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## Numeral-Incorporating Roots in Numeral Systems: A Comparative Analysis of Two Sign Languages

CONTRASTIVE STUDIES offer a broader view of sign language number systems than that afforded by single language research. At the same time, collaboration among research teams leads to enhance scientific results. In this article we compare numeral incorporating roots in the number systems of two languages whose number systems differ: Catalan Sign Language (LSC) and Argentine Sign Language (LSA). We have selected them because most numerals in the

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former derive from manual counting, whereas those in the latter do not, and this might influence the differences in the formation of roots in both languages' cardinal and ordinal numbers. One of the LSA number series bears no relation to either the quantity expressed or the decimal notation, a phenomenon that also appears in English and Spanish. "Twenty" ("veinte" in Spanish), for example, does not refer to the quantity it represents (two times ten) or the decimal system (20). Most LSA numerals function as adjectives. In some languages, the numbers above ten are typically constructed by combining basic hand-shapes. In others, such as Venezuelan Sign Language, they are made up of strings of the basic ten signs, and the resulting sequences are decomposable. In American Sign Language the signs for numbers above eleven are lexical signs historically derived from strings of the basic numerals (probably taken from Old French Sign Language), which are produced with one hand. By contrast, basic numerals are signed with both hands in Uruguayan and Venezuelan sign languages.

The objective of this work is to describe and compare numeral-incorporating roots in the numeral systems of Argentine Sign Language and Catalan Sign Language. As a necessary context for the research, we also describe the main features of both languages' number systems.

First, we examine the ways in which quantity is expressed in Catalan and Argentine sign languages. Then we define numeral-incorporating roots and explain how they are formed by inflection. An inventory of the roots found in these languages is provided, the main features of both number systems is described (for an outline of these features, see Fuentes, Fernández-Viader and Massone 2010), and the role of roots in the formation of ordinals and cardinals is analyzed. We examine the corpus collected and discuss whether derivation from manual counting influences the formation of roots in each language. Finally, we present current and future research lines.

### Quantification in Sign Languages

Sign languages express quantity through lexical, as well as morphemic, mechanisms. Numeral systems and quantifiers (e.g., *little*, *much*, *all*, *less*) are among the former, and reduplication and numeral-incorporating roots among the latter.

Lexical repetition is different from morphosyntactic reduplication. Repetition, whether prosodically or lexically determined, is inherent in

many signs and usually takes place only once. For example, in LSC, the signs WORK, MEAT, and RAIN show lexical repetition. Reduplication, by contrast, often entails a double repetition and serves a grammatical function, such as marking the plural of nouns (Pfau and Steinbach 2006), in both spoken and sign languages. For example, in LSC, CHILD-CHILD-CHILD means CHILDREN. Also, JANUARY TUESDAY-TUESDAY LINGUISTICS CLASS TO BE would mean "There will be a linguistics class every Tuesday in January." The other grammatical functions of reduplication are nominalization and aspectual and reciprocal marking.

Certain sign languages include roots that enable the incorporation of the number of things to be counted, a process called *numeral incorporation* (Chinchor 1982; Frishberg and Gough 1973; Liddell and Johnson 1989; Massone and Johnson 1991, 1994; Stokoe, Casterline, and Croneberg 1965; Wilbur 1985).

### Numeral-Incorporating Roots

Massone and Johnson (1994) have described this process in LSA. Each sign has two morphemes: the classifying root and the numeral hand-shape (HS); the latter varies, whereas the former may not. A specific quantity can be expressed through numeral roots (TWO-WEEK), which may be combined with a deictic referent by pointing in a particular direction along the timeline (TWO WEEK PAST) (Cabeza Pereiro and Fernández Soneira 2004).

Signs of this kind have been observed in American Sign Language (Chinchor 1982; Frishberg and Gough 1973, 1974; Liddell and Johnson 1989; Stokoe, Casterline, and Croneberg 1965) and other sign languages (Wilbur 1985). The distribution of the roots that may incorporate numeral handshapes seems to be very similar to that of numeral classifiers in spoken languages (Greenberg 1972; Hass 1942). In sign languages, however, classifiers and numeral roots are not introduced sequentially but simultaneously with other morphemes (Fourestier 2002). In fact, as Morales et al. (2000) report for Spanish Sign Language (LSE), certain classifiers may function as plural markers and include numeral morphemes.

