Effects of Bimodal Production on Multi-Cyclicity in Early ASL and Libras

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In this study, we test the proposal that bilingual children show phonological cross-language influence between their two languages. We extend this issue to bimodal bilinguals, children simultaneously acquiring both a sign language and a spoken language. Our investigation focuses on multi-cyclicity in the sign production of hearing, bilingual children acquiring either American Sign Language (ASL) and spoken English, or Brazilian Sign Language (Libras) and Brazilian Portuguese. We consider our results against the theoretical debate over whether bilinguals have one or two grammatical systems.

1. Cyclicity in signs

In ASL and Libras, individual signs can be lexically specified for a single cycle of movement (e.g., BED, FORGET, HUNGRY in ASL; ONTEM 'yesterday', SODA 'soft drink' in Libras) or multiple cycles of movement (e.g., CAT, MILK, HORSE in ASL; CHORAR 'cry', AMIGO 'friend' in Libras), as demonstrated in figures 1 and 2. This difference is purely a part of the lexical phonological specification in these examples; it bears no morphological relevance, although there are morphological processes which involve changes to sign cyclicity (e.g., deverbalization of nouns, aspectual marking of verbs).

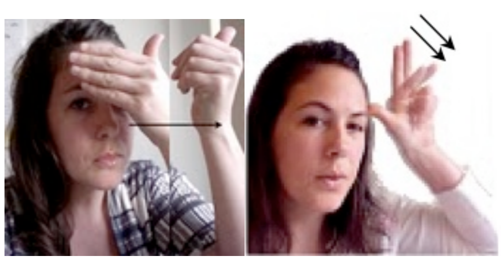

Figure 1. FORGET (mono-cyclic) and HORSE (multi-cyclic) in ASL

Figure 2. SODA (mono-cyclic) and AMIGO (multi-cyclic) in Libras

Previous studies have reported a strong tendency towards multi-cyclicity in the early production of Deaf signing children, for both mono-cyclic and multi-cyclic targets (Meier et al. 2008; Juncos et al. 1997; Morgan et al. 2007). Meier et al. (2008), studying three Deaf children between the ages of 0;9 and 1;5, reported that this tendency towards multi-cyclicity manifested itself in several ways. First, the majority of the children's overall production was multi-cyclic (over 75%), regardless of the cyclicity of the target signs. Second, multi-cyclic forms outnumbered mono-cyclic forms for both mono-cyclic targets (which were signed with repeated movement 50-80% of the time) and multi-cyclic targets (which were signed with repeated movement 81-93% of the time). Third, children showed significantly higher error rates in their production of mono-cyclic targets than they did for mono-cyclic targets (i.e. they incorrectly produced multiple movement cycles for mono-cyclic targets, but correctly produced multiple movement cycles for multi-cyclic targets).

Meier et al. (2008) trace the strong tendency for multi-cyclicity in their subjects' signing to a motoric source. They draw parallels to an earlier report on manual babbling by infants in which over 75% of nonreferential manual activity by both sign-exposed and non-sign-exposed infants exhibited multi-cyclicity (Meier et al. 2002). Additionally, multi-cyclicity is a notable feature of adult ASL and other sign languages, particularly in child-directed signing (Holzrichter & Meier 2000). In light of these motoric and environmental factors, it is not surprising that young Deaf children display a strong bias towards multi-cyclicity in their early signing. However, noting that two of their subjects produce significantly more multi-cyclic signs for multi-cyclic targets than for mono-cyclic targets, Meier et al. (2008) conclude that children begin learning how to inhibit their early bias for repetitive movement while they are still quite young.

2. Two phonology systems in bilingual children

Research on language development has long focused on bilingual children as a valuable comparison to monolingual development. One of the earliest theoretical debates over bilingual language acquisition centers on the question of whether bilinguals initially construct one grammar or two. Some researchers have proposed that bilingual children initially construct a single grammar incorporating elements of both languages, with differentiation occurring only at the age of two to three years (Volterra and Taeschner 1978). Others have argued that language differentiation occurs much earlier. These researchers point to language-specific qualities of children's production and perception as evidence that children construct and maintain distinct grammatical systems from the very beginning of language acquisition, although these two systems may also exert cross-linguistic influence on each other, subject to certain restrictions (Hulk and Müller 2000; Döpke, 2000; Müller & Hulk, 2001). Hulk and Müller (2000) proposed two requirements for cross-linguistic influence: (1) that an interface level between two modules of grammar be involved, and (2) that the two languages overlap at the surface level. Under this view, cross-linguistic effects are a taken as evidence of two distinct though not fully autonomous grammars, rather than as a sign of mixing or fusion of the child's two languages. Furthermore, the result of these effects may be more subtle than outright error. For instance, the bilingual child might employ a rare structure more frequently than her monolingual counterparts due to reinforcement from her other language, or she may proceed at a comparatively accelerated or protracted pace in her acquisition of particular structures.

