საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, 175, №1, 2007
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, 175, №1, 2007

*Semiotics & Linguistics*

# Towards Semiotics of Number

**Vyacheslav Vs. Ivanov**

*University of California, Los Angeles, USA*

**ABSTRACT. Numbers can be understood as signs the signified aspects of which (Saussurian *signifié, signatum*) constituting "the plane of content" can be translated into a special language of the mathematical theory of numbers.**


***Key words:*** *gesture numbers, numeral, written symbols.*

According to the way how the signifying side of numbers (*signifiant, signans*, *signifiers*) that is, the "plane of expression", has been shaped, it is possible to distinguish between the following types of semiotic systems of numbers.

## 1. Gesture numbers

It can be supposed that the existence of a special system of finger counting is universal. Some types of such gesture numbers exist in all the known human cultures particularly in those so-called "primitive" ones that do not know the advantage of special written signs with numerical value. Languages of gestures belong to those systems of signs that are widely used as substitutes of natural language. In modern societies gestures substitute natural phonemic language only in some pathological cases (such as the communication of deaf-mute people) as well as in some exceptional social situations (such as a prohibition to speak in connection with funerary rites of Aranta people in Australia). But the extraordinary importance of this type of semiotic systems not only for communication (particularly between tribes speaking different phonemic languages), but also for the archaic intellectual processes still might have been observed among American Indians in the XIX century. The great American anthropologist Cushing (1857-1900) who had been introduced into the mysteries of the Zuñi tribe stressed the uniformity of the gesture sign systems, particularly signs of finger counting, for different tribes of the American Indians[1]. He performed an experiment that Levi-Bruhl called possible for a genius only: he achieved the formation of *manual concepts* connected to gestures[2]. It was only in XX century that the experiment was appreciated and repeated by the great Russian film director and a forerunner of semiotics Sergei Eisenstein who was fascinated with Cushing's discovery[3].

To the semantic fields in which for a long time gesture signs had coexisted with their synonyms in natural language (originally their own linguistic names) the system of finger counting belonged. The link between counting and gestures of fingers goes back to the ancient period when the left parietal zone of the brain of the *Homo Sapiens Sapiens* has been shaped. A damage to this zone may result both in finger agnosia (incapacity to recognize one's own fingers) and acalculia (incapacity to count[4]) observed in the Gerstmann syndrome[5]. As it is found that not only fingers, but toes as well might suffer in such cases[6] one may suppose that the use both of the hands and feet as instruments for count-

[1] Cushing 1990, pp. 98-99.
[2] Cushing 1892.
[3] Eisenstein 2002; Ivanov 1998, vol. I, p. 496.
[4] Dehaene, Cohen 1991.
[5] Critchley 1966; Ivanov 1998, vol.I, pp. 421-422, 463, Mayer, Martory, Pegna, Landis, Delavelle and Annoni 1999; Gruber, Indefrey, Steinmetz, and Kleinschmidt 2001.
[6] Tucha, Steup, Smely and Lange 1997.

ing goes back to a very old time of the human intellectual and neurosemiotic development. In the systems of counting of many primitive tribes the most important numbers are 5 (designated sometimes as "hand") and 10 ("two hands"). The upper limit of counting and also a measure of the very large number is supposed to be 20 which represents the sum of both the hands (fingers) and the feet (toes). To express higher numbers some ethnic groups on the New Guinea and in other places of the world use also different additional parts of the body (elbows, shoulders etc.). Still the possibilities of such semiotic application of a set of the discrete elements of our organism are restricted. The quantity of the numbers permitted in such systems is rather small; it does not exceed several tens. Some representatives of these cultures refuse to discuss larger numbers considering them to be "inventions of the white people"[7]; such monstrous numbers are considered to be dangerous. Most native peoples of Australia and the Pacific area have continued to use similar archaic systems of body parts counting until the XX century. It may be supposed that in this particular sphere a shift to the oral language from a gesture code occurred relatively late. As Vygotsky remarked in his studies of the fossilized traces of ancient signs in the behavior of modern men, early finger counting is an elementary form of cultural arithmetic[8]. It appears both among small children in modern cities and in the ancient societies as the Egyptian one where it was necessary to show one's ability for finger counting to reach the privileged position in the Netherworld. The first historically known system of finger counting has been preserved in the Ancient Egyptian poem dedicated to this problem[9]. The Ancient Egyptian finger counting can be described in relation to the first 10 numbers in a way shown in the Table 1.

## 2. Numerals

If there is sufficient evidence to study etymology of numerals in natural languages it appears very often that they were related originally to the names of fingers, toes and other parts of the body[11], on the one hand, and to the movements necessary for making corresponding gestures (as in Zulu), on the other hand. Thus the primary role of gestures in this field of communication can be proved by historical linguistics. The relation of the numeral '5' to the name of "hand" is almost universal: it can be seen in many American Indian Languages[12] as well as in Indo-European (cf. the relation of the words like English *five- fist* and cognate forms in other related languages[13]) and in many other linguistic families of the Old World[14]. In the same semantic sphere the origin of the importance of numbers 10 (=5•2 referring either to all the fingers i.e. to two hands or to all the toes) and 20 (=5•2 + 5•2, all the fingers and all the toes, see above) can be originally sought (cf. for instance in Old Tupi *che po che py* "20 = my hands and my feet").