Sign languages differ in the extent to which numeral incorporation takes place. It applies to numbers up to ten in LSE, up to nine in American and Australian sign languages, up to five in LSA (up to six in the case of the NUM-ORDINAL-INC root), and up to ten in LSC (although our data show a certain variation).



Numeral incorporating roots are formed by derivation, not by inflection nor composition. These three morphological processes are the ones through which languages fill lexical lacunae. Thus, in the case of derivation an affix is linked to a root to produce a new meaning. In other words, a new lexeme is developed from a base, which may or may not result in a change of grammatical category. Derivation, in general, generates a new nonproductive word with irregular meaning and does not select the base to which it attaches to. Inflection, by contrast, produces new forms of a given word with regular and productive meaning, such as gender, number, tense, mood, aspect and case, therefore, adding relevant information to syntax. Furthermore, inflection do not alter the grammatical category, while derivation can, and inflection specializes in certain bases while derivation does not. Composition is a derivational process by which two or more words are joined to form a new one (Munguía Zatarain, Munguía Zatarain, and Rocha Romero 1998; Tusón 2003). Isolated components are combined according to the structural principles of the language in question, which results in the union of two morphemes or roots, as in the English words *corkscrew* and *tablemat*. Therefore, numeral incorporating roots, classifiers, and nominal incorporation are the derivational processes found in LSC and LSA. However, LSA also presents the existence of suffixes as another derivational process.

Rules of compound word formation connect two or more independent bases or members of an open lexical class. Composites are, in fact, new lexemes that are learned as a whole and used as any other derived lexeme.

Stokoe (1960) was the first researcher to identify compound signs in sign languages. Liddell and Johnson (1989) have provided the most thorough description so far of the morphological and phonological changes undergone by such signs in ASL. Compound signs derive from two component signs that have been found to constitute independent lexemes in LSA or LSC. Semantically, composites are closely linked to their components. Their production involves a series of changes, whose analysis would go beyond the scope of this article (Massone et al. 2007). Roots, on the other hand, are developed by inflection since they produce new forms without changing word class or grammatical category. Numbers would be part of the handshape, functioning as morphemes and, more specifically, as infixes. Traditionally, linguistics has described infixes from the study of majority languages and thus considered them as sequential. Sign languages present the same com-

ponents of languages, but they are produced differently due to their different modality. Numbers are introduced in the handshape and move with the whole sign, therefore evidencing sequentiality and, as we said, functioning as infixes. We agree with linguists who see sign languages as linguistic objects and not as exotic languages. Therefore, we use the terms linguistics has historically used to describe languages.

### LSC Numeral System

Catalan Sign Language contains a set of independent numerals with two variants (one handed and two handed) from FIVE upward, as well as a set of numeral-incorporating roots. We discuss their main features based on both language-learning materials (videos and books) and linguistics research (Fernández-Viader et al. 1997, 1998, 1999, 2000; Fuentes 1999, 2000; Fuentes and Tolchinsky 2004).

The basic lexicon for both variants of independent numerals derives from manual counting. They are built from handshapes in which the number of raised fingers is the same as in manual counting; these handshapes are used by both male and female speakers. No variation has been reported in this respect among the traditional deaf schools of Catalonia. Figure 1 illustrates EIGHT in both variants (one handed and two handed).

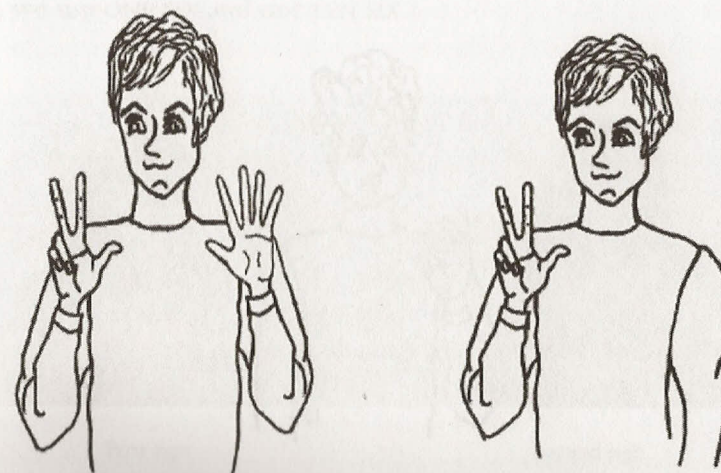


FIGURE 1. EIGHT (two-handed variant)      FIGURE 2. EIGHT (one-handed variant)



