers required the crucial ability to identify meaning and significance as part of their production and consumption of rock art [4]. Such intuitions related to underlying symbolisms and cognitive load are an expression of a particular form of anthropological sensibility, let's say rock art and must be treated with care, confidence and often intricate meanings [5]. They are what enable anthropologists and archaeologists to produce novel and deep insights that depend on systematic procedures introducing predetermined systems of analysis [6]. The brain itself embodies a serial, hierarchical, often non-linear modular bucket bridge organization. This complex architecture and organization of the brain help understanding the many facets of emotion, vision, colour, memory, perception [7] and related symbolisms in rock art both inside and outside the brain. Each of these modules far from being completely hard wired represents basic scaffolding that's determined by genes [8]. However, several observations and experiments suggest that the brain is extremely malleable. In the recent times neuroplasticity has been the buzz word and concept as well that deals with this malleable and ever changing complex neural networks [9] within the brain. Therefore, the modules that are concerned with vision, also work for other explicit and overlapping functions [10]. The modules for vision within the brain also alter and influence touch and perception. The extent of this complex interaction is exceedingly high, especially to the other brains that are consuming the rock art [11] per se both in a bottom up and top down [12] manner. The extraordinary dynamic system is very different from the average computational model of vision. There are multiple areas that make vision and colour perception possible within the human brain. Vision in human beings is not involved looking at

a particular visual zone [13], perceiving and experiencing a specific picture or a set of pictures. Actually, optical image in the eye retina goes through the nerve, screened there and displayed on the screen as people see it in recent times. That's how vision happens and even the hunter-gatherers of the Late Pleistocene period managed to see rock art and create rock art following these basic and fundamental principles. Various aspects of vision in a single image merge together. They are colour, form, shape, structure, motion, combinations and depth. These attributes are related to vision and colour compositions and are analysed by different areas of the brain. A total of about more than thirty brain areas [14, 15] get engaged simultaneously to analyze vision properly and meaningfully. This implies that more than thirty maps, complete or partial maps for vision [16] are responsible within the brain to understand its creation outside the brain which is rock art that invokes certain emotions, senses and sensibilities among the viewers of rock art. These emotions could represent fear, joy, compassion, anxiety, aggression, love et cetera as unified moments of conscious awareness when depicted through rock art. How do we know about the existence of these emotions in rock art? We could deduce these emotions from the depictions in the Central Indian painted rock-shelters. However, we need to understand systematically whether rock art is either an early form of cognitive extension, or a nascent and important form of epistemic technology? When other brains perceive the art the same thirty or more than thirty areas [17] within the brains of the viewers' get activated in synchronicity. It is both an evolutionary, anthropological and creative process [18]. Vision along with memory, colour code, perception and emotions is an opinion on the states of facts in the immediate world [19] of the hunter-gatherers, the everyday challenges they face, the hurdles they cross and in the process the emotions they go through, and not a passive reaction to the input. Because of all this processing the artists can go in and more optimally stimulate specific areas of the paintings by changing and retouching the images. Often these changes take place across generations whereby, the next generations might change the very essence of the paintings by paint rejuvenation taking the meaning and emotion of the painting to a different dimension, either following the needs of the then groups or depicting the artists' imaginations directly. Rock art can be an exaggerated version of key attributes by enhancing particular form and colour codes within the paradigm of entire vision spectrum and areas within the brain to stimulate other brains and respective vision areas [20]. To evoke certain emotions through rock art different areas of the brain get activated and act discreetly. They work more optimally, more powerfully in the producers' brains and the consumers' brains that produce and consume rock art both diachronically and synchronically. This produces multiple stages of engagements and activations within the brain eventually creating and embedding multiple types of emotions through rock art spatio-temporally. The emotional repercussions, influence and experience perhaps happen within a matter of a second. That means simple to complex observations and experiences are happening within the brain quite rapidly and within a short time span. The goal of art in general is to capture the spirit of something, certain emotion and its impact. This evokes a specific mood or sentiment in the viewer's brain. How the hunter-gatherers go from the immediate environment, from the external world to the brain and evoke certain emotions for the peer groups is the fundamental question of archaeology which is directly linked to cognitive neuroscience. The different parts of the brain are used here as a vehicle to resonate to this attribute which are emotions in rock art that are again linked to vision, memory, colour symbolism and perception.

