LESSONS TO BE LEARNED FROM BIMODAL BILINGUALISM

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Abstract: *This article presents a selective overview of topics related to the language experience of early bimodal bilinguals - individuals who are raised from an early age using two languages from two different modalities, typically spoken (or written) and signed. We show that deaf and hearing bimodal bilinguals may display patterns of bilingualism that are similar to unimodal bilinguals in some ways, such as the use of both languages in a single situation or even a single utterance. Nevertheless, there are also differences between bimodal and unimodal bilinguals, and differences among different subgroups of bimodal bilinguals, given large variation in relative access to the dominant and minority language(s) in their environment and their differential experiences in schooling and interactions with potential interlocutors. Moreover, we review studies discussing potential advantages of the sign modality and advantages of bilingualism in this population. We hope to highlight the importance of considering children's overall language experience, including the age(s) at which they are exposed to each of their languages, the richness of their experiences with each of the languages, and the ways that the language-learning experience may contribute to the child's linguistic and cognitive development.*

Keywords: *bimodal bilingual, language acquisition, heritage language, sign language, deaf*

1. INTRODUCTION

Bilingualism is pervasive around the world. Bilingual people use two (or more) languages in various ways; they may have been exposed to both languages from birth (2L1) and use them in a relatively balanced way; they may use one at home (a heritage language) and a different one in the community; or they may use a second language which they learned only after their first language was well established (L2A). Bilingual people are famously not two monolinguals in one person (Grosjean, 1989); they know which language to use when, but their languages interact in rule-governed ways and are never fully 'turned off', even when they seem to be using only one language at a time. The study of bilingualism has provided linguists, psychologists, education experts, and others with deep insights about the ways that languages are acquired, learned, processed, stored, and even forgotten.

Bimodal bilinguals use languages in two modalities: a spoken language in the auditory/vocal modality (although sometimes they use the written version of this language primarily) and a signed language in the visual/gestural modality. Importantly, we refer here and throughout this article to the natural sign languages that emerge in Deaf communities[1] (e.g., American Sign Language/ASL or Croatian Sign Language/hrvatski znakovni jezik/HZJ), not to invented systems that represent the words and sentences of spoken languages in a visual form (e.g., Signed English). Like other bilinguals, bimodal bilinguals may be exposed to both of their languages from birth, and very often their home (sign) language is not the dominant language of their community. They also display typical bilingual effects (both languages are always 'on'), and in addition, show unique bilingual phenomena that are closely tied to the visual-gestural modality (e.g., code-blending, discussed further below).

[1] Following a common practice, we capitalize the word 'Deaf' when referring to Deaf communities and Deaf culture. However, we leave the term lower-case elsewhere, so as not to imply membership in the community or lack of it for any particular persons.

In this article, we will summarize some of the research on bimodal bilinguals, focusing on aspects that inform our understanding of the nature of language. Our goal is to contribute to this volume on 'Sign Language, Deaf Culture, and Bilingual Education' by emphasizing several points. First, research on bilingualism is incomplete if it excludes bimodal bilinguals. Indeed, given increasing research interest in the multimodal nature of all language, it is especially important to consider bilingualism in two different modalities. Second, no exploration of Deaf culture and bilingual education is complete without consideration of bimodal bilingualism. Bilingual deaf education has the potential to nourish deaf and hard of hearing (DHH) children through the use of both a signed language and a spoken/written one. Looking at natural contexts in which children become bimodal bilingual, and the nature of bimodal bilingualism in adults, is crucial for the development of effective early intervention and deaf education approaches. Although this review is far from comprehensive, it touches on major areas of research that form part of the foundation of knowledge regarding bimodal bilingualism. For additional information on bimodal bilinguals, see Chen Pichler et al. (2014), Emmorey et al. (2016), Lillo-Martin et al. (2016), among other sources.

2. LINGUISTIC CHARACTERISTICS OF BIMODAL BILINGUALISM

The broadest definition of bimodal bilinguals would include anyone who knows/uses languages in two modalities, including signed, spoken, written, and tactile. If we focus first on those who grow up using a sign language and a spoken language, our populations of interest will include hearing children whose deaf parents sign with them (known as Codas), and deaf children who use a sign language along with some form of a spoken language, whether this involves speech and hearing technology or the written form of a spoken language. Our overview starts with discussion of both adults and children using a sign language and a spoken language; we subsequently turn to research on the relationship between a sign language and a written language.

