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Phonological Memory and Phonological Acquisition in Bimodal Bilingual Children¹

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1.0 Introduction

This report focuses on a binational study of language acquisition by bimodal bilinguals, or language users with access to two languages in different modalities: spoken and signed. Participants in this study are children from Brazil and America who are simultaneously acquiring Brazilian Portuguese (BP) and Brazilian Sign Language (Libras), and English (E) and American Sign Language (ASL), respectively.

Participants are subdivided into three groups. The first includes hearing children of Deaf, signing parents (hereafter referred to as *kodas*), the second includes Deaf children of Deaf parents with cochlear implants (hereafter designated as *CIDs*), and the third group, unique to the Brazilian participants, includes Deaf children with a cochlear implant from hearing families (designated as *CIHs*). The CIH children have limited exposure to sign language through academic instruction. We tested phonological memory and phonological production by these participant groups, focusing on similarities and difference in performance by *kodas* and both groups of CI-users. All participants in the study ranged from 4;0-8;0.

2.0 Previous Research

A few studies have examined the adult state of bimodal bilingualism, or bilingualism in a signed and spoken language (Berent, 2004; Bishop, 2006; Emmorey et al., 2005). These studies have focused on the hearing children of deaf families (so-called ‘Codas’, for children of deaf adults) who have grown up using both a signed and a spoken language. A few other studies have examined

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the development of bimodal bilingualism, focusing on the fluency levels obtained by children in each language, the use of code-switching (or simultaneous code-blending, an option only available to bimodal bilinguals), and the relation between developing bimodal bilingualism and theories of the mechanisms of language development (Emmorey et al., 2005; Petitto et al., 2001; Van den Bogaerde & Baker, 2005). However, there is a lack of specific language analysis of bimodal bilinguals.

In recent years, cochlear implants (CIs) have offered improved prospects for functional speech and lip reading in children born deaf. Much of the previous research on children with CIs has been focused on CIH monolingual speakers (Geers et al. 2004, 2011). In studies of phonological production, these CIH children reportedly perform behind their hearing, monolingual peers (Carter, Dillon, and Pisoni 2002; Dillon et al. 2004). However, the participants in these groups tend to have been implanted after the age of 3;0, and much of this subpar performance may be attributed to delayed L1 access and acquisition for the CIH monolinguals. In the current study, the CID participants have access from birth to signed language, and receive their cochlear implants at roughly 1;0, resulting in only a slight delay before they are able to acquire a spoken language. Having access to a language from birth, regardless of modality, has been shown to bolster performance in later-acquired languages (Mayberry 2000).

The duration of auditory deprivation related to auditory experience prior of deafness are factors that contributed to the linguistic performance of children with CI (Geers 2004). Linguistic experience, that is, the acquisition of an L1, and not only early listening experience, may have contributed to successful of oral language acquisition for these children. Davidson et al. (2013) reported that CID children performed equal to both their koda counterparts and hearing, monolingual peers on standardized tests. These findings suggest that performance on tests of language production are correlated to language input, not necessarily to any outside factors. It seems that early acquisition of sign language by deaf children with early implantation leads to acquisition of oral language at expected or near expected levels.

3.0 Hypotheses

Given the findings of previous research, it is postulated that CID children, having exposure from birth to a signed language, will develop spoken language competence more readily than their CIH counterparts who have only delayed, limited access to sign language. With this information in mind, it is postulated that kodas, having exposure to both languages from birth on both their spoken and signed languages will perform well on the phonological tests in both modalities. The CID group, having exposure from birth to their signed language will perform with the same or near- same accuracy on sign language tests as the kodas, and it is postulated that their exposure to sign language from birth will bolster their performance on the spoken word tests. The children in the CIH group, conversely, are expected to perform with lower accuracy on both the

spoken and signed language tests, given their delayed access to speech input and acquisition, as well as their limited access to sign language.