All numerals are signed in front of the signer's chest, but palm orientation differs: toward the signer for numbers up to five and away from the signer for those from six on. This is crucial for the one-handed series since it enables signers to distinguish between signs belonging to the same minimal pair, for example FOUR and NINE.



FIGURE 3. FOUR



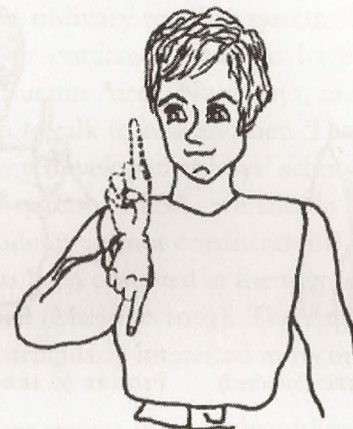
FIGURE 4. NINE

ZERO works as a placeholder; its use is not always mandatory (Fuentes 1999). Figure 5 shows ZERO, which reproduces the written representation of this number in the decimal notation.



FIGURE 5. ZERO

All numbers above TEN consist of strings of the basic ten signs (ONE to NINE and ZERO) and operators or multipliers: HUNDRED, THOUSAND<sub>1</sub>, THOUSAND<sub>2</sub>, THOUSAND<sub>3</sub>, MILLION, and so forth, and the resulting sequences are decomposable. Each numeral is made up of other numerals, each of which can be assigned a value.

FIGURE 6. THOUSAND<sub>1</sub> (LSC)

TEN does not function as an operator: to sign "sixteen," for example, we use ONE SIX and not TEN SIX.



First sign

Second sign

FIGURE 7. ONE SIX (SIXTEEN) (two-handed variant)



Figures in the hundreds may be conveyed in two different ways: For example, 123 may be signed as ONE^TWO^THREE or HUNDRED^TWO^THREE, using in the latter case the HUNDRED operator. A hundred may be signed as ONE^ZERO^ZERO, which we call HUNDRED1.



FIGURE 8. ONE-ZERO-ZERO (hundred)



FIGURE 9. HUNDRED (as an operator)

Numerals are signed in the same order as numbers in the decimal notation: For example, 14 is signed as ONE-FOUR, and 2,345 as TWO-THOUSAND-THREE-FOUR-FIVE. To represent more than two digits, signs are contralaterally displaced. Unlike ordinals, cardinals do not vary with context, that is, with the quantified items, except in the case of roots (Fernández-Viader and Fuentes 2006).

The simplest numeral construction is a noun phrase made up of a cardinal and a countable noun, and the preferred sign order is NOUN NUM. This phrase may function as the subject or object of a clause, as in the following examples:

1. PRO1 CAR TWO. "I have two cars."
2. MAN-BROTHER CHILDREN-THREE. "My brother has three children."

#### LSA Numeral System

Argentine Sign Language contains two sets of independent numerals, a series of numeral-incorporating roots and several classifying suffixes

attached to the former (Johnson and Massone 1994; Massone and Johnson 1991). These sets of independent numerals are somewhat unusual: In most sign languages we find a set of ten basic handshapes derived from manual counting and general hand-placement rules. Such productive numerals are also possible in LSA: An elderly informant signed the numbers from six to ninety-nine with both hands, although others preferred the ordinary number system. This productive two-handed system, now outdated, seems to have been created at the school for girls in Buenos Aires. Nowadays, only elderly women use some of these signs to talk to one another. The current number system, by contrast, was developed at boys' schools. In order to understand the numeral system in LSA, we should point out that public schools for deaf students are not coeducational in Argentina. A similar phenomenon has been observed in the way in which days, months, and colors are signed (Massone 1993). The Argentine Confederation of Deaf People is particularly interested in recording these older signs on video.

