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Mathematical knowledge and language in deaf students: The relationship between the recitation of a numerical sequence and Brazilian Sign Language proficiency

Conhecimento matemático e linguagem em surdos: relação entre recitação da sequência numérica e proficiência em Língua Brasileira de Sinais

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Abstract

The present study investigated recitation skills, constitutive of the number concept, and their relationship with language skills in the Brazilian Sign Language. Different levels of numerical sequence recitation were identified in 1st to 3rd grade deaf students attending a bilingual Elementary School (Brazilian Portuguese and Brazilian Sign Language), as well as the association between numerical recitation and schooling. The ability to enumerate was associated with specific levels of receptive and expressive language in Brazilian Sign Language.

Keywords: Children; Deafness; Learning; Mathematics; Sign language.

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Resumo

O presente estudo investigou a habilidade de recitação, constitutiva do conceito de número, e sua relação com habilidades linguísticas em Língua Brasileira de Sinais. Em escolares surdos do 1o. ao 3o. ano do Ensino Fundamental de uma instituição bilíngue (Português do Brasil e Língua Brasileira de Sinais), foram identificados diferentes níveis de habilidade de recitação da sequência numérica, como a associação entre recitação numérica e a escolaridade. A habilidade de enumerar foi associada a níveis específicos de linguagem compreensiva e expressiva em Língua Brasileira de Sinais.

Palavras-chave: *Crianças; Surdez; Aprendizagem; Matemática; Língua de sinais.*

Research on deaf children deals with a wide range of topics such as the impact of deafness on children and their families, the identification of deaf individuals' behavioral and emotional characteristics (self-esteem, identity), cognition and learning. On this last theme, there is a growing interest of scholars in investigating mathematical cognition and deafness, the focus of the present study. Studies comparing deaf and hearing students indicate that deaf individuals lag behind hearing students in various mathematical notions. However, researchers agree that deafness is not the cause of the lag per se, since deaf individuals have no intellectual limitations; but some difficulties stem from the fact that deafness limits interactions, experiences and access to information of different types, including those relating to situations involving mathematics (Barbosa, 2013; Gottardis, Nunes, & Lunt, 2011; Kritzer & Pagliaro, 2013).

In this scenario, studies that examine the relationship between mathematical knowledge and language are found, showing the role of fluency and the nature of the language adopted in the acquisition and expression of mathematical knowledge by deaf individuals (Barbosa, 2014; Madalena, Correa, & Spinillo, 2017; Madalena, Marins, & Santos, 2012; Nunes, Bryant, Evans, Bell, & Hallett, 2013; Rios, Guimarães, & Dorneles, 2018; Vargas, & Dorneles, 2013). The results of these studies contribute to the understanding of the difficulties experienced by deaf students in relation to mathematics, especially those who make use of a linguistic modality which is different from the oral language of hearing individuals: the sign language.

The investigation of the numerical cognition in deaf individuals who use the Brazilian Sign Language (LIBRAS) indicates that the exposure time and the age at which they had their first contact with this communication system occurred influence students' performance, and there is a relationship between language development and the formation of numerical concepts (Barbosa, 2013; Madalena et al., 2012). Such relationship assumes particular importance with regard to enumeration. In fact, acquiring numerical language skills (reciting the numerical sequency) contributes to the development of basic arithmetic skills such as cardinality and simple calculations (Negen & Sarnecka, 2012).

The verbal numerical representation of hearing individuals is replaced by signing among sign language users. If, for hearing individuals, counting numbers is oral-auditory, for deaf individuals, counting is visuospatial, through manual configurations, with finger and hand positions in place. Thus, the user of this system needs to know the sign language numbers in LIBRAS (linguistic aspect), to recite them in their sequence (principle of stable order) and to understand that the representation of the counted element occurs only once (principle of one to one correspondence). These principles are necessary for the understanding of the notion of numbers by any and all children (Ching & Nunes, 2017; Fayol, 2012).