The brain is made of billions and trillions of neurons and neural connections. It is a collection of dynamic and intricate networks that act as diffusedly connected oscillators. These constant diffused non-random activity oscillations are called the brain rhythms or electrochemical waves. The alpha, beta and theta waves are representations of thoughts, emotions, perceptions, memory, vision and actions. The creation, organization and analyses of rock art imageries are often not based on the calculations, but rather intuitions,

dreams, visions, and innovation. The exploration of rock art, their meaning and the quest for emotional cues take psychological and physical determination. The origin and evolution of rock paintings [21] and their inherent emotional insinuations were driven to discover conscious states in order to use them to mark perceptual and cognitive representations. This cognitive apparatus should be complete, context-sensitive, and stable enough to control effective actions among the producers and consumers of rock art. This delicate but intricate link between seeing, knowing, believing, understanding consciousness and action arise from the fact that the brains of the hunter-gatherers and the modern people use several design principles. They are complementary computing, hierarchical resolution of uncertainty both top down and bottom up and adaptive resonance respectively. Particularly, hierarchical resolution of uncertainty demonstrates that multiple processing stages are required to generate a sufficiently complete, context-sensitive, and stable representation upon which to base a successful action, like painting discreet images involving certain ideas, concepts and emotions [22]. Conscious states and phases light up the processing stages that compute representations and repercussions which control effective actions. The rock art making process and the artwork itself are integral components of emotional cues along with vision, memory and perception that help to understand and elicit certain types of communications through the painted imageries. Creative expressions entangled with a plethora of emotional suggestions in rock art are encouraging and self-regulating within the domain of the producers and consumers of rock art.

2. METHODOLOGY

The domains of both physical and socio-cultural anthropology are intricately related to cognitive science and cognitive archaeology. However, all these connections are poorly understood and little research has been done so far in India to understand these underlying mechanisms. The only way to deduce the inherent and underlying emotions in rock art is to analyze specific paintings and sometimes a set of themes. Central Indian rock art is full of superimpositions [23, 24]. That being said the superimposition takes different forms. It could be the superimposition of colour, motifs, themes, abstract designs and styles. Therefore, each layer is important and the motifs should be analysed accordingly. Often the superimpositions help the rock art researchers to understand the relative timeframes of the paintings [25]. In Central Indian rock-shelters, however, mostly we find Late Pleistocene rock art and later on Holocene period rock art superimposed one over the other. The Chalcolithic paintings of the Holocene period are mostly done in white, yellow, grey and different shades of red colour, whereas the Late Pleistocene period paintings are mostly done in dark and chocolate red colour. Now, how to understand the emotional connotations from rock art? To do this along with the overall nature of rock art in each specific rock-shelter we need to understand the subject matter of the art as well. They are mostly animals, humans, flora, non-figurative markings, abstract designs, anthropomorphs, therio-anthropomorphs et cetera. We need to find discreet themes as well depicted in a combinatorial way. Battle scenes, hunting scenes, war scenes, man and woman together, supernatural scenes et cetera provide us enough clues to deduce the underlying emotional components. However, it is important to curate the images deploying digital enhancement and digital image processing to understand the actual essence of the images in order to analyse and understand them to pinpoint the emotional cues. Here the interpretation has to be sound and the logic behind such interpretation should be self-explanatory. A total repertoire of rock art specific images and/or sets of images have to be identified to deduce the emotional cues. In a wider pan-Indian context this model and methodology could also be implemented. However, a set of such imageries has to be accumulated that invokes specific and discreet emotions. Depending on the contexts the imageries may be subject to more than one interpretation.