But later on the traces of the vigesimal count in such languages as Romance and Celtic can be explained by strictly linguistic facts as a possible substrate influence of the Basque type (having parallels also in Kartvelian and Burushaski)[15]. Early systems of counting are very important for the culture as a whole. That explains why in this part of the vocabulary there are many later borrowings and cases of loan-translation due to later cultural interference. A language of a later period may have at the same time two different systems of numerals as in Japanese where besides a native inherited structure with a kind of ablaut relations (Old Japanese *fito* '1'*: futa* "2" etc.[16]) an ancient Chinese system of numerals is used (in

[7] Frolov 1974; Ivanov 1998, vol. I, p. 466; Closs 1996. A partial interesting typological parallel may be seen in modern mathematics in the views of the intuitive school of Brower (and later in A.A.Markov's constructive mathematics) that insisted on the necessity of showing the concrete ways of building numbers rejecting the traditional view of their potential existence.

[8] Vygotsky 1978; Luria and Vygotsky 1992 (a chapter on number was written by Vygotsky).

[9] Sethe 1918, Ivanov 1998, vol.I, pp. 463-465.

[10] Neugebauer 1993.

[11] Majewicz 1981; Blažek 1999, particularly pp. 324-336 (with the conclusion that "the man is the measure of himself').

[12] Closs 1996.

[13] Gamkrelidze, Ivanov 1995, II, p. 747 (and other traces of the finger counting discussed there, pp. 746-748 with literature), Blažek 1999, pp.225-229.

[14] Blažek 1999, pp.7, 19-20, 38-39, 105 a.o.

[15] Cf. the identical inner form of Basque *laur-ogei* "80=4•20", French *quatre-vignt*, Georgian ¬ *an*-""*ogo*, Burushaski *walti altðr*. See remarks on such parallels in: Price 1992, pp.466-469; Blažek 1999, pp.333-334. The first to suggest a possible link between Basque and Burushaski was N.Ja. Marr. In his works of the early 1920s he considered them as belonging to one linguistic family called "Japhetic" that included also Yenisseyan Ket and thus in a way was comparable (with some important differences) to the "Northern Caucasian – Yenisseyan - Tibetan - Chinese" macrofamily as recently supposed by the late S.A. Starostin. Marr was also among the pioneers of broad linguistic work on numerals. He edited a first collective volume on the topic that contained his important general remarks on their relation to gestures: Marr 1927, pp.84-86. Among his numerous most intriguing unpublished materials there are interesting notes on the writing signs of Glozél (St.Petersburg Archive of the Russian Academy of Sciences, Marr, 2941/477 and 6084/ A-3032) that have still remained unexplained despite the efforts of a number of scholars (Hitz 1997-1998; 2004). The problem might be important for defining the early evolution of written symbols including those for numbers.

[16] Ivanov 1977; Blažek 1999, pp. 132-136, 328 (with bibliography).

Table 1

The Ancient Egyptian finger counting: 1-10.

| Finger | Hand | |
|---|---|---|
| | left | right |
| thumb | 1 | 10 |
| forefinger | 2 | 9 |
| middle | 3 | 8 |
| ring-finger | 4 | 7 |
| little | 5 | 6 |

a relatively archaic phonetic form of the period when it had been borrowed; these numerals are so close to the ancient Tibeto-Chinese ones that there might have been an illusion of a possibility of reconstructing unified prototypes for all these languages although Japanese had originally belonged to a completely different – Altaic-family having also some early Austronesian borrowings). Early loan-words of such a linguistic zone ("Sprachbund") type are supposed in Kartvelian forms of numerals '4' and "6" borrowed from Indo-European and in several other Kartvelian numerals (as that for "9"[17]) having exact parallels in Semitic. Due to such areal repeated borrowing of numerals some of them (as for instance the numeral '2' in a form resembling the English *two*) have been spread across different linguistic zones and leagues of languages of Eurasia and neighboring parts of the world.