The LSA number system includes handshapes that do not appear to derive from manual counting: Most of the numeral signs are complete in themselves, each with a particular location on the face, neck, or body. Most handshapes are not identifiable with those of other numerals. The signs for TWENTY, THIRTY, FORTY, FIFTY, and SIXTY have been developed by young people from manual counting. In this respect they resemble LSC signs.



FIGURE 10. TWENTY (LSA)



FIGURE 11. FORTY (LSA)

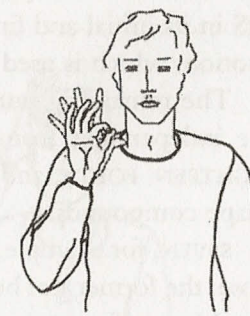


FIGURE 12. FIFTY (LSA)



Cardinals from ZERO to FIVE are built from handshapes in which the number of raised fingers corresponds to the number used in manual counting, as in LSC. SIX is signed by the oscillating motion of one hand. The handshape, increasingly used with roots, derives from an old sign that was a historical residue of two-handed counting. SIX used to be signed by holding upright all the fingers of the nondominant hand and one of the fingers of the dominant hand.



FIGURE 13. SIX

FIGURE 14. SIX  
(variant used by elderly women)

The HUNDRED numeral is a historical residue of ONE<sup>^</sup>ZERO<sup>^</sup>ZERO, which now appears to be lexicalized as (a) a smooth, arclike motion with a 1 + o- HS,<sup>1</sup> (b) a linear movement with the 1 + o- and 1<sup>^</sup>o + HS in its initial and final position, respectively, and (c) an oscillating motion, which is used only for the root.

The remaining numerals of the primary cardinal number system are independent from manual counting, although EIGHT, ELEVEN, EIGHTEEN, FORTY, and FIFTY are historically related to numeral handshape compounds.

SEVEN, for example, is signed with a 1<sup>^</sup>o- HS and a brushing of the nose, the former not being immediately identifiable as a numeral. The handshapes for SEVENTEEN and EIGHTEEN, as used by young male speakers are P + o + and R + o +. Other handshapes are used only by adult women, for example, 1 + a + for SEVENTEEN.

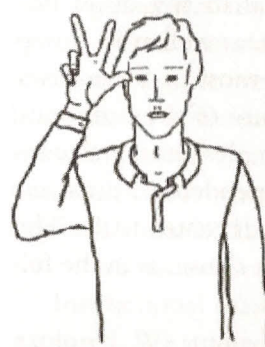


FIGURE 15. EIGHT



FIGURE 16. ELEVEN

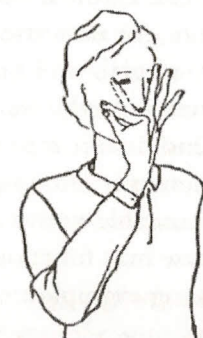


FIGURE 17. FORTY



FIGURE 18. EIGHTEEN2

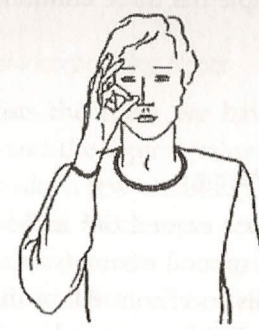


FIGURE 19. TWENTY

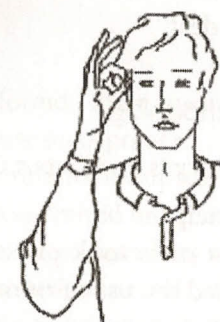


FIGURE 20. THIRTY



FIGURE 21. FORTY



FIGURE 22. SIXTY



The cardinal number series may be used, as in any other language, for indications of size, quantity, or time, as well as in strings of numerals and mathematical expressions. In most of these cases, nouns or verbs are required to specify the nature of the numerical phenomenon represented. As in LSC, the simplest numeral construction is a noun phrase composed of an independent cardinal and a countable noun, and the preferred sign order is NOUN NUM. This phrase may function as the subject or object of a clause, as in the following examples:

1. BIRTHDAY PARTY CHILD EIGHT TO-BE. "There were eight children at the birthday party."
2. TWO-PRO2PL-INCL TO-BE-IN-COUPLE SON THREE HEARING TWO DEAF ONE. "That couple has three children: two hearing and one deaf."

