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NUMERICAL ABSTRACTION IN PREHISTORY. A VIEW FROM COGNITIVE ARCHEOLOGY

ABSTRACCIÓN NUMÉRICA EN LA PREHISTORIA. UNA VISIÓN DESDE LA ARQUEOLOGÍA COGNITIVA

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Abstract
This paper attempts to analyse the origin of numerical abstraction. In his study, a Psychobiological and Social Model (Functional Structuralism) has been used on our cognitive evolution, and causal cognition processes as the main drivers of cognitive and behavioural development. The process takes place over a long historical period, because although it seems that there are antecedents at the end of the Middle Palaeolithic, its main development begins with the beginning of the Upper Palaeolithic, where archaeologically an advanced development of causal cognition related to measurement behaviours is observed. Its subsequent evolution to counting and numbering behaviours would depend on the social, technological and emotional development of Neolithic and Bronze Age societies.

Keywords
Measure; Count; Numerical abstraction; Psychobiological and Social Model; Causal cognition.

Resumen
En este trabajo se intenta analizar el origen de la abstracción numérica. En su estudio se ha utilizado un Modelo Psicobiológico y Social (*Estructuralismo funcional*) sobre nuestra evolución cognitiva y los procesos de *cognición causal* como motores principales del desarrollo cognitivo y conductual. El proceso se realiza en un amplio periodo histórico, pues aunque parece que existen antecedentes a finales del Paleolítico medio, su principal desarrollo comienza con el inicio del Paleolítico superior, donde arqueológicamente se constata un avanzado desarrollo del *cognición causal* relacionado con conductas de medición. Su posterior evolución a conductas de contaje y numeración dependería del desarrollo social, tecnológico y emocional de las sociedades del Neolítico y la Edad del Bronce.

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Palabras clave
Medir; Contar; Abstracción numérica; Modelo Psicobiológico y Social; Cognición causal.

Numeracy, understood as the ability to understand, represent and use numbers (Coolidge and Overmann 2012), is a cognitive process broadly related to human behaviour. We know from the Palaeolithic period the need to have a certain control in several fundamental behaviours; either because of the number of objects to be controlled, their relation with the time of access or consumption, or because of their acquisition in certain spaces. However, the cognitive development of numerical control did not exist in all prehistoric periods. The evolution of these processes in the creation of numerical abstraction will constitute the main task of this work.

1. METHODOLOGICAL APPROACH

Numerical cognition must be understood within the general framework of the cognitive development of the genus *Homo*, so it is necessary to use a methodology reflecting how cognition was created and developed in our evolutionary ancestry. In the creation of such an abstraction it is necessary to know, even briefly, those cognitive processes that interfered in its creation:

* Development is necessary of a broad interdisciplinary work (Evolutionary Biology, Neurology, Psychology, Psycholinguistics, Archaeology and Social Anthropology), which leads us to the creation of the Psychobiological and Social Model or Functional Structuralism (Rivera and Menéndez 2011; Rivera and Rivera 2019) (Table 1). Such a model can be placed within a general interpretive theory, Structuralism, which in the middle of the 20th century focused on the existence of generic structures or models of invisible, unconscious and universal behaviours that condition human behaviour (Lévi-Strauss 1977). At present, following the concept of the common or structural factors of our biology, a psychobiological base has been elaborated on which our thinking and behaviour develops (Damasio 2010), within human social media or cognitive-cultural niches (Tomasello 1999; Bickerton 2009; Rivera and Menéndez 2011; Rivera and Rivera 2019).

<table>
<tr><th colspan="3">Psychobiological and Social Model. Functional Structuralism Rivera and Rivera 2019</th></tr>
<tr><td rowspan="7">Interdisciplinary concept of cognitive and cultural evolution</td><td colspan="2">Causal cognition as a method of Cognitive structuring (social, emotional and technological). Development in 7 grades
Haidle 2014; Stuart-Fox 2015; Lombard and Gärdenfors 2017</td></tr>
<tr><td colspan="2">Neurological evolution is performed mainly by the regulatory genes or Hox genes (Heterochronies) Florio et al. 2015; Suzuki et al. 2018
Alometric and quantitative growth. Greater neurological potential.</td></tr>
<tr><td colspan="2">Basic rational and emotional cognitive abilities (biological evolution). Causal cognition. Grades 1-3/4
Ardila and Ostrosky-Solís 2008; Rivera 2015</td></tr>
<tr><td rowspan="2">Conditions
Environmental requirements
Rivera and Menéndez 2011
Laland 2017
Lotem et al. 2017
Colagè and d'Errico 2018
Muthukrishna et al. 2018</td><td>Social, economic, demographic and technological.
Cognitive-cultural niche
Bickerton 2009; Tomasello 1999</td></tr>
<tr><td>Existence of a language. First symbolic behaviour and means for all cognitive development.
Vygotsky 1934/1978; Luria and Yudovich 1972; Bruner 1984; Belinchón et al. 1992</td></tr>
<tr><td colspan="2">Cognitive development. Emerging cognitive abilities (cultural evolution)
Causal cognition 3 / 4-7. Ardila and Ostrosky-Solís 2008;
Searle 1997; Tomasello 1999; Edelman and Tononi 2000</td></tr>
<tr><td colspan="2">Self-awareness is fundamental for proper symbolic and modern behaviour
Rivera and Rivera 2017</td></tr>
<tr><td rowspan="3">Characteristics of cognitive evolution</td><td colspan="2">The concepts and abstractions that will shape behaviour must be acquired from the observation of the environment and the cultural heritage</td></tr>
<tr><td colspan="2">Evolution as a heterogeneous continuum in time and space. Cognitive-cultural mosaic</td></tr>
<tr><td colspan="2">Multiple intermediate stages of cognitive evolution
Cumulative. Cultural heritage. Demographic stability is needed</td></tr>
<tr><td rowspan="4">General mechanisms of cognitive evolution</td><td colspan="2">Exaptation: functionalities for which we did not evolve</td></tr>
<tr><td colspan="2">Coevolution: reciprocal cognitive modification</td></tr>
<tr><td colspan="2">Emergency: new capacity acquired by the functional sum of the elements of the system (co-evolution)</td></tr>
<tr><td colspan="2">The cognitive-cultural niche constitutes a specifically human Natural Selection. Baldwin effect (Bateson 2004) or mechanisms of genetic assimilation (Waddington 1941)</td></tr>
</table>

TABLE 1. PSYCHOBIOLOGICAL AND SOCIAL MODEL OF HUMAN BEHAVIOUR

1.1. CAUSAL COGNITION MECHANISMS

We will see the current concepts of causal cognition, considered to be the main driving force in human evolution. (Stuart-Fox 2015; Lombard and Gärdenfors 2017; Bender and Beller 2019; Rivera and Rivera 2019; Bender 2020).

Causal cognition is defined as the relationship between two events, one of which is the consequence (effect) of the other (cause) (Bender 2020). The cognitive characteristics of the cognitive processes that are related can be of different modalities (Stuart-Fox 2015), so the definition would remain as the capacity to establish and/or recognize that the action of one or more cognitive processes of the same or different modality (sensory or stored) would be the cause of the production of another behaviour or effect, whether material, emotional or symbolic.

Its realization occurs through the establishment of a cause andeffect relationship between the natural signs of the environment whether observable (e. g. edge of stones with cuts in the base) or unobservable (e. g. wind with falling fruits) and all that we retain in memory (rational and/or emotional mental constructions). In advanced degrees, fully symbolic and/or abstract concepts would be handled, making it possible that with behaviours deduced from nature or from human activity (cause), others of an abstract nature could be created, not present in nature, but in our symbolic world (effect). Only humans evolved the mental capacity to represent an unobservable entity in response to a perceptual representation, and to create a relationship between them (Penn and Povinelli 2007; Stuart-Fox 2015).

The evolution of these cognitive abilities depends on each other for their realization at increasingly higher levels. The structuring of the neural networks that support these capacities has a kind of hierarchical modularity, where small networks are functionally situated within larger networks, and these within even larger networks (Sporns 2011). The overlap of these would explain why in the development of cognitive abilities, common neurological networks or cognitive functions are shared (cognitive or functional co-evolution) (Rivera and Rivera 2019).

We can analyse causalcognition in two ways; one in the sense of cause to effect with a predictive character, and the other from effect to cause with diagnostic aspects (Reips and Waldmann 2008). In Archaeology, where we know the effects or archaeological data, we would mainly use the second one, that is, we would look for the causes that have produced those archaeological data or effect.

Seven degrees of ascending complexity have been established in their production in time and space (Lombard and Gärdenfors 2017). This classification has been expanded by introducing the parameters of *working memory, theory of mind* and *self-consciousness* (Rivera and Rivera 2019).

- Grade 1: *Individual causal understanding*. Simple relation between a *cause* (push) and its immediate resultant *effect* (fall), which are directly perceived. It is done individually and can be explained through conditioning learning.

- Grade 2: *Cued dyadic-causal understanding*. Two different agents in alternative shifts perform a similar action. Both know that the action of the other causes an effect similar to theirs, where mirror neurons are presumably involved in such an inference (two children on a seesaw). For the understanding of the following degrees of causal compression this degree is a requirement, being able to be an antecedent of the theory of mind, when developing in a social environment.

* Grade 3: *Conspecific mindreading*. The causal intention of the actions of others is interpreted as similar to mine, with the same effects (the direction of another's gaze can indicate his intentions, because we presume that he acts as we would). One appreciates the beginning of the basic, social and specific skills of the *theory of mind*.