In the last years a discussion has started on the place of the border seen in natural languages between basic or primitive numerals and the rest of the words of this class[18]. It can be established on the base of the systems of languages with a minimal number of numerals as well as due to the discovery of the primitive roots from which all the secondary numerals are derived in a given system; also one may use the results of the study of syntactic[19], morphological- derivational and inflectional- and etymological features of the numerals denoting the initial numbers of the natural row. In many languages the border divides the numeral "two" from the rest; the role of the dual number as a grammatical category opposed to the Singular and Plural forms is also important from this point of view (in some languages the dual forms are derived from combinations with this numeral that also plays an important role in the structure of some ancient texts[20]). In many languages of the Southern and Northern America, Oceania, Australia[21], Tasmania, New Guinea, Africa all the numbers above 2 are expressed by the combinations of the signs for the first two numbers. In Southern America there are systems with a border dividing '3' from the rest[22] (in some languages there are grammatical forms denoting three objects). Although the number 4 has been established as a limit of the human short-term memory[23], most languages showing a corresponding border belong to one (Indo-European) family. Similar data from other areas are not numerous[24]. Languages differ according to which numbers are chosen as primitive (basic) and what are the principles of their combinations in higher order (secondary) numerals. One language may use two principles simultaneously: in Sumerian there are traces both of a quinary system of counting (as in *i-min* "7": *i*"5"; *min* "2") and a ternary one (using for counting days for instance)[25].

In an overwhelming majority of the oral (natural) languages there are special words expressing numbers. Recently it has been supposed that numerals do not exist at all in such an Amazonian language (of the Muru family) as Pirahã [26]. But it may be supposed that still in this language there are words for 1 and 2 although they have also meaning "small, little" (Pirahã *hói* with a falling tone)

[17] Marr 1925, pp. 74, 77; Klimov 1967; Blažek 1999, pp. 80-88.

[18] Hurford 1987, 2001; 2003; Dehaene, Mehler 1992; Dehaene 2001; Rutkowski 2003; Hammarström 2004, Heine 1997. From previous works one should consult first of all Greenberg 1978, Gonda 1953; McGee 1897-1898.

[19] On syntactic peculiarities of the Indo-European numerals in which the group 2-3-4- is opposed to 5…-(as in Modern Russian *dva, tri, chetyre cheloveka* "2.3,4 +Genitive Singular of the dependent noun 'man'", but *five lyudey* "5..+ Genitive Plural 'men'") cf. Ivanov 1996, p.705 (with the literature).

[20] Ivanov 1996, p. 712.

[21] For semiotic studies a comparison of the role of the binary numerical structures with the numeral '2' in Australian languages (Dixon 1980, cf. Curr 1886-1887) and dual anthropological systems is important.

[22] Greene 1997. On American Indian as a whole cf. also Closs 1996.

[23] Cowan 2001; Rutkowski 2003.

[24] Hammarström 2004. Cf. Hurford 1987; 2001; 2003; Beeler 1967, 1986; Grasso 1939. Especially intriguing seems the etymology of the Hittite kutri - «number» < *"4" (Ivanov 1998, vol. I, p. 526).

[25] Diakonoff 1983; Blažek 1999, p. 331.

[26] Gordon 2004; Everett 2005; Ivanov 2005.

Table 2

An example of designation of numbers in Pirahã (according to P. Gordon, K.Everett and P.Everett)

| Number of objects | Quantitative words for numerals | Finger numbers |
|---|---|---|
| 1 | *hói* "very small number or size, 1" | - |
| 2 | *hoí* «a larger number or size, 2» | 2 |
| 3 | *hoí* «a larger number or size», 2»+ *bá à gì sò* «many» | 3 |
| 4 | *hoí* «a larger number or size, 2»+ *bá à gì sò* «many» | 5/3[27] |
| 5 | *bá à gì sò* «many» | 5 |
| 6 | *bá à gì sò* «many» | 6/7 |
| 7 | *hói* «very small number or size, 1» | 1 + 5/8 |
| 8 | - | 5/8/10 |
| 9 | *bá à gì sò* «many» | 5/10 |
| 10 | - | 5 |

and "a larger quantity" (Pirahã *hoí* with a rising tone). All the other numerals (that did exist in the extinct languages of the Muru family) seem to have disappeared. It can be supposed that in such exceptional cases the differences are expressed mainly through gestures, as numerals are not sufficient for a non-ambiguous description of the numbers, see the Table 1.

Not only in Pirahã, but also in some other languages of this part of the Western Amazonian area as in Munduruku (Tupi-Guarani family) the numerals express only the first two whole numbers (1 and 2), the rest is described by reference to the hand gestures and their combinations[28], see Table 2.

In these Amazonian languages the ability to perceive differences between few things and a much larger amount has been preserved, but as a more qualitative one[29]. The numerals are not used to express this shade of meaning. As recent studies in zoosemiotics have shown several species of animals (starting with some fishes and birds and going up the evolutionary ladder to dolphins and apes[30]) can give an approximate evaluation of quantity that seems to be present also in small children in the very early period of their intellectual development according to Piaget[31]. This archaic ability is known in the primitive tribes the members of which can easily check the wholeness of a certain set of objects (for instance, a herd of cattle) without counting them. For this capacity to be realized the numerals are not necessary and that may be one of the reasons of their disappearance[32] in some primitive languages as in Pirahã. In archaic mythological stories while speaking of very large numbers the authors use an expression like "there was no way to count (them)" (e.g. Hurrian *širi-manga tid-i-bade*= Hittite *kappuwa-uwar* NU.GÁL in an Old Hurrian-Middle Hittite bilingual text[33]); such large numbers are typical for mythological exaggeration; that is why absence of mythology in South American traditions like the one known through Pirahã texts may be responsible for the lack of numbers above very small ones. A series of experiments has demonstrated the difference between two mental concepts of quantity; the one that defines an exact number of objects and another one that evaluates their approximate magnitude (that might be very large, but is not represented by numerical symbols)[34]. The modern systems of count-

[27] A metalinguistic notation / means switching from one finger to another in the framework of one complex gesture, + means juxtaposition of two finger gestures.

