

SIGNED PICTUREBOOKS FOR SIGN LANGUAGE LITERACY

LIVROS IMAGEM SINALIZADOS PARA ALFABETIZAÇÃO
EM LÍNGUA DE SINAIS

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ABSTRACT

Hearing children have long benefited from engaging with literacy materials, although this is not the case for deaf children and signed languages. Sign language literacy is still in its infancy, even in those countries who have an official sign language curriculum. In addition, sign language literacy materials are scarce. With the aim to fill this gap, the *Libras em primeiro* project, (2022 - 2024), funded by FAPERGS (in Portuguese, A Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul), in the postgraduate program *Programa de pós-graduação em Letras*, University of Santa Cruz do Sul, RS-Brasil, has developed hybrid signed language learning material for deaf children in the kindergarten and the first grade of elementary education. In particular, the material is a series of signed picturebooks, which integrates visual-graphics and videos to support deaf children's early sign language literacy and teacher's practice. The paper describes the theoretical foundations of this development mainly on the basis of the Reading Systems Framework and its connections to the cognitive mechanisms of sign language processing and recognition.

Keywords: Signed Language. Picturebook. Literacy. Reading.

RESUMO

Há muito tempo, as crianças ouvintes se beneficiam do envolvimento com materiais de alfabetização, embora esse não seja o caso das crianças surdas e das línguas de sinais. A alfabetização em língua de sinais ainda está em sua infância, mesmo nos países que têm um currículo oficial de língua de sinais. Além disso, os materiais de alfabetização em língua de sinais são escassos. Com o objetivo de preencher essa lacuna, o projeto *Libras em primeiro* (2022 - 2024), financiado pela FAPERGS (Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul), no Programa de Pós-graduação em Letras, da Universidade de Santa Cruz do Sul, RS-Brasil, desenvolveu material didático híbrido de língua de sinais para crianças surdas da educação infantil e do primeiro ano do ensino fundamental. Em particular, o material é uma série de livros imagem sinalizados, que integra gráficos visuais e vídeos para apoiar a alfabetização precoce de crianças surdas na língua de sinais e a prática do professor. O artigo descreve os fundamentos teóricos desse desenvolvimento, principalmente com base na Estrutura de Sistemas de Leitura e suas conexões com os mecanismos cognitivos de processamento e reconhecimento da língua de sinais.

Palavras-chave: Língua de sinais. Livro imagem. Alfabetização. Leitura.

Introduction

With the publication of official curricula for the learning of signed languages as first (L1) and/or second (L2) languages for deaf and hearing students (Mertzani; Barbosa; Fernandes, 2022), signed languages in certain countries (e.g., the U.S.A., Greece, Canada, New Zealand, Australia, Brasil) appear both as the languages of instruction for the delivery of the curriculum, and the academic subject to be studied across the school grades. This paper focuses on the kindergarten and the first year of elementary education, since in these grades the sign language curriculum introduces four components that aim at deaf children's learning of a standard signed language, and in a parallel fashion to the literacy aims of the country's official spoken language. The components are: comprehension, phonological awareness of signed languages, the fingerspelling principle (that partially corresponds to the alphabetic principle; see below), and sign language fluency.

A previous analysis of these components (Mertzani, 2022; 2023a; 2023b) showed that they can all correspond to the literacy components of spoken languages (mainly of the alphabetic ones). For example, since signed languages are proven to have their own morphophonological system (Petito, 2014; 2016), the teaching of the phonological awareness component involves processes of recognising the phonemes that make up words/signs, alliteration, segmentation (see also Di Perry, 2004), and even rhyming (see: Holcomb; Golos; Moses, et al., 2022; Holcomb, 2020; Holcomb; Wolbers, 2020). Signed sentences can be broken down into signs; signs can be broken down into syllables and/or into their individual phonemes; and signs can be changed by manipulating their parameters (e.g., by adding, deleting, or substituting the parameters). With regards the comprehension component, vocabulary learning, prediction, connection (e.g., relating pictures and text to real life), and retelling (Epstein, 2007) apply to all languages, including signed languages (Wall, 2014). A less obvious correspondence is the alphabetic principle, which involves the fingerspelling and lexicalised signs since their handshapes are formed by those of the manual alphabet (e.g., the Libras signs FAMILY and FLOWER are formed by the F handshape).