Counting involves two systems of representation: one verbal and one notational (Fayol, 2012). The first one consists of number words which are the names of numbers (one, two, three etc.), whether oral/auditory or signed; the second consists of Hindu Arabic digits which are the representation of numbers in the mathematical language (1, 2, 3 etc.). Counting practices are fundamental to the appropriation of mathematical knowledge. The use of external supports, such as fingers and signs, facilitates this acquisition (Di Luca, & Pesenti, 2011).

Regarding the verbal numerical sequence, it is known that, initially, hearing children recite the numbers as a single totality ("onetwothreefourfivesix ..."), to later consider the isolated words ("one, two, three, four, five, six, ... "), even if the sequence is not enumerated correctly (Fayol, 2012). However, counting the numerical series that hearing individuals learn informally does not occur in the same way among deaf children. Thus, it is relevant, given the cruciality of this notion for the acquisition of later mathematical knowledge, to investigate how deaf individuals deal with this sequence, which is the focus of the present investigation.

It is noteworthy that there are differences in numerical sequence in different Sign Languages, as evidenced by Rios et al. (2018) when investigating the ability to make estimates in Brazilian (Brazilian Sign Language [*Língua Brasileira de Sinais* (LIBRAS)]) and Colombian (Colombian Sign Language [LSC]) deaf individuals. Students in grades 1 to 4 of elementary school were asked to estimate the location of numbers in a numerical line. Differences found in the accuracy of the estimates possibly stemmed from the specificities in the syntactic structure of the numerals in the sign language used in each country.

In LIBRAS, the number 5 is no longer a quantity representation but a symbolic representation, while in LSC, the number 5 is a quantity representation, and from this number onwards an additive rule is introduced (five fingers extended plus one finger). Other investigations also point out the specificities of sign languages as influencing the way deaf individuals represent their mathematical knowledge (Leybaert & Van Cutsem, 2002; Madalena et al., 2017).

Madalena et al. (2017) analyzed the different types of errors presented by deaf students in elementary school when reciting the numerical sequence up to 100 in LIBRAS. Some types of errors were associated to the specificities regarding the way numbers are indicated in LIBRAS, highlighting the role of linguistic knowledge in the construction of the numerical sequence and the difficulties experienced by its users. Thus, knowledge about the recitation of the numerical sequence depends not only on the logic of the users of a given representation system, but also on the system itself, so that in LIBRAS, as in any other representation system, there are epistemological challenges to consider.

Leybaert and Van Cutsem (2002) raise an important question about the impact of the visuomanual modality and the structure of the numerical sequence on Sign Language in the development of counting in deaf children. Deaf and hearing children (3-6 years) were evaluated for their use and accuracy in reciting the numerical sequence. Three counting situations were presented: abstract counting (counting from one to the maximum that the child could), concrete counting (telling how many objects were in a given set) and formation of sets of elements from a given amount (cardinality). In general, differences between deaf and hearing individuals were identified in relation to reciting the numerical sequence: there were lags in the performance of deaf individuals whose recited sequence was shorter than that of hearing individuals. The errors that deaf children presented differed from those made by hearing children, errors that were somewhat associated with the specificities of the sign language used in Belgium, whose structure follows a base-5 rule.

Leybaert and Van Cutsem (2002) report the fact that deaf individuals usually stop counting after making a mistake at number 5 and after making a mistake at number 15. It is important to note that this relationship was also documented by Madalena et al. (2017) with deaf children who use LIBRAS. However, both groups of children were similar in their performance in counting objects and forming sets (cardinality). Deaf children had a proper understanding of the quantities they produced, and the notion of one-to-one correspondence seemed to develop in the same way for both groups. Differences in counting between groups seem to be associated with the structure of language, not with other aspects of counting such as understanding of its language-independent principles. Therefore, counting in sign language is a topic that deserves further investigation, either because of its theoretical relevance in understanding how the mathematical knowledge of deaf children is processed, or because of its applied relevance to the implications that this understanding has for the mathematical education of deaf children.