4.0 Pseudoword test

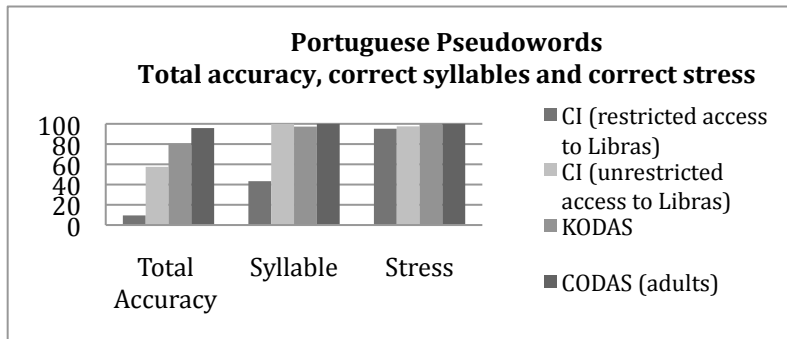
The pseudoword tests focus on nonce words that follow permissible phonotactic parameters in English and BP. The English task utilizes the two- three- and four- syllable pseudowords developed by Carter, Dillon, and Pisoni (2002), for a total of fifteen target stimuli. The BP task uses the stimuli developed by Santos and Bueno (2003), consisting of forty pseudowords, split evenly into three categories; words with high similarity to actual BP words, words with medial similarity, and words with low similarity. Pseudoword production by participants was rated for accuracy according to number of syllables, stress placement, and overall accuracy (for overall accuracy, the child must reproduce the pseudoword exactly as it is presented to them. In our analysis, each pseudoword was phonetically transcribed in IPA. A value of '1' meant that the production was comparable to that of the examiner while a value of '0' (zero) indicated omission, addition, inversion and/or substitution of one or more phonemes. Even if a child did not receive credit for overall accuracy, it was still possible for him to receive credit for correct syllable and stress production for the pseudoword.

Tests were administered by a native speaker of the target language, and participants were instructed that they were going to hear some 'funny' words, and to repeat the word that they heard to the best of their ability. Only the Brazilian pseudoword test did not allow lip reading, restricting access to the experimenter's mouth by covering the lips with a sheet of paper. Adult Codas were used as controls on both tests.

4.1 Brazilian group

For the Brazilian group, twenty three kotas and six CI children were tested. Of the CI children, five were CIH, and one was CID. The graph below illustrates total, syllable, and stress accuracy for the Brazilian groups.

(1)

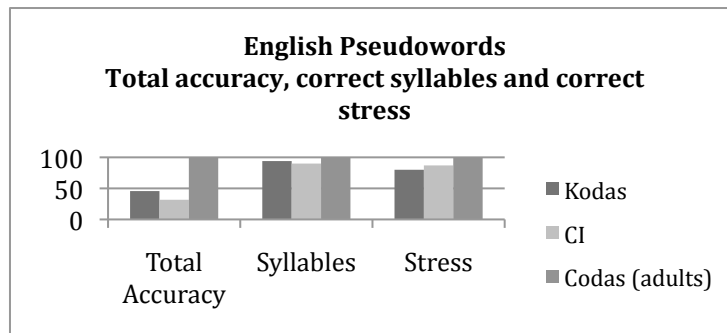


As seen in Figure 1, the CIH children performed below their CID and koda counterparts in both total accuracy and correct number of syllables. In terms of correct stress placement, however, they performed on par with the other groups. This matches the hypothesis that the delayed exposure to BP and limited exposure to Libras would result in less accurate performance by this group in comparison to the others. The one CID child in the study, while below the koda group in total accuracy of production, matches them in the categories of syllable and stress accuracy. The CID participant also far outperforms the CIH participants in total accuracy, giving credence to the prediction that exposure to Libras from birth bolsters their spoken language performance.

4.2 American group

As previously noted, the American group did not contain any CIH participants. Nineteen kodas and four CID children were tested, as well as adult Codas for control purposes. The results, shown in figure 2 below closely match those of the koda and CID participants from the BP study.

(2)



The CID group performed with slightly lower total accuracy on the pseudowords, but performed equal to the koda group for syllables and stress placement. Again, these findings support the hypothesis that exposure from birth to ASL bolsters spoken language performance.

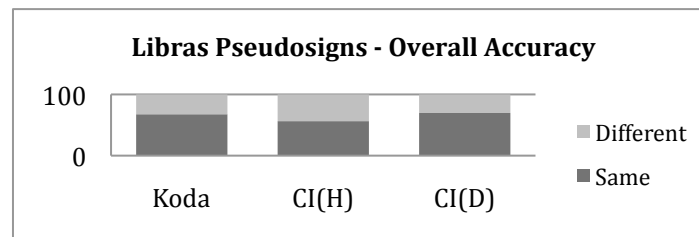
5.0 Pseudosigns test

The pseudosign tests consisted of nonsense signs that followed permissible phonotactic parameters of Libras and ASL. The Libras test consisted of thirty three target stimuli and the ASL test consisted of thirty nine target stimuli. Both tests were run by Deaf near-native signers of the respective language. Participants were instructed that they were going to see some silly signs, and were asked to copy them to the best of their ability. For the analysis of accuracy, the four basic phonetic parameters of signs were analyzed: handshape, location, movement, and orientation.