During literacy learning, the young child must compose meaning *from* a printed text and *into* text (Dierking, 2013 p. 4), an ability strongly connected to *print awareness*, the component that is not yet included in the official sign language curriculum. Print awareness aims at developing children's ability in processing visually *print* (see Table 1), a term that is traditionally associated to written scripts (for signed language scripts see: Grushkin, 2017; 2021) although sign language literature expanded its meaning to signed videos (Mertzani, 2022; Hoffmeister; Karipi; Kourbetis, 2022). This paper discusses this last component in relation to the visual-graphic representation of signed languages as unscripted languages, as the latter is the object of study in the ongoing project *Libras em Primeiro* (2022 - 2024), funded by FAPERGS (in Portuguese, A Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul), in the postgraduate program *Programa de pós-graduação em Letras*, University of Santa Cruz do Sul, RS-Brasil. The project develops *hybrid* signed language learning material for deaf children in the kindergarten and the first grade of elementary education, integrating visual-graphic signed texts and videos to support children's early *signed language literacy* and teacher's practice in the target school grades.

In doing so, the project adopted a signed language centred approach in the teaching of signed language literacy, supported by current neuroimaging research in sign language processing and recognition. Hence, all five literacy components were studied for the construction of *signed*

texts and activities that aimed to teach *signed language reading*. This examination of the components initiated an investigation of the visual-graphic characteristics of signed languages that the first section of this paper presents. The second part then discusses these components within a cognitive framework of signed language reading, as it is currently applied in the construction of the *Libras em primeiro* learning materials - the signed picturebooks. The paper closes with future considerations in developing reading materials for the early learning of signed languages in the official curriculum.

Signed languages in print

Signed languages are met in print in signed language dictionaries and children's illustrated books. For the purposes of this study, pictorial publications for American Sign Language (ASL) was chosen, mainly because such material can track its teaching as L1 and L2 from the 1970s to present, a period of major educational shifts in deaf education (e.g., Stokoe's ASL linguistics publication; total communication in the 1980s; bilingualism in the 2000s). The total material under examination comprised twenty one (21) dictionaries and eighty eight (88) children's picturebooks. These latter fell in the following three categories: thematic vocabulary books; English picturebooks with few ASL illustrations; and thematic ASL workbooks. Due to the fact that the majority of picturebooks presented isolated ASL signs rather than signed texts, the study also involved fifteen (15) ASL textbooks that taught the language as an L2 to adults.

In the dictionaries, ASL is displayed through line drawings or black and white photos, where each sign-word is presented in a framed window, mainly in a receptive viewpoint¹, from waist to head of an illustrated signer, and with sign its phonological parameters marked. However, up to the 1990s, the dictionaries are not constant in providing complete sign phonological representations. For example, facial and non-manual representations are missing; signs are illustrated with torso depictions only and without the signer's head; and when signing involves the hand, palm, or the arm(s), the hand/palms are illustrated only, without any other body reference and representation. From the end of 1990s onwards, both in ASL dictionaries and textbooks sign parameters are depicted through certain graphic symbols and/or English glosses. Thus, movement is displayed by certain arrow symbols, by numbers (e.g., the numbers 1 and 2 indicate order of hand configuration changes; movement changes in compound signs); and by the plus (+) symbol (e.g., double ++ for sign repetition). Additionally, the temporal property of the movement is also depicted by dotted lines, circles, or square frames to indicate change from the first position of the hand(s) to its/their final position.

In the 1970s and early 1980s, signs appeared in sentences but in the syntax of English. An illustrative example is the Signed English picturebook series by the Gallaudet Pre-School Signed English Project, which integrated child-friendly illustrations to communicate visually the stories. In this series the signed text presented direct and indirect discourse patterns through character illustrations. For

¹ This viewpoint refers to the perspective experience of someone observing another person signing, the addressee, opposite the signer (Hoffmann-Dilloway, 2017; Shield, Meier, 2018). In contrast, the "expressive" viewpoint (adopted by few sign language dictionaries) refers to the perspective of a signer, in which the sign articulation is depicted from a viewpoint "oriented above a signer's head, from below, or from a signer's right or left" (p. 1).

example, a signer-narrator was illustrated to narrate in signing the stories (e.g., an old person narrating the Red Riding Hood story), hence representing the indirect discourse; and the remaining characters (e.g., the Red Riding Hood, the wolf) were depicted as if their signing is directed to each other, in a sort of dialogic format (direct discourse). As a result, the reading of these signed texts required the understanding of the sequential order of the signs that formed signed sentences; and of the progressive character shifts in these sentences.

