Peer Review

Review of: "Assimilating Neuroimaging with the Archaeology of Early Mark-Making: A Critical Assessment"

Manoel de Campos Almeida[1]

1. Independent researcher

Review

Assimilating Neuroimaging with the Archaeology of Early Mark-Making:

A Critical Assessment

The aim of this review is to propose a constructive critique of the very interesting article written by Derek Hodgson entitled "Assimilating Neuroimaging with the Archaeology of Early Mark-Making: A Critical Assessment". Hodgson pursues an important line of research on the origins of the oldest hominid graphics, using neuroscience, notably neuroimaging technologies, among other means.

Currently, in academia, there is debate as to whether the oldest hominid scribbles, incisions, and engravings originated from a proto-aesthetic or were proto-symbols, which has given rise to two competing schools of thought.

The Neurovisual Resonance Theory (NRT), advocated by Hodgson (2006, 2014), postulates that the oldest marks engraved by hominids reflected preferences of the ancient visual cortex and obeyed aesthetic rather than symbolic purposes; therefore, they would originate from a proto-aesthetic.

Studies by Mellet et al. (2019) consider that the human brain perceives these engravings as graphic entities that have regularities with which semantic information can be connected, which supports the hypothesis that these engravings may have been used by ancient human cultures to store and transmit coded information. In other words, they would constitute proto-symbols, within a Symbolic Model (SM). Hodgson assumes that the production of these ancient engravings by hominids depends on how their visual brain extracts primitive geometric perceptual information from the environment, arguing that the oldest areas of the virtual cortex would be the crucial regions of the human brain responsible for sensitivity to repetitive patterns. According to this hypothesis, natural scenarios such as the vertical trunk of a tree sitting on a plain would suggest a character of perpendicularity, a flat horizon, such as a desert or lake, a horizontal line, branches sprouting from trunks, bifurcations, rounded stones, curves, crystals, and so on, giving rise to primitive perceptual patterns. These visual signals were gradually selected to match the types of contours found in natural scenes, influencing the evolution of visual processing.

In this article, Hodgson analyzes the advantages, disadvantages, and limitations of the different neuroimaging techniques currently used to study the upper visual region and other brain areas known to be involved in recognizing these patterns. He states that the corpus of neuroscientific studies using functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and magnetoencephalography (MEG) shows that the oldest areas of the visual cortex play a critical role in processing basic line configurations. He emphasizes a limitation of fMRI, as it does not take into account the grouping processes, as well as the dynamic processes involved, which would lead neuroscientists to recommend that this technology be complemented with studies involving EEC and MEG. However, there is a *caveat* here. All current neuroscientific studies focus on the brain of *Homo sapiens sapiens,* modern man, as expected, but they have no way of measuring the evolution of his brain, as well as his visual system. The brain of the *Homo* genus has undergone gradual evolution over millions of years, so we must proceed with caution when extrapolating data from its modern configuration to its ancestral configuration. Obviously, it is very difficult to proceed otherwise.

As for considerations about the *Homo* visual system, we remember that its companions in the animal kingdom also have their visual, cerebral systems, which are profoundly different from its own, but adequate for the survival of their species. The comparative study of pattern processing in their visual systems with that of hominoids needs to be further studied.

Our visual system briefly retains traces of stimuli before they disappear. This phenomenon is called iconic memory, and its contents are considered to be temporally integrated with subsequent visual inputs to produce a single composite representation, that is, a percept.

A percept is a perceived form of stimuli external to the body or its absence. There is an important distinction between stimulus and percept: stimuli are not necessarily translated into a percept, and rarely does a single stimulus translate into a percept. Because of this, multiple stimuli are sometimes required for percepts to be produced.

Our visual system briefly retains traces of stimuli before they disappear. This phenomenon is called iconic memory, and its contents are thought to be temporally integrated with subsequent visual inputs to produce a single composite representation, i.e., a percept.

Visual stimuli are maintained by iconic memory, and when integrated with subsequent visual inputs, they would produce a single composite representation, that is, a percept, a mental fact. So far, we have what can be considered a proto-aesthetic, operating only at a sensory-mental level.

A perceptual revolution occurs when there is a significant change in the ratio or proportion of the participation of the senses in perception. A perceptual revolution can be associated with a technological (or scientific) revolution throughout the history of humanity. Each technological revolution provides an extension of our senses and faculties, which give rise to new collective conscious behaviors (Almeida, 2011).