5.1 Libras group

In this test, nineteen kodas and six CI children participated. The CI participants were the same CIs that took the BP pseudowords test. As shown in figure 3, a general first-pass analysis was conducted on participant productions, rating signs as ‘same’, when they matched the pseudosign model, and ‘different’ when the production did not match the model, on all phonotactic parameters.

(3)

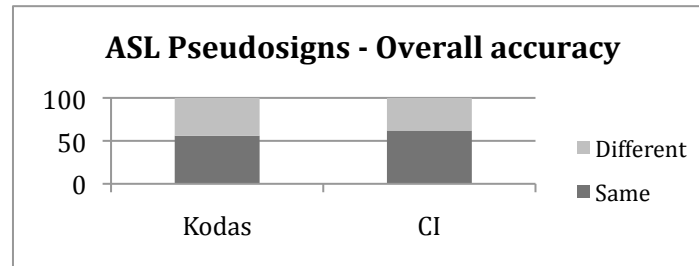


The CID participant performed with the same accuracy as the koda group. As predicted, the CIH group, with limited access to Libras, performed with less accuracy than the koda and CID groups, however, they performed with higher accuracy than predicted, compared to the two native signing groups.

5.2 ASL group

Twenty-eight kodas and four CID children participated in the ASL pseudosign test. The four CID children are the same participants as in the English pseudowords task. Data results are summarized in figure 4 below.

(4)



The koda and CID groups' performances look similar to the results for the Brazilian koda and CID groups. In both groups, the CIDs slightly outperformed the kodas, but the respective results of the two groups show kodas and CIDs on par with one another with regards to overall accuracy.

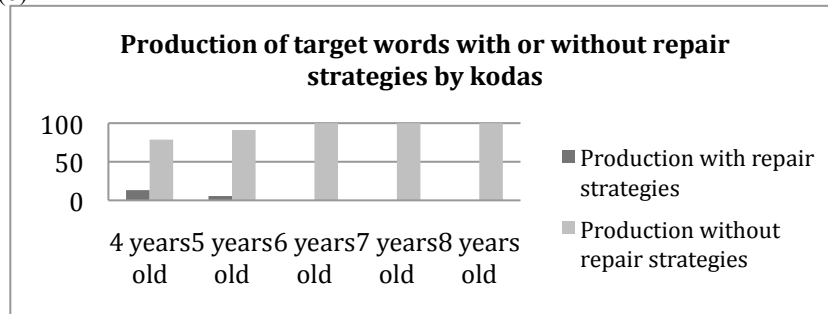
6.0 Phonological production in English and Brazilian Portuguese

Phonological production was also analyzed for the Brazilian and American groups. Participants were administered spoken and signed naming tasks, and were scored for accuracy in their production, and whether or not repair strategies were applied (whether production was expected for the age group, compared to monolingual children). We used a BP picture naming task (Andrade et al. 2004) in which the experimenter elicits words using 34 pictures to determine the phonetic inventory of the child and to verify the occurrences of phonological processes and the distribution and types of syllabic structure used by the child. An experimenter presents the child with pictures and asks him/her to name each one. If the child does not know a picture's name, the experimenter names it and continues through the next five items before returning to the unnamed picture and prompting the child again to name it. The English picture naming task (Goldman-Fristoe Test of Articulation 2; Pearson) is a very common standardized test of English articulation that has been used in previous studies examining children with CIs. The experimenter shows children a series of pictures for which the child must provide English labels, designed to cover a wide range of English phonemes. When scoring the Goldman-Fristoe test, it is recommended that researchers also use the Khan-Lewis Phonological Analysis (Pearson) for more comprehensive error analysis.