Numerical Representations in LIBRAS

As with oral languages, each country has its own sign language, with no universality in relation to numerical signs. Thus, LIBRAS has its own linguistic signs for each number/numeral. Any number can be signed with just one hand. Cardinal numerals from 1 through 4 are iconically represented by their amount, since the number of fingers raised corresponds exactly to the amount to be communicated. From the numeral 5 on, there is no more transparency in the relationship between the quantity to be represented and the numerical sign. The "word-number" in LIBRAS no longer has an iconic relationship, being a linguistic sign, as arbitrary as any other.

To understand the regularity associated with the representation of multiples of ten in the decimal base numbering system, one must understand the positional value of each digit. For deaf children, this process will occur without the support that oral language provides for hearing individuals.

In order to deepen the knowledge about the relationship between language and mathematical knowledge in deaf individuals, this study aimed to investigate the ability to recite the numerical sequence in deaf students with different levels of proficiency in LIBRAS. It is important to highlight that, as explained, one of the most frequently observed difficulties among deaf students refers to the production of the numerical sequence, which is fundamental for the acquisition of the concept of number, for counting and for performing arithmetic operations. Therefore, knowing how deaf students deal with the numerical sequence may have practical implications that may contribute to more effective teaching situations that help to overcome the difficulties faced in the school context.

Method

Participants

The study included 67 students from the 1st, 2nd and 3rd grades of elementary school, users of LIBRAS as their first language (L1). These students use sign language for their communication, as well as oral language in sporadic vocalizations, or as a supporting tool in the expression of isolated words. Among the students, 27 were enrolled in the 1st grade (M = 9 years old, SD = 19 months), 19 in the 2nd grade (M = 12 years old, SD = 35 months) and 21 in the 3rd grade (M = 13 years old, SD = 24 months) of elementary school in a bilingual school (LIBRAS and Brazilian Portuguese).

The first three years form a school cycle for the consolidation of basic knowledge in mathematics. Since students rely on vision as their main learning channel, visual teaching strategies are used. Students have six weekly math classes, held in LIBRAS, in a total of 270 class minutes per week.

It was found that 20 students had deaf family members. Of these, only three were children of deaf parents. The other 17 students reported other levels of relatedness, such as siblings, uncles, grandparents, or cousins with hearing loss.

Regarding the etiology of deafness, 58% were of congenital nature, 11% of acquired causes and 31% of unidentified causes. Regarding the age at which participants had their first contact with sign language, it was found that 36% were exposed to it at an early age (before they were 4 years old) and 64% at a later age (after they were 4 years old). The vast majority of participants (90%) had their first contact with LIBRAS at school.

About 67% (n = 45) of the students had a diagnosis of hearing loss before they were 24 months old. However, most of them (64%) only had contact with LIBRAS after 48 months of age. In addition to the age at which students had their first contact with sign language, the frequency with which they use LIBRAS outside the school environment is an important factor. However, not everyone uses it daily. Among the participants, 52% make sporadic use of LIBRAS when not in school, which means they do not have language peers in their social life.

Instruments and Procedures

Enumeration

Initially, each participant performed the task to evaluate their number-reciting skills in LIBRAS, starting from the question: "Can you count to 100?". However, for younger students, or those who had not understood the previous question, it was proposed, "Count with me, 1, 2, 3, and then?". Thus, the researcher started the sequence, signing the first three numbers, and the child continued the recitation.

In cases in which the participant began to recite correctly and stopped at some point in the sequence, the last three numbers were repeated by the researcher to encourage him or her to continue. When the student made a mistake, he or she would be interrupted by the same procedure: the last three correct numbers were signed. If the participant was able to advance from the point where her or she stopped counting correctly, this interruption was not counted as an error, even if this procedure had to be repeated throughout the sequence. However, if the student persisted in the error, even if he could reach 100, the last correct number of the sign sequence was recorded. Also as a correction criterion, if the student preferred to restart the recitation, after acknowledging by him or herself that he or she had made a mistake or because the researcher had interrupted him or her, this procedure was not counted as an error either: the objective of the task was that the student could demonstrate his or her numerical knowledge in LIBRAS.