[28] Pica, Lemer, Izard, Dehaene 2004 (cf. Crofts 1973, p.160, NN 213-217, for a description of a previous state of the language). Compare the recent investigation of the semiotic spatial (geometric) notions of the same tribe: Dehaene, Izard, Pica, Spelke 2006.

[29] Gelman and Gallistal 2004.

[30] Davis and Pérusse 1988; Boysen and Copaldi 1993; Gallistel 1990; Dehaene 1997; Dehaene, Molko, Cohen, Wilson 2004; Wiese 2003, pp.95-107. At the same time it is possible to train monkeys and apes to use numerical symbols: Matsutzawa 1985; Brannon and Terrace 1998.

[31] Wiese 2003, pp.151-179.

[32] See on this process also Schuhmacher 1975.

[33] See the text with comments and further bibliography: Wegner 2000, S. 186-188. Jaan Puhvel has found a wonderful etymology of the Hittte *kappuwa* - 'count' which he had identified to Latin *com-putŭ* (<**kom*-+*pu*-), Puhvel 1997. It can suggest an ancient Indo-European prototype for the modern term for "computer" (in Hittite most contexts for the word were of a ritual and mythological type).

[34] Fias, Lammertyn, Reynvoet, Dupont and Orban, 2003; Dehaene, Cohen 1991; Dehaene, Molko, Cohen, Wilson 2004.

Table 3

Numbers and quantitative words in Munduruku (after Pica, Lemer, Izard, Dehaene)

| Number, quantity | Word | Meaning and the inner form |
|---|---|---|
| 1 | *pūg, pūg ma* | 1 |
| 2 | *xep xep eba* | 2<br>2 hands |
| 3 | *eba- pūg* | 3=2 hands +1 |
| 4 | *eba-dip-dip* | 4=2 hands +1+1 |
| 5 | *pūg pōgbi* | 1 hand |
| Words designating quantity | *adesū* | «few » |
| | *burumākū* | «small quantity» |
| | *ade* | «many» |

ing combine these two approaches[35] called by Leibniz who had first discovered them as continuous versus discrete. Modern methods to evaluate quantity in an approximate manner have been enriched by the use of computers. At the same time for the modern scientific view of the world a definition of several very large numbers seems particularly important[36].

To understand cultural differences in number representation grammatical features of numerical expressions are important. In the area of Western Brazil to which Pirahã belongs usually numerical expressions are used in verbal constructions only: Arara Caro *ma'wit ip #iy matet iagárokûm-nem* "yesterday a man has (in a "binary" manner) caught [two] fishes"[37]; Hixcaryana *nyamoro marma n-oknomtxowni asako marma* «they have remained, only [two] (of them) remained in a dual way»[38]. This areal feature may be connected to a dominant role of verb as opposed to noun in Amazonian and other American Indian languages[39]. In Kwaza (a language of the Pirahã zone according to Cysoew) verbs are built on the base of numerals: *ka'nwã aky-'kai e'mã ele'le-tse* «a car has over-two-leg (classifier)-three (= four wheels)"[40]. I in Paumari (a language of the same zone) a verbal prefix (*vi-*, 3 Person Plural.) appears in a numeral: *vi-kha-mai-'a-ha adani ija'ari vi-'bami-ki* «the people has come to a neighboring house- there were three of them»[41]. It seems that the development of mathematics as a science has been made possible in those languages where the numbers were represented as nouns similar to words for objects (in Frege's sense) and not to predicates.

## 3. Paleolithic Tallies and Notches

The oldest archaeological traces of a visual system (outside the human body) that encoded the earlier finger count are supposed to be seen on the Paleolithic monuments. According to an important hypothesis put forward almost simultaneously by Marshack[42] and Frolov[43] the oldest tallies have numerical function. Tallies and notches that were made with straight lines at the earliest period were divided into sets in each of which there were 5 or 10 members. That makes a comparison to finger counting probable. Marshack supposes that some groups of signs represent a lunar calendar. If these signs started to be related to some objects in the skies one might think of the beginning of the use of such representations of numbers in paleoastronomy. Later on it might have led to building of some structures of the Stonehenge type where the number code had been represented in a more complex manner.

## 4. Tokens (three-dimensional signs)

At the early Neolithic time the development of prewriting devices was caused by the new functional needs of a growing food-producing society. As supposed by Schmandt-Besserat[44] tokens considered by her as the first precursors of writing appeared after the Neolithic revolution in connection with the necessities of developing economy of production.