However, studies of bilingual phonological development, that also involve an interface level, have reported more equivocal results. Comparisons of early phonetic inventories of bilingual children acquiring two spoken languages report similar phonetic features and phonological processes applying across the children's production in both languages. This absence of language-specific features has led some to argue that bilingual children begin with a single phonological system (Vogel 1975; Celce-Muria 1978). In contrast, other researchers point out that similarities in phonetic features are not surprising, for two reasons. First, many of the above-mentioned studies focus on language pairs with a high degree of overlap in phonetic inventory (e.g. Spanish and English). Second, certain phonological processes cited in these studies, such as the substitution of stops for fricatives, are widely attested in monolingual speech, raising the possibility that they are simply universal features of any developing phonology.

One study designed to avoid the two complications described above is Paradis (2001), an experimental study of word truncation by French-English bilingual children. When asked to repeat multi-syllabic words, young children frequently omit one or more syllables, a process influenced by prosodic features for which French and English differ. Rhythmically, the majority of English disyllabic words conform to a trochaic template (strong-weak), while French favors an iambic (weak-strong) template. In addition, English is quantity-sensitive, meaning that heavy syllables (CVC) tend to attract stress, regardless of syllable position; the same is not true of French, a quantity-insensitive language in which stress regularly falls on the final syllable. When bilingual children with a mean age of 29 months were instructed to repeat French-like and English-like nonce words of four syllables with varying rhythmic and syllabic structure, Paradis (2001) found that their truncation patterns exhibited many of the language-specific features also exhibited by monolingual French and English controls. For instance, both bilinguals and English monolinguals exhibited a trochaic bias, truncating English nonce words such that the resulting form preserved a strong-weak syllable sequence. In contrast, bilingual and monolingual French children exhibited an iambic bias in their truncation of French nonce words. Paradis (2001) concludes from this evidence that the bilingual children have developed differentiated phonological systems for French and English.

At the same time, Paradis (2001) reports that her bilingual subjects also diverged from their monolingual counterparts in insightful ways. For instance, whereas English monolinguals preferentially preserved heavy syllables, in accordance with the quantity-sensitive status of English, bilinguals were much less likely to do this. Employing the assumption that bilingual transfer is expected wherever interlanguage structural ambiguity exists, Paradis (2001) suggests that this relative lack of attendance to heavy syllables by the bilinguals is the result of simultaneously acquiring a quantity-insensitive language (French) in tandem with English. Thus, although French-English bilinguals develop differentiated phonological systems from a young age, these systems are not fully autonomous; they are susceptible to cross-linguistic influence, particularly with respect to prosodic properties.

Bimodal bilinguals must develop two phonological systems that are expressed in different modalities via different articulators. For this reason, it might be presumed that these systems would be fully autonomous from the start. Nevertheless, some features of the two phonological systems may still interact, particularly at the prosodic level, a possibility that we explored in this study.

3. Development of cyclicity in bimodal language acquisition

3.1 Participants

We investigated the question of whether bimodal bilingual children show cross-language influence at the phonological level by analyzing the signs produced by two hearing children who are acquiring a sign language and a spoken language in two language pairs. One child, Ben, is acquiring American Sign Language (ASL) and English (AE), while the other child, Igor, is acquiring Brazilian Sign Language (Libras) and Brazilian Portuguese (BP). The ages of Ben and Igor during the sessions analyzed, and the number of signs produced at each of these ages, are given in Table 1.

Table 1. Ages and number of signs produced by the participants in this study

Name	Lang's	Age	Sessions	# Signs
Ben	ASL / AE	1;05	2	59
		1;09	1	146
		1;10	1	90
		1;11	1	249
		2;01	1	117
			Total	661
Igor	Libras/BP	2;01	1	19
		2;02	2	37
		2;08	1	102
		2;10	1	59
			Total	217

3.2 Data Collection

We filmed Ben and Igor in weekly naturalistic sessions, alternating between the children's two languages on a weekly basis. On weeks when ASL or Libras was targeted, the children interacted primarily with Deaf, signing interlocutors. When English or Brazilian Portuguese was the target, the child interacted with hearing interlocutors. However, the children were aware that the adults with whom they interacted were in fact bilingual, and the locations we used for filming the sessions analyzed here (i.e. the children's homes and Gallaudet University) were heavily bilingual settings. As a result, both the children and adults produced varying degrees of simultaneous sign and spoken language, a phenomenon known as *code-blending* (Emmorey et al. 2008). These code-blended utterances prove to be interesting loci for us to study the interaction of the two phonologies of the bilingual children with respect to cyclicity.