* Grade 4: *Detached dyadic-causal understanding*. This degree depends on the ability to have two or more mental representations at the same time, but of different aetiology. A direct sensorial observation and a memory of similar experiences, in order to understand their cause-effect relationship. A conscious causal cognition is established from the observed effect (clothing in a chair) to the unobserved cause (its owner, whom we can recognize, left it there). An expansion of the *working memory* is observed to maintain more than two unequal mental representations at the same time. The *theory of the mind* is reaffirmed by thinking that the other acts as we would.

* Grade 5: *Causal understanding and mindreading of non-conspecifics*. Same as above but with different species. Understanding of the cause-effect of the actions of other species, carried out indirectly (traces of their displacement) and with previous experiences. It also requires some development of the *working memory*.

* Grade 6: *Inanimate causal understanding*. Attribute causes to inanimate objects (seeing an apple fall when there is wind). The cause is not directly perceived, but inferred. It requires the use of *working memory* and some development of *behavioural flexibility* (linked to language and self-awareness).

* Grade 7: *Causal network understanding*. It would be the understanding of how a set of causal nodes specific to one domain connects or links to the causal networks of other different domains. It allows for the modern human trait of cognitive flexibility and unlimited behaviour, expressed in complex technological, symbolic, and scientific innovations. A full development of *working memory, theory of mind, language* and *self-consciousness* is required. It allows the creation of significant causal hypotheses that facilitate learning andcognition about new causal systems in a very effective way (Tenenbaum and Niyogi 2003).

The discussed antecedents of the first forms of causal cognition among non-human primates are limited to grades 1 and 2, to a lesser extent to grade 3 and very limited to grade 4, but with a minimal and controversial development of the theory of mind within a specifically social context (Sánchez-Cubillo *et al.* 2012; Seyfarth and Cheney 2013).

The differences between grades 3 and 4 (conspecific) and grade 5 (non-specific) are gradual, depending largely on experience with other people (grades 3 and 4) and the behaviour of other species (grade 5). Grades 4 and above facilitate the relationship between known facts (sensory experience and memory), being able to predict the interventions of other species (grades 3 and 4) and the behaviour of other species (grade 5).Grades 4 and above facilitate the relationship between known facts (sensory experience and memory), being able to predict causal interventions and transfer them to other contexts (Haidle 2014; Stuart-Fox 2015; Lombard and Gärdenfors 2017). In this last group appears an expansion of the *working memory*, being key in the behavioural development of our gender (Stuart-Fox 2015). Similarly, the theory of mind developed some evolution of episodic memory and spatial and temporal planning. (Lombard and Gärdenfors 2017), favoring the progressive development of language and self-awareness (Rivera and Rivera 2017).

1.2. ARGUMENTS INTERTWINED, LINKED OR BRIDGED

The successive complexity of the formation of these networks and their consequent behavioural development is achieved by creating a series of arguments intertwined, linked or bridged one after the other (Wynn 2009; Botha 2010; Wadley 2013; Haidle 2014; Gärdenfors and Lombard 2018), which can be traced in the archaeological data (d'Errico *et al.* 2017; Gärdenfors and Lombard 2018; Overmann 2018a).

1.3. MATERIAL ENGAGEMENT THEORY (MET)

The importance that perceptions (material or conceptual) have on the functional structuring of the brain (Malafouris 2013).

In conclusion, the diversity of the information received and stored can be grouped into highly interconnected functional structures, so that for the development of each of them the existence of the others is necessary (cognitive co-evolution). These are: social, emotional and technological cognition (Rivera and Rivera 2019) (Table 2). It is within this cognitive and causal framework that numbers would develop, although with an irregular ontogenetic development in their geographical and temporal production.

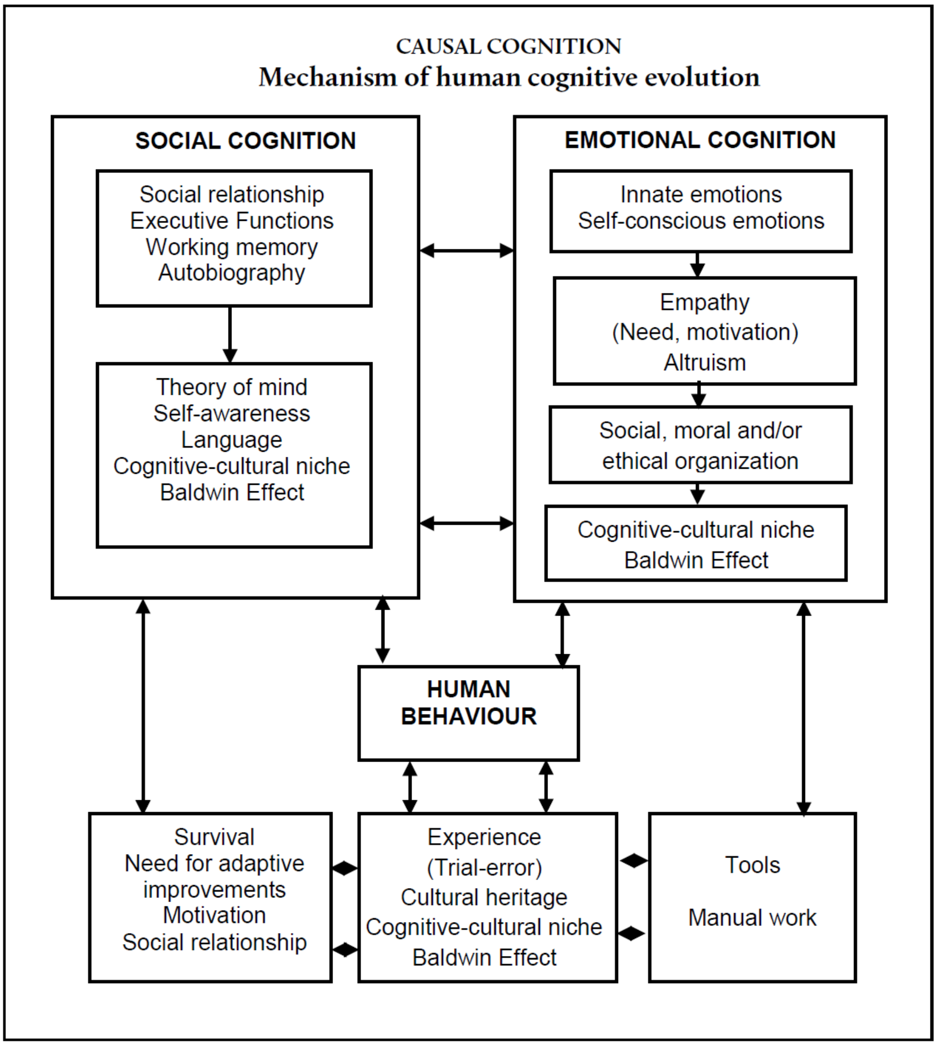


TABLE 2. IT REFLECTS THE DIFFERENT FORMS OF COGNITION (SOCIAL, EMOTIONAL AND TECHNOLOGICAL), THE RELATIONSHIP BETWEEN THEM AND THEIR DEPENDENCE ON CAUSAL COGNITION AS THE ENGINE OF THEIR CREATION

2. PSYCHOBIOLOGY OF NUMEROSITY

In order to understand the development of numerical abstraction, we must also understand the several psychobiological processes which underpin it.

2.1. INNATE SENSORY APPRECIATION OF SEVERAL SIMILAR COMPONENTS

There exists an innate perceptual or concrete numeration that allows the sensory appreciation of several similar components (several, few, and many) (Carey 2009). Its existence is independent of language (Brannon 2005; Varley *et al.* 2005; Overmann 2016, 2018a), and presents two functional aspects. First, the approximate number system (ANS) facilitates an estimation of the magnitude of a group without depending on language or symbols. This would act in groups greater than four, allowing us to perceive value differences in magnitude between the groups (many or few). Second, the object tracking and quantification system (*subitization*) that works with values less than four (Dehaene 1997; Tomasello and Call 1997; Butterworth 1999; Cantlon *et al.* 2006; Nieder and Dehaene 2009; Coolidge and Overmann 2012). Its existence has been proven in rats, lions and several primate species (Dehaene 1997; Nieder and Dehaene 2009), which would indicate evidence of a neuronal substrate that has been evolutionarily maintained.

However, the universality of this innate character does not imply a systematic evolution to systems of numerical quantification, since nowadays human populations are known with a numerical cognition that barely exceeds the limits of this innatism. All known human societies have a language, but not all of them have numbers (Flegg 1983; Everett 2005). This fact can reasonably be attributed to differences in the social needs for numbers (Epps *et al.* 2012; Overmann 2018a), i.e. the lack of adequate social, technological and emotional cognitive development to motivate their evolution.

2.2. NUMERATION AND LANGUAGE

The development of language would facilitate the creation of a new representational system that would allow our ancestors to reinterpret the observable world by referring to unobservable physical and mental causes (Stuart-Fox 2015). During neurological maturation, within a suitable environment (cognitive-behavioural niche), there is an interaction of language with thought, in this way, it is verbalized and acquires the functional characteristics of language. It is as if we were talking to ourselves, using an internal language (Vygotsky 1934/1978; Luria and Yudovich 1972; Bruner 1984; Belinchón *et al.* 1992). With it, one can quickly and easily learn known abstractions (individuality, social condition, time, space, negation, religion, art, numeration, etc.). Language, largely a consequence of cultural heritage, is the fruit of thought, but it is also a modulator of thought (intellectualized language), and both are controllers of human action and behaviour (Bruner 1984). Therefore, it is necessary to understand language as the necessary means and coordinator of human cognitive development in all its aspects (Vygotsky 1934/1978; Belinchón *et al.* 1992; Mercier 2000), being the appropriate way to access numerical cognition, by complementing, explaining and expressing the ideas obtained through manual interactions with materiality and social development (Clark 2006; Roepstorff 2008; Overmann 2018a).