2.1 Sign and Spoken Languages

Some of the earliest research on bilingual development focused on children's ability to distinguish between multiple languages in their input (Vihman, 1985; Volterra & Taeschner, 1978). Researchers might think that for bimodal bilingual children, it is obvious that each language is associated with a single modality; but in fact, this assumption is not consistent with recent views of language as multi-modal (Perniss, 2018): visual characteristics are quite relevant and important to spoken languages as well as to sign languages. Furthermore, even if children classify their input in terms of modality, does this lead them to differentiate their production by modality according to the language(s) used by their interlocutors?

In a preliminary study, Petitto and colleagues (Petitto et al., 2001) investigated three Coda children's development of la Langue des Signes Québécoise (LSQ; the sign language used in parts of Quebec, Canada) and spoken French. They found that as young as 1;02 (years;months), the participants differentiated their language use by interlocutor. Even in their mixed production, the children used a higher proportion of French with French-speaking interlocutors and a higher proportion of LSQ with signing interlocutors. This overall pattern was replicated for three children acquiring Nederlandse Gebarentaal (NGT, the sign language used in the Netherlands) and Dutch by van den Bogaerde (van den Bogaerde, 2000; van den Bogaerde & Baker, 2005, 2009), for eight children acquiring FinSL (the sign language used in Finland) and Finnish by Kanto et al. (2015), for two children acquiring American Sign Language (ASL; the sign language used in the U.S. and parts of Canada) and English, and two acquiring Libras (the sign language used in Brazil) and Brazilian Portuguese by Lillo-Martin et al. (2014). Across these six language pairs, we see that very young children can begin to appropriately classify their bimodal bilingual input and differentiate between their two languages in their own production. It is overall quite interesting to additionally note that both the child participants and the adults in these studies used language mixing to a high degree; that is, even the deaf signers produced aspects of the spoken language (including gram-

matical structures, spoken words, and mouthing) when interacting with their hearing children, and children are sometimes observed to produce mixing in similar proportions as found in their input (van den Bogaerde, 2000).

Language mixing is a very common bilingual phenomenon in both bimodal bilinguals and unimodal bilinguals (unimodal bilinguals use two languages in the same modality; almost all the research on unimodal bilinguals focuses on those using two spoken languages). There are several types of bilingual productions that can be considered as mixing, some with negative connotations, but we will only use the term to refer to the natural output of bilinguals in which their languages interact in rule-governed, systematic ways. *Code-switching* is one category of language mixing that has been extensively studied by researchers, who have discovered that it adheres to specific (unconscious) grammatical rules (an early version is found in Woolford, 1983) and serves various sociolinguistic functions, such as establishing and reinforcing group identity (e.g., Auer, 1998).

Bimodal bilinguals sometimes code-switch from one language to another (intersententially or intrasententially), but it is much more common for them to *code-blend,* which involves simultaneous signed and spoken production of (parts of) an utterance (Emmorey, Borinstein, et al., 2008). Bimodal bilinguals may switch between unimodal production (e.g., speech only or sign only) and bimodal production (e.g. code-blending), a type of switching that they employ much more frequently than "classic" code-switching between languages (Emmorey et al., 2020). Code-blending serves similar sociolinguistic functions to code-switching, as a specifically bimodal bilingual phenomenon that is particularly associated with Codas. It is important to note that while code-blending has superficial similarities to Simultaneous Communication, or SimCom, they differ in both social and grammatical dimensions. SimCom is typically used in educational settings where the spoken language is prioritized, and when hearing second-language (M2L2) signers interact with deaf and hard-of-hearing (DHH) people. It is characterized by complete, and often relatively long spoken utterances (e.g. lectures or speeches in educational contexts), accompanied by a "supporting" signed component that does not convey the full meaning of the utterance to DHH viewers who access only the signed component (Tevenal & Villanueva, 2009). In contrast, both the signed and spoken languages contribute to the structure of code-blending, although individual code-blended utterances usually reflect more grammatical characteristics from one language than the other. Code-blending is typical of lower-stakes, conversational interactions and is common among mixed deaf-hearing groups of friends and family. Coda children spontaneously engage in code-blending from a young age (Kanto et al., 2017; Lillo-Martin et al., 2016; Quadros et al., 2016; van den Bogaerde & Baker, 2005, 2009).