## Methodology

### *Informants and Corpus Gathering*

Participant observation was carried out in both languages, which in most cases took place in natural contexts where the informants discussed the use of numerals and roots. All of the informants were deaf adult signers.

Ten deaf researchers took part in the LSC data collection, and the resulting database was examined by all of the deaf associations of Catalonia and approved at a meeting of deaf researchers and sign language teachers. Eight LSC signers, among them teachers, were interviewed on numeral-incorporating roots. Each was given a root that included the numerals ONE or TWO (for example, ONE-THOUSAND-INC, TWO-THOUSAND-INC) and asked to complete the numeric series up to a preestablished number. They were also asked about the roots found in the other language to ascertain whether a similar one exists. Once approved, the numeral and root signs were videorecorded.

Informants with a good command of LSA were identified during fieldwork. Written notes were taken on numeral production and use,

and signing was filmed at deaf associations, as well as cultural and sports events, attended by deaf people from all over the country. Later on, fluent signers were invited to weekly meetings in which the deaf associations of Buenos Aires took part. Researchers then traveled to other important cities and worked with members of the local deaf associations, with whom they compared data and made an inventory of regional variants. Six LSA signers and members of the deaf community were interviewed on roots.

Instructional materials about numeral and root signing were also explored. We studied the videos available at [www.youtube.com/con-fargsordos](http://www.youtube.com/con-fargsordos) for LSA, the videos and books provided by the ILLESCAT Foundation (Fernández-Viader et al. 1997, 1998, 1999, 2000), as well as descriptions for LSC provided by Fuentes (1999, 2000) and Fuentes and Tolchinsky (2004).

### *Inventory of LSC Numeral-Incorporating Roots*

The following table lists the roots we have found, their meaning, grammatical category, and the typical values they incorporate.

We would like to make a few clarifying comments about some of the roots included in table 1. With regard to those linked to time, the NUM-MONTH-INC root enables the incorporation of numbers from one to five, which might exceptionally extend to ten, as a result of the influence of Spanish Sign Language (LSE). The NUM-YEAR-FUTURE and NUM-YEAR-PAST roots show incorporation of both numerical and temporal information by means of a timeline.

Referring to roots that convey ordinal information, the orientation of the root NUM-ORDINAL-INC2 specifies the animate-inanimate feature of the referent: When the palm of the hand is perpendicular to the ground, the root refers to an animate object such as a person, and when the palm is parallel to the ground, it refers to an inanimate object. The root NUM-ORDINAL-INC1 imitates the signs for Roman numerals up to III.

Finally, when the root NUM-.DESC.CL PERSON incorporates the number ten, accompanied by a forward/backward motion perpendicular to the ground, it often means *a lot of people* instead of specifically *ten people*.



TABLE 1. Inventory of LSC Numeral-Incorporating Roots

Category	Root	Typical Values	Meaning
adjectives	NUM-HUNDRED-INC	1-10	number of hundreds
	NUM-THOUSAND1-INC	1-10	number of thousands
nouns	NUM-ORDINAL-INC1	1-10	number of times the name of a monarch or pope has been repeated
	NUM-ORDINAL-INC2	1-10	people's place in a line, floors of a building, flat number, order of objects on a piece of furniture, order in which children are born
	NUM-ORDINAL-INC3	1-3	people's place in a competition
	NUM-HOUR-DURING-INC	1-5	duration in number of hours
	NUM-HOUR-INC	1-12	number of hours
	NUM-MONTH-INC	1-9	number of months
	NUM-YEAR1-INC	1-4	number of years, including years of age, with motion along a timeline; a point in time in the future or in the past, measured in years
	NUM-YEAR2-INC	1-5	number of years, including duration, measured in years
	NUM-WEEK-INC	1-5	number of weeks
	NUM-.DESC.CL person-INC	1-5	number of people
	NUM-.DESC.CL person in a lineINC	1-10	number of people
	NUM-.DESC.CL people coming and going-INC	1-10	number of people
	NUM-HOTEL or RESTAURANT STAR-INC	1-5	hotel or restaurant rating (number of stars)
	US	2-4	number of people of reference
	YOU (pl.)	2-4	number of people of reference; eye gaze is directed toward the addressee
	THEY	2-4	number of people of reference (orientation varies according to whether they are standing or lying down)
verbs	NUM-TO LOSE-INC	1-10	score by which a game or match is lost
	NUM-TO TIE-INC	0-5	score at which a game or match is tied