We can identify the oldest perceptual revolutions in our species with, first, the decline of its olfactory sense in favor of its trichromatic vision; second, with evolutionary pressures that provided fine-tuning in our hearing, perhaps in favor of a better understanding of speech, but possibly with a decrease in our auditory range compared to that of other animal species.

The first extension of the sense of touch can be identified with the appearance of the first tools, the first weapons, a technological revolution that complemented and expanded the functions of the human hand, limited to grasping, pinching, and holding.

Hodgson observes that “NRT suggests the necessity of an intermediary phase [before MS] underpinned by a proto-aesthetic tendency conditioned by the satisfaction derived from producing finely-honed geometric tools.”

At this point, it is worth remembering the Oldowan technology of Polyhedra, sub-spheroids, spheroids, and balls (PSEB), which are enigmatic stone balls from the Paleolithic, whose functions, whether utilitarian, social, or ideological/symbolic, are currently the subject of intense debate, although their tradition extends over 2 Ma. Their artifacts were basically intended for “hitting, breaking.”

Spheroids and balls are carefully produced artifacts, with a careful spherical symmetry, apparently without utilitarian use, perhaps induced only by a proto-aesthetic, as suggested by the NRT.

There is debate as to whether they could represent a social status or whether they could have some symbolic content. I introduce here the hypothesis that this Oldowan technology could represent the evolutionary link, the step that would connect a proto-aesthetic with proto-symbols. Acheulean

doi.org/10.32388/H9ABXD

technology, on the other hand, with its more refined vertical symmetry, requires greater dexterity in the making of its tools, being more suitable for “scraping, cutting.”

The next notable technological revolution was man’s mastery of fire. It led to a reduction in the masticatory muscles. Therefore, a new perceptual revolution occurred, with an appreciation of the sense of taste.

At a certain point in our evolutionary history, another perceptual revolution occurred, associated with an impactful technological revolution: the introduction of graphics.

This revolution accentuated the participation of the sense of sight; in addition, it can also be suspected that the introduction of graphics also contributed to evolutionary mechanisms that favored the visual sense as a priority.

An important point is the notable difference between the simple perception of geometric patterns and their deliberate production. Since the similarity of the oldest hominid graphics with children's drawings raises serious questions, I will briefly discuss this topic, summarizing concepts from developmental psychology.

One of the main scholars on this subject was Viktor Lowenfeld; his book Creative and Mental Growth (1947) is still an essential reference on the subject today. He classified the stages of development of children's drawings as follows: 1. Scribbles or doodles (2-4 years): creation of uncontrolled marks due to lack of motor control; 2. Pre-schematic (4-7 years): conscious creation of images; 3. Schematic (7-9 years): identified schema, awareness of the concept of space. It should be noted that the first drawings made by hominids rarely go beyond Lowenfeld's stage 1, that is, they are similar to children's scribbles or doodles. Piaget believed that children's knowledge evolved over a series of four stages, different qualitatively and quantitatively:

1. Sensorimotor stage (0-2 years approx.)

2. Pre-operational stage (2-7 years)

3. Stage of concrete operations (7-11 years)

4. Stage of formal operations (from 11 years)

As soon as the child develops the pincer movement, which allows them to hold a pencil, which occurs between their first and fourth year, they begin to scribble. Scribbles may be lines created more for the pleasure of scribbling than for the attempt to draw something.

doi.org/10.32388/H9ABXD

Scribbles are grouped into three types related to child development. These types will manifest themselves as the child has time and space to scribble and express themselves freely.

• Disorderly scribbles, which come from the pleasure of movement, without being restricted to the limits of the sheet of paper.

• Orderly scribbles, with greater fine motor control, with the presence of circular movements and representations of the world around them.

• Named or identified scribbles, when the child begins to set intention and often name what they are drawing.

The oldest hominid scribbles can be considered as disorderly scribbles, within the sensorimotor stage and perhaps the beginning of Piaget's preoperational stage.

Now, a question arises. Let's suppose that there is a people devoid of any form of art, therefore, of graphics. What would be the likely trigger that would induce them to produce them? First of all, it is worth noting that such a people exist, the Pirahãs. The Pirahã language is the last surviving language of the Muran language family and is spoken by approximately 450 people who live along the Maici River, in the state of Amazonas, Brazil.