Another phenomenon that has been extensively studied for unimodal bilinguals concerns cases in which the structural elements from each language appear to be 'mixed'; this kind of situation is sometimes referred to as *cross-linguistic influence*. For example, children acquiring both a Germanic language (German or Dutch) and a Romance language (Italian or French) produce more sentences with missing objects in their Romance language than monolingual comparison groups; this effect is attributed to cross-linguistic influence of the Germanic languages, with their productive process of object drop, on the Romance languages (Hulk & Müller, 2000). Similar cases of cross-linguistic influence have been studied as part of a more general investigation of the ways bilinguals can combine, or 'synthesize' aspects of their two languages, as they do in code-switching and code-blending. This research found, for example, that bimodal bilinguals show evidence of language synthesis in their production of WH-questions. Lillo-Martin and colleagues (2012) found that 2-year-olds acquiring ASL and English, or Libras and Brazilian Portuguese, produced structures in their spoken language that reflect the order of WH-questions more frequently used in their sign languages. By the time the participants entered school, where the spoken language was used, they had lost this use of sign-influenced speech, but also adopted some patterns reflecting the influence of the spoken language on their signing.

We end this subsection by discussing another group of bimodal bilinguals, DHH signers who access a spoken language using some form of hearing technology, such as cochlear implants and/or hearing aids. Many DHH children have some exposure to both a sign language and a spoken language, but unfortunately they often experience delays in access to any language, a situation known as language deprivation (Hall, 2017). We return to the important discussion of language deprivation and ways to prevent this in the conclusion. For now, we focus on DHH children in language-rich environments where family members use a natural sign language with the child from birth, and exposure to a spoken language begins before the age of three.

Some researchers have worried that exposing DHH children to a sign language while they are learning a spoken language using hearing technology will confuse the child or lead to delays in their development of speech (e.g., Geers et al., 2017). However, there are several factors that lead to questioning this conclusion (Hall et al., 2019). For example, these studies have not included DHH children with fluent, early sign language input at home. When such children have been studied, the results have shown that spoken language and sign language can develop together, just as they do for hearing bimodal bilinguals (Davidson et al., 2014; Goodwin & Lillo-Martin, 2019; Hassanzadeh, 2012; Rinaldi & Caselli, 2014). Davidson and colleagues (2014) examined ASL and English language development for five DHH children with Deaf, signing parents, comparing them to a group of 20 hearing Coda children. The DHH children all received cochlear implants before the age of three, and used ASL at home from birth. These children performed no differently from the Coda children on assessments of spoken English vocabulary, syntax, and even phonology (Davidson et al., 2014).

2.2 Sign and Written Languages

In the previous subsection, we focused on bimodal bilinguals using both a sign language and the spoken form of a language. Many deaf people can be considered bimodal bilinguals whether they use speech or the written form of a spoken language. In this subsection, we briefly summarize some of the research from this perspective.

There is a great deal of research examining potential relationships between children's development in a sign language and their development of the spoken/written language. While the methods and findings from such studies vary widely, we can make two general conclusions for current purposes. First, it is important to recognize such children as bilinguals, and to anticipate bilingual effects such as structural transfer from the sign language into the spoken/written language (Wolbers et al., 2014). Second, bilingual deaf children with greater sign language proficiency generally also display greater proficiency in the spoken/written language (e.g., Hrastinski & Wilbur, 2016; Lederberg et al., 2013; Mounty et al., 2014; Nussbaum et al., 2012; Swanwick, 2016). Furthermore, as for other bilinguals (Bedore & Peña, 2008), any comprehensive assessment of deaf children's language competency should include both languages. Further discussion of the educational benefits of using a sign language can be found in a number of articles (for discussion, see Lillo-Martin et al., 2021; Scott et al., 2021).

Shifting to psycholinguistic studies, a number of works have examined the common bilingual finding that both languages are always 'on' (Marian & Spivey, 2003) to see whether the same is true for bimodal bilinguals. A number of studies have concluded that both deaf and hearing bimodal bilinguals show evidence of the influence of one language (e.g., their sign language) when completing psycholinguistic tasks that involve the other language (e.g., the written version of their spoken language). This cross-modal activation has been demonstrated for several bimodal language pairs (Gimeno-Martínez et al., 2021; Hosemann et al., 2020; Morford et al., 2011; Shook & Marian, 2012; Villameriel et al., 2016). See further discussion below.