Language and numeration share the characteristics of sequencing, analogy and metaphorization or symbolization (Coolidge and Overmann 2012), which would indicate an important relationship between them (cognitive co-evolution) of ontogenetic and cultural characteristics (Booth and Siegler 2006). The ability to calculate in normal circumstances requires not only the understanding of numerical concepts, but also the conceptual and cognitive skills that make it possible. Therefore, numeration should be understood as the representation of a multifactorial skill that includes verbal and spatial skills, memory and executive functions (Ardila and Rosselli 2002). Its origin is to be found in the cognitive co-evolution that occurs in human ontogenesis in general (Hurford 1987; Wiese 2007; Macizo *et al.* 2016; Rivera and Rivera 2019).

A different neuronal organization is known between language and numerical cognition (Carreiras *et al.* 2015; Overman, 2018a). Thus, language preferentially involves the areas of Broca and Wernicke in the frontal and temporal lobes by means of the *Arched Fascicle* (Rilling *et al.* 2008). While numeration is more associated with parietal activity (Orban *et al.* 2006; Coolidge and Overmann 2012; Amalric and Dehaene 2016), by relating it to the ability to recognize previously learned information about objects, people or places through the fingers (tactile gnosis) (Penner-Wilger *et al.* 2007; Reevee and Humberstone 2011), as well as motor and visual movement planning (Frank and Barner 2012; Brooks *et al.* 2014). These data would relate the development of the parietal lobe with the increase of the capacity of numerical abstraction (Bruner *et al.* 2017, 2018).

However, depending on the characteristics of environmental influence (teaching methods), neuronal reorganizations specific to numeration may have different neuronal locations (Dehaene *et al.* 2008; Zamarian *et al.* 2009). Thus, we find a greater contribution of language areas in Westerners, resulting from memory learning of arithmetic facts, and a greater participation of the premotor area in Chinese speakers, presumably as a result of instruction through the calculation of the abacus (Tang *et al.* 2006). Its definitive neurological structure seems to depend more on the perceptual characteristics of our senses and learning techniques than on the existence of a basic structure or instinct evolved for this purpose (Malafouris 2013; Macizo *et al.* 2016; Rivera and Rivera 2019).

2.3. MEASUREMENT ACTIONS

There are two cognitive processes closely related to numeration, but which correspond to different behaviours: measuring and counting. To measure, a cultural and cognitive background to counting, would be to establish a causal relationship between an action performed (hunting, gathering, manufacturing, etc.), space travelled (time required), or any object (cause), with a record or material basis (effect) that can be sensibly perceived (acoustic, visual and tactile) each time the action of measuring is performed. The creation of these marks refers to the concrete facts carried out, but expressing them independently of the other characteristics that may exist.

Some of these processes, in order to be measured, require a previous comparison with units or patterns of measurement of suitable characteristics such as: day, certain volume of grain, hunting unit, etc. This process constitutes another causal relationship (cause/effect), resulting in the concrete creation of the pattern or unit of measurement, which in turn may be noted or recorded with a mark in an appropriate materiality. These measurements and/or signals are limited to showing their order and sequencing of the series of elements measured and their relationship with each other, since each mark reflects an act that is equal to the others, as occurs in the Palaeolithic. The degree of causal cognition required for their development could be between 6 and 7 (Lombard and Gärdenfors 2017), which would justify their possible existence from the mid-advanced Palaeolithic and African MSA (d'Errico *et al.* 2017).

2.4. NUMERICAL ABSTRACTION. COUNTING ACTIONS, THINGS, ANIMALS, ETC.

Abstraction is a cognitive process of concept formation through the identification of common properties of sets of objects or living beings, which is achieved by fixing attention and/or thinking about such concepts while ignoring some of its other properties (e. g. Ferrari 2003). This definition applied to the origin of numbers takes us to the periods of prehistory where their origin, use and development have been archaeologically proven. The obligatory approach to this broad historical period presents important problems, since it is done through the cognitive development of the present day, which makes us "see" numbers too easily, when there is no archaeological or cognitive evidence of their creation and social use. The problem increases when we also cannot know the degree of cognitive development presented by these populations, since the potential capacity (psychobiological basis) of human beings in these periods was equal to the current one, but their cognitive development was not the same (e. g. Colage and d'Errico 2018; Bender and Beller 2019; Rivera and Rivera 2019).

Numbers, obviously do not have in nature a material base that can induce their creation, which leads us to think that we must create the material forms that achieve it (Overmann 2018a). These material forms make the perceptive experience of quantity tangible (Malafouris 2010), comprehensible (Frege 1953) and stable, in such a way that their properties would act as representatives for the future conceptual relations (Hutchins 2005).

Numbers begin as an adequate perceptive experience of quantity instantiated by material forms (Overmann 2018a). This experience is acquired with the recognition of sets of objects that share the same amount of measurement marks in an appropriate signalling register (Russell 1920; Overmann 2018a). In short, it is not the mind that makes the tool, but it is the tool that makes the mind, or rather, both collaborate in their mutual development (Malafouris 2013). Thus, the processes of analogy (signs of general and particular common characteristics) would be fundamental in the process of creating numerical abstraction. In this context, one speaks of the capacity to abstract quantity, while suppressing other information (e. g., form, colour, etc.), which seems to be exclusive to humans (Christie and Gentner 2007; Overmann 2018a).

Numerical abstraction is a behavioural and social process, since its development is observed in the continuous use of measurement behaviours, favouring the production of similarities or analogies between the measurements obtained and pointed out with the patterns used (marks); with important dependence on the materiality of the objects, since they are concepts whose content, structure and organization are influenced by the material forms used to represent and manipulate them; and cognitive, where an abstraction would be formed that arises from the reiterative process of measuring, and that leads us to give a cardinal number (symbolization) as representative of a precise and constant set of marks. This symbolization is essential, because what cannot be named (social language), represented (graphic symbolization or materiality) and pointed out (cognitive behaviour) is as if it did not exist. Linguistic signs allow numerical concepts to be communicated, learned and applied in social contexts in ways that are not possible only through visuospatial means (Ferrari 2003).

Therefore, numbers constitute a symbolized abstraction whose cognitive origin is an emergent process (McClelland *et al.* 2010; Zorzi and Testolin 2017; Rivera and Rivera 2019), which is produced through mechanisms of *cultural exaptation* within our particular cognitive-cultural niche (d'Errico *et al.* 2017) and cognitive development of modern characteristics with grade 7 causal cognition, which allows the modern human traits of unlimited cognitive and behavioural flexibility, expressed in current technological and scientific innovations (Lombard and Gärdenfors 2017; Rivera and Rivera 2019).

However, the origin of this cognitive capacity is not well defined, since it is induced that its origin has certain innate character, and that only humans possess it (Christie and Gentner 2007; Overmann 2018a). At present, the concept that human cognitive abilities would be formed (with emerging characteristics) as a result of the functional union of other cognitive abilities (co-evolution) is being validated. The process can be repeated until it reaches those capacities with a clear innate foundation, which we can assume would be the ones presented by the first hominids of our genus (Rivera and Rivera 2019). In this process we can distinguish two parts.

- The development of a specific transformation of materiality, through a series of causal processes (linked or bridged arguments) (Haidle 2014), until a series of groups of analogous or equal measurements are shown, which differ from other groups due to the different amount of measurement marks.
- These analogous groups will develop the abstraction, since they only refer to the quantity and not to other characteristics of such groups (material components of the groups). Such a process has to be symbolized (graphically or orally) in order to be operational.

The progressive transformation of materiality is a good example of causal cognition, where the components of cause and effect would be well defined (Table 3). There are more doubts about the formation of abstraction, since it is not clear that there is a causal relationship between adequate materiality and the formation of numerical abstraction. However, between the formation of analogous marks and the creation of numerical abstraction there is an apparent relationship of causality (cause-effect), since the creation of these equal marks is a necessary and sufficient condition (cause) for certain innate human cognitive capacities e. g. attention, perception and memory) together with cultural influence (adequate materiality) to create processes of co-evolution and emergence of the abstract concept of number (effect). If the materiality did not manifest itself in a constant and repeated way in groups of equal quantities that call our attention and make us perceive such analogy, this abstraction could not be developed.

DEVELOPMENT OF NUMERICAL ABSTRATION			
Bridging arguments	**Archaeological data Material**	**Historic period**	**Causal cognition**
1st bridged link Measure without counting	Successive Marks on bones and stones, ¿beads, perforated shells, fingers, etc.?	End of the middle Palaeolithic African MSA Upper Palaeolithic.	Grade 6/7 Cause: control of complex events Effect: creation of marks Concrete measurement
2nd bridged link Creation of measurement patterns	Each pattern can have its own materiality and characteristics	All historical periods	Grade 6/7. Cause: The need to create appropriate and socially recognisable marks Effect: Creating comparative units or patterns
3rd bridged link Measuring without counting Specification of concrete measurements.	Simple and complex Tokens mainly in baked clay.	Neolithic/ Bronze Age c. 8300-4500 to first millennium BC	Grade 7. Cause: Commercial and social control (ceramics, quantity and quality). Effect: creation of specific tokens Concrete measurement
4th bridged link Introduction of simple tokens into bullae	Hollow *bullae* the simple tokens and solid and complex baked clay	Bronze Age c. 3300 BC	Grade 7 Causa: Commercial and social control of measured products and tokens. Effect: Introduction into the bullae
5th bridged link Printing on walls	Walls of hollow bullae with impressions of the tokens they contained. Impressions of the solid bullae	Bronze Age c. 3250 BC	Grade 7 Cause:ignorance of the tokens inside the closed bulla Effect: impressions on hollow and solid bullae
6th bridged link Grouping of token values	Variation in size and shape of tokens indicating various quantities and products	Bronze Age Mid to late 4th millennium	Grade 7 Cause:need to reduce the number of tokens with variations in shape and size Effect: new tokens with different quantity values

