THE NUMERICAL SYSTEM OF GREEK SIGN LANGUAGE (GSL)

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Introduction

Since the beginning of human life on earth, man needed to express countable multiplicity so he created the symbolic language of numbers known as numerical systems. Throughout time quite a few numerical systems have been developed. Mathematicians studying these numerical systems of spoken languages have categorized them into 3 types: cumulative or merely cumulative or additive, positional and mixed numerical systems.

We consider language as a three set system:
- a finite set of signs or symbols called the alphabet
- a finite set of syntax rules. Rules that determine the order in which the elements of the alphabet constitute permissible (grammatically correct) sequences or rules that are internal combinatorial laws in a signal set-codes or a naturals language syntax rules.
- a set of labeling or semantic rules. Rules that attach importance to each element or compound of elements of the alphabet which are involved in the formation of an permissible sequence (word) and also to the whole sequence.

The combined application of syntactic and semantic rules on the vocabulary is a realization of the language that result to the realization of word. Word, this human communication process whichever the mean, the alphabet is distinguished into written if the alphabet is a set of graphs, verbal if the alphabet is a set of phonemes and signed if the alphabet is a set of signs, as in the case of GSL .

The syntax rules of artificial languages and certain natural languages, with artificial features, are been described by formal rules. The theory of genetic transformations grammars of Chomsky is one of the theories describing such languages. Grammar is defined as an ordered quartet consisting of the alphabet, a start symbol, a few more symbols of variables and some production rules. These rules are of the form $X \rightarrow Y$ and are understood as the command "write the symbol Y in place of the symbol x". A set of such rules fully describes the syntax rules of a formal language. The complexity of these rules is related with the complexity of the syntax of the language. The simplest languages in Chomskys' hierarchy are those governed by linear production rules and called regular languages.
The languages that man shaped to express his countable multiplicity are the very specific languages of numbers known as numerical systems. These are the oldest formal languages.

1. cumulative or merely cumulative or additive systems

In cumulative systems each sequence of symbols from the alphabet is acceptable (indicates a number) even if users had every time a preference in the order of writing the symbols. It is languages free from the context. Such systems are: the Minoan, the Egyptian, the Babylonian, the Ionic.

The Minoan numeric system has:

Alphabet:

| , — , O , ◇ , ◇
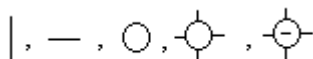
Syntax   Rules:
a)   Apposition   of   symbols   with   virtually   no   restrictions
b) Every ten symbols of a class are replaced by the symbol of the next class. The symbol
| is the first class, the – the second class and the remaining the third, the fourth, the fifth
respectively.

Semantic Rules: It is a decimal system. For the representation of the natural numbers the
modern notation is used:

(| ,1), (—, 10), (O, 100), (◇ , 1000), (◇ ,10000)

So the signified ◇◇◇OOO — | | | , is the number 12313.

   2. positional systems

The positional systems are bound by the context regular languages. Such is the current in
use numerical system.

Alphabet: S = {0,1,2,3,4,5,6,7,8,9}

Syntax Rules: Any sequence of elements is acceptable (i.e. 'word') only if it has not as a
first symbol on the left the symbol 0, except 0. Symbolizing with S´ the set of words, with
S´ ⊆ S *, where S * denotes the set of all possible sequences of elements of S.
The regular expression that describes it is: {0} {1,2,3,4,5,6,7,8,9} · {0,1 , 2,3,4,5,6,7,8,9} *
We note with · the act of tile sets.

Semantic Rules: All the semantic rules described by the semantic function f: S → N, where
S is the set of permissible (good grammar) sequences from S and N is the set of natural
numbers, containing 0.
With a_i ε S, the type of the function is:

$$f(a_n a_{n-1}\ a_2 a_1 a_0) = a_n 10^n + a_{n-1} 10^{n-1} + ... + a_2 10^2 + a_1 10^1 + a_0 10^0$$

   3. mixed systems

Mixed numerical systems are a combination of the cumulative and the positional ones, as
syntax rules are concerned.

Purpose
The purpose of this study was to record, analyze and categorize the numerical system of
Greek Sign Language.

Method
In this survey data was collected from nine (9) deaf and hard of hearing Greek sign
language teachers and six (6) Greek sign language interpreters from Patra, Athens and
Thessaloniki, four (4) deaf and hard of hearing university students from Patra and Athens
as well as a (1) deaf teacher of mathematics and a (1) deaf student at the University of
Athens, Department of Mathematics. They were asked, while digitally recorded, to sign

numbers using the numerical system they use in their everyday life in GSL. The numbers they were asked to sign were from 0 to 100 in ones, from 100 to 900 in hundreds and from 1000 to 1000000 in thousands.