## Inventory of LSA Numeral-Incorporating Roots

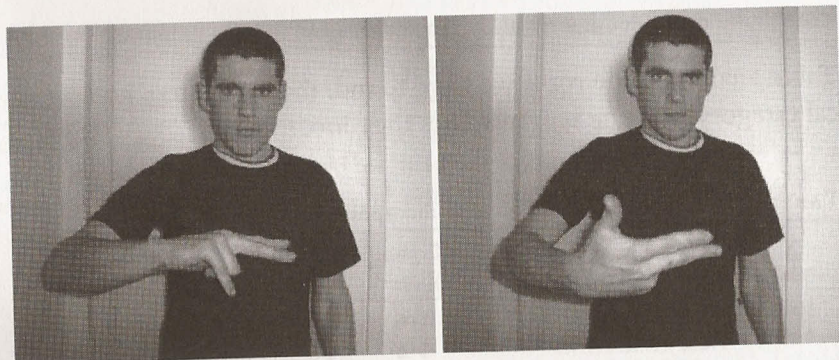
Table 2 contains the roots we have found, their meaning, grammatical category, and the typical values they incorporate.

TABLE 2. Inventory of LSA Numeral-incorporating Roots

Category	Root	Typical Values	Meaning
adjectives	NUM-TWENTY-INC	1-6	number of units added to twenty
	NUM-THIRTY-INC	1-6	number of units added to thirty
	NUM-SIXTY-INC	1-6	number of units added to sixty
	NUM-THOUSAND-INC	1-5	number of thousands
	NUM-HUNDRED-INC	1-6	number of hundreds
	NUM-ORDINAL-INC	1-5	position in a series
nouns	NUM-FLOOR-INC	1-5	number of floors of a building
	NUM-SECOND-INC	1-5	time in seconds
	NUM-YEAR-INC	1-5	number of years
	NUM-WEEK-INC	1-5	number of weeks
	NUM-MINUTE-INC	1-5	time in minutes
	NUM-HOUR-INC	1-6	number of hours
	NUM-BLOCK-DIRECTION-INC	1-5	number of blocks (in giving directions)
pronouns	US	2-4	number of persons of reference
	YOU (pl.)	2-4	number of persons of reference; the signer's look is directed to the addressee
	THEY	2-4	number of persons of reference; the orientation parameter changes if persons are standing or lying down
verbs	NUM-TO TIE-INC	0-5	score at which a game or match is tied
	NUM-TO-BE-THINGS-INC	1-5	number of things

We show an example of the LSA root:





First position

Second position

FIGURE 23. TWO-BLOCK-AHEAD-INC

### Numeral-Incorporating Roots in the Cardinal and Ordinal Number Systems

We found five numeral-incorporating roots in the numeral system in LSC and six in LSA. Table 3 shows those in LSC:

TABLE 3. Numeral-Incorporating Roots in the Number System of LSC

Root	Typical Values
NUM-HUNDRED-INC	1-10
NUM-THOUSAND1-INC	1-10
NUM-ORDINAL-INC1	1-5
NUM-ORDINAL-INC2	1-10
NUM-ORDINAL-INC3	1-3

Numerals may also be signed without using the roots, that is, as a sequence of independent numbers. For example, the number 5,234 may be signed as follows:

- FIVE-THOUSAND-INC TWO-HUNDRED-INC THREE FOUR
- FIVE-THOUSAND TWO THREE FOUR

The numeral-incorporating roots found in the LSA cardinal number system are shown in table 4:

