Blending languages: Bimodal bilinguals and language synthesis

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1 Introduction

As the chapters of this book illustrate, multilingual signers, as multilinguals everywhere, have specific rule-governed ways of allowing their languages to interact. In this chapter,[1] we focus on multilinguals who use a sign language alongside a spoken language in its oral form (as opposed to the written form of a spoken language); these are bimodal bilinguals since their languages occupy two different modalities. The primary members of the group of bimodal bilinguals so defined are often known as Codas – a name derived from the name of an organization called CODA, for Child of Deaf Adults (see Bishop 2006), which serves as a social organization for adults who share the experience of having grown up in a household with Deaf, signing parents. Codas are bilingual by virtue of their exposure to a sign language at home together with a spoken language in the majority (hearing) community.

Multilinguals sometimes produce structures that combine aspects of more than one language. We will use the term 'code-mixing' as a cover term for different types of language combinations (without intending to impute confusion or unorderliness to such 'mixing'). One type of mixing presents as words in one language produced in the order appropriate to the other. Children's production of such structures is sometimes referred to as 'cross-linguistic influence', while for adult learners such mixing is considered 'transfer'. As will become clear, we see such cases not necessarily as intermediate stages limited to learners, but as natural products of multiple linguistic components.

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Utterances by Codas involving use of spoken words in the order or form appropriate to a sign language are sometimes called Coda-Talk. This label is also applied to a particular style of talking which may involve spoken glosses of signs that are not actual translation equivalents (e.g., 'orange eyes' for ASL 'SURPRISED', because the form of that sign is similar to that of ORANGE, but located near the eyes; Bishop and Hicks 2005), or vocal patterns that imitate the voices sometimes produced by the Deaf parents of Codas. Codas also often engage in 'sign-speaking' simultaneously, or what we call 'code-blending', following Emmorey, Borinstein, Thompson, and Gollan (2008). Code-blending refers to the simultaneous use of both speech and sign within a single utterance; for example, while primarily speaking, a bimodal bilingual may produce a signed word that is a translation equivalent to a spoken word (see below for other examples). In some ways, code-blending is similar to code-switching, the (possibly intra-sentential) change from one language to the next produced by unimodal bilinguals, in that it is prevalent among highly proficient bilingual users, and may be an identifier of members of a particular sociolinguistic community, namely (adult) children with typical hearing whose Deaf parents use a sign language. Code-blending may also follow grammatical restrictions similar to those observed for code-switching. This possibility leads to one of the major questions of our research: what are the grammatical characteristics of code-blending produced by bimodal bilinguals?

Our chapter focuses on Kodas ('kids of Deaf adults,' a term used for young Codas) and as such, is the only chapter in this book to address multilingual signers as very young children. In particular, we ask how the languages of a young bimodal bilingual child develop, how they influence each other and interact, and how they are kept distinct in appropriate contexts. The children in our study and their interlocutors use American Sign Language (ASL) and English (Eng), or Brazilian Sign Language (Libras) and Brazilian Portuguese (BP). In the remainder of this first section, we summarize previous studies on unimodal and bimodal bilinguals that help to set the stage for our research by defining the characteristics of language 'mixing' in developing bilinguals.

1.1 Adult Codas

Adult bimodal bilinguals (Codas) have been raised with a sign language as their home language. Given that the dominant language of the majority surrounding (hearing) community is a spoken language, Codas resemble 'heritage speakers' in that their home language is different from that of the community (see Chen Pichler et al. 2017; Quadros et al. 2016). One common pattern for heritage speakers is highly variable proficiency in the home language, ranging from passive

receptive knowledge of the home language to, in rare cases, dominance in the home language. Typically, heritage speakers become dominant in the community language after being immersed in it at school. Similarly, Codas report a wide range of ability in their sign language proficiency, but the majority become dominant in the community spoken language once they enter school.

For Codas who keep in contact with other Codas (such as through the CODA organization), the intermixing of sign and speech may be a special phenomenon used in language play and in close social groupings (Bishop and Hicks 2005), parallel to the use of a combination of German and Spanish known as Esplugish, used by students of a particular German-Spanish bilingual school (González-Vilbazo and López, 2011). Bishop (2010) studied the interactions of 19 ASL/Eng Codas, divided into six different groups, conversing about various Coda-related topics. She found that when instructed to "communicate in any way that is comfortable for you," almost all of the participants code-blended. She also noted a relationship between participants' attitudes towards Coda-talk and CODA events and their use of code-blending, with those showing no interest in such events choosing to use almost exclusively either English or ASL, without blending. Nevertheless, she suggested that code-blending generally emerged across groups as a "strategy of neutrality" or an unmarked choice for communication between Codas.

Emmorey et al. (2008) also studied adult ASL/Eng Codas interacting in conversation, and additionally recorded them retelling a story from an animated cartoon clip. They found that the Codas used code-blending in almost 36% of the utterances analyzed (as opposed to code-switching, which only occurred in 6% of the utterances). They reported that the code-blends typically expressed semantically congruent information in both speech and sign. They also found a high degree of temporal synchronization of the blended speech and sign: the onset of the ASL sign was almost always simultaneous with that of the English word, or only slightly offset.