3. BIMODAL BILINGUALS AS HERITAGE LANGUAGE USERS

Bimodal bilinguals share many characteristics with a particular group of unimodal bilinguals called

heritage language (HL) speakers, or more broadly, *HL users* (e.g., Chen Pichler et al., 2018; Compton, 2014). Consideration of the experience and outcomes of HL has provided crucial insights on the impact of acquisition factors that are often overlooked, such as the relative contribution of the number of interlocutors (both peer and adult), the age of exposure to each of the languages (e.g., through schooling), and the number of contexts and topics of conversation that HL users experience (Benmamoun et al., 2013; Polinsky, 2018; Rothman, 2009). The commonly-cited example of a HL user is that of a child of immigrants to a new country. For example, consider a family that has moved from Croatia to Germany. The parents will likely speak Croatian to their children when they are together. However, outside of the home, German is the primary language of the community. The children will likely attend a German-speaking school and interact with friends using German. If the family wants to continue using Croatian in broader contexts, they will have to seek out other sources of Croatian speakers and media, none of which are readily available in most parts of Germany.

In this example, the children receive Croatian input from birth from parents who are fluent Croatian speakers and naturally use Croatian in their daily interactions with their children and with each other. However, as time goes on, especially after the children begin schooling in German, differences in the children's experiences in Croatian compared to German come to light. One difference is in the number of varied interlocutors that the children interact with (Gollan et al., 2015), and the second is in the variety of contexts that each language is used for (Benmamoun et al., 2013). The children from this family will interact with many more German speakers than they will Croatian speakers. Even if the family finds a Croatian-speaking nanny or has extended Croatian-speaking family members in the home, the number of Croatian speakers in that child's life is likely smaller than the German speakers that the children interact with in their daily lives. Second, the number of German vocabulary items the children will learn at school far exceeds the vocabulary used to discuss daily life topics at home using Croatian.

These children exemplify the prototypical HL speaker: they receive early, fluent input in their home language, yet when they join school and interact with speakers of the larger community, they receive much more input in the community language than they do in the home language. Importantly, the experience of the individual child and their heritage language does not necessarily define the language or the experience of all its speakers. Definitions of a heritage language versus a community/ dominant language varies from context to context (Rothman, 2009).

The experiences of the Croatian HL user example above parallel that of bimodal bilinguals in many ways. Sign languages are almost always minority languages, even in their country of origin (Chen Pichler et al., 2019; Compton, 2014). Hearing bimodal bilinguals rarely attend schools or programs with deaf peers and therefore have less interaction with adults or peers in sign language than they do in the community's spoken language. Their parents may be fluent in the sign language, serving as excellent language models, yet the number of opportunities to sign with others and the number of contexts in which hearing bimodal bilinguals are exposed to sign are greatly outnumbered by the number of people and contexts in which they will be exposed to the spoken language.[2]

There is an assumption among the general public that a child with access to language models for multiple languages early in life (irrespective of the number of interlocutors or contexts), should develop equal skill in each, becoming a balanced bilingual or multilingual. The underlying message is that access to at least *one* fluent speaker of a language provides enough information for a child to develop the language at a level comparable to that of a child who was immersed in a

[2] Even if the child is DHH and only uses a written form of the spoken language, written language is still arguably much more ubiquitous than sign is in the larger community, especially when one considers all the media, captioned television and movies that a deaf bimodal bilingual would encounter. However, we note that success with written language for DHH children involves the influence of a number of factors that are beyond the scope of discussion in this article.

community speaking that language. Upon closer inspection, the evidence from heritage language users suggests otherwise (Gagne, 2017). Heritage bilinguals, due to the differential amounts of interaction in each of their languages, present unique patterns of acquisition for their heritage (home) language. Their acquisition patterns are somewhat predictable, but interestingly distinct from either the language patterns of someone who learned that language as their primary/ only language (early L1 and dominant) or someone who learned that language as a later second language (L2).

One typical developmental pattern for HL users is relatively high proficiency in phonology, but more variable proficiency in other aspects of the HL grammar. This pattern can in part be explained by the varying levels of exposure that HL users receive in each of their languages across childhood. Phonological development is one of the earliest stages of language development, so most HL users pass through this stage while they are still immersed in their HL at home with their caregivers. It is thus unsurprising that HL users often become proficient in the phonology of their home language (Montrul, 2010; Oh et al., 2003).