6.1 Brazilian group

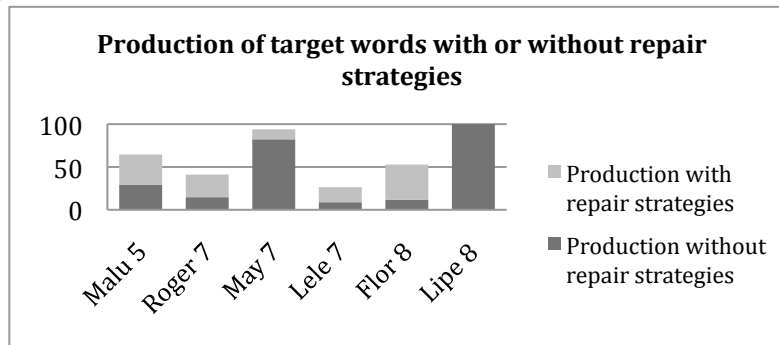
In this test, twenty-four kodas and six children with CIs were evaluated. The children with CIs were the same CI participants as in the BP pseudoword/signs tests: five CIH and one CID. Figure 6 below shows the results of this group where the children were separated by age. Koda performance was similar to that of monolingual hearing children acquiring BP.

(6)

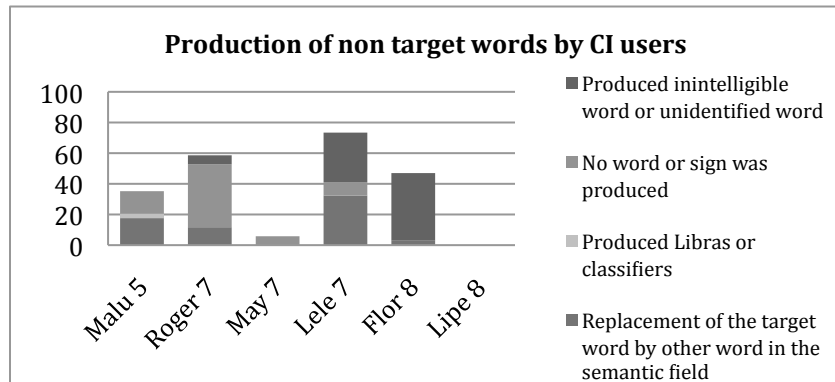


The analysis of the CIs group is small enough to display participants individually, in Figures 7 and 8. Figure 7 shows the production of target words with or without repair strategies and Figure 8 shows the production of non target words. Almost all CI participants performance below kotas, except the CID, who performed on par with the kotas. Four of the six subjects produced target words near or less than 50% of the time. When they did not produce the target word, they used various strategies for naming the pictures. This may have occurred because of gaps in their vocabulary, since even after hearing the name of the target word produced from the examiner, these children still did not produce the words. If these words are not yet part of the mental lexicon of these children, the would be harder to evocate in the next step of the test. Another possible explanation could be that these children had difficulty concerning the conduction and/or processing of sound information that allows the storage of a new lexical item. In Figure 7, the graph shows the performance of children with CI with and without repair strategies, and the following graph shows the kinds of different productions for the target word.

(7)



(8)

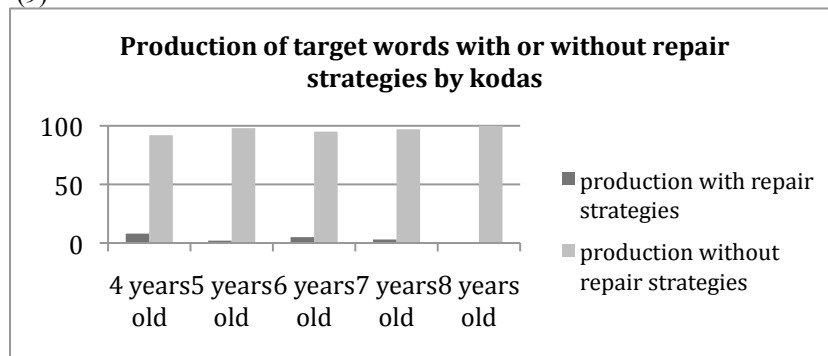


As can be seen, the CID participant performed the same as most Kodas children, without using repair strategies. The CIH children performed below the CID child and Koda groups.