Results

All subjects signed all numbers in GSL in more or less the same way. The differences have to do with the geographical part of Greece, where the participants are living. Like every other language, in GSL we can see some differences in some signs throughout the country, that have to do with the geographic area of Greece where deaf and hard of hearing people live.

Apart from the normal way of signing numbers, GSL has also signs for numbers that are usually signed with two hands with only one hand and some special signing for some specific numbers.

Ones: The key numbers, i.e. 0,1,2,3,4,5,6,7,8,9 in GSL are formed by the plurality of fingers with the right hand, then with both. The number 0 is singed using all fingers of the right hand. We form the chirality of the letter 'O' with the right hand in front of the height of the right shoulder. Chirality of the letter 'O' is signed by forming with all the fingers a small circle (photos A1).

Number 1 (photos A2) is formed with the right palm, the index finger stretched upwards and the hand at the height of the right shoulder. In a similar manner are formed the numbers 2,3,4,5. Number 2 (photos A3) with the index and the average finger, number 3 with the index, the average and the ring finger, number 4 with the index, the average finger, the ring and the little finger and of course number 5 with all five fingers of the right hand. In all figures the fingers of the palm "look" (palm orientation) towards the torso of the individual that signs and are not joined together.

Photos A1 (number 0) – A2 (number 1) – A3 (number 2)
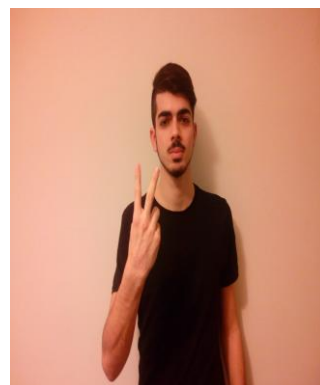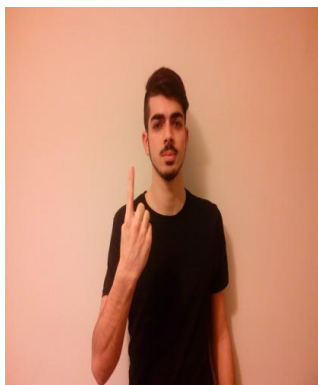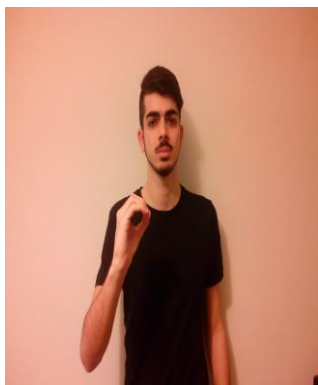
Number 6 (photos B1) is formed by keeping the left hand to a height in front of the left shoulder and the right hand in front of the right shoulder with the thumb finger stretched upwards. Figures 7, 8 and 9 are formed in a similar manner except that we use not only the thumb finger but also the index finger for number 7, the index and average fingers for number 8 (photos B2) and the index, the average and the ring fingers for number 9. In all figures the fingers of the palm "look" (palm orientation) towards the torso of the individual that signs and are not joined together. Numbers 6, 7, 8 and 9 can also be signed without the use of the left hand.

Photos B1 (number 6) – B2 (number 8)
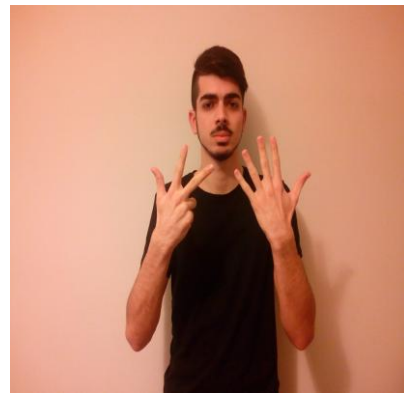
In the area of Thessaloniki number 9 has a unique way of been singed. By using the index finger you form the "tale" of number 9.