In several natural languages numerical quantifiers exist. They are used with specific nouns denoting

[35] Spelke, Tsivkin 2001.
[36] Rees 1999.
[37] Dryer 2005, p. 363; Cysouw n.d.
[38] Derbyshire 1986, p. 292, Supplement, sentence 65.
[39] Cf. Ivanov 1988, p. 122-124; 1996, p. 707; 1997; Sasse 1993. In the languages of Siberia a similar picture is seen in Yukagir where both numerals and adjectives are rendered as verbs.
[40] Van der Voort 2004, p. 215. In Kwaza (as also in Pirahã) the old names of fingers have disappeared and the number has not been expressed grammatically.
[41] Chapman and Derbyshire 1991, p.255.
[42] Marschak 1991.
[43] Frolov 1974.
[44] Schmandt-Besserat 1992.

objects to be counted. A similar tactile and visual three-dimensional system has been developed after the Neolithic revolution covering the whole area of the Ancient Near East. The main step in developing this notation had consisted in the representation of the tokens on the envelope containing the signs themselves. The cuneiform writing in its primitive form started from these "metasemiotic " two-dimensional signs representing the three-dimensional sculptured ones; they included signs for number of certain important objects.

## 5. Written Symbols

The earliest known systems of writing used mostly logograms[45] to represent numbers; only in some rare cases the numerals were written in a phonetic (syllabic) way; typologically it is similar to the predominant use of logograms to represent numbers in the modern alphabetic systems of writing.

Some of the written signs used in classical antiquity and inherited by later European cultures have preserved old features transferred from the earlier signifiers. The subtractive inner structure of such Roman signs as IV (=5-1) and IX (=10-1) is based on the subtractive principle used in many Etruscan numerals that influenced the Roman representation of numbers. This subtractive principle continued one of the possible variations of the finger counting in some Eurasian languages[46]. It is possible that Etruscans brought this feature of their numerals (in the oral language as well as in writing) from Asia Minor where such written forms are known in the ancient Lycian tradition of representing numerals.

From a semiotic point of view, one can consider the culture of Athens as belonging to an ***alphabetic type***, as distinguished from the predominantly ***hieroglyphic type*** of almost all the preceding large cities in the history of culture. The use of a relatively small system of discrete elements, the combination of which causing all following steps to be deduced, is important not only for alphabetic writing, but also for the development of other related semiotic systems such as mathematics, logic, philosophy. The coincidence of some basic features of the main semiotic systems is revealed in the formal connection between alphabetic order and the natural row of numbers: $\alpha = 1$, $\beta = 2$, $\gamma = 3$, etc.; also compare the use of linguistic metaphors to clarify the atomic concept of the world as consisting of the combinations of οτοιχεῖα "elements". In a later development of some alphabetic systems that descend from the Greek one most signs have preserved both phonetic and numeric value, but some symbols ("episemons") that were not used phonetically still retained numerical values[47]. From the notional point of view (of the plane of content) among the new concepts that were introduced into the highly developed systems of the ancient cultures of the Old and New World the sign for zero is particularly interesting. For the semiotic study it seems important that the Old Indian sign for the zero º (Sanskrit *úûnya-cakra-* "zero=empty- circle") is used in the two branches of ancient knowledge that had flourished in India several thousand years ago: in mathematics and linguistics[48] (where one still speaks of a zero ending of a word continuing the discovery of the Ancient Indian linguists). On this example one may see that the studies of the history of numbers in general may become important for these sciences as well as for other disciplines close to semiotics.

[45] Gelb 1952.
[46] Ivanov 1977 (with literature).
[47] Gamkrelidze 2006, p. 183.
[48] Kaplan 1999, pp.41-48; Ifrah 2000, pp.368-406, 433, 437-438, 483, 509, 534 ; Ivanov 2004, p. 9, fn.3.

*სემიოტიკა და ენათმეცნიერება*

# რიცხვის სემიოტიკის შესახებ

**ვიაჩესლავ ივანოვი**

*კალიფორნიის უნივერსიტეტი, ლოს-ანჯელესი, აშშ*

**„რიცხვი“ შეიძლება განხილულ იქნეს როგორც „ნიშნები“ სემიოტიკური გაგებით, რომელთა „აღსანიშნები“ (სოსიურის *signifié, signatum*), ენის „შინაარსის პლანის ერთეულები — შესაძლებელია თარგმნილ იქნეს რიცხვთა მათემატიკური თეორიის ენაზე. იმისდა მიხედვით, თუ როგორ გამოიხატება „რიცხვი“ (*signifiant, signans*), ე.ი. თუ როგორ ფორმდება „რიცხვთა გამოხატულების პლანი“, შესაძლებელია გამოვყოთ რიცხვთა სემიოტიკური სისტემის შემდეგი ტიპები:**

**1. ჟესტებით გამოხატული რიცხვი;**
**2. რიცხვითი სახელები;**
**3. პალეოლითური პერიოდის ზეზე ამოჭრილი ნაჭდევები;**
**4. სიმბოლოები (სამგანზომილებიანი ნიშნები);**
**5. წერილობითი ნიშნები.**

**განიხილება „რიცხვთა“ აღწერილი ტიპების მაგალითები სხვადასხვა სისტემის ენებში.**

## REFERENCES

Beeler, M.S. (ed.) The Ventureño Confesario of José Señan. The University of California Publications in Linguistics. Vol.47. Berkeley: University of California Press, 1967.