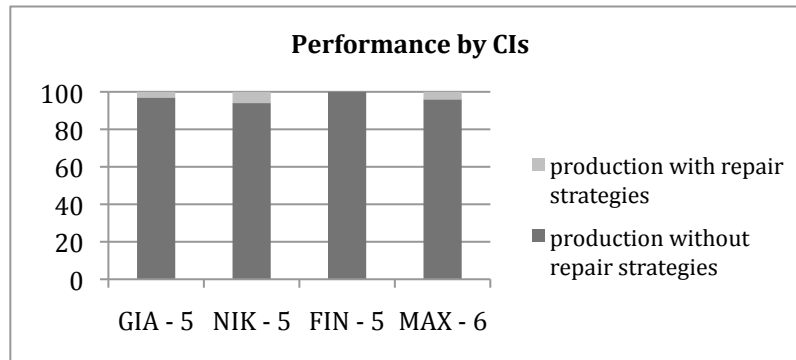
6.2 American group

In this test, twenty kodas and four CID children participated. The American group, as previously noted, did not contain any CIH participants. The findings show that the American koda group closely matched those of the Brazilian koda group, according to Figure 9 below.

(9)



(10)



Unlike the CIH Brazilian group, no unintelligible or non-target words were produced by the American CID children. However, the CID Brazilian child performed the same as the CID American group. The analysis shows that children with CI from Deaf families performed like their koda counterparts with respect to phonological production with and without repair strategies, while the children with CI and only restricted access to sign language made more errors in the phonological production tests.

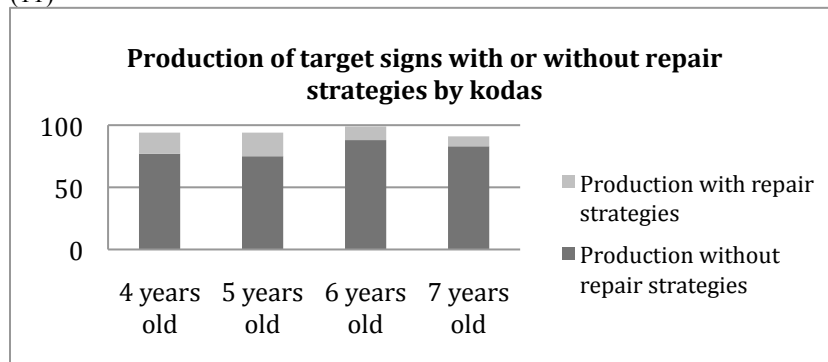
7.0 Phonological production in Libras and ASL

The Libras and ASL picture naming tests (Cruz 2008) followed the same methodology as the BP picture naming test described earlier. The ASL version was adapted from Cruz's original Libras test for the purposes of the Bibibi project. This test evaluates articulation of signs with different handshapes, locations, movements and orientations. An experimenter presents a picture to the child and asks him/her to produce the corresponding sign. This test always precedes the tests of phonological awareness and phonological perception, since it introduces the items used in those tests, ensuring that the child knows the corresponding signs. If a child does not know the sign for a given picture, we follow the same technique as in the spoken BP test: the experimenter provides the sign, continues through the next five items, then returns to the picture that the child was unable to name and prompts him/her to try again. If the child still has problems, the experimenter will teach the child the sign so that he/she knows it for the phonological awareness test. A native speaker of each target language administered these tests and Adult Codas were evaluated as control groups.

7.1 Libras group

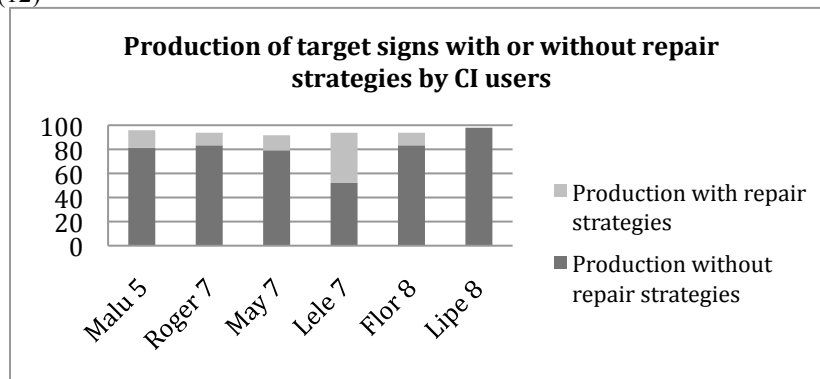
Thirteen kodas and six CI children participated in this test. The CI participants were the same CIs without repair strategies by the koda users. Almost all children were able to produce the words without any repair strategies, performing near ceiling for this test.