We should clarify at this point why we consider code-blending to be distinct from Simultaneous Communication or "Sim-Com." First, code-blending results from interaction between sign and spoken language grammars, while Sim-Com is driven by spoken language grammar only. Sim-Com nearly always follows the structure of the spoken language, artificially imposing linear organization onto signs and stripping away prosodic information important for parsing signed utterances (e.g. rhythm, brow movement and other nonmanual cues that mark phrase boundaries). As a result, Sim-Com is easily understood by hearing listeners, but largely inaccessible to Deaf viewers, especially when it is used for extended stretches in high-stake contexts such as classroom lectures, meetings, etc. (Johnson, Liddell and Erting 1989, Tevenal and Villanueva 2009). In contrast,

code-blending is a natural outcome of bimodal contexts comparable to code-switching in unimodal bilingual contexts, occurring spontaneously in mixed Deaf-hearing households or among bimodal bilinguals. Unlike SimCom, code-blending reflects both the spoken language and the sign language grammars, a balance that is easier to manage for the relatively short utterances typical of spontaneous code-blends used by young children. Finally, code-blending is better suited than SimCom to the visual modality in its maintenance of nonmanual prosodic cues typical of sign languages, facilitating accessibility for Deaf addressees. Because successful code-blending requires knowledge of the grammatical and prosodic rules of the sign language, researchers have proposed that its use indicates skill in both languages (van den Bogaerde and Baker 2002), whereas SimCom is typical of individuals who speak well, but do not sign well.

1.2 Kodas

Petitto et al. (2001) studied three Kodas ages 1 to 4 acquiring French and la Langue des Signes Québécoise (LSQ; the sign language used in parts of Quebec); they compared these children to three unimodal bilinguals acquiring French and English. Their study focused on establishing parallels between the bilingual acquisition of a sign language and a spoken language versus two spoken languages. By comparing the two groups of children, they established that both the unimodal and bimodal bilinguals achieved linguistic milestones such as first words, first two-word combinations, and a 50-word vocabulary at equivalent ages, within the typical age range observed for monolingual children developing each language. Furthermore, they reported that the bilingual children demonstrated sensitivity to the language of their interlocutors by modifying their language choices accordingly, even if they were unable to achieve a complete match to the interlocutor's use in their non-dominant language.

Petitto et al. (2001) also reported that the older participants produced more of what they called 'mixed' language use, particularly, 'simultaneous language mixing', which we are now calling code-blending. They noted that this mixing generally consisted of semantically 'congruent' mixes, in which a sign and a word express congruent meanings (which we would characterize as rough translation equivalents) expressed simultaneously. They also observed much less frequent 'non-congruent' mixes, in which signs and words each contributed some part of the utterance meaning.

Extensive studies of Kodas acquiring Dutch and Nederlandse Gebarentaal (NGT; Sign Language of the Netherlands) have been conducted by van den Bogaerde and Baker (2005, 2008). They categorized children's code-blending into

four categories according to which language provided what they considered the semantic base for a given utterance. In Dutch BL (base language) code blends, the full content is expressed in Dutch, with no additional content expressed by the accompanying signs; NGT BL code blends have the opposite profile: full NGT content with redundant Dutch words; mixed utterances contain some content from each language; full blends express the same content in both languages.

Van den Bogaerde and Baker (2008) reported that the three Kodas they studied produced code-blending with increasing frequency when interacting with their Deaf mothers at ages 1;06, 3;00, and 6;00, moving from a relatively higher proportion of spoken utterances to a higher proportion of signed and code-blended utterances. At 3;00, the majority of code-blends were Dutch BL, moving to more Mixed and Full blends by 6;00.

Finally, a recent longitudinal study of language choice and code-blending by eight Finnish Kodas (Kanto, Laasko, and Huttunen, 2015, 2016) reported patterns very similar to those of the Canadian and Dutch Koda studies above. Already at the age of 12 months, the youngest age at which the Finnish Koda children were observed, they used more FinnSL with their Deaf parents and more spoken Finnish with hearing interlocutors, exhibiting early sensitivity to language choice that became more pronounced with time (the final observation point occurring at 24 months). The authors propose that this early language differentiation also manifested in the children's use of a wider range of gesture, sign and speech combinations when interacting with Deaf adults than with hearing adults. Specifically, the Finnish Kodas used more code-blended utterances with their Deaf parents than with hearing interlocutors, although this tendency did not clearly reflect parental use of code-blending, as was the case in van den Bogaerde and Baker's study (2005, 2008). With respect to the structure of the code-blends produced by the Finnish Kodas, most were redundant congruent blends ("Equally strong," in the terminology of Kanto et al. 2016) in which FinnSL and Finnish words contributed equivalent content to the utterance and avoided violations of either grammar. Like van den Bogaerde and Baker (2002), Kanto et al. (2016) reasoned that code-blending of this type requires considerable language competence in both FinnSL and Finnish, and so should not be regarded as an indication of weak language skills or lexical gaps. Notably, the MLU of Equally strong code-blends was shorter than for code-blends categorized as either Finnish base language or FinnSL base language, and mostly reserved for labeling, a common occurrence in spontaneous child language.

The general pattern that emerges from the three Koda studies summarized here is that young Koda children differentiate between their signed and spoken languages from a very young age, adjusting their use of one or the other according to interlocutor. They use code-blending from an early age,

particularly with their Deaf parents, and display a preference for congruent structures, in which there is redundancy and synchronization across spoken and signed content. We will return to discuss these characteristics of code-blending with respect to our own Koda data later in this chapter.

1.3 Unimodal bilingual development

Numerous studies of unimodal bilingual spoken language acquisition have explored the ways that languages interact in development (for recent reviews, see Serratrice 2013, Unsworth 2013). In many cases, researchers have noted that children combine aspects of their two languages. For example, children acquiring a Germanic (e.g. Dutch or German) language and a Romance (e.g. French or Italian) language seem to follow the Germanic pattern permitting object drop in their Romance language, for a longer period than monolingual children do (Hulk and Müller 2000). Such effects have been attributed to temporary cross-linguistic influence in the developing grammars. Note that such influence may be facilitative, as in the case of faster acquisition of German determiners by German-Italian bilingual children (Kupisch 2007). In either case, researchers have treated this phenomenon as a stage of language development that is abandoned once children receive sufficient input.