Beeler, Madison S. Chumash Numerals. Native American Mathematics. Austin: Texas University Press, 1996 (paperback printing), pp. 109-128.

Blažek, Václav. Numerals. Comparative- etymological analyses and their implications (Saharan, Nubian, Egyptian, Berber, Kartvelian, Uralic, Altaic and Indo-European languages). Opera Universitatis Masarykianae Brunensis Facultas Philologica, è.322. Masarykova Univerzita v Brnì, 1999.

Boysen, S.T. and Copaldi, E.G. The Development of numerical Competence : animal and human Models. Hillsdale, NJ: Erlbaum. 1993.

Brannon, E.M.and Terrace, H.S. Ordering of Numerosities 1 to 9 by Monkeys. Science,1998, 282 (5389), pp. 746-749.

Chapman, Shirley and Desmond C. Derbyshire. Paumarí. Handbook of Amazonian Languages. Vol. 3. Ed.Desmond C. Derbyshire and Geoffrey K. Pullum. Berlin: Mouton de Gruyter, 1991, pp.160-351.

Closs, Michael P. Native American Number Systems. Native American Mathematics. Austin: Texas University Press, 1996 (paperback printing), pp. 3-43.

Cowan, D. The magical number 4 in short-term memory.: A reconsideration of mental storage capacity. Behavioral and Brain Sciences, 24, 2001, pp.87-114.

Critchley, M. The Enigma of Gerstmann's Syndrome. Brain. 1966 Jun;89(2):183-98.

Crofts, Marjorie. Gramática mundurukú. Brasília, 1973.

Curr, E.M. The Australian Race. London, 1886-1887.

Cushing, Frank Hamilton. .Manual Concepts: the study of the influence of hand usage on culture-growth. American Anthropologist, 5, 1892, pp. 289-317.

Cushing, Frank Hamilton. The Correspondence and Journals 1879-1884. "Cushing at Zuni", ed. Jesse Green. Albuquerque; University of New Mexico Press. 1990.

<Cysouw, Michael>. Area centered on Pirahã. <http://email.eva.mpg.de/~cysouw/pdf /cysouwKOELNAPPENDIX> n.d.

Davis, H. and Pérusse, R. Numerical Competence in Animals: Definitional Issues, Current Evidence and a New Research Agenda. Behavioral and Brain Sciences, 11, 2, 561-615, 1988.

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

Dehaene, S. Author's Response. Is Number Sense a Patchwork?// Mind and Language. 16, N.1, 89-100, 2001.

Dehaene, S., Cohen, L. Two mental calculation system: a case study of severe acalculia with preserved approximation. Neuropsycholgia, 29(11), 1045-1074, 1991.

Dehaene,S., Izard, V., Pica, P, Spelke,E. Core knowledge of geometry in an Amazonian indigene group. Science, January 2006, 311(5759):381—384.

Dehaene, S., and J. Mehler. Cross-linguistic regularities in the frequency of number words. Cognition, 43, 1992, pp. 1-29.

Dehaene,S., Molko, N., Cohen, L. and Wilson, A. J, Arithmetic and the Brain. Current Opinion in Neurobiology, 14, 2004, pp. 218-224.

Derbyshire, Desmond C. Topic Continuity and OVS Order in Hixcaryana. Native South American Discourse, ed. J.Sherzer, G. Urban. Berlin: Mouton- de Gruyter,1986, pp. 237-306.

Diakonoff , Igor M. Some reflexions on numerals in Sumerian: towards a history of mathematical speculation. Journal of the American Oriental Society, vol. 103, 1983, pp. 83-93.

Dixon, R. Australian Languages. Cambridge, 1980.

Dryer, Matthew S. Order of Numeral and Noun.// World Atlas of Lingustic Structures. 89. Berlin, 2005, pp. 362-363.

Eisenstein, S.M. Metod. Pt.I. Grundproblem.(Method. Pt.I. The Main Problem). Moscow: Muzei kino/Eisenstein-Center, 2002.

Everett, Daniel L. Cultural Constraints on Grammar and Cognition in Pirahã. Current Anthropology, vol.46, N4, August-October 2005, pp. 621-646.

Fias, W. , Lammertyn, J., Reynvoet, B., Dupont, P. and Orban, G. A.

Parietal Representation of Symbolic and Nonsymbolic Magnitude. Journal of Cognitive Neuroscience, January 1, 2003; 15(1): 47 - 56.

Frolov, B.A. Chisla v grafike Paleolita (Numbers in Paleolithic Drawings). Novosibirsk: Nauka, 1974.