Tens: Tens are formed by maintaining the chirality indicating the plurality of the numbers and position of the corresponding number in ones but with making a small movement by closing and opening the fingers of the right hand twice. For the numbers 60, 70, 80 and 90 we close and open both hands.
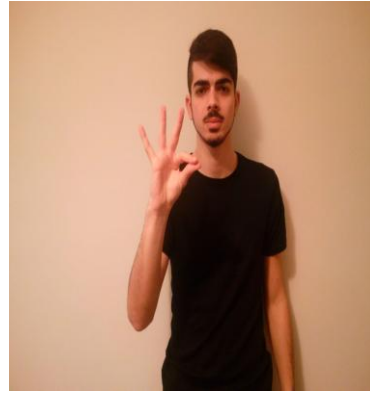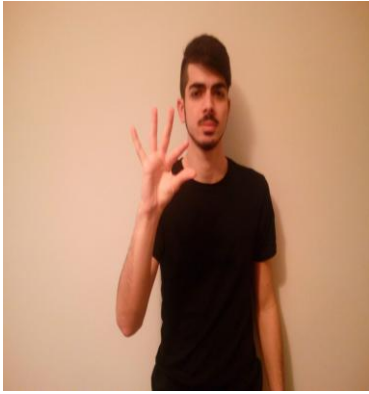
Photos C (number 10)
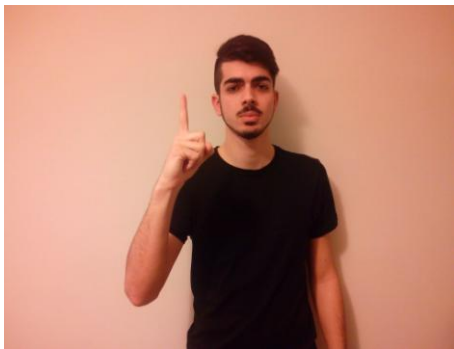
Photos D (number 70)
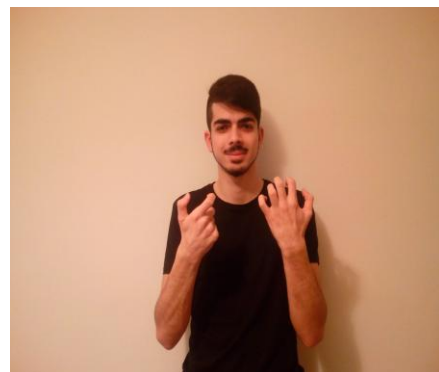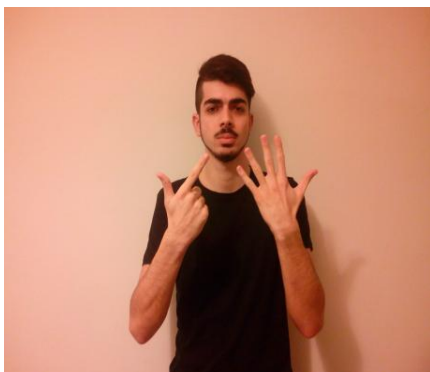
For the number 50 (photos E) we use the chirality that we use for the Greek letter "Φ", we do not close any fingers but just move the index and the thumb finger continuous and repetitive, compounding and separating them.

Photos E (number 50)

The singing of tens follow the rules of a cumulative numerical system, the chirality of ones but with a motion that indicates tens.

Hundreds: For the signing of hundreds we also use the chirality of the ones but with a different motion this time. The right hand or both of them, it depends on the plurality of the signed number, are moved horizontally and outwardly without returning to the starting position (photos F & G).

Photos F (number 100)
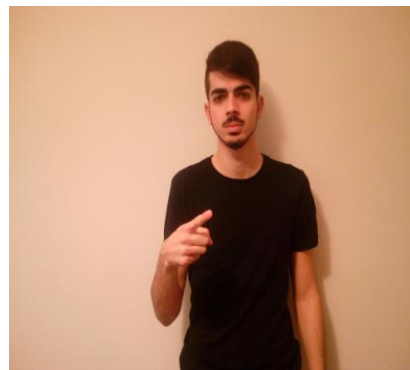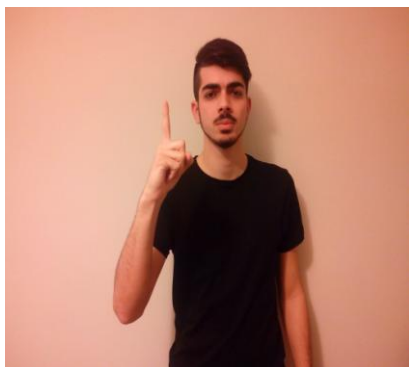
Photos G (number 900)
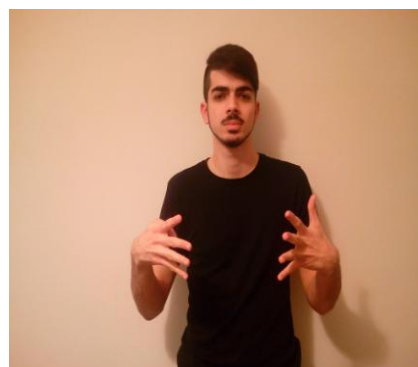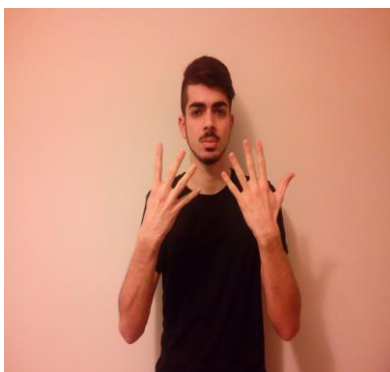
In this case we see again that the singing of hundreds maintains the cumulative numerical system logic as the chirality is concerned with a motion, different than the one in tens.