To reduce such approximations we need more temporal, spatial and hierarchical resolution in the dataset. Rock art from several regions of India should be compared and accordingly the dataset should be assessed. For the sake of brevity and precision I would only consider a few examples since the objective of this conceptual research article is to introduce the paradigms of cognitive neuroscience in archaeology and anthropology to elaborate its potential in future research studies and not an exhaustive account, analyses and review of all the related disciplines like psychology, neurobiology, computer sciences, philosophy and other associated disciplines. two major enigmatic issues were addressed here, taking the cues from cognitive neuroscience to interpret the rock art of Central India, which is how the makers perceived the rock art and their motivations behind such creations.

3. DATASET, MATERIALS AND RESULTS

Rock paintings from the Central Indian painted rock-shelter sites provide typical examples of emotional cues, as if they were created to convey certain concrete ideas and imaginations. The marching soldiers with weapons (Figures 1, 2); battle scenes and fight between two people (Figure 3) demonstrate the emotions of anxiety, fear and aggression. On the contrary a praying motif (Figure 4), dancing motifs and people with raised hands (Figures 5, 6, 7) invoke the emotions of compassion, joy, happiness and fraternity. The hunting scenes (Figures 8, 9) on the contrary raise anxiety, thrill and a sense of adrenaline rush. A chariot scene of historic period in Mirzapur area of Uttar Pradesh (UP) exhibits the idea of speed and concept of the means of transport in the ancient times. This also shows how rock art and the themes including subject matter evolved over time to depict different types of imaginations, ideas and emotions (Figure 10). A pregnant quadruped has been shown in one of the rock-shelters of Pachmarhi Biosphere (Figure 11) which again introduces the emotions of empathy, compassion and happiness. This signifies that the artists of the ancient times were able to communicate their own ideas and emotions through different subject matters. Here both humans and animals have been used as subject matter to depict similar types of emotions. Finally, a profusely decorated huge wild boar can be seen in one of the rock shelters of UNESCO World Heritage Site of Bhimbetka, Madhya Pradesh (MP). This image invokes the emotions of awe, grandeur and totemic allegory. A small animal can be seen at the snout portion of the wild boar, which signifies the grandeur and stature of the boar. This small animal has been painted deliberately to transmit the idea of awe and grandeur among the viewers' activating the specific areas and modules inside the brain. Therefore, it is quite clear that the rock paintings don't stand in isolation; rather they communicate [26] and invoke specific sets of emotions quite diligently. Identifying certain emotional signatures from the immediate environment and depicting the information through rock art is shaped by behavioural success. Group thinking and working together to generate patterned behaviour made the creators of rock art and their descendants capable of adapting quickly to new environmental challenges. Optimal survival of each and every species depends on precise brain functioning on the behavioural level. The specialized circuits of the brain, especially the microcircuits and modal architectures are responsible for vision, memory, colour symbolism and perception that help to adapt on the fly to many different and even hostile situations.

4. DISCUSSION AND CONCLUSION

The production of rock-art in several Central Indian rock-shelters involved a considerable cost and cognitive load to the individuals in terms of the amount of time and energy they spent collecting all the important materials. Pigments and other binders all required a lot of effort in both their gathering and subsequent complex preparation stages. Furthermore, paintings made in the inaccessible locations of the

rock-shelters [27, 28] in the Central Indian regions of Mirzapur, Rewa, Raisen and Hoshangabad also involved an element of risk with a need to negotiate hazardous routes towards the rock-shelters located deep inside the jungle and hills. These combined costs would seem to indicate that the motivation to produce rock art in the study area [29] was quite strong. It was emphasized here that the creation of rock art by our ancestors in Central India was indeed a truly significant cognitive event. It demonstrated an ability to place raw information in the form of naturalistic, figurative and often abstract representations out in the world. This was an unparalleled and unprecedented cognitive feat at that particular time in our evolution. Furthermore, rock art clearly demonstrates the knowhow of the hunter-gatherers and their awareness of the immediate environment that encouraged them to paint actively.