On the other hand, researchers have also observed that young bilingual children engage in code-switching, which is considered a bilingual phenomenon related to high levels of proficiency (Cantone 2007). In code-switching, speakers combine their languages sequentially, whether inter- or intra-sententially. While researchers agree that this phenomenon is not haphazard, characterizing the constraints that regulate where switches can and cannot (grammatically) occur remains a topic of energetic debate.

On our view, cross-linguistic influence and code-switching are two natural outcomes of a bilingual language system, given that vocabulary items from two languages are available to contribute towards any given derivation. Likewise, code-blending, the simultaneous production of speech and sign, is also a natural result of combining languages in two modalities. However, we expect that it is constrained, as code-switching and cross-linguistic influence are, according to the principles of the language computational system. We will discuss this view of bilingual language architecture in more detail in section 7. In order to investigate the constraints on code-blending, however, we need to see just how it is used in young bimodal bilingual children. For this reason, the rest of this chapter will focus on describing the types of code-blending produced by bimodal bilingual children in our study.

2 Binational bimodal bilingual language acquisition project

For several years our research team has been engaged in investigation of bimodal bilingual language development for two language pairs: ASL and English, and Brazilian Sign Language (Libras) and Brazilian Portuguese (BP). Our original grant project, The Development of Bimodal Bilingualism, is unique in that it involves two groups of bimodal bilinguals: hearing children from Deaf families (Kodas) and young Deaf children from Deaf families with a cochlear implant (DDCI). We have collected both longitudinal spontaneous data and experimental data from these children between the ages of roughly 1;0 to 7;0.

Our research project addresses multiple research questions and includes several design features that are unique among existing studies of bimodal bilingualism. Most fundamentally, we are interested in how the developmental patterns for simultaneous acquisition of a signed and spoken language compare to those previously reported for each language individually, and those reported for young unimodal bilinguals and bimodal bilinguals learning other language pairs. By including two sets of languages with different grammatical properties, we can study the effects of particular languages on the development process, resulting in a greater degree of generalizability for our findings. Generalizability is a critical aspect of our research project as we articulate a theoretical model of language interaction that applies over the course of childhood development and into adulthood. We call our model the *Language Synthesis Model* and will introduce it in more detail below.

We are also interested in the effects of cochlear implants on bimodal bilingual acquisition, specifically for children who receive sustained exposure to a natural sign language from birth. Most of the existing literature on cochlear implanted children focuses on those with severely restricted exposure to signing, usually in the form of Total Communication rather than a full and natural sign language. Not surprisingly, such studies typically report poor development of the spoken language, compared with that of cochlear implanted children who adhere to an "oral-only" philosophy (e.g., Niparko et al. 2010). However, none of these studies has examined the development of sign language and spoken language as two systems of a child bilingual, comparing them with the natural bilingual situation of Codas. Our project has observed extensive similarities between bimodal development of our Koda and DDCI participants (Davidson, Lillo-Martin and Chen Pichler 2014, Goodwin 2016). With respect to their sign language developmental patterns, some resemble those reported for (non-implanted) Deaf signing children, while others are noticeably divergent (Palmer 2015). We are

investigating the degree to which the latter can be considered characteristics of *heritage signers,* parallel to developmental patterns reported for heritage speakers of minority spoken languages (for more on our heritage signer analyses, see Chen Pichler et al. 2017).

3 Method

3.1 Participants

The participants for the data reported in the present chapter are two hearing Koda bimodal bilingual children, one (Ben) from the U.S. and one (Igor) from Brazil. The children are participants in our long-term project, 'Development of Bimodal Bilingualism' (see www.bibibi.uconn.edu for more information on this research project). Ben has two Deaf, signing parents, and both Deaf and hearing siblings. Igor has a Deaf father and a hearing mother who is a fluent L2 signer. Like all of the children in our project, Ben and Igor receive input in a signed home language (ASL or Libras, respectively) from their parents, and a spoken majority language (English or BP, respectively) from other relatives, neighbors, and the community.

For this chapter, we have analyzed four videos collected from each child (ranging from 30 to 60 minutes in length each), in the age range from 2;00 (years;months) to 2;07, as detailed in Table 1 (see section 3.3 for information on how the utterances were coded). The linguistic productions of the adults interacting with Ben in all four sessions, and those of the adults in one speech-target session with Igor, were also analyzed. For Ben, the adults in the Sign target sessions were his mother (2;00) or a Deaf experimenter (2;06); the adult in the two Speech target sessions was the same hearing, fluent signer. For Igor, the adult in the Sign target sessions was his father, and in the Speech target sessions it was his mother.

Table 1. Participants and number of analyzable utterances produced in each modality as a function of the session target language (NB: participants generally used the target language, but most did not adopt that language exclusively)

Participant	**Total**	**# Signed**		**# Spoken**		**# Bimodal**	
Target lang.		*Sign*	*Spch*	*Sign*	*Spch*	*Sign*	*Spch*
Ben (2;00, 2:06)	1349	211	31	17	783	66	241
Adults to Ben	1197	436	2	25	610	6	118
Igor (2;02, 2;07)	1239	137	21	261	523	134	163
Adults to Igor (2;02 sp only)	817		7		615		195

3.2 Data collection

Participants were video-taped to collect a sample of their ordinary language use that was as natural as possible. Generally, a target language was established for each session (either Sign or Speech) and alternated every week. Our goal was to elicit natural language use and observe any mixing that occurred; we did not try to enforce language separation. See Chen Pichler et al. (2016), Quadros et al. (2014) for more detail about our filming methods and the best practices we developed for building our corpora.