It is the third category of picturebooks where short ASL texts appear in combination with sequential pictures and with a narrative and/or informative intent. Best examples are the books by Annie Kubler (e.g., *Twinkle, twinkle, little star, Teddy bear, teddy bear!*); Anthony Lewis (e.g., *Going out, Five little ducks*); and Isaac Millman (e.g., *Moses goes to school; Moses goes to the circus; Moses sees a play*). In these books, the following structures are met: (i) sign windows (as in the dictionaries) always accompanied by the corresponding English word; (ii) sign windows in order (e.g., as in Isaac Millman's picturebooks) to form short ASL sentences, followed by written English (words and/or whole paragraphs); and (iii) single signs to accompany the meaning of the English word, sentence, or paragraph (e.g., as in Annie Kubler's and Anthony Lewis's books). In other words, these books are not bilingual, but ASL is used to complement the English text.

In contrast, signed texts appear in the ASL textbooks for hearing learners (e.g., Humphries; Padden; O'Rourke, 1981; Smith; Lentz; Mikos, 1988; Zinza, 2006), as short phrasal examples of target ASL structures under learning (e.g., Madsen, 1982; Zinza, 2006). These texts feature the use of established graphic symbolism (as in the ASL dictionaries) for the presentation of the sign parameters; the presentation of joint² signs and/or the adaptation of panels (see Cohn, 2013) for the formation of single sentences; and the illustration of adult signers (again as in the dictionaries) in contrast to children's characters in the picturebooks. In Zinza (2006), each signed phrase was followed by a bar as a punctuation mark, signaling the end of the sentence.

All these features show that the reading of signed texts requires the processing of graphophonetic, syntactic, semantic, and pragmatic cues of a signed language, in the same way this happens in the reading of spoken languages (Wall, 2014). Thus, the graphic cueing system is the line drawings of the signs; the syntactic, the syntax and grammar relationships of signs in the sentences; the semantic, their meaning relationships in the sentences; and the pragmatic, the sociocultural and historical context of the signed language in use. By reading these sentences, the deaf child is called to recognize that sentences are made up of signs; that signs are made of specific parameters; how signs are aligned to form sentences; to read the signed texts from left to right and from top to bottom; to understand the difference between pictures, graphic symbols, and signs; to understand the relation among the signs, pictures, and other visuals; and to understand that signed texts have certain functions (narrative, informative, etc.). All these abilities refer to the print awareness component displayed in Table 1. As it is noted above, this component is not yet included in the official sign language curriculum.

² There is no gap in the sign order, and each sign "touches" slightly the other in the same sign order-sentence. This technique creates the sense that signs belong in the same sentence and make part of a single phrase.

Table 1: The print awareness component in spoken and signed languages

PRINT AWARENESS		
a. Book concepts	<p>The child:</p> <ul style="list-style-type: none"> - Identifies front and back covers - Identifies print on a page - Identifies where one starts reading - Holds the book right side up - Turns pages properly and understands page sequence - Follows text from left to right - Views pages from top to bottom - Has developed one-to-one correspondence between oral and written words - Demonstrates a return sweep - Understands that words tell a story 	<p>The child:</p> <ul style="list-style-type: none"> - Identifies front and back covers - Identifies signed language on a page - Identifies where one starts reading - Holds the book right side up - Turns pages properly and understands page sequence - Follows signed text from left to right - Views pages from top to bottom - Has developed one-to-one correspondence between verbalized and printed signs - Demonstrates corrective signing - Understands that signs tell a story
b. Print concepts	<p>The child:</p> <ul style="list-style-type: none"> Is aware of print in the environment Understands that print is the words that are read Recognizes that words are made up of letters Recognizes that there are spaces between words Recognizes that sentences are made up of words Knows words are read from left to right and from top to bottom Understands the difference between pictures and print Understands that pictures relate to print Observes that print has different functions (street signs, recipes, letters, stories, labels, etc.) 	<p>The child:</p> <ul style="list-style-type: none"> - Is aware of printed signed language in the environment (e.g., in the classrooms) - Understands that print is the signs that are read - Recognizes that signs are made up of parameters - Recognizes that in print there are spaces between the signs - Recognizes that sentences are made up of signs - Knows signs are read from left to right and from top to bottom - Understands the difference between pictures and signs - Understands that pictures relate to printed signed language - Observes that printed signs have different functions (e.g., stories, vlogs)

Source: Author's elaboration based on Flora (2011, p. 148).