Thousands: Thousands are been signed into two steps. The first step is for indicating the plurality of the number and the second one to indicate that its a thousands number.

Number 1,000 (photos I) is signed while retaining the chirality of number 1 but modifying the position and adding motion. Specifically first we sign number 1, then we hold the left hand with the fingers stretched but closed vertically just near the left part of the chest, with fingers pointing diametrically from the chest while the inner side of the palm 'looks' to the right. The right hand using the chirality for number 1 moves straight and horizontally from the position of number one in the inner side of the left palm.

Photos I (number 1000)
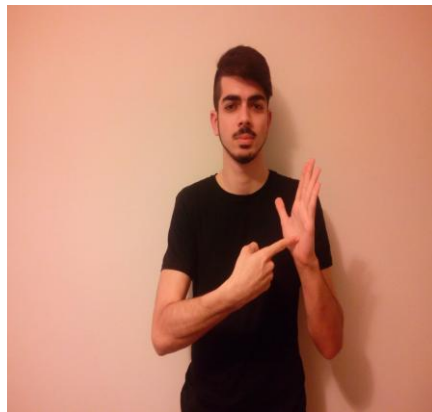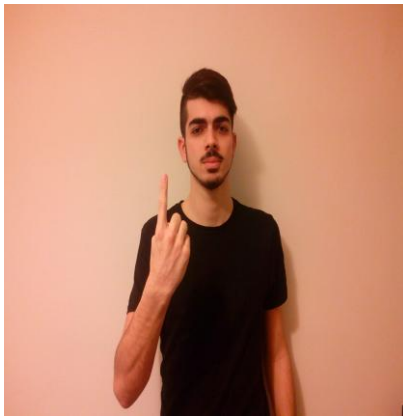
For signing the numbers 2000, 3000, 4000 and 5000 we do the same. During the first step we keep the chirality of the numbers 2, 3, 4 and 5 and for the second step we move, like in number 1000, the right hand towards the left one keeping the chirality unchanged. To sign the numbers 6000, 7000 (photos J), 8000 and 9000 we do the same like all the previous thousands with the difference that during the second step we move the right hand using the chirality of the number 5 towards the left hand in all numbers.

Photos J (number 7000)
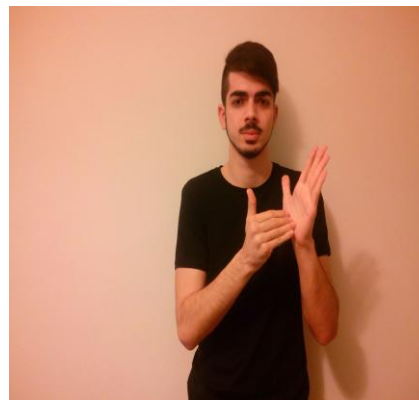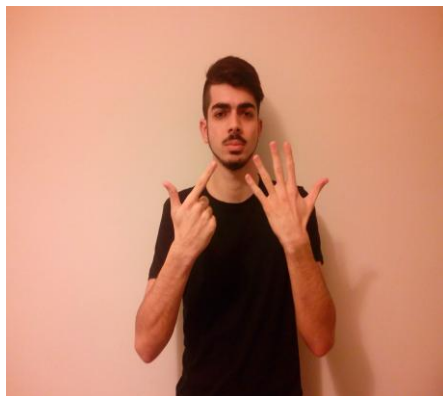
Millions: The signing of larger numbers like millions are simply by signing the number (units, tens, hundreds) eg 2, 20, 358 and adding the sign 'million' (photo K). This 'word' is signed with the right hand. The chirality having manually closed palm as punch but with the index finger raised and retracted (as the number 10 but without motion). The position of the sign is at chest height and the motion of the whole hand is in straight line and horizontal direction from left to right.

Photo K (number 1000000)

Intermediate numbers: The signing of intermediate numbers eg 21, 23, 34 (photos L), 123, 2351 etc. is by quote signing from the larger class to the smaller one.