3.3 Coding

Our first step was to annotate all speech and sign produced by the child subject and his interlocutor(s). Our procedures and conventions are described in detail in Chen Pichler et al. (2010) and summarized here. We used the ELAN program (http://tla.mpi.nl/tools/tla-tools/elan/; Crasborn and Sloetjes 2008) for all video annotation. Ordinary orthography supplemented with special symbols was used for all spoken language utterances. Glosses were used to annotate signs, following the principles of ID glossing, using a written word in Eng/BP to stand for a particular sign generally having overlapping meaning (Johnston 1991).

Utterance breaks were determined by considering both prosodic and syntactic information. An utterance is a group of signs/words usually delimited by prosodic patterns, which in the case of signing includes lowering or relaxation of the hands, a longer pause than normal, or lengthening of the final sign in the group; or in the case of speech, falling tone or a stretch of silence following the last syllable. Although prosodic information is used to help determine utterance boundaries, at the analysis stage we also used syntactic and meaning information in constructing an utterance for analysis that essentially follows the AS-unit (analysis of speech unit) described by Foster et al. (2000: 365): "consisting of an independent clause, or sub-clausal unit, together with any subordinate clauses associated with either". Each utterance is classified as sign-only or speech-only or bimodal, where utterances are bimodal if any part contains both speech and sign simultaneously.

We further coded all bimodal utterances for several features. First, we coded the Content of a bimodal utterance as falling into one of five possible categories, according to how much content was expressed in each language (independent of structural differences between the information expressed in each language). These categories, which were developed from the categories used by van den Bogaerde and Baker (2008), are listed below.

- Fully bimodal: Utterances that have the same information expressed in sign and speech. There may be some differences, such as an overt article in speech without a corresponding element in sign, but the information content is considered the same in both modalities.
- Sign-base: Utterances that have more information expressed in sign than in speech.
- Speech-base: Utterances that have more information expressed in speech than in sign.
- IX+Speech: Utterances in which speech is accompanied by a point (IX) but no other signed element. These are a special type of Speech-base utterances, since the point usually corresponds to content that is also expressed in speech. Although non-signers often point while speaking, we consider IX+Speech a potential type of blending for bimodal bilinguals (see Gökgöz et al. under revision).
- Complementary: Utterances in which neither language expresses a subset of information expressed in the other language. For these utterances, both languages are needed to grasp the total content (labeled 'Mixed' by van den Bogaerde and Baker 2008).

A second type of coding related to the Timing of sign and speech in bimodal utterances. For each utterance we determined the relative extent of signed and spoken material as shown in Table 2. Note that this coding concerns the timing of the full utterance rather than individual signs and words, diverging in this regard from the timing coding employed by Emmorey et al. (2008).

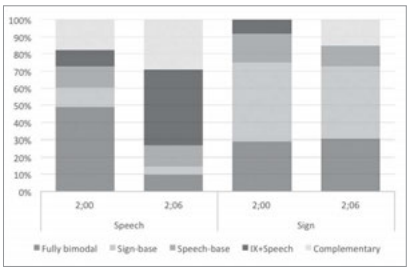
Table 2. Three types of timing between sign and speech in bimodal utterances

Coextensive	sign speech	---------- ----------	Sign and speech start and end at the same time
Included	sign/speech speech/sign	---------- ----------	The extent of one modality is completely within the other
Mismatch	sign/speech speech/sign	---------- ----------	One modality starts before the other; the second ends later

Finally, we examined the Syntax of bimodal utterances produced by Ben and his adult interlocutors in more detail. In particular, we examined those bimodal utterances containing more than one sign and more than one spoken word, so we could compare the word order used in either modality. We coded these utterances in two steps. First, we determined whether the corresponding signed and spoken words were in the same order ('congruent') or not. Next, we considered whether the signed and the spoken utterances would be considered grammatical (target-like) on its own. Utterances missing obligatory elements (e.g. articles in English), in the wrong word order for the target language, or with additional inappropriate elements (e.g. signs for English prepositions used where ASL does not normally use prepositions) were coded as ungrammatical (even though in some cases, such as missing verbal inflections in English, these are common productions for 2-year-old children).

4 Results – Content and timing

The results of the coding of Content and Timing for Ben and his interlocutors, and Igor and his interlocutor, are given in Figures 1-2 and 3-4, respectively. The charts show the proportion of each utterance type out of all the bimodal utterances produced for a particular session.

a. 

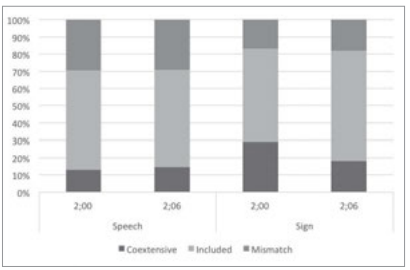
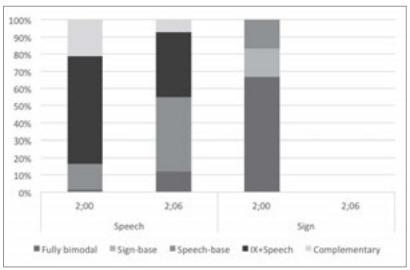
b. 