TABLE 4. Numeral-incorporating Roots in the LSA Number System

Root	Typical Values
NUM-TWENTY-INC	1-6
NUM-THIRTY-INC	1-6
NUM-SIXTY-INC	1-6
NUM-HUNDRED-INC	1-6
NUM-THOUSAND-INC	1-5
NUM-ORDINAL-INC	1-5

Roots are used regularly for two- and three-digit numerals. However, numerals may also be signed independently except in the formal register. As the manual-counting-based signs for 20, 30, 40, 50, and 60 become more widespread, the roots NUM-TWENTY-INC, NUM-THIRTY-INC, and NUM-SIXTY-INC, though grammatically correct, are less frequently used. For example, the number 5,234 may be signed as follows:

- FIVE-THOUSAND-INC TWO-HUNDRED-INC THREE FOUR
- FIVE TWO-HUNDRED-INC FOUR-THIRTY-INC
- TWO-FIFTY-INC FOUR-THIRTY-INC
- FIVE-THOUSAND-INC TWO THREE FOUR

These examples also illustrate a language usage restriction as a sequence may not include more than two numeral-incorporating roots.

In formal or political discourse both hands may be used simultaneously. The root (e.g., NUM-YEAR-INC) is signed with the dominant hand, and the numeral (e.g., FOUR) with the nondominant hand. Thus, both signing space and distance between signers are used to the greatest advantage. In more intimate registers, numbers tend to be used as previously described.

Roots are not used in signing three-digit numbers designating public transportation buses, the first and second numbers of which are considered as a single unit, to which the third is added: FOURTEEN^EIGHT would mean (bus number) 148, and ELEVEN^FIVE would mean (bus number) 115. Such linguistic economy does not apply to the numbers of public transportation buses not known by the signer; these would be signed as any other numeral.



## Discussion

In both LSC and LSA, numeral-incorporation roots are formed by derivation. As happens with roots in Western spoken languages, the process involves the incorporation of a lexeme into a base: For example, in LSC, combining the handshape TWO and the base NUM-THOUSAND-INC produces "two thousand"; similarly, in LSA, the handshape FOUR and the base NUM-HUNDRED-INC means "four hundred." Numeral-incorporating roots do not meet the semantic criteria for compounds: They are developed by a derivational process that generates a new form of the word without changing its grammatical category or type. The resulting sign is also a numeral: The sign for TWO, coupled with THOUSAND, means "two thousand."

In LSC, most of the numerals derive from manual counting and resemble the decimal notation (e.g., "thirty-four" is signed by extending first three and then four fingers) and therefore do not generate roots. In the most widespread LSA series, by contrast, numerals resemble the Indo-European ones, which bear no relation to the numbers they represent.<sup>2</sup> Our findings indicate that, in both sign languages, numeral roots are derived from numerals that do not derive from manual counting. This may be due to a modality restriction, which deserves further research, as nearly all cardinal numerals share the same location in front of the chest. The NUM-HUNDRED-INC root, in LSC, which is the same as in LSA, seems to constitute the only exception to the rule, which also deserves more research. On the other hand, no roots have been developed from the LSA signs for numbers 20, 30, 40, 50, and 60, which derive from manual counting (see figures 10, 11, and 12). Thus, the data collected in these two sign languages suggest that roots in numeral systems are formed from numerals that do not derive from manual counting; that is, they do not reflect in a transparent way the cardinality or the decimal notation.

Relevant changes are currently taking place in the deaf communities examined in Catalonia and Argentina. In Spain, LSC has been officially recognized as the natural language of the Catalan Deaf community (June 28, 2007). Besides, the creation of a national center for Catalan Sign Language (LSC) and one for Spanish Sign Language (LSE) standardization is being planned. In Argentina, a national

law for LSA recognition is being discussed in parliament, and several regional laws have already been approved. These facts will surely promote the presence of these sign languages in educational and other public settings. Research in these languages, particularly their number systems, would have an application in these contexts.

## Acknowledgments

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## Notes

1. We use the transcription system designed by Liddell and Johnson (1985–1989) and adapted to LSA by Massone and Johnson (1994).
2. This also happens, for example, in Spanish in the numbers from one to fifteen, round decades, and the irregular pronunciation of the numeral *quinientos* (five hundred).

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