The emergence of art and aesthetics in human societies does not correspond and correlate well with the standard ideals of Darwinian evolutionary theory. Producing rock art perhaps required a lot of time and effort, yet it is not immediately obvious how it imparts emotional connotations among the producers and consumers. If we hypothetically frame that the artistic behaviour could be an adaptation and then it must be demonstrated eventually how it either enhances the chances of survival or improves reproductive success in the past societies. This definitely has implications for the production of rock art and its origins including evolution and social meaning as well as art in general in the recent times. The urge, necessity, importance and passion to produce rock art might be instinctive. This occurs in spontaneity all across the world and throughout human history, from remote prehistory of the Late Pleistocene times to the historic phases in the recent and/or Holocene times in Central Indian regions as well. The ability to communicate effectively imbibing emotional intelligence through the paintings in the rock-shelters has obvious adaptive advantages. Rock art has several benefits and emotional underpinnings and transmitting emotional knowledge to the peer groups and the posterity is surely one of them. The hunter-gatherers had a hunger for information. So is true in the modern times. Humans feel emotions and often they like to share what they learn with their peer groups. While searching for information they look out for patterns in the immediate environment. The everyday challenges are embedded in the human memory and perception as cognitive feedback loops. This cognitive feature is a crucial aspect of humans' complex intelligence mechanisms. Rock art attracts the attention of the ancient people by activating the pattern-hunting, memory, perception and vision parts and modules of the brain. Additionally, the mechanisms behind the creation of art are both the social and individual phenomena for stimulating and materializing imagination tangibly that begets creativity [30]. The production of rock art also required that the artist should remember the various techniques and stages involved coherently. It is a proper chaine operatoire comprised of paint preparation and application, as well as memorizing the methods for reproducing mental imageries on the canvas of the sandstone rock-shelters [31, 32]. The retention and later reproduction of detailed mental imageries and/or maps appear to be both a new innovation and development. A specific type of memory is required for the creation of rock art named working memory. The control of working memory allowed the artists of the Late Pleistocene and Holocene periods in Central Indian rock-shelters to focus on complex procedures that produced no immediate relatable reward but offered better returns later on in the form of group cohesion and community building. This cognitive competence was also a requirement for creating complex, multi-stage artifacts like geometric and non-geometric microliths.

Therefore, although rock art was not the only driving force behind symbolic and creative thinking, it did make use of the symbolic and abstract capabilities that the brain had developed overtime. Cognitive fluidity is the ability of the brain to exchange knowledge, belief systems, ideologies and emotions among its specialised domains rather than them being isolated from each other in the ancient hunter-gatherer groups.

The possession of specialised domains and modules within the brain may demonstrate intelligence and skill in particular areas of behaviour, but cognitive fluidity facilitates a more flexible and creative behaviour; that is the creation of a lay out to transmit and transfer emotional intelligence. The depiction of non-actual, fictional and mythical beings, such as human-animal hybrids, anthropomorphs and therio-anthropomorphs for example, demonstrate the artists' ability to combine thoughts on different subjects as a result of cognitive fluidity in Central Indian rock art, to be precise. Rock art was a method of transferring information from the brain into the world, resulting in reduced internal cognitive load and hence apparent costs. It also improved and further facilitated the fidelity of information transfer. Most importantly, rock art gradually began a process of allowing curious minds [33, 34] to share information and ideas without the need for verbal communication. By producing such abstract but tangible patterns, the underlying neural heuristics were stimulated leading to neural and brain wave resonance. This has induced emotions leading to a repetition of the procedure.

A. Marching Soldiers with weapons: Invoking anxiety and fear from a central Indian rock art site in Mirzapur, UP.

B. Marching Soldiers with weapons: Invoking anxiety and fear from a central Indian rock art site in Pachmarhi, MP.

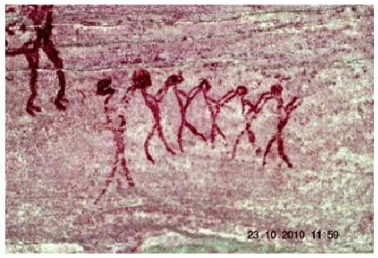
C. Two people with weapons fighting, superimposed on a deer: Invoking Anxiety and Fear from a Central Indian rock art site in Pachmarhi, MP.