The Pirahãs, as well as their language, have notable characteristics that make them practically unique, as follows: they do not have terms for colors; they do not draw or practice any other art, and they have one of the simplest documented material cultures; they do not have recursion; they do not have numbers or any type of concept of counting or any terms for quantification; they have the simplest kinship system ever documented; fiction or creation myths are absent; there is no collective or individual memory of more than two past generations; they have the simplest inventory of known pronouns; they are monolingual despite more than 200 years of contact with the Tupi-Guarani speakers of Kawahiv (Everett, 2005). In response to the question posed, the trigger for the introduction of graphics in these cultures would probably be the creation of one that would embody a minimum of symbolic content, that is, semantic content, important to such people. Which would be the first, this is impossible to answer, from the perspective of millions of years of evolution, as it would depend on the circumstances, social relations, survival needs, and many others.

We can only propose hypotheses. I will focus on the simplest human gesture, the raising of a single finger. When a hominoid associated this simple gesture with a unit, be it an enemy, prey, fruit, or anything else, he was adding semantic content to a gesture. For the first time, he associated a quantity, a unit, to this gesture, thus creating the first symbolic gesture, perhaps the first symbol.

Hodgson summarizes the conclusions of his article by recommending that:

"... research into understanding the first engravings would be in a much better place by bringing those various strands together, a synthesis is possible that can potentially unify NRT, the symbolic model, and material engagement theory in that the earliest marks, as proto-aesthetic precursors, provided the conditions that could be eventually exploited for 'symbolic' purposes".

At this point, I have proposed a Synthetic Theory of the Origins of Graphics (STOG), intended to unify views on the origins of the earliest graphics, whether they originate from a proto-aesthetic or whether they are proto-symbols. I will illustrate this theory by showing how the example of the raised finger gesture, or of primitive geometric concepts, can be explained by this theory.

To recap, the visual system briefly retains traces of stimuli before they disappear, causing the phenomenon known as iconic memory, and its contents are considered to be temporally integrated with subsequent visual inputs to produce a single composite representation, that is, a percept. A percept, a mental fact, is therefore a perceived form of stimuli external to the body or its absence. A sign, on the other hand, is a materialized percept, therefore an artifact.

To illustrate this theory, I will continue with the numerical example of the raised finger. Initially, the visual system captures visual (sensory) stimuli that are aggregated into percepts (mental facts). Up to this stage, we are within the scope of a proto-aesthetic, as advocated by NRT (Fig. 1).

At this point in evolution, a technological revolution occurred with the introduction of graphics, that is, signs, materialized percepts, consequently artifacts. Associated with this technological revolution, a perceptual revolution occurred that accentuated the participation of the sense of sight. It can also be suspected that the introduction of graphics contributed to evolutionary mechanisms that favored the visual sense as a priority.