3.3 Transcription and Coding

The videotaped sessions were transcribed and coded in ELAN (http://www.lat-mpi.eu/tools/elan), a free multi-media annotation program widely used in sign language and gesture research. ELAN offers easy integration of transcripts with the corresponding digitized video data into a single file. Each annotation is time-locked with the relevant segment of the video, providing a quick and efficient way of locating relevant utterances for analysis. ELAN allows coding tiers to be added directly within the transcript, and also offers useful tools for word counts and searches across multiple transcripts.

For our analysis, we excluded routines, interjections, and complete imitations. Each included sign was first coded as having either a mono-cyclic or multi-cyclic target form, based on the most common citation form of that sign. Then we coded for whether the child's production was mono-cyclic or multi-cyclic, and whether it was produced unimodally (sign only) or bimodally (with accompanying speech). Bimodal utterances were further coded for the degree of temporal alignment of the signed production with the speech production. A sample of our ELAN transcription system is shown in Figure 3.

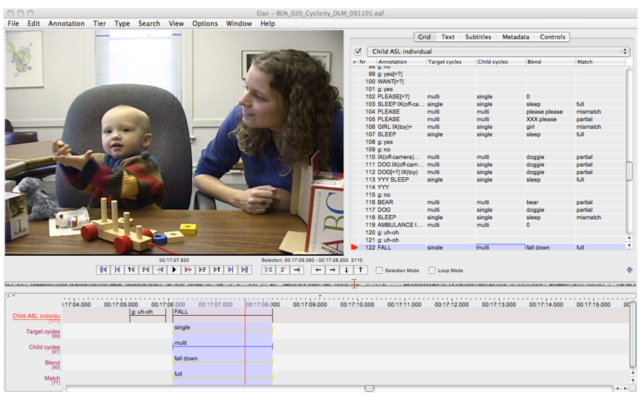

Figure 3. Screen shot sample of coding in ELAN

3.4 Results

Like Meier et al. (2008), we found that our subjects produced a greater proportion of multi-cyclic targets than mono-cyclic targets. However, our data diverged from those of Meier et al. in two interesting ways. First, our bilingual subjects exhibited a much higher accuracy rate for mono-cyclic target signs than did Meier's subjects. We found few cases of non-target repetition for monocyclic target signs in the production of either bilingual child, as shown in Figures 4 and 5 below.

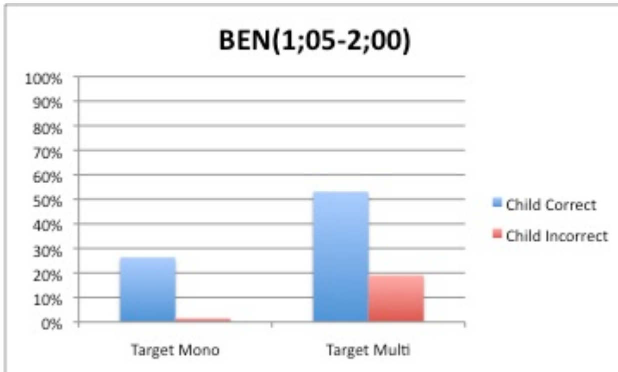

Figure 4. Accuracy with respect to target cyclicity for Ben

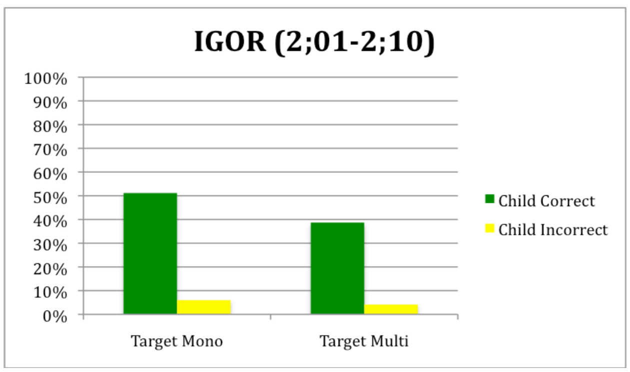

Figure 5. Accuracy with respect to target cyclicity for Igor

Since our subjects are older than those studied by Meier et al. (2008), their higher accuracy for mono-cyclic target signs might simply be due to the fact that children become increasingly successful at inhibiting their multi-cyclicity bias for mono-cyclic targets as they grow older. However, age-related effects alone do not account for the observed differences, as we found a similar pattern of cycle accuracy across all the ages observed for Ben and Igor, as demonstrated in Figures 6 and 7.