In contrast, morphosyntactic and discourse knowledge of the HL reflects a dramatic decrease in HL exposure that children experience once they enter school in the dominant language, between the ages of three and seven years old in most countries. Again, it is not surprising that children experiencing this shift in their language "diet" should display developmental patterns that are more variable than those observed for typical acquisition contexts. For example, young ASL-English bimodal bilinguals diverge from their deaf peers (although both groups are raised in Deaf signing families) in their use of overt noun or pronoun subjects versus null subjects in ASL narratives (Reynolds, 2018). Importantly, both English and ASL allow for overt and null subjects, but the specific distribution of those forms in narratives differ between the two languages. The signed narratives of young bimodal bilinguals studied by Reynolds displayed some discourse features typical of English narratives, even though the target language was ASL. Conversely, Koulidobrova (2017) found that young ASL-English bimodal bilinguals used more null subjects in their spoken English as compared to monolinguals. Cross-linguistic influence such as these examples is of course not limited to ASL-English HL users; similar results have been reported for unimodal HL users of Italian (a language with a distribution of null subjects similar to that of ASL) and English (Serratrice, 2007).

Another characteristic of HL development is a high level of variability (Unsworth, 2016). Two HL users, even from the same family, may present very different patterns of language development and use (Bridges & Hoff, 2014; Kinsella, 2020; Nesteruk, 2010). Studies of this diversity in spoken languages points to the critical role of at least three important factors: (1) the age at which the child's language experiences shift from being dominant in the minority language to dominant in the community language (Montrul, 2012); (2) relatedly; the patterns of continued interactions with both adults and peers/siblings in the heritage (home) language (Gollan et al., 2015);[3] and (3) the structures within each language being learned (e.g., Sorace & Serratrice, 2009).

Theorists have offered several accounts for the variable outcomes of HL acquisition, variously appealing to concepts of *incomplete acquisition, divergent acquisition,* and *language attrition* or *language regression* (Domínguez et al., 2019; Kupisch & Rothman, 2018; Montrul, 2008). These different approaches reflect the complex nature of language acquisition and the variable outcomes that result from the great diversity of individual experiences across bilingual children. Regardless of the terminology, an important lesson to be learned from HL research is that the acquisition process and outcomes are very sensitive to the acquisition experiences of individual learners, so the variation displayed across HL users is normal and expected. Accordingly, any study of early-exposed bimodal bilinguals should be conducted with heritage language learning in mind. This recommendation ap-

[3] Consider, for example, siblings who are peers but who may also become dominant in the community language rather than the home language, showing a possible birth order effect.

plies not only to Coda children, but also to the many DHH children who experience differential exposure to more than one language, be they signed, spoken, or written. In all those cases, researchers must take into consideration the contextual factors of age of exposure to each of the languages, the number of fluent interlocutors in each language, and the number of contexts in which the languages are used by and with the child.

4. BIMODAL BILINGUALISM AS AN IMPORTANT TEST CASE FOR "ADVANTAGES"

The unique affordances of bimodal bilingualism make it a valuable test case for a variety of new research questions, offering insights that were not available to studies restricted to the spoken modality. In the sections below, we summarize important contributions of bimodal bilingualism research to our understanding of how modality affects the ways that humans process, acquire, and switch between languages. In particular, we examine the role of sign languages with respect to two "advantages": the so-called "sign advantage" for first language acquisition and the "bilingual cognitive advantage" often reported for (unimodal) bilinguals.

4.1 The "Sign Advantage"

Early research on bimodal bilingual children reported that they produced their first signs earlier than their first spoken words (Bonvillian et al., 1983; Orlansky & Bonvillian, 1985). This finding, as well as reports of chimpanzees and apes supposedly learning signs, gave rise to the idea of a "sign advantage," according to which sign languages are simply easier to learn than spoken languages, by virtue of their iconic properties (Brown, 1978). First, the high degree of iconicity in many signs might facilitate the mapping of a signed vocabulary item to its meaning. Whereas a child exposed to spoken English must learn from multiple exposures that the arbitrary form *tree* maps onto certain types of tall woody plants, an ASL-exposed child might more quickly recognize the resemblance of the ASL sign for TREE (see https://aslsignbank.haskins.yale.edu/dictionary/gloss/342/) and thus be able to map it onto the appropriate concept with less exposure.