Sign language processing and reading

All components require “the acquisition of the ability to comprehend and communicate language expressed in visual form” (Goswami, 2009, p. 134). When it comes to a physical book, the above study demonstrates that this visual form refers to the visual-graphic modality of the signed language on paper, which, in turn, allows a transparent mapping of the language onto the medium (at the morpho-phonological level). Hence, the reading of a signed language in print involves a combination of top-down (knowledge-driven) and bottom-up (word-based) processes, similar to the ones in the reading of spoken languages. In line with this, the *Libras em primeiro* project studied and adapted the *Reading Systems Framework* (RSF) by Stafura and Perfetti (2017) as it finds support in neurobiological models of language (such as sign recognition and processing; see below) that justify choices in the design of language learning material. In the system's present version (for the purposes of signed language reading), “language” also refers to the *visual language* (see Cohn, 2013) of the medium, which in this case is the picturebook.

According to RSF, reading is using three classes of knowledge sources: the linguistic knowledge, the orthographic knowledge, and the general knowledge (e.g., knowledge about the world, knowledge of text forms like text genres) (Stafura; Perfetti, 2017, p. 11-12). For signed languages, the orthographic knowledge is replaced by the visual-graphic knowledge. Thus, the processes of reading (e.g., decoding, word identification, meaning retrieval, constituent building, inferencing, comprehension monitoring) use these knowledge sources in both constrained ways (e.g., decoding uses visual-graphic and phonological knowledge but not general knowledge) and in interactive ways (e.g., meaning extracted from sentences; inferences use general knowledge), which, in turn, “take place within a cognitive system that has pathways between perceptual and long-term memory systems and limited processing resources” (p. 12). Although it is beyond the scope of this paper to describe RSF in detail, this section discusses those processes that relate to signed language reading in particular.

Neuroimaging studies (for a recent review see Caldwell, 2022) demonstrate linguistic processing of signs in a left-lateralized network, strikingly similar to the language network involved in spoken language processing, especially when lexical effects are considered. Input is provided simultaneously by all phonological parameters, although the parameters handshape, orientation, and location are identified first (probably because there are few signs identical in terms of these three parameters), followed by the identification of movement, which is the decisive parameter for sign recognition. However, extra-personal³ spatial signs (as opposed to interpersonal ones) are first processed in the right hemisphere and then transmitted in the left for linguistic coding (Schermer; Pfau, 2016, p. 39).

When phonological information reaches working memory, input is temporarily stored in a repetitive visuo-spatial loop, comparable to the phonological loop. Hence, deaf signers store information based on the form of signs. Moreover, deaf signers have difficulty in remembering signs phonologically similar than signs phonologically different, and signs with longer movement, in the same way hearing people cannot retain words with many syllables. However, there are differences between hearing and deaf subjects in the capacity of working memory. Overall, signers can retain fewer items than speakers (Schermer; Pfau, 2016), probably due to the lengthy nature of sign articulation (word articulation takes less time). Also, their mistakes are based on phonological rather than semantic features (p. 36).

Lexical retrieval of signs is modulated by strong links between semantics and phonology. Overall, signs, like words, are recognized faster and more accurately than non-signs (the lexicality effect), familiar signs are recognized faster than less familiar signs (the frequency effect), and signs are categorized faster when they are preceded by semantically related signs (the semantic priming effect). “Meaning is the first part to be accessed during production, followed by the phonological form of the signs” (p. 48). For example, more frequent semantic clusters are found for handshape and location categories. Additionally, there is some evidence in favor of iconicity, aiding semantic processing. For example, in picture-naming tasks, deaf and bimodal bilingual signers are faster at signing pictures whose corresponding signs are iconic; that is, when the presented picture highlights the same iconic property as the sign (e.g., a picture of a bird highlighting the beak, the property in the sign BIRD rather than the wings). However, iconicity has opposite effect when phonological processing is required, probably because the direct form-meaning mapping prevents learners from focusing on the exact phonological structure of the sign (p. 64). The selected semantic lemmas (from the mental lexicon) are combined in grammatical structures, allowing the lexemes to be retrieved from the phonological lexicon, which, in turn, lead to the production of the signs.