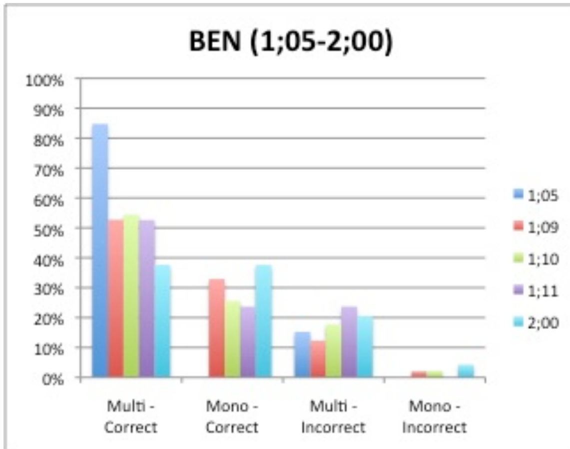

Figure 6. Accuracy with respect to target cyclicity and age for Ben

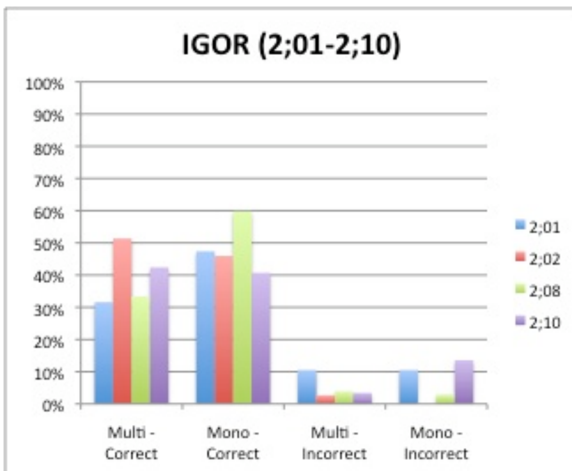

Figure 7. Accuracy with respect to target cyclicity and age for Igor

The second observation about our data is that Ben reduces a larger proportion of multi-cyclic target signs to mono-cyclic forms than Meier found for young Deaf signers, as shown in Figure 4 above (note that this is not the case for Igor; Figure 5). This pattern is unexpected, given the strong bias for multi-cyclicity that young children initially display. In the next section we suggest two factors that might contribute to the differences between our results for bimodal bilingual children and those found by Meier et al. (2008) for (monolingual) Deaf signers.

4. Discussion

As noted above, the children we observed were older than the Deaf subjects in the Meier et al. (2008) study, and this is one plausible factor contributing to the divergences between our results and theirs. In addition to growing increasingly successful at inhibiting their multi-cyclicity bias when necessary, older children also generally produce more multi-sign utterances than younger children, and begin applying various phonological processes in ASL and Libras such as compound reduction, pre-nominal reduction, or phrase-final lengthening. These processes often result in changes in sign cyclicity. For example, one of Ben's multi-cyclic non-target forms at age 1;09 is the sign BALL produced in the phrase BALL WHERE 'where's the ball?' In this phrasal context, his reduction of the number of cycles in the sign BALL is reminiscent of the process of compound reduction in ASL, whereby multi-cyclic signs appearing as the first sign in the compound become mono-cyclic (Liddell & Johnson's (1986) 'single sequence rule'). Such reduction in cyclicity for signs appearing in the same prosodic phrase is common in both ASL and Libras, but our initial coding did not focus on such factors. If Ben used more multi-cycle target signs in such contexts for phonological reductions than did Meier's participants, this could be one explanation for the differences in cyclicity patterns observed between our study and theirs.