Gallistel C.R. The organization of learning. Cambridge, Mass. :MIT Press, 1990.

Gamkrelidze, Thomas. Typology of writing, Greek alphabet and alphabetic scripts of the Christian Orient.// Gamkrelidze, Thomas. Selected Writings. Linguistic Sign, Typology and Language Reconstruction, Innsbrucker Beiträge zur Sprachwissenschaft, Bd.122, Ed. Ivo Hajnal. Innsbruck, 2006.

Gamkrelidze, Thomas, Ivanov, Vyacheslav. Indo-European and the Indo-Europeans. Vol. I, II. Berlin/NewYork: Mouton- de Gruyter, 1995.

Gelb, I.J.. A Study of Writing : The Foundations of Grammatology. Chicago: The University of Chicago Press. 1952.

Gelman R. and Gallistal C.R. Language and the Origin of Numerical Concepts. Science, vol. 306, 2004, N 5695, pp. 441- 443.

Gonda, J. Reflections on the Numerals 'One' and 'Two' in the Ancient Indo-European Languages . Utrecht: A.Oosthoek, 1953.

Gordon, P. Numerical Cognition without Words. Science, 2004, N 306 (5695), pp. 496-499.

Grasso, D.E. I. Las numeraciones cuaternarias, Boletín de la Academía Argentína de Letras, VII, 28, pp. 585-606.

Green, D. Diferenças entre termos numéricos en algunomas linguas indígenas do Brasil. Boletin do Museu Paruense Emílio Goeldí. Série antropologia, 13, 1997, N2, pp. 179-207.

Greenberg, J. Generalizations about Number Systems. Greenberg, J. (ed.) Universals of Language, vol.3, Cambridge, Mas.: MIT Press, 1978, pp. 250-295.

Gruber, O., Indefrey, P., Steinmetz, H., and Kleinschmidt, A. Dissociating Neural Correlates of Cognitive Components in Mental Calculation. Cerebral Cortex, April 1, 2001; 11(4), pp. 350 - 359.

Hammarström, Harald. Properties of Lower Numerals and their Explanation: A Reply to Pawel Rutkowski. Journal of Universal Language, 5, N 2, 2004, pp. 1-20.

Heine, B. Cognitive Foundations of Grammar. Oxford: University Press, 1997.

Hitz, H.-R. Les inscriptions de Glozél: Essai de déchiffrement de l'écriture. I-II. Erlangen: éd. De l'auteur, 1997-1998.

Hitz, H.-R. Étude comparative des inscriptions de Glozél. Actes du 6ème Colloque Internationale Glozél. Vichy, 2004, pp. 39-65.

Hurford, J.R. Language and Number. Oxford: Basill Blackwell, 1987.

Hurford, J.R. Languages treat 1-4 specifically : Commentary on Stanislas Dehaene's précis of The Number Sense. Mind and Language, 16, 2001, N. 1, pp. 60-75.

Hurford, J.R. The Interaction between Numerals and Nouns. Plank, F. (ed.) Noun Phrase Structure in Languages of Europe. (Empirical Approaches to Language Typology),Vol. 20-7. Berlin: Mouton-de Gruyter, 2003.

Ifrah, G. The Universal History of Numbers. New York: John Wiley and Sons, Inc., 2000.

Ivanov, Vyacheslav V. K tipologii chislitel'nykh pervogo desjatka v iazykakh Evrazii (On the typology of the first ten numerals in the languages of Eurasia). Problemy lingvisticheskoj tipologii i struktury iazyka. Moskva-Leningrad, 1977, pp.36-41.

Ivanov, Vyacheslav V. Sovremennye problemy tipologii (k novym rabotam po amerikansko-indeyskim iazykam basseina Amazonki). [Modern Problems of Typology (on the new works on the American Indian languages of Amazonia)]. Voprosy Jazykoznanija, 1988, 1, pp. 118-131.

Ivanov, Vyacheslav V. Iz zametok o praslavyanskikh i indoevropeyskikh chislitel'nykh. (From the Notes on Slavic and Indo-European Numerals). Russistika. Slavistika. Indoevropeistika. Sbornik k 60-letiju A.A. Zalizniaka. Moscow: Indrik, 1996, pp.704-727.

Ivanov, Vyacheslav V. Imya ili glagol?Variacii na temu statyi G.O. Vinokura "Glagol ili imya/")(Noun or Verb? Variations on the Topic of G.O.Vinokur's article "Verb or Noun ?"). Forschungen zur Linguistik und Poetik: Zum Andenken an Grigorij O.Vinokur (1896-1947). Frankfurt am Main: Peter Lang, 1997, SS. 37-46.

Ivanov, Vyacheslav V. Izbrannye trudy po semiotike i istorii kul'tury (Selected Works on Semiotics and History of Culture). Vol.I. Moscow, yazyki russkoi kul'tury, 1998.

Ivanov, Vyacheslav V. Lingvistika tretjego tysyacheletiya (Linguistics of the third millennium). Moscow' Jazyki russkoy kul'tury, 2004.