7th bridged link First printed tablets	Engraved, baked tablets	Bronze Age late 4th millennium c. 3200 BC	Grade 7 Cause: improve impressions on bulla's Effect: tablets creation
8th bridged link Concrete numbering		End of 4th and 3rd millennium BC	Grade 7 Cause: The increase in the quantity and variety of products measured or counted Effect: simplification of registrations, those of equal quantity, and those of specific quality
9th bridged link Abstract numbering		Bronze Age c. 1900 to 1600 BC	Grade 7 Cause: measure group analogy Effect: only quantity signals with graphical and linguistic symbolization already as number
10 bridged link Numerical representation, numerical bases		Bronze Age c. 1900 to 1600 BC	Grade 7 Cause: problems with numerical representations Effect: Creation of rules of representation and organisation

TABLE 3. SHOWS THE DIFFERENT COGNITIVE STEPS OR LINKED OR SIGNALLED PILLARS USED IN THE INITIAL DEVELOPMENT OF NUMERATION

In this context, the repeated production of the same groupings of marks (perceptual analogy) would produce a highly reiterative sensory perception, facilitating a notable strengthening of the sensory memory (capacity to register the sensations perceived through the senses), and an increase in its cognitive permanence and a greater possibility of memory (Manzanero 2008). These perceptions would be the most general and those that best describe the objects, actions or facts on which the processes of abstraction are going to be carried out, being, at the same time, those that will be remembered first when the processes of attention are activated. Their realisation would take place in the areas of temporary parietal association where the processes of memorisation, memory and cognitive abstraction would be initiated. However, the processes of abstraction would be some what *latent* in these areas of association, as they cannot manifest themselves until a cognitive medium is developed that can create a form, of an equally cognitive nature, that allows its internal (verbal or conscious thought) and external (language or graphic representation) manifestation, facilitating numerical expression as we conceive it today. It would represent a good example of the processes of *co-evolution* and *emergence* that will characterise the manifestation of our cognitive capacities (Rivera and Rivera 2019).

3. DEVELOPMENT OF NUMEROSITY IN PREHISTORY

3.1. NUMERATION IN THE PALAEOLITHIC

The use of the fingers in numerical learning, and the knowledge of numerous hand paintings in various caves in Upper Palaeolithic Europe, has led to the idea that the hands could have been used as templates for measuring and/or counting with the fingers (Leroi-Gorhan 1967; Overmann 2016). Likewise, the accumulation of various equal elements (shells, stone beads, perforated or grooved bones, etc.) has been related to these measuring behaviours, where each measuring event would correspond to one of these elements (e. g. Vanhaeren *et al.* 2013). Such use is possible, but the ignorance of the causes that justified its development makes the majority of authors opt for its use as elements of personal and/or social differentiation. The archaeological data best associated with these practices would be the successive marks that are observed in different mediums, because they acquire a homogeneous and regular form in their production, giving the sensation of a more or less continuous act, in which the events that are to be measured would be recorded by simple event-sample comparison. They have been found in easily transportable and manageable objects, although their actual purpose is unknown (Barandiarán 2006; González Redondo *et al.* 2010; Overmann 2016) (Table 4).

These measurement behaviours would be a consequence of an adequate cognitive development, by favouring the conscious perception of the complexity and difficulty of their actions (social cognition), emotionally encouraging (emotional cognition: interest and motivation) to try to improve their performance and effectiveness. Its realization requires the existence of a material base (technological cognition) on which to create a certain concrete abstraction of the measurement, because although its reference is not reflected in the marks, they would be in the mind of the action performer (Table 3) (Rivera and Rivera 2019). Behavioural improvement could consist in the acquisition of certain control in its realization (cause), such as measurement actions or marks in bones (effect).

This process would be the first linked or signalled argument of the process of evolution of numerical abstraction (Table 3). However, its realization would not be possible without the existence of patterns or units of comparison (effect), within the need to create appropriate and socially recognizable marks (cause). With their development, the concrete abstraction of patterns was achieved, and a way of measuring without counting was initiated, since numbers did not yet exist. They constitute the second linked or signalled argument of the process of evolution of numerical abstraction (Table 3), being an example of causal processes interrelated with other referents or modes that make up our complex causal framework. With the scarce archaeological data, three forms of temporo-spatial pattern (causal cognition 6-7) related to quantification processes can be recognized.

Possible measurement behaviours have been noted in the Upper Palaeolithic, although recently the possibility has been added that incisions or marks on a 72-60000 BP hyena femur of the Mousterian de Les Pradelles in France, and the 44-42000 BP baboon fibula incisions in Border Cave (Table 4: A) in South Africa (d´Errico *et al.* 2017), are also related to this behavioural form. What is certain is that its existence is very irregular, in terms of both temporal and geographical distribution, and there remains the doubt that its purpose was an activity of measurement or of another unknown cause (Reese 2002; Barandiarán 2006; González Redondo *et al*. 2010).

Abri Blanchard plaque of 30-25000 BP (Aurignacian) (Dordogne, France) would be at the beginning of the modern cognitive journey of *Homo sapiens* (Rivera and Menéndez 2011). It has 69 marks of different shapes that could represent the continuity of the four phases of the moon; that is, slightly more than two lunar phases (González Redondo *et al.* 2004). This interpretation would be the so-called *Marshack´s notation* hypothesis (Marshack 1991), reflecting a clear continuity that fits very well with temporal measurements (Table 4: B).

The reindeer horn of *Brassempouy* of 15000 BP (Magdalenian) (Las Landas. France). The piece seems to bear clear and similar marks, intentionally divided in groups of ascending numbering (1, 3, 5, 7, 9) that are not repeated. (Table 4: C) (Ifrah 1997; González Redondo *et al.* 2010).

The rectangular ivory plate of *Mal´ta* (Irkutskaya Oblast in Siberia. Russia) from 18-15 ka, has the same cognitive and temporal connotations as the previous case. There are many very similar marks that seem to offer an important approximation to the yearly cycle, as it has a spiral of 243 signals accompanied by other spirals with 122 signals, being the total of 365. In addition, in the Siberian zone of Mal´ta the duration of winter is approximately 243 days, as is the gestation cycle of the reindeer, a basic animal in the diet of the area, which would reaffirm the possibility of being a long (annual) temporal record (Frolov 1974) (Table 4: D).

With the archaeological data that we have in this period we see that the groupings of marks are very irregular, lacking constant groupings of equal measurements that generate analogy processes. Well, his training would have the ability to create processes of abstraction that can be symbolized through a materiality (technological, graphic, sound, gestural, etc.) that gives body to numerical abstraction.

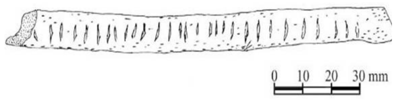
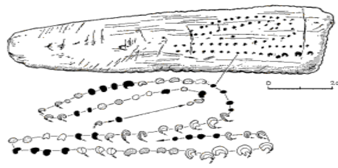
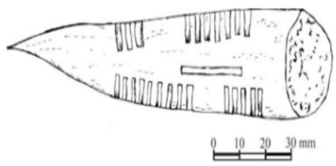
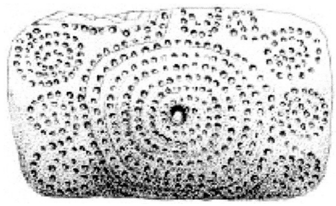
POSSIBLE PALAEOLITHIC MEASUREMENT SAMPLES			
Chronology	**Support References**	**Graphic representations. Notches**	**Image**
A. Border Cave Lebombo. South Africa. Africa 37000- 42000 BP	Lebombo bone, Baboon fibula González Redondo *et al.* 2010 d´Errico *et al*. 2017	29 parallel incisions made at different periods	
B. Abri Blanchard 25000 BP Dordogne. France	Blanchard Plate Marshack, 1991 González Redondo *et al.* 2010	69 marks of different shapes, depth and sizes Lunar calendar?	
C. Brassempouy 15000 BP Magdaleniense Las Landas France	Reindeer horn Ifrah, 1997 González Redondo *et al.* 2010	25 notches in 5 groups of 1, 3, 5, 7 y 9 rectilinear lines	
D. Yacimiento de Mal´ta (Irkutskaya Oblast) Siberia. Russia18000-15000 BP	Rectangular mammoth ivory plate Bednarik, 2013 Frolov, 1974	Central spiral with 243 notches Side spirals with 122 notches. Total 365 holes	

TABLE 4. SOME SAMPLES OF TESTIMONIES OF MEASUREMENT BEHAVIOUR IN THE PALAEOLITHIC

3.2. NUMERATION IN NEOLITHIC/BRONZE AGE

With the beginning of the Neolithic period, the need to control its new activities appeared, so measuring and counting behaviours were imposed as a necessary condition, so that without their use, the socio-political development that is known in wide geographical and historical areas would be impossible.Thus, the first archaeological data on the existence of these behaviours are proven in societies organized from the Neolithic in the Ancient Near East, Egypt (Schmandt-Besserat 1992 ;MacGinnis *et al.* 2014; Overman 2016), Mesoamerica and China (Chrisomalis 2005), acquiring an adequate cognitive (social, technological and emotional) and causal development (grade 7). We must bear in mind that the reality is more in line with heterogeneous progress in time and geography, where some advances could coexist with older customs, such as cases of long periods of use of various forms (simple tokens), complexes and tablets, or the multiple numerical systems in contact with each other (e. g. Sumerian sexagesimal; Akkadian and Elamite decimal) (Overmann

2018b). This complex socio-cultural and cognitive world was one of the places where the material changes that led to the creation of numerical abstraction took place.