Figure 1. Ben's utterances: Proportion of utterances produced at each age for each target language (a) Bimodal content; (b) Bimodal timing

a. 

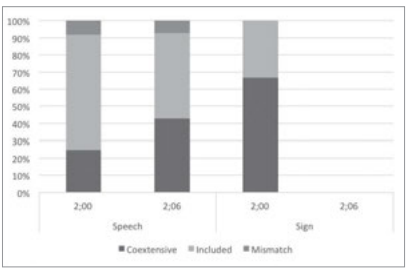
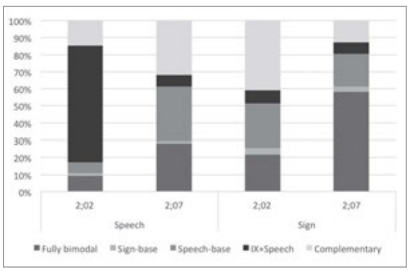
b. 

Figure 2. Adults' utterances to Ben: Proportion of utterances produced at each of Ben's ages for each target language (a) Bimodal content; (b) Bimodal timing (no bimodal utterances were produced in the 2;06 Sign session)

a. 

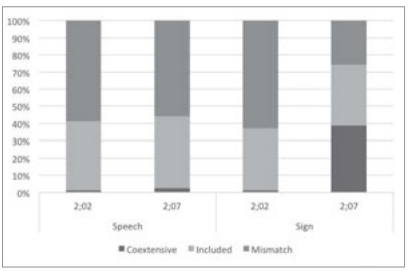
b. 

Figure 3. Igor's utterances: Proportion of utterances produced at each age for each target language (a) Bimodal content; (b) Bimodal timing

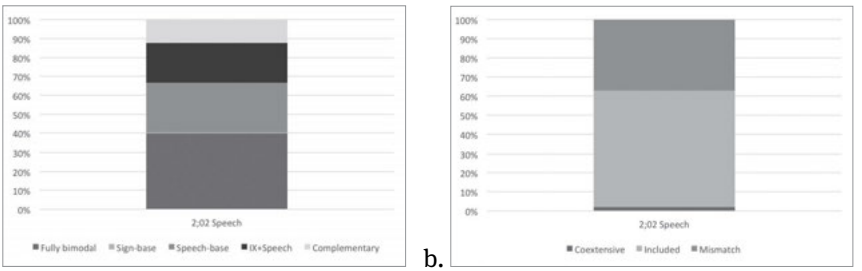


Figure 4. Adult's utterances to Igor in Speech-target session at 2;02: Proportion of utterances (a) Bimodal content; (b) Bimodal timing

5 Discussion – Content and timing

In this section we consider the bimodal utterance types produced by the children and their interlocutors by content and timing. For Ben, there is a clear difference in his blending content during sign-target sessions compared to speech-target sessions. In the sign-target sessions his blends are mostly Sign-base. An example of such a Sign-base blend produced by Ben during a sign-target session is given in (1a).[2] Sign-base plus Fully-bimodal blends (as in (1b)) constitute 70% or more of his blended utterances during sign-target sessions. This does not change over time for Ben.

(1) a. ASL: HAVE COOKIE (Ben, 2;00, sign-target)
Eng: cookie
'(he) has a cookie'

b. ASL: GREEN TRIANGLE (Ben, 2;00, sign-target)
Eng: green triangle
'(it's a) green triangle'

In speech-target sessions, half of Ben's blends are Fully bimodal at the youngest age, as illustrated in (2). It should be borne in mind, however, that at this age

2 We follow the sign linguistics convention of using glosses in all caps to represent signs, with additional annotations as needed. IX represents a pointing sign, with the referent of the point indicated in parentheses. For code-blending examples, the signed production is indicated on the top tier, and the spoken production on the bottom tier. Vertical alignment indicates co-temporal production, with dashes following a sign gloss to indicate the temporal extent when needed.

his utterances generally consist of only one or two words/signs. By 2;06, Ben's blends in speech-target sessions are either Speech-base, as in (3a), or IX+speech, as in (3b). In fact, overall Ben's output is highly speech-dominant by 2;06; as reported in Lillo-Martin et al. (2014), nearly all of his output in speech-target sessions was speech alone by that age. His blending shows parallel development to his overall output: speech-target sessions move from a mixture of speech-only and speech-based blending to almost all speech; sign-target sessions include sign-only utterances and a fair amount of blending, but blending is primarily Full or Sign-base, and hence comprehensible to a Deaf interlocutor even without access to his speech.

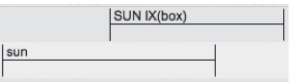
(2) ASL: BIRD (Ben, 2;00, speech-target)
Eng: bird
'(it's a) bird'

(3) a. ASL: POUR (Ben, 2;06, speech-target)
Eng: I wanna dump this
'I wanna dump this'

b. ASL: IX(off-camera)
Eng: I wanna train
'I want a train'

The timing of Ben's bimodal utterances is generally Included, meaning that in most cases, the utterance in one modality had a longer duration than in the other, as in example (3a) above. Even for Full bimodal utterances, it is possible for production in one modality to extend longer than in the other, such as when extra words are present in one modality but not the other (e.g. articles 'the/a' that are produced in English output but not in the accompanying ASL output). In some Included cases as well as many Mismatch cases, there is a clear asymmetry in timing, as in example (4a), where we reproduce the ELAN segment showing that the spoken word begins much earlier than the signed word (approximately 18 video frames). Occasionally such mismatch examples are corrected with repetition, as in (4b), which comes from a session in our database that was not analyzed for this chapter. In (4b), after a couple of tries, Ben moves his hand to the location for the second signed instance of SNAKE and produces the sign movement exactly together with the third spoken instance of 'snake'. According to the study by Emmorey et al. (2008) on adult Codas, individual signs and words usually start simultaneously or within a few video

frames of one another, but this tight temporal coordination appears to still be under development for the two-year olds observed in the current study.