³ The signs that demonstrate space localized away from the signer’s body.

The planum temporale in the superior temporal gyrus is the brain site where speech and signed language phonology is processed (Petito, 2016). Moreover, the left superior parietal lobe and the left supramarginal gyrus appear to have a greater role in signed than spoken language processing. This activation is sensitive to the characteristics of the signed modality, attributed to phonological encoding and proprioceptive monitoring; that is, to the somatosensory and proprioceptive feedback (anterior parietal activation); to the voluntary production of motor movements (posterior parietal activation); and to the sensorimotor integration for the phonological encoding of signs (inferior parietal activation) (Giezen, 2021).

Reading two-dimensional signed language material

Eye tracking research has focused on video sign language recognition, demonstrating that: (i) native signers fixate their eyes on the face of the signer (in the video), and fingerspelling in their peripheral vision (Siple, 1978; Agrafiotis; Canagarajah; Bull; Dye, 2003; Emmorey; Bosworth; Kraljic, 2009; Kacorri; Harper; Huenerfauth, 2013; Muir; Richardson, 2005); (ii) native signers focus on or near eye region to understand information, whereas beginner signers focus on or near the mouth region to comprehend additional information (e.g., lip-reading) (Emmorey; Thompson; Colvin, 2008); (iii) the hands, as primary articulators, fall almost outside or far below the foveal region (Bosworth; Wright; Dobkins, 2019; Kacorri; Harper; Huenerfauth, 2013); (iv) facial fixations pick up small detailed movements, whereas peripheral vision processes information from larger rapid signing movements (Muir; Richardson, 2005); (v) sign language identification is poor in low peripheral vision and when signers identify a sign from the back view of the hand compared to the front view of the hand (Emmorey; Bosworth; Kraljic, 2009); and (vi) when native and novice signers face complex difficult signed context (e.g., classifier constructions), their gaze is redirected to the hands (Emmorey et al., 2009; Muir; Richardson, 2005), and when the signer gazes at his/her own hands (Emmorey; Thompson; Colvin, 2008).

Overall, efficient sign reading is quickly learnt even among late signers (Bosworth; Stone; Hwang, 2020), most probably because signers need to see only about 35% of a sign to identify it, compared with 83% of a spoken word needed by speakers (Grosjean, 1980; Emmorey; Corina, 1990). This easiness, though, does not hold when deaf native signers watch avatars signing. They perceive them difficult to understand (in comparison to human signing), thus exhibiting less fixations on the face, and greater gaze shifts to the body in the parafoveal and peripheral regions (Kacorri; Harper; Huenerfauth, 2013). While viewing static face images, deaf participants focus more on the eyes, whereas hearing participants on the nose region, a reading behavior attributed to both different cognitive strategies involved (e.g., holistic vs. analytic approach to visual information) and to sociocultural norms (deaf vs. hearing norms; see Watanabe; Matsuda; Nishioka; Namatame, 2011).

As the signing is displayed from a frontal view, the reader is called to perform a visual perspective shift, rotating 180° the displayed signing (Emmorey et al., 2009). Native signers are more accurate and faster when recognizing signed videos from this recipient's perspective (the addressee-perspective) than from the signer's perspective that, for example, SignWriting uses (Hoffmann-Dilloway, 2017). For children, this reversing perspective-taking is a difficult cognitive task. For example, the deaf child needs to recognize in these two-dimensional depictions difficult phonological sign representations, such as lateral path movements, inward–outward movements, and inward–outward palm

orientations (Shield; Meier, 2018, p. 4). Additionally, as children base their sign language acquisition on imitation⁴, they may produce incorrect signing during reading. For example, they may produce what they see from their perspective (using a visual matching strategy), generating inward–outward movement and palm orientation reversals; or they may produce a mirror image of the modeled signing (through a mirroring strategy), committing lateral movement reversal errors or using the non-dominant hand instead of the dominant hand (p. 5). An important finding of their study is that sign language exposure does change the way imitation strategies are used, yielding to a switch from the error-generating imitation strategies (e.g., mirroring, visual matching) to the correct reversal strategy. This result addresses the importance of sign language instruction by systematically exposing the child to signed language learning.