- *Measure without counting independent products (concrete measurements with material specification).* The behaviour of controlling actions with measurement mechanisms by equating (one to one) facts, objects or animals with patterns expressly created for that purpose, is recorded again archeologically with at beginning of the Neolithic, although with specific characteristics, because the patterns of measurement would be appropriate to what one wants to measure (e. g. units of volume to measure cereals, weight patterns, surface area, specific animals, etc.). Thus, due to the growth and complexity of the Sumerian economy, accounting records made with simple marks were not practical. To solve the problem of the variety of articles measured and their commercial or administrative purpose (cause) it was necessary to increase the information registered with the creation of trademarks indicating the quality of what was measured in each operation one by one (effect). Such development can be seen in the first tokens that the Sumerians created as reference measurements of quality and quantity. These were exclusive for each one of the measured elements, as many tokens as objects to be measured: the oil bottles were counted with ovoids, small measurements of grain with cones and large measures of grain with spheres (Schmandt-Besserat 1992). These tokens were widely used for accounting in Mesopotamia, particularly associated with the Neolithic (Moore 2000), but lasted during the Bronze Age in its two forms (Schmandt-Besserat 1986, 1992; MacGinnis *et al.* 2014). Simple tokens (Table 5: A) of specific form (disks, triangles, rectangles, ovoids, spheres, cones, cylinders and tetrahedrons) signifying a unit of what is measured (e. g. grain spheres and animal cylinders), particularly associated with the Neolithic (c. 8300-4500 BC) and the development of agriculture (Schmandt-Besserat 1986, 1992). Complex tokens (Table 5: B) that appear in the first cities, which are more recent and limited in geography have a wider repertoire of shapes and various types of markings on their surface. They appear at the end of the fourth millennium and last until the first BC millennium and are closely related to the development of the Sumerian temple and industrial and political control (Schmandt-Besserat 1986, 1992). The tokens are the result of a relatively complex causal relationship, since they are the result of the union of several causal modes (ceramics, quantity and quality), constituting the third linked or signalled argument (Table 3) (Schmandt-Besserat 1986, 1992). They show a concrete measurement reflected in the shapes of the tokens.
- *Introduction of tokens in bulla (hollow).* For better control in their commercial use (cause), these simple tokens were stored in a kind of clay envelopes or bullae (c. 3.300 BC) (effect) (Table 5: A). The complex tokens were perforated and eventually strung on a string that was attached to a solid oblong clay bulla, where their impressions identified the beads in question. It would be the fourth linked or signalled argument (Table 3) (Schmandt-Besserat 1986, 1992). It is a clear example of the cognitive crossing of different causal processes.
- *Impressions on the walls of hollow and solid bullae.* Around 3250 BC these envelopes of the simple tokens were shown to be insufficient, because once they were closed

their content (cause) was unknown with exactitude. The surface of the bulla was marked with the footprint of the accounting tokens (effect) (Schmandt-Besserat 2010). This new system was identified as the period of accounting by tokens-bullae in order to differentiate it from the previous period and there bylocating the origin of ideographic writing and abstract calculation (Mattessic 2000). These impressions emphasised the use of identity marks (cylinder-stamp impressions) and a record of their content (Ifrah 1997) (Table 5: A). Their linear organization and stable order would ultimately facilitate the development of positional value at the end of the third millennium (Robson 2007; Overmann 2018a). They form the fifth linked or signalled argument (Table 3).

- *Grouping the value of tokens*. In the middle and the end of the fourth millennium BC, as commercial and administrative transactions increased, it was necessary to group the values of the tokens (cause), constituting new tokens of greater value (effect). The grouping ratios were based on old forms of measurement or counting such as fingers (5, 10 measurements) (Table 5: C, D). These new codings based on their shape and size were suitable for measuring most discrete objects; ten small cones were equivalent to a small sphere, six small spheres to a large cone (Nissen *et al.* 1993). Likewise, the conventions of shape and size were also used to indicate the measured product (grain, fish, etc.), resolving the need to represent what was measured or counted in the absence of writing (Overmann 2018a). An analysis of mathematical texts from later periods suggests that these tokens may have been used to count on boards, turning them into an abacus-like device (Høyrup 2002). This would be the sixth linked or signalled argument (Table 3).
- *First clay tablets*. With time the bullae start losing their usefulness, because the information printed on their walls seemed to be enough for the purpose proposed, making the tokens inside obsolete. What made the bullae important were the zones where the transaction data were printed. That is why they were isolated from the rest to give way to the tablets at the end of the fourth millennium BC (Schmandt-Besserat 1986, 1992). In principle, the same printing forms used in the bulla were maintained, that is, series of marks relative to each of the products measured with their particular shapes (concrete measurement). A new causal relationship was established between the practical need to improve the impressions in the bulla's (cause), and the creation of the slats as a new material way to reflect the information (effect). Their realization would constitute the seventh linked or bridged argument (Table 3).
- *Numbering with limited or concrete abstraction*. A development of the previously initiated grouping of the value of the tokens, as it implies a certain level of concrete abstraction of a numerical nature. Given the constant increase in the complexity of commercial relations and religious and/or state control in relation to the quantity and variety of products measured or counted (cause), a practical simplification of the inscriptions was created (effect). They began to use simple signs of universal character in the measurements (one measurement, a signal), to which an exclusive mark of the measured was added (Table 5: D). Its evolution obeys the same social, technological and emotional pressures that were indicated in the development of the concrete measurement. Such practical development seems to be the beginning

of the numerical system, since the groups of quantity signals were universal and equal, increasing as what was measured grew. The only differentiation resided in the symbol of the measured or quantified merchandise. This separation of the representation of the quantity of quality occurred at the end of the fourth millennium (Friberg 1994; Malafouris, 2010; Schmandt-Besserat 1992). Until the end of the third millennium BC, however, numbers were not thought of as independent entities but as attributes of concrete objects: the length of a line, or the number of sheep in a flock (Robson 2007). This form of specific marking of the first tablets can be known as *numbering with limited or concrete abstraction*, as they would always be related to concrete measurable entities. This would be the eighth linked or signalled argument of numerical abstraction development (Table 3).

- *Total and independent abstract numbering*. One of the most significant changes was the separation of the representation of measurements from that of products measured at the end of the fourth millennium (Schmandt-Besserat 1992; Friberg 1994; Malafouris 2010). With this, groups of equal measurements are formed, generating a cognitive analogy that allows easy separation of quantity from quality of what is measured. With the appreciation of this constant analogy or groups of measurement signals without pointing out what is measured (cause), a graphic and linguistic symbolization is made for each group (effect), emerging the numerical abstraction thanks to the graphic characteristics of the materiality of the measurements (Table 5: E).
- Numerical abstraction acquires practically all its meaning with the development of cuneiform writing and numbering, which is fully achieved in the ancient Babylonian period (c. 1900 to 1600 BC) (Schmandt-Besserat 1992). The ninth linked or signalled argument of the causal cognition process is produced (Table 3).
- *Numerical representation, numerical bases*. Independently of any other information, numbers would better represent the abstract concepts of measurement and/or counting. However, the isolated use of the quantity component with respect to the information of what was measured and/or counted, could only be used in short series, because if these were many the individual symbolization of each one of them would be impracticable due to their difficult manipulability. In their pragmatic solution, recurrent marking systems were created, that is to say, the creation of numerical bases as abstract structures, adequate and easy to use, which simplified the notation of quantities. Thus, in all numerical systems the first numbers are a replica of the representation of the measurement marks, in order to introduce a new numerical convention when a certain number of measurements is reached and so on. Its clear antecedent was already seen in the grouping of the value of the tokens (Table 5: E).

The elaboration of a numerical organization would facilitate the ability to objectify and simplify the problem of the conception of the number, and to restructure the cognitive task necessary for its solution (Malafouris 2010). This situation (cause) requires the creation of numerical systems or ordered sets of symbols or digits governed by rules on their combination to represent infinite numerical quantities. That is to say, new numerical abstractions would be created based on a repetitive and ordered ordering of their symbolization (effect), where the position of each symbol representing a different value, would be the numerical bases (Table 5: E). Their development seems to be highly mediated by the representational materiality of the measures that originated them, as there is no materialization (fingers, beads, marks, tokens, etc.) that can represent large units of measurement in a simple and linear way. They would constitute the tenth linked or signalled argument of numerical cognitive development (Table 3).

The material used for counting would mark the production of the numerical base. Thus, the cycles formed by numerical bases of ten, five, and twenty suggest the use of hands and feet as material forms for counting (Overmann 2018a). Likewise, the base 12 would arise from counting with the fingers but in another way, because using the thumb as a pointer; the three phalanges of the remaining four fingers give us a count of twelve. On the other hand, if each time we complete, we point to a finger of the other hand, up to a total of five fingers, we could count up to 60. The use of large measurements and/or counts requires an adequate material symbolization, both for their production (e. g. abacus) and for their fixation (e. g. clay tablets) and social use, facilitating the necessary stability of representation (Hutchins 2005), making possible the production of operations with numbers aimed at the task of controlling trade and administering the measurable resources.