(4) a. 

(Ben, 2;00)

b. 

(Ben, 2;01)

Ben's adult interlocutors in speech-target sessions also differ dramatically from interlocutors in sign-target sessions in their use of blending content types. In the speech-target sessions, the adult produces mostly Speech-base utterances, especially IX+speech, as illustrated in (5), with some Complementary cases as well. As reported by Lillo-Martin et al. (2014), speech-target interlocutors for Ben had a higher proportion of blending at earlier sessions than later, with the majority of utterances being speech-only. On the other hand, interlocutors in sign-target sessions used very little blending at all after age 1;11. The categories represented in Figure 2 for the sign-target session at 2;00 are based on only 6 blended utterances, mostly Full bimodal, as illustrated in (6).

(5) ASL: IX(plane)------ (Hearing adult to Ben, 2;00)
Eng: he flies in the plane
'He flies in the plane there'

(6) (Deaf adult to Ben, 2;06)

ASL:	IX(DCP)	ALLERGIC	CLEAN	IX(DCP)
Eng:	she's	allergic to	cleaning	

'She's allergic to cleaning, she is!'

As for timing, in sign-target sessions the Full type adult blends are always coextensive in length, while the others are Included. In speech-target sessions, this pattern generally holds, except that there are also some Full types that are Included, a combination that Ben himself also uses. Additionally, there are Mismatch cases, which are either Complementary or IX+speech types.

Turning to Igor, the largest contrast in blending types comes between his youngest speech-target session and the other three. In the former, his blends are primarily IX+speech, as illustrated in (7a). In the other three sessions, his blends

are generally either Full bimodal or Speech-base, illustrated in (7b, c). This pattern is not surprising in view of the observation by Lillo-Martin et al. (2014) that even in sign-target sessions, Igor produced more blending and speech-only than sign-only (although his distribution of these modes is different in speech-target sessions, where speech-only is dominant).

(7) a. Libras: IX(brinquedo) (Igor, 2;02 Speech target)
IX(toy)
BP: olha, olha aqui vermelho
look look here red
'Look, it's red here!'

b. Libras: PÁSSARO (Igor, 2;02 Sign target)
BIRD
BP: pássarinho
birdie
'(it's a) birdie

c. Libras: IX(brinquedo) NÃO (Igor, 2;07, Speech target)
IX(toy) NO
BP: mãe quer esse não
Momwants this no
'Mom doesn't want this'

In terms of timing, Igor's blends are often Mismatches; this category includes blends of each content type produced. In his last sign-target session he produced a number of Coextensive blends, all of which are Full content type.

The adult interlocutor in Igor's speech-target sessions was his mother, and her code-blending was analyzed for one session (2;02). His interlocutor in sign-target sessions, his father, blended very infrequently, so no adult code-blending data from sign sessions was analyzed. Unlike Ben's interlocutors, blending by Igor's mother was more likely to be Fully bimodal, as illustrated in (8a). Speech-base and IX+speech made up most of the rest of the blending she produced, illustrated in (8b). Like Igor, his mother used code-blends that included Mismatch examples from every content type produced.

(8) a. Libras: E(caiu) (Hearing adult to Igor, 2;02)
E(fell)
BP: acabou
fell-3sg
'(s/he) fell down!'

b. Libras: UM----------
ONE
BP: uma florzinha só
one little-flower only
'only one little flower'

Our finding that Sign-base blending is the least frequent type overall is consistent with reports by van den Bogaerde and Baker (2005, 2008) for Kodas acquiring NGT and Dutch. This is also the pattern observed in Bishop's (2010) study of blending by adult US Codas, where ASL base language blends are reported to be 7% of total blending, with the majority (59%) English base language. The one reported exception is one of the Deaf mothers in the study by van den Bogaerde and Baker (2008), who produced a majority of NGT base language blends to her 6-year-old Koda son. Thus the general pattern for base language choice tends to lean towards the spoken language, but this tendency is subject to personal preference.

6 Results and discussion – Syntax (Ben and his interlocutors only)

As a first step toward understanding how code-blended utterances are derived, we evaluated the syntax of each utterance in sign and speech separately, for all of the bimodal utterances with at least two spoken words and at least two signs produced by Ben and his interlocutors, as summarized in Table 3. The table shows the number of utterances of each type produced by Ben and his interlocutors (comparable analysis of Igor's data have not yet been performed).

Table 3. Syntactic distribution of bimodal utterances for Ben's sessions (√=grammatical for target language; *=ungrammatical for target language; each row corresponds to one possible type)

Type	Sign	Speech	Ben	Adults to Ben
Congruent	✓	✓	18	11
	✓	*	40	0
	*	✓	0	10
	*	*	0	0
Not congruent			1	0

Our first observation is that virtually all of the bimodal utterances produced by Ben, and all of those produced by adults, display the same word order when signs and spoken words are near translation-equivalents. For example, when Ben (2;06) signs PLAY GAME and speaks "play game", the signs and spoken words occur in the same order. Note that Complementary types (as in (9)) may display different word orders for sign and speech, but because they involve different parts of the sentence, they are excluded from the Not Congruent category here.