Correction Criteria for the Enumeration Task

If the children started the task by showing their fingers, adding one at a time, their recitation would be counted as correct only up to number four and not up to ten, since from number five the numerical signs have their own hand configuration. Initially, the researcher recorded the sequences made by the participants according to the largest number correctly signed. Soon after, all numerical sequences were jointly reviewed by the researcher and by a mathematics teacher of the *Instituto Nacional de Educação de Surdos* (INES, National Institute for the Education of the Deaf) who is proficient in LIBRAS. In some situations, students from the final grades of elementary school were also invited to give their opinion on how to sign. In case of disagreement between the evaluators, a third mathematics teacher of the mentioned institution watched the film and together they registered the largest number signed before the first error was made. Thus, for data analysis, the largest number correctly signed, prior to the first error, was used for the classification of the students' number-reciting skills in levels.

Proficiency in LIBRAS

The assessment of proficiency in LIBRAS, either for comprehensive or expressive language, is performed through the *Instrumento de Avaliação em Língua de Sinais* (IALS, Sign Language Assessment Instrument). This is an evaluation paradigm about the sign language proficiency of deaf individuals, elaborated by Quadros and Cruz (2011), with evidences of validity for Brazil. Through the application of the IALS, it is possible to identify the level of language development in deaf individuals, as altered patterns of this development, in the acquisition of LIBRAS.

In the comprehensive language subtest, previously recorded sentences are presented, and the student should point to the figure, among three options, which corresponds to what was signed. In another stage of the test, after watching a recorded sign story, the student selects and orders the pictures according to the story told. For evaluation of expressive language, the student watched the excerpt of a movie lasting 1 minute and 10 seconds twice. Afterwards, he or she was informed that the story should be retold to a person who did not know it, and that his narration would be filmed. The IALS was performed in a single evaluation session, which did not exceed 30 minutes.

Correction criterion for the LIBRAS proficiency test

The subtests were analyzed following the correction standards prescribed in the IALS (Quadros & Cruz, 2011). For the purposes of statistical analysis, in the present investigation, data were grouped into fewer student performance categories than those suggested by the IALS handbook. Performance in comprehensive language tasks (sentence comprehension and history ordering) was classified according to the percentage of correct answers as: insufficient or good. For expressive language, the deaf student's performance in vocabulary and number of facts narrated was classified according to the frequency of occurrence as: poor or good.

References in space (spatial syntax) were evaluated by employing the representation of points in space to indicate something that is not present at the time or place of conversation. Finally, the use of the logical sequence was analyzed, that is, if the narration made by the student presented the events in the same order as they occurred in the assisted film.

Results analysis procedures

In order to examine the association between enumeration skills and education, the chi-square test was used. The same analysis procedure was also employed to verify the existence of a statistically significant association between number-reciting skill levels, both with the acquisition period and with the LIBRAS proficiency. The relationship between LIBRAS exposure time and number-reciting skills was examined using the Pearson correlation test.

Results

Deaf students were grouped into three levels according to their performance in the number-reciting activity (Table 1). Those who correctly recited to 20 were classified as having lower enumeration skills. The students whose number-reciting was between 20 and 60, were assessed as having intermediate enumeration skills. The higher skilled ones were students who presented correct recitation from the number 60 onwards.

Table 1
Distribution of students according to their recitation skills in LIBRAS and school grade

Grade	LIBRAS recitation skills					
	Lower skills (n = 27)		Intermediate skills (n = 17)		Higher skills (n = 23)	
	n	%	n	%	n	%
1st grade (n = 27)	19	70	8	30	0	0
2nd grade (n = 19)	7	36	6	32	6	32
3rd grade (n = 21)	1	5	3	14	17	81

Note: LIBRAS: Brazilian Sign Language.