EVOLUTION OF THE MATERIALITY OF THE MEASURES UNTIL CREATING THE ABSTRACT NUMBERING	
A. Simple tokens and clay bulla. You can see the marks of the tokens that it contained inside. The owner's stamp is barely visible on the outside of the bulla. About 3,250 BC Susa, Iran. Musée du Louvre, Département des Antiquités Orientales, Paris. Photo Denise Schmandt-Besserat Image: Wikimedia Commons	
B. Complex tokens. They present a greater repertoire of shapes and with various types of marks on their surface. End of the fourth millennium to the first millennium BC. They were drilled and strung on a rope that was attached to a massive oblong ball of clay. © Marie-Lan Nguyen / Wikimedia Commons / CC-BY 2.5	
C. Printed and incised tablets. Drawing of goat or sheep and number (probably 10). Al-Hasakah (Uruk), 3300-3100 BC. British Museum. Paul hudson Creative Commons CC0 License	

D. Printed and incised tablets. Godin Tepe (Iran), c 3100 BC. Circular impressions represented tens and wedges represented units. The incised figure on the right is a representation of an oil bottle, and records 33 oil bottles.
On this tablet, the six impressions represent numbers still attached to specific objects (incised figure).
Image by Denise Schmandt-Besserat and T. Cuyler Young Jr. Royal Ontario Museum, Toronto, Canada.

E. The Mesopotamian numbering system. It is a system of representation of the numbers in the cuneiform writing of various peoples of Mesopotamia. This system first appeared around 1900-1800 BC. It is also credited as the first positional numbering system, in which the value of a particular digit depends on both its value and its position in the number to be represented.
Wikimedia Commons Creative. Commons License Attribution Share Alike 3.0.

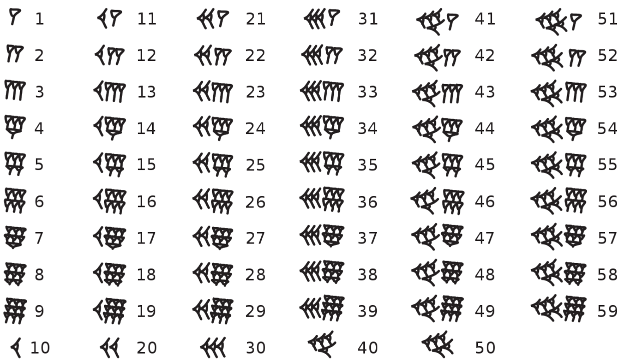


TABLE 5. SHOWS VARIOUS PERIODS OF THE EVOLUTION OF MATERIALITY TOWARDS THE DEVELOPMENT OF ABSTRACT NUMBERING

4. CONCLUSIONS

Numeration is found in human cognitive evolution, within its particular cognitive-cultural niche (Rivera and Rivera 2019). Numerical abstraction, like all human abstractions, would be determined by the confluence of the adequate development of social cognition (language, self-consciousness, theory of mind, working memory, social relations of all kinds, etc.), emotional cognition (motivation and interest in developing forms of numerical control) and technological cognition (material support that makes numerical symbolization possible). This cognitive confluence is brought about through the realization of a series of cognitive-behavioural achievements (causal cognition) linked to each other in time and space, forming a theoretical succession of processes linked or signalled (Haidle 2014) within complex cognitive networks (Sporns 2011). However, such an explanation, with the appearance of a constant and homogeneous evolution, is not reflected in the archaeological reality, since its data offer an image of great temporal and geographical heterogeneity of its production. This does not prevent us from deducing the cognition that would lead their creators to use measurements and/or counts with abstraction characteristics. However, in its complex evolution there is doubt about the very nature of the numerical abstraction achieved, since we cannot consider it homogeneous in all its extension and independence from what is measured, counted and of the material itself where it is represented (Malafouris 2013), as happens with Palaeolithic marks, tokens and the great variety of printing forms in Sumerian tablets.

In the creation of numbers, the previous existence of measurement marks, concrete numbers and their later evolution with the invention of writing to abstract or second order numbers has been accepted (Damerow 1996). Recently the abstract-concrete distinction of Ancient Near East numbers has been questioned, presenting a vision where numbers can be abstract from the beginning. The conceptual and cognitive change would have occurred through the change in the materials used to represent and manipulate numbers: fingers, beads, tokens and numerical notations, so that the numerical meaning of the multiple systems of representation can have an abstract concept of number, in the sense of being independent of any material form (Overmann 2018a). However, it is the conceptual development of numerical independence from measurement and/or counting processes that would mark the beginning of a full numerical abstraction (Table 4). The concept of abstraction, with greater or lesser development, can be applied to many human behaviours. Thus, the measurements and the creation of the first measurement patterns of the Palaeolithic, such as the use of Sumerian tokens, can be considered concrete abstractions to the measurement behaviours, but not of a numerical or counting character, since the numbers did not yet exist. The key would be to admit that the processes of measurement and counting do not mean the same thing, although the former is an evolutionary antecedent of the latter.

The development of numerical abstraction facilitated in the second millennium the so-called pure mathematics that included complex algorithms to calculate answers to artificial and practical problems (Høyrup 2002; Friberg 2007; Overmann 2018b). However, it seems that they always referred to arithmetic situations related to certain accounting objects, whether or not they were indicated in the respective labels, information that was lost when adding or subtracting them with other determined quantities. This is why various authors define the Babylonian mathematical tradition as sub-scientific (Høyrup 1994). This confusing situation would disappear with the study of the nature of number as a concept and subject of independent study, which Greek philosophers developed in the first millennium (Høyrup 1994; Damerow 1996; Overmann 2018b). Effectively, even among the ancient Greeks numerical abstraction acquired new connotations such as the mystical character they acquired with the Pythagoreans, which gives us an idea of the complexity and importance that numerical abstractions acquire in our culture. Everything in nature can be measured and counted, but for this it is essential to find the appropriate measurement patterns for its realization, and that numerical abstraction acquires a practical sense in its use.

BIBLIOGRAPHY

Amalric, M. and Dehaene, S. 2016: «Origins of the brain networks for advanced mathematics in expert mathematicians». *Proceedings of the National Academy of Sciences of the United States of America*, 113 (18), 4909-4917. *doi: https://doi.org/10.1073/pnas.1603205113*

Ardila, A. and Rosselli, M. 2002: «Acalculia and dyscalculia». *Neuropsychology Review,* 12: 176–232. *doi: 10.1023 / A: 1021343508573*

Ardila, A. and Ostrosky-Solís, F. 2008: «Desarrollo histórico de las Funciones Ejecutivas». *Revista Neuropsicología, Neuropsiquiatría y Neurociencias*, 8 (1) 1-21. *doi: https://dialnet.unirioja.es/servlet/articulo?codigo=3987433*

Barandiarán, I. 2006: *Imágenes y adornos en el arte portátil paleolítico.* Ariel. Barcelona.

Bateson, P. 2004: «The Active Role of Behavior in Evolution». *Biology and Philosophy* 19: 283-298. *doi: https://link.springer.com/article/10.1023/B%3ABIPH.0000024468.12161.83*

Bednarik, R. G. 2013: «The Pleistocene Art of Asia». *Arts*, 2, 46-76.
doi: https://doi.org/10.3390/arts2020046

Belinchón, M., Igoa, J. M. and Riviére, A. 1992: *Psicología del lenguaje. Investigación y teoría*. Trotta. Madrid.

Bender, A. and Beller, S. 2019: «The Cultural Fabric of Human Causal Cognition». *Perspectives on Psychological Science*, Vol. 14(6) 922–940

Bender, A. 2020: «What Is Causal Cognition?» *Frontiers in Psychology* 11.

Bickerton, D. 2009: *Adam´s Tongue: How Humans Made Language, How Language Made Humans*. Hill and Wang. New York.

Booth, J. L. and Siegler, R. S. 2006: «Developmental and individual differences in pure numerical estimation». *Developmental Psychology,* 42(6):189–201.
doi: 10.1037 / 0012-1649.41.6.189

Botha, R. 2010: «On the soundness of inferring modern language from symbolic behaviour». *Camb. Archaeol. J*. 20, 345–356. *doi: https://doi.org/10.1017/S0959774310000454*

Brannon, E. M. 2005: «The independence of language and mathematical cognition». *PNAS,* 102(9):3177–3178. *doi: https://doi.org/10.1073/pnas.0500328102*

Brooks, N. B., Barner, D., Frank, M. C. and Goldin-Meadow, S. 2014: «Abacus: Gesture in the mind, not the hands». In P. Bello, M. Guarini, M. McShane, and B. Scassellati (eds.), *Proceedings of the Cognitive Science Society,* Vol. 36, pp. 72– 73. Austin, TX, USA: Cognitive Science Society.

Bruner, E.; Preuss, T. M.; Chen, X, and Rilling, J. K. 2017: «Evidence for expansion of the precuneus in human evolution». *Brain Structure and Function*. Vol. 222, (2): 1053-1060.

Bruner, E., Spinapolice, E., Burke, A. and Overmann, K.A. 2018: «Visuospatial integration: Paleoanthropological and archaeological perspectives». In di Paolo, L.D., di Vincenzo, F., and de Petrillo, F. (eds), *The evolution of primate social cognition* (pp. 299-326). Cham, Switzerland: Springer.

Bruner, J. 1984: *Acción, pensamiento y lenguaje*. Alianza. Madrid.

Butterworth, B. 1999: *The mathematical brain*. Macmillan Publishers. London.

Canthlon, J. F., Brannon, E. M., Carter, E. J. and Pelphrey, K. A. 2006: «Functional imaging of numerical processing in adults and 4-y old children». *PLOS Biology* 4 (5), 844-854. *doi: https://doi.org/10.1371/journal.pbio.0040125*

Carey, S. 2009: *The origin of concepts*. Oxford University Press. Oxford.

Carreiras, M., Monahan, P. J., Lizarazu, M., Duñabeitia, J. A. and Molinero, N. 2015: «Numbers are not like words: Different pathways for literacy and numeracy». *NeuroImage*, 118, 79-89. *doi: 10.1016 / j.neuroimage.2015.06.021*

Clark, A. 2006: «Language, embodiment, and the cognitive niche». *Trends in Cognitive Sciences,* 10 (8), 370-374. *doi: https://doi.org/10.1016/j.tics.2006.06.012*

Chrisomalis, S. 2005: *Evaluating Ancient Numeracy: Social versus Developmental Perspectives on Ancient Mesopotamian Numeration*. Paper delivered to the Annual Meeting of the Jean Piaget Society (Vancouver, British Columbia).