This is imperative, since current international research demonstrates the benefits of early sign language exposure (Caldwell-Harris, 2021; Caselli; Pyers; Lieberman, 2021; Hall; Hall; Caselli, 2019; Hoffmeister; Caldwell-Harris, 2014; Hoffmeister; Henner; Caldwell-Harris; Novogrodsky, 2022; Humphries; Mathur; Napoli et al., 2022; Hrastinski; Wilbur, 2016; Koulidobrova; Kuntze; Dostal, 2018; Mayberry; Giudice; Lieberman, 2011; Mayberry; Kluender, 2018; Mayer; Trezek, 2020; Pontecorvo; Higgings; Mora et al., 2023; Scott; Hoffmeister, 2016), recognising the right to early sign language learning (Humphries, 2014; Kourbetis; Karipi, 2021; Krausneker; Becker; Audeoud; Tarcsiová, 2020; Ormel; Kerkhoff; Baker; van der Aa, 2023). Additionally, reading is shown to be significantly correlated with the deaf child's sign language ability (Bochner et al., 2016). In fact, deaf signers show enhanced eye-gaze-tracking ability and increased eye span while reading (Petito, 2016).

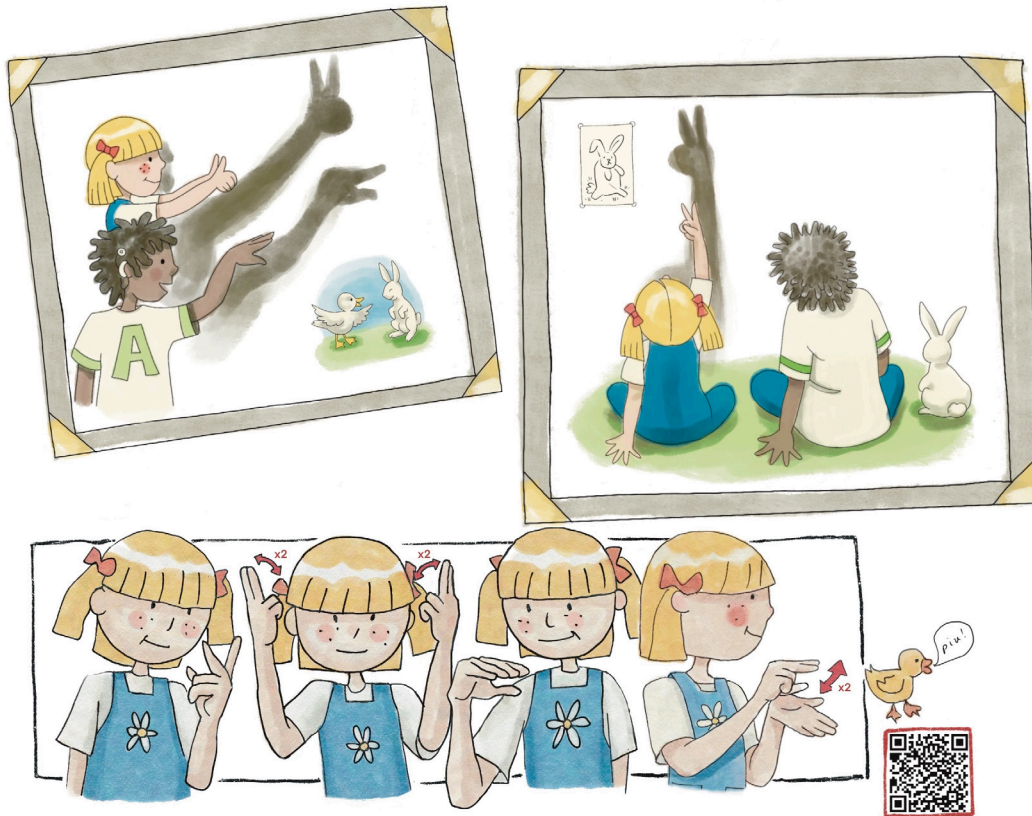
Hence, in line with this research context, sign language literacy is more to the academic study of signed texts than just simply having students to watch signed videos (Golos, 2010a; 2010b; Mertzani; De Monte; Fernandes, 2023; Wall, 2014). Such instruction requires the use of signed materials that teach the child to use both visual-semantic strategies (they are already at play in the reading of spoken languages; see Costello et al., 2021; Holcomb et al., 2022; Holcomb; Wolbers, 2020; Morford; Corrine; Megan et al., 2019) and signed-based phonological processes. It is worth mentioning that sound-based phonological awareness has a limited role in deaf children's spoken language reading (Hoffmeister; Caldwell-Harris, 2014; Hoffmeister; Henner; Caldwell-Harris; Novogrodsky, 2022).