The association between schooling and numerical recitation was significant (χ^2 (4) = 36.80; p < 0.01). Most of the students in the 1st grade of elementary school had reduced knowledge of the numerical sequence in LIBRAS. In the 2nd grade, the three number-reciting skill levels were found, with no predominance of any of them. In the 3rd grade, most students showed good number-reciting skills. Thus, the positive influence of schooling on the organization levels of the numerical system in LIBRAS is evident.

Numerical recitation and the period of acquisition and time of exposure to LIBRAS

The first aspect considered in the relationship between the performance of deaf students in number-reciting and LIBRAS was the age they had their first contact with sign language. Some deaf students had their first contact with sign language before the age of four, being considered as having early language acquisition. In contrast, children whose first contact with LIBRAS came only after this age were designated as having late language acquisition (Quadros & Cruz, 2011). Considering the importance of a first language in numerical learning, the age when they had their first contact with sign language could be directly related to the enumeration performed by deaf students (Table 2). No significant association was observed between the students' number-reciting skills and the period of initial contact with LIBRAS, whether early or late (χ^2 (2) = 4.16; p = 0.12).

The relationship between the time of exposure to LIBRAS, that is, the years of learning of sign language, and the number-reciting skills was then analyzed. The exposure time to LIBRAS showed a significant positive correlation with the recited numerical sequence size (r = 0.27; p = 0.03). The students with the longest contact with sign language were those who presented the highest numerical sequences in the recitation task.

Relationship of enumeration ability to LIBRAS proficiency

In order to understand the relationship between different levels of LIBRAS proficiency and enumeration skills, the performance of deaf students in the IALS was examined according to their skill levels in reciting the numerical sequence. After the evaluation of the comprehensive language, different aspects of expressive language were analyzed.

Numerical recitation ability and comprehensive language

Their comprehensive language assessment was examined by sentence recognition and the organization of narrative events through a sequence of pictures. The distribution of students in comprehensive language tasks according to their numerical skills is shown in Table 3.

Recitation ability and organization of facts from the signed story were significantly associated (χ^2 (2) = 22.07; p < 0.01). The same did not occur between the ability to recite and the comprehension of

Table 2

Distribution of students according to their recitation skillsin LIBRAS and the starting period of acquisition of LIBRAS

Acquisition of LIBRAS	LIBRAS recitation skills					
	Lowerskills (n = 27)		Intermediate skills (n = 17)		Higher skills (n = 23)	
	n	%	n	%	n	%
Early acquisition (n = 24)	10	42	9	37	5	21
Late acquisition (n = 43)	17	39	8	19	18	42

Note: LIBRAS: Brazilian Sign Language.

sentences (χ^2 (2) = 2.60; p = 0.27). Sentence comprehension involves more basic language skills compared to the comprehension required for understanding the LIBRAS numbering system. On the other hand, understanding the facts of the story narrated in LIBRAS and knowing how to order them in a sequence, establishing a correspondence between them, are more elaborate language skills, also requiring the use of logical reasoning. It is possible, then, that more elaborate comprehension language skills favor the comprehension of the linguistic rules used for the formation of the LIBRAS numbering system.

Numerical recitation ability and expressive language

Expressive language was evaluated considering semantic levels, such as vocabulary, and syntactic and discursive levels, such as reference in space, logical organization of narrative and the number of facts narrated. Table 4 presents the distribution of students according to their numerical ability and the different aspects of expressive language.

Table 3
Distribution of students according to their recitation skills in LIBRAS and comprehensive language

Comprehensive language	LIBRAS recitation skills					
	Lower skills (n = 27)		Intermediate skills (n = 17)		Higher skills (n = 23)	
	n	%	n	%	n	%
Understanding of sentences						
Insufficient (n = 13)	7	26	4	23	2	9
Good (n = 54)	20	74	13	77	21	91
Ordering the story						
Insufficient (n = 38)	21	78	13	76	4	18
Good (n = 29)	6	22	4	24	19	82

Note: LIBRAS: Brazilian Sign Language.