(9) ASL: MOTHER IX(out-window) (Ben 2;00)
Eng: I want Mommy
'I want Mommy (who is over there)'

As for the syntactic grammaticality of speech and sign in blends produced by adults, blends were always grammatical in speech, but not always in sign. That is, the blends follow English syntax; when ASL grammar is not compatible, English dominates. However, it is important to note that in the data analyzed for this part of the study, all but one of the code-blends came from speech-target sessions, so it is not surprising that English grammar should dominate for adult production.

In contrast, we see that for Ben, most of his bimodal productions are considered grammatical in ASL, but many are not grammatical in English. However, many of these cases of ungrammatical English are due to common developmental errors such as missing articles, possessive markers, and copulas, or uninflected verbs, as in example (10). In such utterances, the speech is typical for 2-year-old child English.

(10) ASL: HORSE FALL (Ben 2;00)
Eng: horsie fall down
'The horsie fell down'

However, there are cases in Ben's blending where English follows an ASL-like word order along with accompanying signs, as illustrated by the WH-final word order in (11).

(11) ASL: MOTHER WHERE (Ben 2;00)
Eng: Mommy where
'Where's Mommy?'

Monolingual English-speaking children are not known to produce utterances with non-target word order such as these. Such cases could be interpreted as evidence that knowledge of ASL negatively effects development of English syntax. However, we have argued (Lillo-Martin et al. 2012, 2016) that such examples, like code-switching in unimodal bilingual adults, are more accurately regarded as what we call *Language Synthesis*, reflecting the fact that the mental linguistic computational system can incorporate elements from both of a bilingual's languages into a single derivation. We detail our analysis of language synthesis in the next section.

7 Language synthesis

We have proposed a model of *Language Synthesis* designed to capture the range of possibilities by which multiple languages can interact in all multilinguals, including bimodal bilinguals (Koulidobrova 2012, 2016; Lillo-Martin et al. 2012, 2016). Consistent with the view of language competence assumed by generative theories of grammar, particularly Minimalism (Chomsky 1995), the Language Synthesis model describes how sentences are generated; it is not a production model, attempting to capture real-time aspects of sentence construction from 'left to right' online. Finally, the model also incorporates aspects of the theory of Distributed Morphology (Halle and Marantz 1993), in particular, the idea that abstract roots enter into the computation of a sentence before they are specified for a particular language, and that insertion of particular phonological forms occurs relatively late in the derivation. A simplified version of the Language Synthesis model is shown in Figure 5.

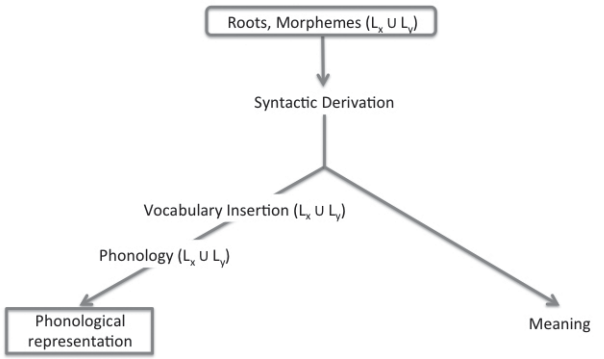


Figure 5. Language Synthesis model

Following MacSwan (2000), we assume that no special machinery should be added to our conception of the linguistic system to account for bilingual effects; rather, these should fall out from the design of the system when more than one grammar is included. Thus, according to the Language Synthesis model, a monolingual speaker will build up a sentence using abstract roots and morphemes from their single language. A bilingual speaker can also use just those elements that come from a single language, but also has the option of selecting elements from both languages in constructing a single sentence. If at the point of Vocabulary Insertion some elements are inserted from one language and others are inserted from the other language, the result will be code-switching. In some cases, a speaker might use null functional elements from one language even if all the phonological elements come from the other language. This will often result in utterances of the type variously known as transfer, calquing, or cross-linguistic influence. These processes will be constrained by the requirements of the elements chosen from each language: they must be mutually compatible for feature-checking to succeed.

For bimodal bilinguals, there exists an additional possibility. At the point of vocabulary insertion, the bilingual might choose elements from *both* sign and speech, resulting in code-blending. For the children whose productions we focus on here, they may have additional factors influencing their production, such as potentially incomplete knowledge of the target grammar morpho-syntax. However, as long as the pieces chosen for the syntactic computation are not in conflict, nothing will prohibit production of both speech and sign simultaneously (see Lillo-Martin, Quadros, and Chen Pichler 2016).

The Language Synthesis model takes as its starting point the observation that code-blended utterances express a single proposition (Emmorey et al.

2008). Although it may be physically possible to simultaneously produce sign and speech, bimodal bilinguals have not been observed to produce code-blended utterances in which the sign and a speech encode completely different content. There may be various reasons one could posit for such a restriction, including memory or processing limitations that would not be directly represented in a model of linguistic competence. Under the Language Synthesis model, this restriction follows from the fact that the computational system only generates one proposition at a time, even in bimodal cases.

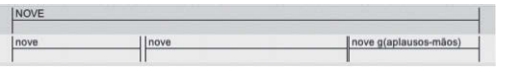
A more controversial aspect of the Language Synthesis model is the proposal that bilingual utterances including code-blending make use of a single derivation. That is, the Synthesis model rejects simultaneous distinct derivations for sign and speech, even if both are based on the same underlying proposition. Instead, the signed and spoken elements are combined in a single computation that includes two output modalities. The need for two separate simultaneous computations in the derivation of code-blending between Italian and Italian Sign Language has been argued for by Branchini and Donati (2016).