Photo L (number 34)
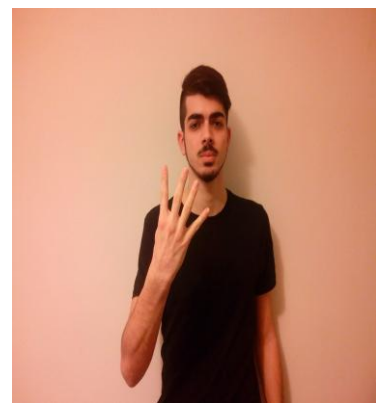
Numbers 11 to 19: For the numbers 11 to 19 there is a particular way of signing them, regardless of how number ten is signed. We sign them in two steps. In the first one we place both hands with the fingers open, every palm facing the other in front of our breast perpendicular with the fingers upwardly. This sign represents number 10. The right palm makes a move on upward forming the chirality of the numbers 1 to 9 (slightly turned towards the left hand).

Photos M (number 11)

In the area of Thessaloniki number 15 (photos N) has a unique way of been singed.

Photos N (number 15 – Thessaloniki)
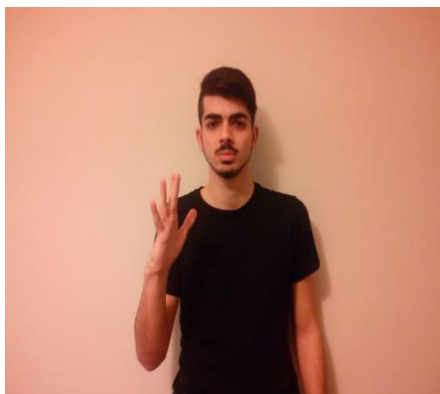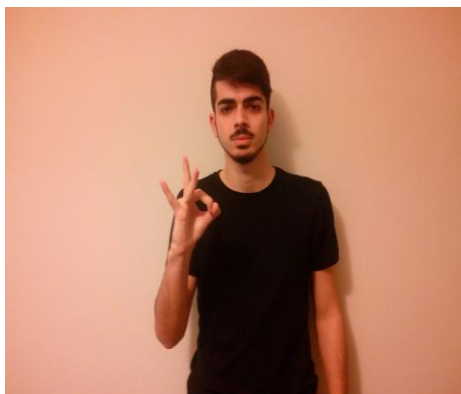
Special intermediate numbers: Double two digits numbers eg 22, 33, 44 (photos O), 55, 66, 77, 88, 99 can be signed in a different way. We use the chirality of the digit and we move our hand or hands slightly and horizontal a little bit on the right and on the left a few times.

Photos O (number 22)
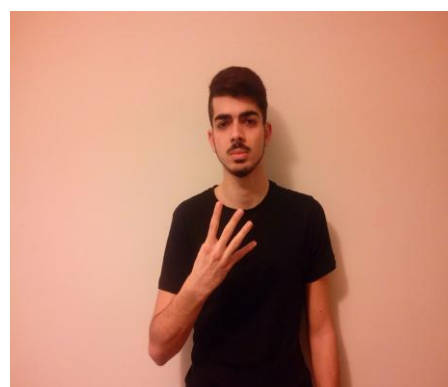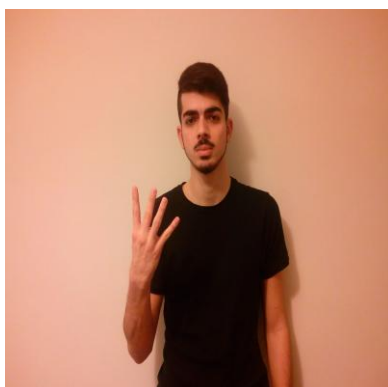
Conclusions
Results indicated that the numerical system of GSL is a mixed numerical system.

Alphabet: The chirality and the positions of the signs that give the numbers 0,1,2,3,4,5,6,7,8,9 give us the alphabet with which all numbers are formed.
Syntax Rules: Each sign that represents a number has a specific chirality, position, motion and palm orientation. The chirality gives us the value of the number without revealing whether it is a unit, a hundred, a thousand etc. This particular distinction is given by the combination of position, motion and palm orientation of the chirality. We consider as a 'word' each sequence of elements of the alphabet, except for the sign for the number zero. If we come across the number zero at any other sequence, we do not sign it (as we do using the oral Greek language of numbers). Of course there is no any other 'word' (number) that has more than two elements and starts with zero.
Semantic Rules: The numerical system in GSL is a decimal based numbering system.

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