Sign language literacy with picturebooks

In line with the RSF and the above research context, learning material construction took into consideration children's pre-operational developmental stage, during which they rely heavily on visual input (Yu, 2012; Wang; Fu; Cheng et al., 2021). Picturebook is the book genre that provides such rich visual input over various themes and concepts (Kümmerling-Meibauer, 2018; Yu, 2012; Williams, 2008), following children's cognitive development (Kümmerling-Meibauer; Meibauer, 2018). In fact, picturebook reading is shown to benefit deaf children and to support their creative graphic skills (Wang; Fu; Cheng et al., 2021).

4 The reversing of the signed text is an imitation strategy.

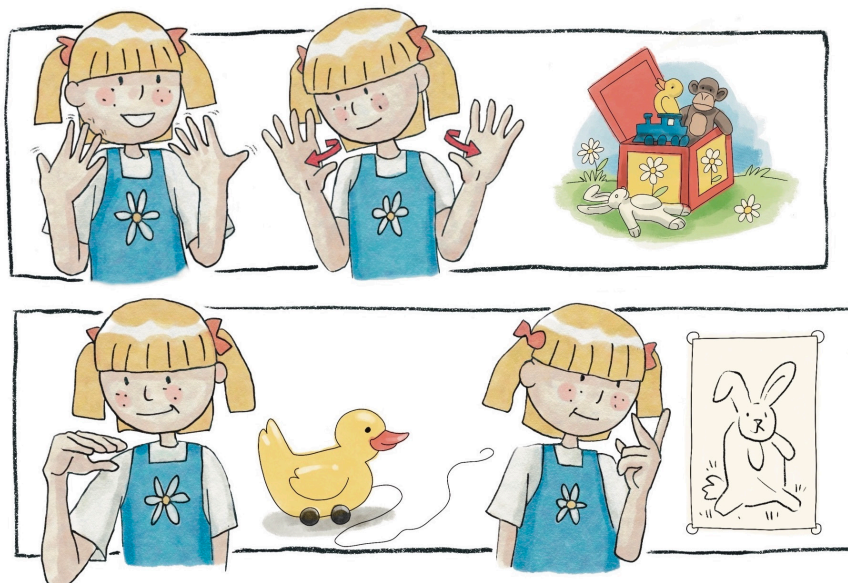
Figure 1: Example of an image dependent signed text



Source: Author's archive.

Obs.: The signed text depicts joint signs within a panel to form a sentence. Conventional sign symbolism is also used. The characters are all deaf children. Following the sociocultural perspective, the children are presented in playful moments. The signed text is also in video, through the QR option.

Figure 2: Example of activity with image prompts



Source: Author's archive.

Obs.: The task calls for the student to replace the content image with the proper sign. There is a semantic relationship among the image and the phrases.

Picturebooks blend the sequentiality of the image with text, a feature that the ASL illustrated books also exhibited to a certain degree. Thus, for the purposes of the project, a new picturebook genre was conceived - the signed picturebook - that has the following features: (i) pictorial content (e.g., narrative, informative) sequentially; (ii) sequential signs (as discussed above); and (iii) the visual language of both the signed texts and picturebook structure (e.g., panels, page layouts, movement symbolism) (Cohn, 2013; Kümmerling-Meibauer, 2018). So far, the project has developed ten signed picturebooks, covering topics that teachers teach annually in the kindergarten and the first year of elementary school (e.g., the change of seasons, mother's day, animal cycles, self-image). Following the Libras Curriculum of the city of Rio Grande (Mertzani, Fernandes, Duarte, 2020), the units were developed to cover all five literacy components, hence comprising of signed texts and tasks as well as of students's self-evaluations and the teacher's manual.