Ivanov, Vyacheslav V. Tipologiya jazykov bassejna Amazonki. I I.Chislitel'nye i schet (Typology of the languages of Amazonia. I I, Numerals and Counting). Voprosy Jazykoznanija, 2005, 5.

Kaplan,R. Nothing that is: a natural history of zero. Oxford; University Press. 1999.

Klimov, Georgii A. Zaimstvovannye chislitel'nye v obshchekartvel'skom?(Borrowing of Numerals in Kartvelian?) //Etimologija 1965, Moscow: Nauka, 1966, pp. 306-310.

Luria, Alexander R. and Vygotsky, Lev S. Ape, Primitive Man, and Child. Essays in the History of Behavior (Classic Soviet Psychology). Orlando, Florida; Paul M.Deutsch Inc., 1992.

McGee, W.J. Primitive Numbers. Bureau of American Ethnology. Annual Report, 19, 2, 1897-1898, pp. 821-851.

Majewicz, Alfred P. Le role du doigt et de la main et leurs designations dans la formation des systèmes particuliers de numération et des noms des nombres dans certaines langues. La main et doigt dans l'expression linguistique. II,éd. F, Sivers, Paris: SELAF, 1981, pp. 193-212.

Marr, Nikolai Ja. Grammatika drevneliteraturnogo gruzinskogo iazyka. Materialy po iafeticheskomu iazykoznaniju 12. Leningrad, 1925.

Marr, Nikolai Ja. Predislovie. O chislitel'nykh (K postanovke geneticheskogo voprosa) [Preface. On Numerals {Towards putting a Question about the Origins}]. Jazykovednye problemy po chislitel'nym. (Linguistic Problems seen through Numerals) Sbornik statej (A Collection of Articles). Leningrad: izdanie Instituta literatury Zapada i Vostoka pri Leningradskom Gosudarstvennom Universitete. 1927, pp. V- X I I I , 1-96.

Marshack, A. The Roots of Civilization, the Cognitive Beginnings of Man's First Art, Symbol and Notations. 2nd edition, revised and expanded. Mt. Kisco, NY: Moyer Bell Limited New York, 1991.

Matsutzawa, T. Use of Numbers by a Chimpanzee. Nature, 1985, N 315(6014), pp.57-59.

Mayer, Eugène, Martory, Marie-Dominique, Pegna, Alan J., Landis, Theodor, Delavelle, Jacqueline and Annoni, Jean-Marie. A pure case of Gerstmann syndrome with a subangular lesion. Brain, June 1, 1999; Volume 122, Number 6, pp. 1107-1120.

Neugebauer, Otto. The exact Sciences in Antiquity. New York: Barne & Noble Books, 1993 (2 ed.).

Pica P., Lemer C., Izard V., Dehaene S. Exact and approximate Arithmetic in an Amazonian Indigene Group. Science, vol. 306, 2004, N 5695, pp. 499-503.

Price, Glanville. Romance. Indo-European Numerals. Ed. J.Gwozdanoviæ. Berlin/New York: Mouton de Gruyter, 1992, pp. 447-496.

Puhvel J. Hittite Etymological Dictionary. Vol.IV. Words beginning with K. Berlin/New York: Mouton de Gruyter,1997.

Rees M. Just Six Numbers. London, 1999.

Rutkowski, Pawel. On the universal neuropsychological basis of the syntax of numerals. Journal of Universal Language, 2, 2003, pp. 147-182.

Sasse, H.-J. Das Nomen – eine universale Theorie? Sprachtypologie und Universalienforschung. !993. Bd.46, Heft 3, SS. 187-221.

Schmandt-Besserat, Denise. Before a Number. Austin: University of Texas Press, 1992.

Schuhmacher W.W. On the Liquidation of Numerals in"Primitive' Societies. Dialectal Anthropology, 1(1), 1975, pp.94-95.

Sethe, K. Ein altägyptischer Fingerzählreim. Zeitschrift für ägyptische Sprache. Bd. 54, 1918, SS.16-39.

Spelke, E.S., Tsivkin, S. Language and Number: a bilingual training study. Cognition, 78, 2001, pp. 45-88.

Tucha, O., A. Steup, A., Smely, C. and Lange, K. W. Toe agnosia in Gerstmann syndrome. Journal of Neurology, Neurosurgery, Psychiatry, September 1, 1997; 63(3), pp. 399 – 403.

Van der Voort, Hein. A Grammar of Kwaza. Mouton Grammar Library 29. Berlin: Mouton de Gruyter, 2004.

Vygotsky, Lev S., Mind in Society: The Development of Higher Psychological Processes. Edited by Michael Cole et al. Cambridge, MA: Harvard University Press, 1978.

Wegner, Ilse. Einführung in die hurritische Sprache. Wiesbaden: Harrassowitz, 2000.

Wiese, Heike. Numbers, Language, and the Human Mind. Cambridge: University Press, 2003.

*Received January, 2007*