Our basic assumptions of one proposition and one derivation are supported by the results we reported from our coding of child and adult blending in sections 4–6. We will expand on this claim first regarding the one proposition assumption, and then turn to the question of derivation.

Fully bimodal, Sign-base, and Speech-base utterances are 'Redundant' in the sense that whatever is produced in each modality has a match in the other modality. Such cases are clearly instances where speech and sign contribute to one proposition. For Complementary cases, each modality has something different to contribute, but we were able to readily see how an interpretation combining the pieces from speech and sign could be assigned and would fit the context in nearly all the code-blended utterances we analyzed.

There were three possible exceptions to the generalization that speech and sign contribute to a single proposition. All three instances clearly involved lexical issues. The first was produced by the adult interacting with Ben in his speech-target session at 2;06 when she said, "We don't have a trashcan" with the word 'trashcan' aligned with the sign SHEEP. In the previous utterances this adult had been discussing sheep, and the ASL signs TRASH(CAN) and SHEEP are both two handed signs produced on the non-dominant forearm. This is thus likely to be a lexical error, influenced by both priming of sheep and phonological overlap. The other two instances were produced by Igor, and both involved the use of the sign PRETO ('black') along with different spoken color terms (*branco* 'white', and *rosa* 'pink'). Again, these are likely cases of lexical error, as it appears Igor substituted the color sign PRETO for other color signs that he had not yet acquired.

The one-proposition proposal also entails that when sign and speech are produced together, they result in a single utterance. Then, an example like (12) might come as a surprise. This example comes from Igor at (2;10) (Quadros et al. 2013), a session not otherwise included in the current analysis.

(12) 

(Igor, 2;10)

The ELAN screenshot in (12) shows what appears to be a single utterance in the sign modality co-occurring with more than one utterance in the speech modality. The sign NOVE ('nine') is held during three iterations of the spoken word *nove*. Rather than attesting different numbers of propositions in the two modalities, the example shows that sign and speech can use different means of 'lengthening' an utterance, a technique that may be used as a conversational strategy for emphasis, holding attention, maintaining the topic, etc. (Bennett-Kastor 1994).

Recall also example (4b) above, in which repetition was used for a timing repair. Ben's first spoken utterance of 'snake' doesn't match up temporally with his sign SNAKE, so he repeats the spoken word, but again it is misaligned. Finally, in the last repetition for both, the sign starts slightly before the spoken word so that the primary movement of the sign can be aligned with the stressed syllable nucleus of the word. As mentioned earlier, young bimodal bilingual children need time to develop the tight temporal coordination between sign and speech observed for adult Codas. The examples above thus reflect developmental errors or discourse strategies and are not counter-evidence to the 'one proposition' assertion of the Language Synthesis model.

What about the 'one derivation' proposal? All of the examples from children and adults presented in the current study are quite consistent with this proposal, since the word order for signed and spoken production analyzed separately are virtually always Congruent, as shown in Table 3 above. The one Not congruent example for Ben is rather unclear, because his speech is whispered and one crucial sign is marked with the notation [?], indicating uncertainty in the assigned gloss. The uncertainty in both the spoken and signed portions of this example prevents us from analyzing it completely.

It is important to note that a difference in word order between sign and speech is not automatically counter-evidence for the 'one derivation' proposal, but rather, an indication that these utterances warrant more detailed analysis to determine how they can be derived. Relevant examples are attested for various language pairs studied by previous research. Petitto et al. (2001) report six examples (out of 320 code-blended examples) in which the speech and sign follow different orders, each appropriate for the target (monolingual) grammar, such as spoken French

mon chien ('my dog') signed together with LSQ CHIEN MON. Likewise, Donati and Branchini (2013) report examples of different word orders for spoken Italian and Italian Sign Language (LIS) bimodal bilinguals. Whether such examples are compatible with the one derivation proposal is discussed in Lillo-Martin et al. (2016).

One intriguing question that can be raised about code-blending in young Kodas is whether they use this type of language mixing primarily as a reflection of code-blended input in their environment, or as a natural combination of their knowledge of two languages that would be produced even in the absence of such input. Of course, this question cannot be answered here, given that we have only observed less than four hours of interactions between Ben and a variety of adults, and one hour of interaction between Igor and his mother. Based on our observations of both Kodas in these and other sessions, they clearly have experience with adults using code-blending. However, they do not use blending types in the same way as their interlocutors do, and Ben even uses Sign-base blending in speech-target sessions where this type is not observed for his adult interlocutors. This hints that the Kodas may be combining their languages in ways that they have not observed in their input, or have observed only infrequently. In any case, they are clearly not simply mimicking the code-blending patterns used by their interlocutors, but generating their own patterns. At the same time, Kodas display awareness of the appropriate contexts for different language choices by adjusting their output to the different adults with whom they interact (see Lillo-Martin et al. 2014 for more discussion of this last point).

8 Conclusion

We have shown that even very young bimodal bilingual children are able to combine their developing languages in rule-governed and creative ways. They produce code-blending in which some part of an utterance is produced in both sign and speech simultaneously, an option only afforded to bimodal bilinguals. Yet, their code-blends express a single proposition, and are compatible with our proposal that only one syntactic derivation is involved.

Theories of bilingualism have largely been based on data from unimodal bilinguals alone. While it is widely acknowledged that bilinguals creatively 'mix' their languages, the possibility of simultaneous code-blending would not even be considered without data from bimodal bilinguals. Thus, continued, detailed study of the language combinations produced by bimodal bilinguals of a wide range of sign+spoken language pairs, both children and adults, will be eagerly anticipated.

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