Table 4
Distribution of students according to their recitation skills in LIBRAS and expressive language

Expressive Language	LIBRAS recitation skills					
	Lower skills (n = 25)		Intermediate skills (n = 17)		Higher skills (n = 23)	
	n	%	n	%	n	%
Vocabulary						
Poor (n = 40)	19	76	10	59	11	48
Good (n = 25)	6	24	7	41	12	52
Reference in space						
Not used (n = 32)	17	68	7	41	8	35
Used (n = 33)	8	32	10	59	15	65
Logical sequence						
No (n = 20)	13	52	3	18	4	17
Yes (n = 45)	12	48	14	82	19	83
Narrated Facts						
Poor (n = 42)	21	84	12	70	9	39
Good (n = 23)	4	16	5	30	14	61

Note: LIBRAS: Brazilian Sign Language.

There was a significant association between vocabulary and recitation only for the less skilled students in number-reciting (χ^2 (1) = 6.76; $p < 0.01$). Thus, it can be noted that a poor vocabulary is associated with a poorer performance in the numerical skills assessment. To succeed in recitation, students need to make use of the collection of signs designating each numeral and their combinations to form the entire numerical sequence in LIBRAS, which could explain the significant association found with vocabulary for less skilled students in numerical recitation.

The use of a reference in space when retelling the story was significantly associated with the number-reciting skills (χ^2 (2) = 5.88; $p = 0.05$). An expressive percentage of the most skilled students in number-reciting made a reference in space, in contrast, approximately 70% of students with reduced numerical skills did not. Thus, one more aspect of expressive language is associated with numerical skills, reinforcing the relationship between language proficiency and early numerical skills.

The logical sequence was present in the narrative of the most skilled students in number-reciting (83%). Thus, there was a significant association between recitation (χ^2 (2) = 8.60; $p = 0.014$) and the logical organization of the narrative. Knowing how to order the facts of a story or the numerical signs requires the use of sequential logic to correctly sequence ideas and signed numerals, as in the case of enumeration.

After watching the IALS-indicated movie excerpt twice, the students were asked to retell the story to someone who supposedly did not know it. Thus, they needed to remember the facts experienced by the characters to make sense of the story. There was a significant association between number-reciting and the number of facts narrated (χ^2 (2) = 10.90; $p < 0.01$). The less skilled deaf students in number-reciting corresponded to 84% of those who performed poorly on the number of facts narrated. On the other hand, 61% of students with better numerical ability could remember most of the facts of the story, showing good performance.Thus, the recitation skills are associated with mathematical and linguistic knowledge.

Discussion

The focus of this study was the acquisition of numerical knowledge by deaf children who use LIBRAS as a first language. Specifically, the recitation skills, constitutive of the concept of number, and its relation to language skills in LIBRAS were investigated. Different levels of number-reciting skills were identified in deaf students, such as the association between number-reciting and schooling. The students' performance in the recitation activity from 1 to 100 showed that as the school grades progress, the domain of enumeration progresses, indicating the importance of the deaf child's experience at school for the acquisition of the LIBRAS numerical sequence.

Deaf first-grade students, observing the regularity used in forming the signs of numerals 1 to 4, generalized the rule and applied it to recite the numeral 5, placing one more finger. This additive logic, employed in the block formed by the numerals up to 4, is modified in the numerical sequence in LIBRAS from the hand configuration of the numeral 5. This is the first hand configuration that is not performed by adding elements in a similar way to the amount represented. Several first-grade students encountered an obstacle at this point in the sequence, which was not observed among those in subsequent school grades.

Using just one hand to make the entire numerical sequence represents an important advance from the point of view of symbolic acquisitions. Thus, the numerical sequence in LIBRAS, with the relations involved in its organization, becomes the first system of mathematical representation that the deaf child will domain. The learning of numerical signs and their sequence organization play an important role in the development of the notion of number.