Secondly, given the high degree of code-blending in many of our subjects' utterances, (bi-) modality is another possible explanation for the divergence in accuracy patterns observed for our subjects with respect to those reported by Meier et al. (2008). Indeed, a greater proportion of the bilingual children's non-target forms are bimodal than unimodal, seeming to indicate that bimodality is a factor in the bilingual children's errors. Specifically, the children are sometimes observed to synchronize the movements of their signing with the syllables in their speech. This rhythmic and temporal alignment of bimodal speech and signs was observed in 20% - 30% of Ben's non-target forms, and 40% of Igor's non-target forms.

Figure 8 illustrates two instances of this type of error. In the first, Ben produces the normally mono-cyclic ASL sign FALL-DOWN with two movement cycles, temporally aligned with his production of the English words *fall down*. In the second, Igor produces the normally multi-cyclic Libras sign MAMÃE 'mom' with a single movement, temporally aligned with his production of the Brazilian Portuguese word *mãe* 'mother.' These non-target forms can clearly be attributed to bimodality.

Fig. 8. Examples of bimodal errors for Ben (left) and Igor (right)

However, the effect of bimodality is not restricted to instances of non-target cyclicity. We found that children's *correctly* produced target forms were also more likely to be bimodal than unimodal, as shown in the graphs below. That is, bimodal utterances outnumbered unimodal utterances for both the children's non-target *and* target forms. Clearly, further study is required to better understand the specific role of bimodality in each of these cases.

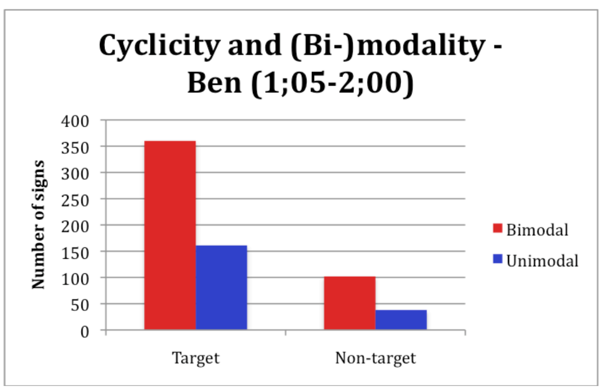

Figure 9. Effect of target cyclicity and (bi-)modality on accuracy for Ben

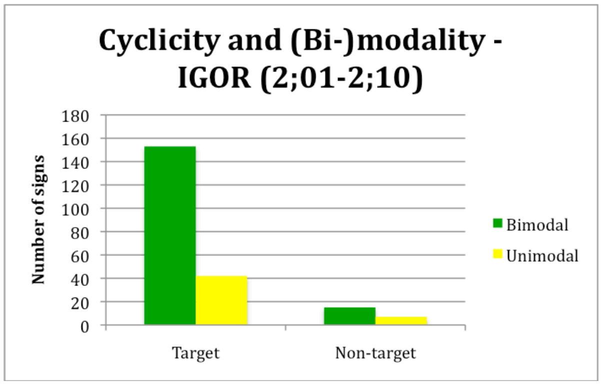

Figure 10. Effect of target cyclicity and (bi-)modality on accuracy for Igor

In their study of adult bimodal bilinguals, Emmorey et al. (2008) discuss similarities between ASL-English code-blending and co-speech gesture (McNeill 1992; Kita and Özyürek 2003). Of particular interest to us, given our observations of syllable structure patterns of young bimodal bilinguals, is the report that both adult code-blending and co-speech gesture display synchrony between the phonological peak of the spoken utterance and the movement of the hands. Emmorey et al. (2008) propose a model that allows for simultaneous output of the PFs for both of a bimodal bilingual's languages, making code-blending possible. They argue that it is in fact less costly computationally to allow simultaneous PF output than to inhibit it, a claim supported by the fact that adult bimodal bilinguals do not completely inhibit one language when producing the other. Whereas Emmorey et al. (2008) focus on simultaneous PF output as manifests in adults as code-blended sign and speech, it may also manifest as nonmanual expression and speech, as in the case of the ASL-based facial expression used to mark conditional clauses accompanying spoken English (Pyers & Emmorey 2008). Interestingly, the latter instance of code-blending occurred even when adult bimodal bilinguals knew that they were conversing with non-signers. If even adults fail to suppress one language when producing the other, it is not surprising that the bimodal bilingual children observed in the current study do, too.