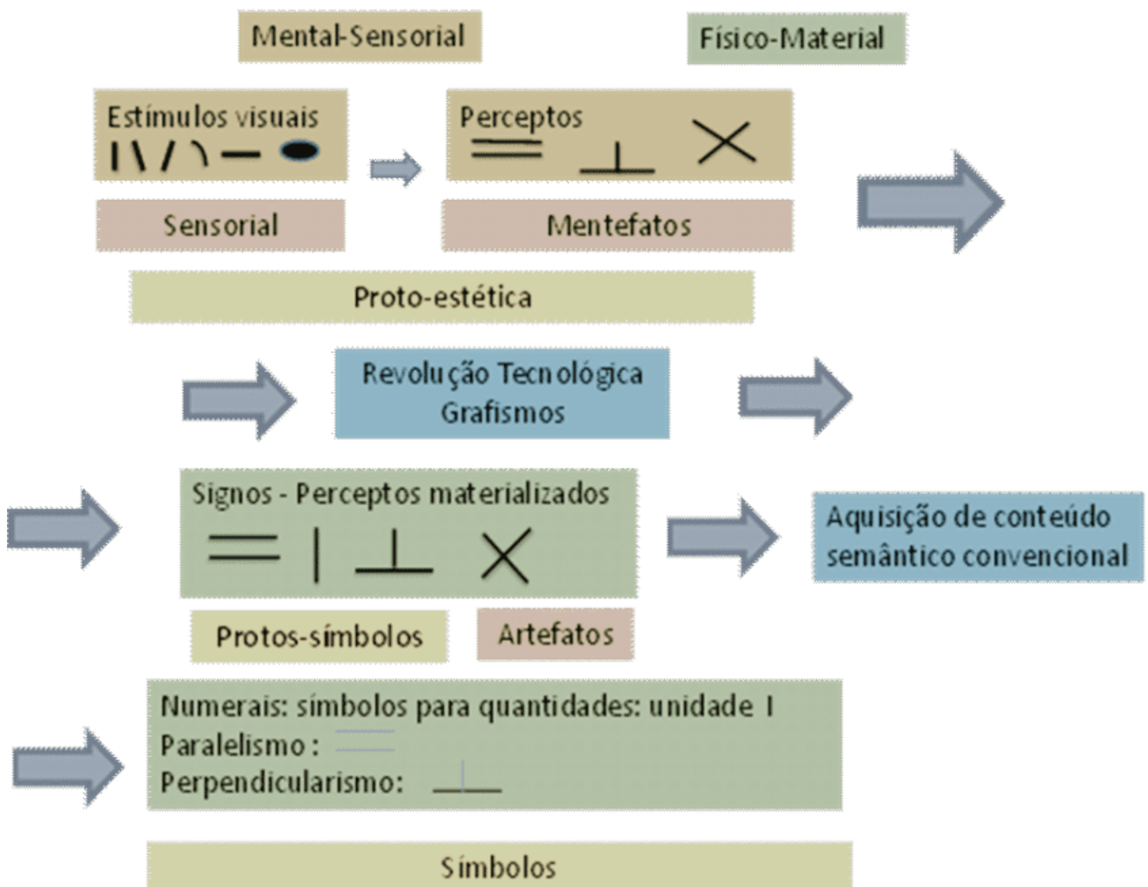
These primitive graphics had not yet acquired complete symbolic content; they were nothing more than proto-symbols, mere scribbles or doodles, that is, signs, materialized percepts. However, the barrier of solely verbal communication had been broken, and the volatility of oral and gestural symbols had been overcome.

At this point, perhaps the role of the spheroids and balls of Oldowan culture can characterize the bridge stage between a proto-aesthetic and the introduction of proto-symbols. This is a question that deserves

doi.org/10.32388/H9ABXD

to be explored in depth.

Only when (proto)cultures began to emerge, for reasons linked to the survival of their species, which felt the need for property marks, paintings, tattoos, which distinguished families or clans, personal adornments, records of time, seasons, primitive counts, etc., which embedded a symbolic value, did the signs acquire complete semantic value, that is, they became symbols in their broad sense. The meaning of the symbols could then be fully understood and shared among the members of these (proto)cultures.



Therefore, I consider that some of the contributions included here, which should be included in an article to appear in the Brazilian Journal of History of Mathematics, and which are presented in this review, may be useful. Furthermore, Derek Hodgson's remarkable article deserves to be published.

Some useful references:

Dos Rabiscos às Figuras Geométricas: proto-estética ou protos-símbolos? Visões da Neurociência. In: anais do XV Seminário Nacional de História da Matemática. Maceió, 2023.

Grafismos Hominídes.Proto-estética ou Protos-símbolos. O Homo naledi Geometrizava? In: Revista Brasileira de História da Matemática. Vol. 24(no 48):155-175. Setembro 2024. DOI: 10.47976/RBHM2024v24n48130-150

*Recursão-Neurociência e História da Matemática.*In: Revista Brasileira de História da Matemática 23(47):42-54. DOI: 10.47976/RBHM2023v23n4742-54. Outubro 2023.

ALMEIDA, Manoel de Campos. JUSTINO, Edson José Rodrigues. Como o Cérebro

Processa a Matemática ? - Ensinamentos da Neurociência para uma Pedagogia Renovada. Ed.: Manoel de C. Almeida, 2020.

ALMEIDA, Manoel de Campos. *PRÉ-HISTÓRIA DA SIMETRIA - Poliedros, Subesferoides, Esferoides e Bolas. October* 2024. Revista Brasileira de História da Matemática. DOI: 10.47976/RBHM2024v24n4966-80

Declarations

Potential competing interests: No potential competing interests to declare.