The development of numerical knowledge involved in recitation over the school years is related to the Conceptual Field Theory (Vergnaud, 2013) by referring to how children acquire complex skills, observing affiliations, continuities and disruptions between the knowledge that the child already has. Like other verbal numbering systems, the numerical system in LIBRAS has several characteristics and rules that are not understood at once. As knowledge progresses, more knowledge may be acquired, taking the former as the basis for new learnings or even a rupture to enable new acquisitions.

The results of this study also revealed that number-reciting skills were associated with deaf students' performance in comprehensive and expressive language tasks. Hearing children and deaf children begin to develop their numerical cognition based on the language they use. It must be considered that the laws of linguistic composition of the numerical sequence have degrees of complexity that vary from one language to another (Fayol, 2012). Thus, it was sought to identify the linguistic levels in LIBRAS associated with the appropriation of the numerical sequence knowledge, in order to describe the specificities of sign languages that influence the way deaf individuals represent their mathematical knowledge (Leybaert & Van Cutsem, 2002; Madalena et al., 2017).

The performance of the students in the enumeration task was significantly associated with some specific linguistic levels in LIBRAS, such as the logical sequence in the chain of events when ordering and retelling a story. Such linguistic levels are involved, respectively, in the construction and expression of concepts, as in the organization of thought.

Vocabulary is the repertoire of words of a language user, and through it, invariants and contexts that give meaning to concepts gain linguistic representation (Vergnaud, 2013). Thus, words give expression to the concepts we construct and employ, with the expansion of vocabulary being the raw material for learning, including mathematics itself and, in particular, enumeration (Negen & Sarnecka, 2012). This was no different, in this study, for the less skilled deaf students in recitation. Since words mediate our experience in the world, interventions aimed at building and expanding vocabulary can make a significant contribution to understanding the concept of number. This only confirms the need for deaf children to be in contact with LIBRAS as early as possible, and to have longer exposure to Sign Language in order to advance their acquisition of mathematical concepts that underlie more complex later acquisitions.

The association between enumeration and narrative progression, either in comprehensive language (in the form of recognition and ordering of figures) or in expressive language (through the logical sequencing of retelling events), evidences the presence of logical invariants linking linguistic and mathematical knowledge. Learning the numerical signs implies memorizing them in the sequence in which they are organized. At the same time, it should be considered that it would be very demanding to store all signed combinations to form the numerical sequence in memory. The association between the enumeration task and the number of facts narrated, as well as the reference in space, demonstrates the demand for memory resources at the moment of numerical recitation. Based on a repertoire of signs, the gradual mastery of the rules governing the decimal numbering system will enable deaf children to understand the generative character of the decimal numbering system, being able to form the numerical sequence in LIBRAS. This demands not only that information is stored, but also numerical information to be processed.

Numerical knowledge acts in the formation of concepts that are gradually being refined. Once again, the situations in which this knowledge is used will help the child to activate and develop their linguistic-cognitive skills. The experience gained in the various situations in which this number-reciting knowledge is used will give meaning to the numerical concept that is being built in LIBRAS.

Finally, it is important to note that while observing recitation skills develop with schooling, there is a lag in relation to the age at which deaf students are learning to recite the numerical sequence. It should be considered that the vast majority of hearing children come into contact with the numerical words and their organization in their verbal sequence even before entering school, while deaf children often initiate this contact more systematically only when they start going to school.

Learning situations occur in different socio-communicative contexts, however, in relation to deaf children these situations and contexts are limited, which was pointed out by the precarious knowledge that the family members of the participants in this study have about LIBRAS. Mathematical activities need to be put into practice also in the day-to-day situations of deaf children and, if mediated by their parents, can support future numerical learning (Pagliaro & Kritzer, 2013). Therefore, access to mathematical knowledge through LIBRAS cannot be postponed nor restricted to strictly school situations.

Contributors

S.P. MADALENA contributed to the conception and design. All authors contributed to data analysis and interpretation, discussion of results, revision and approval of the final version of the manuscript.

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