(11)



As the CI group is small in comparison to the koda group, their results can be analyzed individually. Figure 11 shows the production of target words with or without repair strategies by these participants. While their speech production differs from that of kotas, their Libras production is similar, even with restricted access to Libras.

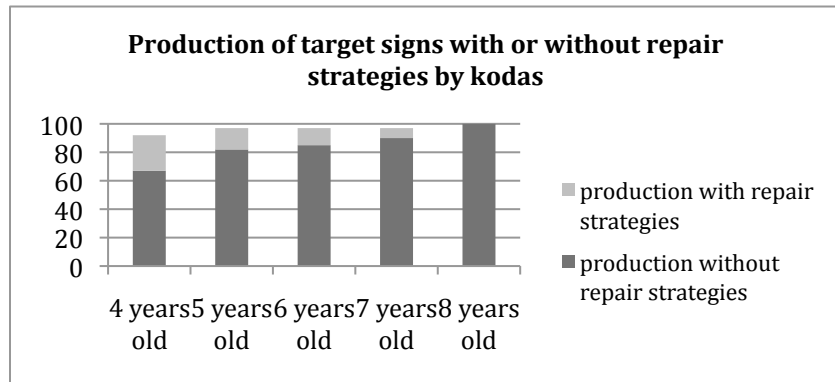
(12)



7.2 ASL group

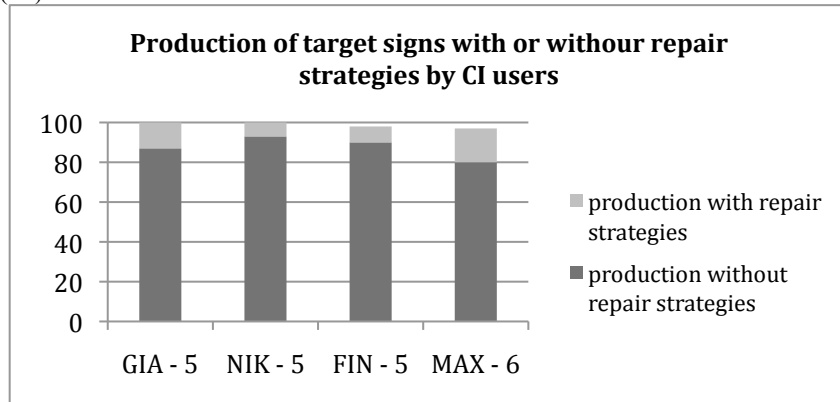
Twenty kotas and four CIDs participated in this test. The American group, as previously noted, did not contain any CIH participants. Figure 13 below shows the production of target signs with or without repair strategies by kotas.

(13)



Individual results for CID participants illustrate their production of target words, with and without repair strategies, in Figure 14 below.

(14)



The analysis shows that CID children performed on-par with their koda counterparts with regard to phonological accuracy, and their use of repair strategies mirrored that of kodas in their respective age groups.

8.0 Conclusions

This study presented demonstrates that koda acquisition of phonology in two languages and modalities is comparable to that of monolinguals. We conclude that access to two languages, one in sign and one in speech, does not obstruct phonological acquisition in either. The CIDs displayed close or

equivalent performance to koda children on all phonological tests, and displayed superior performance compared to the CIHs, especially in the spoken language tests. We propose that the restricted access of these CIDs to sign language, as well as their late age of implantation, contributed to their lower performances compared to other groups. Sign language exposure from birth seems to be an advantage for deaf children with early implantation, who are already acquiring sign language when their exposure to spoken language begins. In these cases there is no linguistic deprivation, even in the first months of life, and sign language can help them to access information in the spoken language.

In the sign language phonology tests, the CIH performance was a bit of a surprise. It is interesting to observe that these children, who acquired sign language later than their CID counterparts due to restricted exposure to sign, nevertheless seem to favor the visual channel for language. Their performance on sign tests in comparison to the other groups was superior to that on the speech tests. In the Libras phonological production test, in contrast to the BP test, they were able to produce previously unfamiliar signs upon seeing them demonstrated by the experimenter.

The present study contributes to the investigation of language development by bimodal bilingual children, both with early access and restricted access to sign language. Our results show that not only is bimodal bilingual acquisition for children with CIs possible, but that early access to sign language presents an advantage to implanted children for the acquisition of spoken language.

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