The signed texts are also provided in videos (through QR options) (see Figure 1), for modeling the target signing and its fluency, considering: the limitations of print in presenting sign language articulation; the fact that the majority of deaf children has limited signed language exposure (e.g., in mainstream schools); and the fact that parents and teachers have limited signed language knowledge. Although adult fluent signers feature in the videos, the printed material is child-friendly, depicting elementary-aged deaf children in familiar environments. Hence, deafness is approached through a socio-cultural perspective rather than a disability one (Golos; Moses; Wolbers, 2012; Golos; Moses, 2013; Moses; Golos; Holcomb, 2018). Moreover, careful attention was given to illustrating the characters' facial expressions following the aforementioned eye-tracking findings. Furthermore, knowing that the reading of visual language passes through stages (see Cohn, 2013; also the discussion for children's reversing errors), the signed texts employed to the maximum conventional sign symbolism, which children must acquire gradually through explicit instruction.

Throughout the units there is a picture-dependent information structure (Figure 1) since it is shown to support children's long-term memory (Brookshire; Scharff; Moses, 2002). Thus, the signed texts strongly agree with the content of the images. In fact, sign language iconicity is also integrated, since it appears to support lexical retrieval (see discussion above). Additionally, the sequence of the images uses a canonical order, having a normal narrative structure similar to the verbal one (Cohn, 2013), although more techniques are employed (e.g., image substitution, alteration, deletion, reordering) in the construction of the tasks (Figure 2). For the design of these latter, research-led tasks with semantic and phonological distractors were also consulted (Mertzani, 2019).

Discussion and conclusion

Hearing children have long benefited from engaging with literacy materials, although this is not the case for deaf children and signed languages. Sign language literacy is still in its infancy, even in those countries who have an official sign language curriculum. In addition, sign language literacy materials are scarce. With the aim to fill this gap, the Libras em primeiro project, PPGL-UNISC, Brasil, has developed signed picturebooks for deaf children in the kindergarten and the first year of elementary school, whose application in the classroom is an on-going process in a local mainstream elementary school with three deaf students. This paper aimed at presenting the theoretical foundations of such development, focusing on the RSF and its connections to the cognitive mechanisms of sign language processing and recognition.

In doing so, signed languages are viewed as languages with an academic status at schools that students need to learn (Supalla, 2017; Supalla; Blackburn, 2021). In line with this, the signed texts are constructed with this purpose in mind, calling the deaf student to decode and encode the signs, a process, when learnt, they can use in cross-language activations during L2 processing (see Morford; Corrine; Megan et al., 2019). However, further investigation is needed since a systematic instruction of such visual material entails changes in the neural circuitry in language processing (see Tan; Laird; Li; Fox, 2005; also Grushkin, 2017). What results can we expect then when reading printed signed language? What happens in children's minds while reading a sequence of printed signed images? What aspects of the visual-graphic modality do children store that enable their comprehension/production of signed language? Can such reading be compared with the reading of written signed languages and/or other types of scripts (alphabetic, logographic, etc.)?

A visual-graphic approach to sign language reading does not engage children in script reading. However, it does expose them in sign language phonology representations, the learning of which permits cross-language activations and transfers (Snoddon, 2021, p. 30). As this reading is also a linguistic act, different skill(s) need to be acquired and with a different instructional approach. For example, research in comix reading shows that experienced readers have smoother fixations and advanced skipping skills than the novice readers, who focus more on the text than the images, and take longer to read a single page (Cohn, 2013, p. 111). The assumption is deaf children might develop similar reading behaviors, should they have a frequent exposure to printed signed language material. However, more research is needed for further insights on the development of such literacy behaviors.

Picturebooks encompass *visual literacy* and meaning-making processes that are difficult for the pre-operational child (Williams, 2007; Williams, 2008). For example, children at this age demonstrate literal retranslations and/or short descriptions of the images (Williams, 2007; Yu, 2012), a finding that addresses the importance of intervention strategies and guided picturebook reading, especially for the deaf child who enters school with delayed language. Hence, signed language reading does raise concerns about the teacher's appropriate knowledge and training in teaching such reading strategies and skills effectively to deaf students (Supalla, 2017). Apart from being fluent proficient signers, teachers need to be familiar with both top-down (e.g., shared reading; image use for sign recognition and meaning) and bottom-up (e.g., repetition, sign decoding) practices that focus on meaning and individual parameters (Mertzani, 2022). As teachers have little knowledge of sign linguistics and sign language grammar, they may not provide optimal instruction.

As a last note, it is stressed that this proposal of signed language reading does not suggest to replace the teaching of spoken language literacy. On the contrary. Both literacies are important in the education of deaf children, and a careful language assessment must determine the educational program and the teaching hours for each language.

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Received: 30/11/2023

Accepted: 13/02/2024