D. A praying person from Bhimbetka Rock-shelter in Central India, MP: Invoking compassion.

Figure 1 A-D: Photo and Image Processing: Ruman Banerjee

Apart from this I would also like to mention the specific roles of the occipitotemporal area engaging feedforward and feedback neural loops [35-38]. Creativity and the experience of aesthetic reflection are

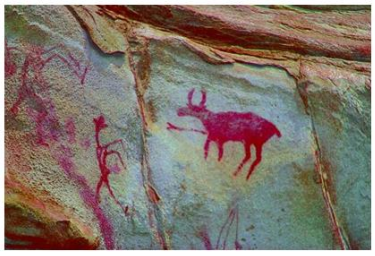
two of the most profound mysteries of the human brain. Both of them enable us to continually innovate through problem-solving and express complex emotions that help define what it means to be human in the remote past and present. In the aesthetic encounters and experiences, we may bring ourselves willfully; however, the act of involvement totally relies upon the distributed apparati of culture, social context, a curated viewing context, personal memory, group memory and experiences including perceptions and emotions. To see something meaningfully, to do what one might call viewing rock art is also to express one to the underlying emotional allegories. It is an act that exists on a continuum in the brain with the same faculties required for the imagining and making of things per se. To engage with the hunter gatherer rock art is to bring equal parts active expectation and passive sensory collection within the whole spectrum of the ancient belief systems. One affects the outcome of an entanglement and engagement with rock art simply by the act of bringing one's own body to the task, an apparatus full of the personal interior emotions and intimately linked to the political tangible exterior. Cognitive Neuroscience is increasingly influencing the various domains of human subjectivity. The sacred and profane imaginative apparatus and emotions of the ancient artists, the complex brainwaves of modern humans while producing and consuming art and the discussions of aesthetic engagements of what happens in the brain when we view or create any form of art, actually becomes a proxy conversation for the real change in the near future. A thorough understanding of how brains simulate minds also leads to practical insights into the prehistoric and present human conditions, and how our minds manage to negotiate with a world that is full of surprises and unexpected events both synchronically and diachronically.



A. A group of dancers holding each other's shoulders from Mirzapur Rock-shelter in Central India, UP: Invoking joy and glee.

B. A group of dancers with raised hands from Mirzapur Rock-shelter in Central India, UP: Invoking joy and happiness.

C. A group of dancers with raised hands from Mirzapur Rock-shelter in Central India, UP: Invoking joy and happiness.

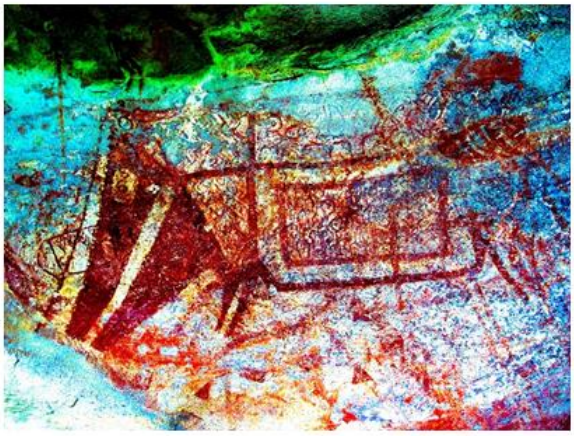


D. A deer hunt from Mirzapur Rock-shelter in Central India, UP: Invoking anxiety and thrill at the same time.

Figure 2 A-D: Discovery, Photo and Image Processing: Ruman Banerjee.

Figure 3. A deer hunt from Mirzapur Rock-shelter in Central India, UP: Invoking anxiety and thrill at the same time. Discovery, Photo and Image Processing: Ruman Banerjee.

A. A chariot scene from Mirzapur Rock-shelter in Central India, UP: Invoking the emotion of speed and aristocracy.



B. A supernatural scene from the UNESCO World Heritage Site Bhimbetka Rock-shelter in Central India, MP: Invoking the emotion of awe, grandeur and totemic allegory.

Figure 4 A-B: Photo and Image Processing: Ruman Banerjee

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