Christie, S. and Gentner, D. 2007: «Relational similarity in identity relation: The role of language». In S. Vosniadou, D. Kayser, and A. Protopapas (eds.). *Proceedings of the 2nd European Cognitive Science conference* (pp. 402–406). NY, USA: Lawrence Erlbaum Associates. New York.

Colagè, I. and D'errico, F. 2018: «Culture: The Driving Force of Human Cognition». Topics in Cognitive Science, 1–19. In Bender, A., Beller, S.and Jordan, F. (Topic Editors). *The Cultural Evolution of Cognition*. For a full listing of topic papers.

doi: http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1756-8765/earlyview

Coolidge, F. L. and Overmann, K. A. 2012: «Numerosity, Abstraction, and the Emergence of Symbolic Thinking». *Current Anthropology*, 53(2) 204-225. *doi: 10.1089/664818*

Damasio, A. 2010: *Self Comes to Mind: Constructing the Conscious Brain*. Pantheon Books. New York.

Damerow, P. 1996: «Number as a Second-Order Concept». *Science in Context* 9, 139-149.

Dehaene, S. 1997: *The Number Sense*. Oxford University Press. Oxford.

Dehaene, S., Izard, V., Spelke, E. and Pica, P. 2008: «Log or linear? Distinct intuitions of the number scale in Western and Amazonian indigene cultures». *Science* 320 (5880):1217–1220. *doi: 10.1126 / science.1156540*

D´Errico, F., Doyon, L., Colagè, I., Queffelec, A., Le Vraux, E., Giacobini, G., Vandermeersch, B. and Maureille, B. 2017: «From number sense to number symbols. An archaeological perspective». *Philos Trans R Soc Lond B Biol Sci*. 19; 373(1740). *doi: 10.1098/rstb.2016.0518*

Edelman, G. M. and Tononi, G. 2000: *A Universe of Consciousness.* Basic Books. New York.

Epps, P., Bowerin, C., Hansen, C. A., Hill, J. H. and Zentz, J. 2012: «On numeral complexity in hunter-gatherer languages». *Linguistic Typology*, 16(1), 41–109.

Everett, D. E. 2005: «Cultural Constraints on Grammar and Cognition in Pirahã». *Current Anthropology*, Volume 46 (4). doi: *https://doi.org/10.1515/lity-2012-0002*

Ferrari, P. L. 2003: «Abstraction in mathematic». *Phil. Trans. R. Soc. Lond. B*. 358, 1225–1230. *doi: 10.1098 / rstb.2003.1316*

Flegg. G. 1983: *Numbers: Their History and Meaning*. Dover Publications. New York.

Florio, M., Albert, M., Taverna, E., Namba, T., Brandl, H., Lewitus, E., ...Huttner W. B. 2015: «Human-specific gene ARHGAP11B promotes basal progenitor amplification and neocortex expansion». *Science,* 347 (6229): 1465-1470. *doi: 10.1126 / science.aaa1975*

Frank, M. C. and Barner, D. 2012: «Representing exact number visually using mental abacus». *Journal of Experimental Psychology*: General, 141(1), 134-149.

doi: http://dx.doi.org/10.1037/a0024427

Frege, G. 1953: *The foundations of arithmetic: A logical-mathematical investigation into the concept of number* (J. L. Austin, Trans., 2nd rev.). NY, USA: Harper and Brothers. New York.

Friberg, J. 1994: «Preliterate Counting and Accounting in the Middle East: A Constructively Critical Review of Schmandt-Besserat's Before Writing». *OLZ* 89, 477-489.

Friberg, J. 2007: *A Remarkable Collection of Babylonian Mathematical Texts. Sources and Studies in the History of Mathematics and Physical Sciences*. Springer Science+Business Media, LL. New York.

Frolov, B. A. 1974: *Numbers in Paleolithic graphic*. Russian. Novosibirsk. Nauka.

Gärdenfors, P. and Lombard, M. 2018: «Hypothesis and Theory Causal Cognition, Force Dynamics and Early Hunting Technologies». *Frontiers in Psychology*, vol. 9, nº 87. *doi: https://doi.org/10.3389/fpsyg.2018.00087*

González Redondo, F. A. and Silván Pobes, E. 2004: «Pensamiento simbólico y Matemática en el Paleolítico Superior». *Boletín de la Sociedad Puig Adam;* 68: 78-93. *doi: http://scielo.isciii.es/pdf/dyn/v30/07.pdf*

González Redondo, F. A., Martín-Loeches, M. and Silván Ppbes, E. 2010: «Prehistoria de la matemática y mente moderna: pensamiento matemático y recursividad en el Paleolítico franco-cantábrico». *Dynamis*. 30: 167-195.
doi: https://www.raco.cat/index.php/Dynamis/article/view/218639

Haidle, M. N. 2014: «Building a bridge-an archeologist's perspective on the evolution of causal cognition». *Front. Psychol*. 5:1472. *doi org/10.3389/fpsyg.2015.01472*

Høyrup, J. 1994: *Measure, Number, and Weight: Studies in Mathematics and Culture. SUNY Series in Science, Technology, and Society.* State University of New York Press. Albany, NY.

Høyrup, J. 2002: «A Note on Old Babylonian Computational Techniques». *Historia Mathematica* 29, 193-198. *doi: https://doi.org/10.1006/hmat.2002.2343*

Hurford, J. 1987: *Language and number: the emergence of a cognitive system.* Blackwell. Oxford.

Hutchins, E. 2005:«Material anchors for conceptual blend». *Journal of Pragmatics* 37: 1555-1577. *https://doi.org/10.1016/j.pragma.2004.06.008*

Ifrah, G. 1997: *Historia universal de las cifras*. Espasa. Madrid.

Laland, K. N. 2017: *Darwin's Unfinished Symphony: How Culture Made the Human Mind.* NJ: Princeton University Press. Princeton

Leroi-Gourhan, A. 1967: «Les mains de Gargas: essai pour une étude d'ensemble». *Bulletin de la Société Préhistorique Française* 64 (1), 107-122.
doi: https://www.persee.fr/doc/bspf_0249-7638_1967_hos_64_1_4105

Lévi-Strauss*, C.* 1977: *Antropología estructural*. Eudeba. Buenos Aires.

Lombard, M. and Gärdenfors, P. 2017: «Tracking the evolution of causal cognition in humans». *Journal of Anthropological Sciences*. 95, 1-16.
doi: http://www.isita-org.com/jass/Contents/2017vol95/Lombard/28489015.pdf

Lotem, A., Halpern, J. Y., Edelman, S. and Kolodny, O. 2017: «The evolution of cognitive mechanisms in response to cultural innovations». *PNAS* | vol. 114 | no. 30 | 7915–7922. *doi: https://doi.org/10.1073/pnas.1620742114*

Luria, A. and Yudovich, F. 1972: *Speech and the development of mental processes in the child*. Penguin Books. Harmondsworth, UK.

Macginnis, J., Monroe, M. W., Wicke, D. and Matney, T. 2014: «Artefacts of cognition: the use of clay tokens in a Neo-Assyrian provincial administration». *Cambridge Archaeological Journal* 24 (2), 289-306. *doi: 10.1017/S0959774314000432*

Macizo, P., Colomé, A., García-Orza, and Herrera, A. 2016: «Cognición numérica». In: Bajo Molina, T., Fuentes Melero, L. J., Lupiañez Castillo, J. and Rueda Cuerva, CH. (eds.). *Mente y cerebro. De la Psicología experimental a la Neurociencia cognitiva*. Alianza. Madrid.

Malafouris, L. 2010: «Grasping the concept of number: how did the sapient mind move beyond approximation?» In: Renfrew, C., Morley, I. (eds.). *The Archaeology of Measurement:*

Comprehending Heaven, Earth and Time in Ancient Societies. Cambridge. Cambridge University Press, pp. 35-42.

Malafouris, L. 2013: *How Things Shape the Mind: a Theory of Material Engagement*. Cambridge: MIT Press. Cambridge.

Manzanero, A. L. 2008: Aspectos básicos de la memoria.i n A. L. Manzanero, *Psicología del Testimonio* (pág. 27-45). Ed. Pirámide. Madrid.

Marshack, A. 1991: *The roots of civilization*. Weidenfeld and Nicolson. New York.

Mattesich, R. 2000: *The beginnings of accounting and accounting thought*. Garland Pub., New York.

Mcclelland, J. L., Botvinick, M. M., Noelle, D. C., Plaut, D. C., Rogers, T. T., Seidenberg, M. S. and Smith, L. B. 2010: «Letting structure emerge: connectionist and dynamical systems approaches to cognition». *Trends Cogn. Sci*. 14, 348– 356. *doi:10.1016/j.tics.2010.06.002*

Mercier, N. 2000: *Words and Minds. How we use language to think together*. Routledge 11 New Fetter Lane. London.

Moore, A. M. T. 2000: «Stone and other artifacts». In A. M. T. Moore, G. C. Hillman, and A. J. Legge (eds.), *Village on the Euphrates: From foraging to farming at Abu Hureyra* (pp. 165–186). Oxford University Press. Oxford, United Kingdom.