5. Conclusion

The question motivating the current study was whether bilinguals employ one linguistic system or two. Bimodal bilinguals offer a unique opportunity to study this question because their two languages are expressed through different sets of articulators, making possible unusual types of mixing not observed in unimodal bilingual production. Based on the results reported here, it is still too early to characterize bimodality as the primary factor that either facilitates or hinders sign accuracy with respect to cyclicity. Much more data is needed to clarify the role of bimodality on the accuracy of sign production in general. However, in light of cases of synchronized speech on signing such as that described above, bilingualism should still be considered as a factor contributing to divergences between young bimodal bilinguals' ASL and Libras and that of their Deaf counterparts. In the same way that the French-English bilinguals studied by Paradis (2001) produced non-target error patterns attributable to cross-linguistic influence between their two languages, our bimodal bilinguals' errors also exhibit cross-linguistic effects, despite their two languages being expressed in different modalities. Furthermore, in both cases the cross-linguistic influence is prosodic in nature, involving syllable structure and timing. While our observations reported here are still preliminary, they point to the importance of considering bimodality as a factor contributing to divergent patterns of acquisition between bimodal bilinguals and their monolingual counterparts.

References

Celce-Murcia, M. 1978. The simultaneous acquistion of English and French in a two-year-old child. In E. Hatch (Ed.), Second language acquisition: A book of readings (pp. 38–53). Rowley, MA: Newbury House.

Döpke, S. 2000. Generation of and retraction from cross-linguistically motivated structures in bilingual first language acquisition. Bilingualism: Language and Cognition (3), 209-225. Cambridge University Press.

Döpke, S. (1998). Competing language structures: the acquisition of verb placement by bilingual German-English children. Journal of Child Language, 25(3),555-584.

Emmorey, K., Borinstein, H., Thompson, R. & Gollan, T. (2008) Bimodal bilingualism. Bilingualism: L&C 11(1), 43–61.

Holzrichter, A. S., & Meier, R. P. (2000). Child-directed signing in American Sign Language. In C. Chamberlain, J. P. Morford, & R. I. Mayberry (Eds.), Language acquisition by eye (pp. 25–40). Mahwah, NJ: Erlbaum.

Hulk, A. & Müller, N. 2000. Bilingual First language acquisition at the interface between syntax and pragmatics. Bilingualism: Language and Cognition (3), 227-244. Cambridge University Press.

Kita, S. & Özyürek, A. 2003. What does cross-linguistic variation in semantic coordination of speech and gesture reveal? Evidence for an interface representation of spatial thinking and speaking. Journal of Memory and

Language, 48 (1), 16–32.

Liddell, S. & Johnson, R. E. 1986. American Sign Language compound formation processes, lexicalization, and phonological remnants. Natural Language and Linguistic Theory, 4, 445-513.

Lillo-Martin, D., Quadros, R., Koulidobrova H., Chen Pichler, D. (2009). Bimodal bilingual cross-language influence in unexpected domains. GALA, Lisbon.

MacSwan, J. (2000) The architecture of the bilingual language faculty: Evidence from code-switching. Bilingualism: L&C 3(1), 37–54.

Meier, R. P., Cheek, A., & Moreland, C. J. 2002. Iconic versus motoric determinants of the form of children's early signs. In B. Skarabela, S. Fish, & A. H.-J. Do (Eds.), *BUCLD 26: Proceedings of the 26th Annual Boston University Conference on Language Development*, vol. 2, pp. 393–405. Somerville, MA: Cascadilla Press.

Meir, R., Mauk, C. E. Cheek, A. & Moreland, C. J. (2008). The form of children's early signs: Iconic or motoric determinants? Language Learning and Development 4(1), 63–98.

McNeill, D. 1992. Hand and mind: What gestures reveal about thoughts. Chicago, IL: University of Chicago.

Müller, N. & Hulk, A. 2001. Crosslinguistic influence in bilingual language acquisition: Italian and French as recipient languages. Bilingualism: Language and Cognition 4 (1), 1-21

Paradis, J. (2001). Do bilingual two-year-olds have separate phonological systems? International Journal of Bilingualism 5(1), 19–38.

Pyers, J. and Emmorey, K. 2008. The face of bimodal bilingualism. Association for Psychological Science. Volume 19. Number 6. 531-536.

Quadros, R.M., Chen Pichler, D., Lillo-Martin, D. (in preparation). Two languages but one computation: Code-blending in bimodal bilingual development.

Unsworth, S. (2003) "Testing Hulk & Muller (2000) on crosslinguistic influence: Root Infinitives in a bilingual German/English child." Bilingualism: Language and Cognition 6 (2), 143–158.

Vogel, I. 1975. One system or two. Papers and Reports on Child Language Development, 9, 43–62.

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