Muthukrishana, M., Doebeli, M., Chudek, M. and Henrich, J. 2018: «The Cultural Brain Hypothesis: How culture drives brain expansion, sociality, and life history». *PLoS Computational Biology* 14(11):e1006504. *https://doi.org/10.1371/journal.pcbi.1006504*

Nieder, A. and Dehaene, S. 2009: «Representation of number in the brain». *Annual Review of Neuroscience* 32: 185-208. *doi: 10.1146 / annurev.neuro.051508.135550*

Nissen, H. J., Damerow, P. and Englund, R. K. 1993: *Archaic bookkeeping: Early writing and techniques of economic administration in the ancient Near East* (P. Larsen, Trans.). University of Chicago Press. Chicago, IL, USA.

Orban, G. A., Claeys, K., Nelissen, K., Smans, R., Sunaert, S., Todd, J. T., . . . Vanduffel, W. 2006: «Mapping the parietal cortex of human and non-human primates». *Neuropsychologia*, 44(13), 2647-2667. *https://doi.org/10.1016/j.neuropsychologia.2005.11.001*

Overmann, K. A. 2016: «The role of materiality in numerical Cognition». *Quaternary International*, 405: 42-51. *doi: 10.1016 / j.quaint.2015.05.026*

Overmann, K. A. 2018a: «Constructing a Concept of Number». *Journal of Numerical Cognition*. Vol. 4, núm. 2, 464-493. *doi: https://jnc.psychopen.eu/article/view/161/pdf*

Overmann, K. A. 2018b: «Updating the Abstract-Concrete Distinction in Ancient Near Eastern Numbers». *Cuneiform Digital Library Journal*. 001 ISSN 1540-8779.

doi: *https://cdli.ucla.edu/pubs/cdlj/2018/cdlj2018_001.html*

Penn, D. C. and Povinelli, D. J. 2007: «Causal Cognition in Human and Nonhuman Animals: A Comparative, Critical Review». *Annu Rev Psychol* 58: 97-118.

doi: *10.1146 / annurev.psych.58.110405.085555*

Penner-Wilger, M., Fast, L., Lefevre, J.-A., Smith-Chant, B. L., Skwrchuk, S.-L., Kamawar, D. and Bisanz, J. 2007: «The foundations of numeracy: Subitizing, finger gnosia, and fine motor ability». In D. S. McNamara and J. G. Trafton (Eds.), *Proceedings of the Cognitive Science Society* (Vol. 29, pp. 1385–1390). Cognitive Science Society. Austin, TX, USA.

Reese, D. S. 2002: «On the Incised Cattle Scapulae from the East Mediterranean and Near East». *Bonner Zoologische Beitrage,* 50, 183-198.

Reeve, R., and Humberstone, J. 2011: «Five- to 7-year-olds' finger gnosia and calculation abilities». *Frontiers in Psychology*, 2, Article 359. *doi: 10.3389 / fpsyg.2011.00359*

Reips, U. D. and Waldmann, M. R. 2008: «When Learning Order Affects Sensitivity to Base Rates Challenges for Theories of Causal Learning». *Experimental Psychology*; Vol. 55(1):9–22. DOI 10.1027/1618-3169.55.1.9

Rilling, J. K., Glasser, M. F., Preuss, T. M., MA, X., Zhao, T., Hu, X. and Behrens, T. E. 2008: «The evolution of the arcuate fasciculus revealed with comparative DTI». *Nature Neuroscience*, 11 (4), 426-428. *doi: 10.1038 / nn2072*

Rivera, A. 2015: «Arqueología de las emociones». *Vínculos de Historia*, 4, 41-61. *http://www.vinculosdehistoria.com/index.php/vinculos/article/view/149/144*

Rivera, A. and Menéndez, M. 2011: «Las conductas simbólicas en el Paleolítico. Un intento de comprensión y análisis desde el estructuralismo funcional». *Espacio, Tiempo y Forma,* Nueva temporada, 4. *http://revistas.uned.es/index.php/ETFI/article/view/10739/10277*

Rivera, A. and Rivera, S. 2017: «Estudio transdisciplinario de la autoconciencia». *Ludus Vitalis*, 25 (48), 155-180. *http://www.ludus-vitalis.org/ojs/index.php/ludus/article/view/757/763*

Rivera, A. and Rivera, S. 2019 «Mechanisms of cognitive evolution of the Homo genus». *Ludus Vitalis*, 27 (51), 1-22. *http://www.ludus-vitalis.org/ojs/index.php/ludus/article/view/840*

Robson, E. 2007: «Mesopotamian Mathematics». In V. Katz, ed., *The Mathematics of Egypt, Mesopotamia, China, India, and Islam: A Sourcebook*. NJ: Princeton University Press, pp. 57-186. Princeton.

Roepstorff, A. 2008: «Things to think with: Words and objects as material symbols. *Philosophical Transactions of the Royal Society of London: Series B. Biological Sciences*, 363(1499), 2049-2054. *doi: https://doi.org/10.1098/rstb.2008.0015*

Russell, B. 1920: *Introduction to Mathematical Philosophy*, 2[nda] edition. George Allen and Unwin, Ltd. London.

Sánchez-Cubillo, I., Tirapu Ustárroz, J. and Adrover-Roig, D. 2012: «Neuropsicología de la cognición social y la autoconciencia». In *Neuropsicología del córtex prefrontal y funciones ejecutivas*. J. Tirapu Ustárroz, M. Ríos-Lago, A. García Molina, and A. Ardila, (eds.). Viguera, 353-390. Barcelona.

Searle, J. R. 1997: *The mystery of consciousness*. The New York Review of Books. New York.

Seyfarth, R. M. and Cheney, D. L. 2013: «Afiliación, empatía y los orígenes de la teoría de la mente». *Ludus Vitalis*. 25 (40), 29-51.
doi: http://www.ludus-vitalis.org/ojs/index.php/ludus/article/view/46

Schmandt-Besserat, D. 1986: «The Origins of Writing: An Archaeologist's Perspective». *Written Communication* 3, 31-45.
doi: https://doi.org/10.1177/0741088386003001003

Schmandt-Besserat, D. 1992: *Before Writing: from Counting to Cuneiform*, vols. 2 University of Texas Press. Austin.

Schmandt-Besserat, D. 2010: «The Token System of the Ancient Near East: Its Role in Counting, Writing, the Economy and Cognition». In C. Renfrew and I. Morley, eds., *The Archaeology of Measurement: Comprehending Heaven, Earth and Time .in Ancient Societies*. Cambridge University Press, pp. 27-34. Cambridge:

Sporns, O. 2011: *Networks of the Brain*. London. The MIT Press Cambridge. Massachusetts.

Stuart-Fox, M. 2015: «The origins of causal cognition in early hominins». *Biology and Philosophy* 30 (2), 247-266. *doi: 10.1007 / s10539-014-9462-y*

Suzuki, I. K., Gacquer, D., Van Heurck, R., Kumar, D., Wojno, M., Bilheu, A. ,... Vanderhaeghen, P. 2018: «Human-Specific *NNOTCH2NL* Genes Expand Cortical Neurogenesis through Delta/Notch Regulation». *Cell.* 173 (6), 1370–1384.
doi: 10.1016 / j.cell.2018.03.067

Tang, Y., Zhang, K., Chen, S., Feng, Y., JI, J., Shen, E., Reiman, E.M. and Liu Y. 2006: «Arithmetic processing in the brain shaped by cultures». *PNAS*, 103:10775–10780. doi: *https://doi.org/10.1073/pnas.0604416103*

Tenenbaum, J. B. and Niyogi, S. 2003: *Learning causal laws.* Proceedings of the Twenty-Fifth Annual Conference of the Cognitive Science Society. American Psychological Association.

Tomasello, M. 1999: *The Cultural Origins of Human Cognition*. Harvard University Press.

Tomasello, M. and Call. J. 1997: *Primate Cognition*. Oxford University Press. Oxford.

Vanhaeren,, M., D'errico, F., Van Niekerk, K. L., Henhilwood, C. S. and Erasmus, R. M. 2013: «Thinking strings: additional evidence for personal ornament use in the Middle Stone Age at Blombos Cave, South Africa». *Journal of Human Evolution* 64 (6), 500-517. *doi: 10.1016 / j.jhevol.2013.02.001*

Varley, R. A., Klessinger, N. J. C., Romanowki, CH. A. J. and Siegal, M. 2005: «Agrammatic but numerate». *PNAS*. 102 (9):3519–3524. *doi: https://doi.org/10.1073/pnas.0407470102*

Vygotsky, L. S. 1934/1978: *Mind in Society*. MA: Harvard University Press. Cambridge.

Waddington, C. H. 1941: «Canalization of development and the inheritance of acquired characteristics». *Nature* 150: 563-565. *doi: https://www.nature.com/articles/150563a0*

Wadley, L. 2013: «Recognizing complex cognition through innovative technology in Stone Age and Palaeolithic Sites». *Camb. Archaeol. J.* 23, 163–183.
doi: https://doi.org/10.1017/S0959774313000309

Wiese, H. 2007: «The co-evolution of number concepts and counting words». *Lingua* 117, (5): 758-772. *doi: https://doi.org/10.1016/j.lingua.2006.03.001*

Wynn, T. 2009: «Hafted spears and the archaeology of mind». *Proc. Natl. Acad. Sci*. U.S.A. 106, 9544–9545. doi: *https://doi.org/10.1073/pnas.0904369106*

Zamarian, L., Ischebeck, A. and Delazer, M. 2009: «Neuroscience of learning arithmetic: evidence from brain imaging studies». *Neuroscience and Biobehavioral Reviews* 33 (6):909–925. *doi: 10.1016 / j.neubiorev.2009.03.005*

Zorzi, M. and Testoloin, A. 2017: «An emergentist perspective on the origin of number sense». *Phil. Trans. R. Soc. B* 373. *doi: https://doi.org/10.1098/rstb.2017.0043*

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