Second, iconicity in sign languages is not restricted to lexical items; certain aspects of sign language grammar are also iconic, or transparent, such as the referential use of space. For example, the ASL pronoun I/ME (as in other sign languages) is articulated as a point towards the signer, and it is possible to express 'blame me' by moving the sign for BLAME towards the location of the signer, while the same verb form is articulated with a movement away from the signer to mean 'I blame you'. Even hearing people without any knowledge of sign language use space similarly in their gesture (Brentari et al., 2012). Proponents of the "sign advantage" reasoned that the combination of a highly iconic vocabulary and transparent aspects of sign language grammars set the stage for accelerated lexical and grammatical development (Brown, 1978).

Indeed, early research reported that native signing children (many of whom happened to be bimodal bilinguals) achieved developmental milestones of the first signed word, first ten signed words and first signed word combination about 2-3 months earlier in ASL than observed in spoken English produced by hearing, nonsigning children (Bonvillian et al., 1983). This pattern persists in studies that directly compare bimodal bilinguals' English and ASL development (Prinz & Prinz, 1979; Schlesinger & Meadow, 1972), seemingly confirming the notion of sign languages as intrinsically simpler to learn than spoken languages. However, subsequent research has revealed that once consistent criteria are followed for counting babies' utterances as "words" (e.g. either counting communicative gestures as words for all babies or not counting them at all), bimodal bilingual children do not reliably produce their first signed words significantly earlier than their first spoken words (Petitto et al., 2001; Volterra & Iverson, 1995).[4] Furthermore, they do not show precocious mastery of syntax milestones in their sign language (Meier & Newport, 1990),

[4] There is evidence, however, that signs with a high degree of iconicity are disproportionately represented in the early vocabularies of young deaf children (Caselli & Pyers, 2020).

not even for highly iconic aspects of their grammar (e.g., pronouns, Petitto, 1987; and verb agreement, Meier, 1987; for discussion, see Emmorey, 2002). In retrospect, this outcome is unsurprising and underscores the status of sign languages as complex natural languages with the same fundamental/underlying linguistic organization as their (relatively less iconic) spoken counterparts. As such, they are not intrinsically simpler than spoken languages to learn.

However, it is important to note two crucial qualifications to our rejection of the "sign advantage." The first is that there may be a *motor advantage* for signs, in that signed words may be easier to perceive and produce than spoken words (Meier & Newport, 1990; Orlansky & Bonvillian, 1985). The articulators and articulatory space are much larger for signing than for speech, such that young children (and primates, for that matter) who lack the fine motor skills of adults can still manage to produce signs that are reasonably intelligible if not completely accurate. Second, and more importantly, sign languages are, without question, perceptually more accessible than spoken languages for DHH children with limited access to sound. The long history of language deprivation suffered by DHH children limited to spoken language input bears grim testimony to this fact (Hall, 2017). Even for children who benefit from advanced hearing technology, sign languages offer critical advantages for their overall language development (Davidson et al., 2014; Secora & Smith, 2021), making bimodal bilingualism the most promising option for families who wish for their DHH children to develop spoken language.

4.2 The "Bilingual Cognitive Advantage" among Bimodal Bilinguals

If sign languages are fundamentally parallel to spoken languages in their underlying organization and acquisition, we might also expect parallels with respect to cognitive advantages reported for bilinguals over monolinguals. In the early 2000's, studies began to emerge showing marked advantages for spoken language bilinguals over monolingual speakers in areas of cognitive control, including language processing, language inhibition/selective memory, cognitive flexibility and working memory (Bialystok et al., 2009; Crowe & Cupples, 2020). Collectively, these advantages became known as the "bilingual cognitive advantage" and were widely touted by the academic and mainstream media alike as an outcome of bilinguals' frequent engagement in language switching. Researchers reasoned that in order to switch from one language to another, bilinguals must inhibit the language that is currently active and activate a language that is currently inhibited. Bilinguals typically experience an increased cognitive burden or "switch-cost" when they code-switch from one language to another. In studies that measure response times to bilingual stimuli, switch cost manifests as longer response times and/or higher error rates for tasks that require a switch from one language to another, compared to tasks that are conducted in the same language. Until recently, it was unclear whether switch-costs resulted from inhibition of an active language or activation of an inhibited language, but researchers posited that extended experience with repeated inhibition and activation eventually led to bilinguals having exceptionally well-developed skills (by monolingual standards) in these areas, manifested as superior performance on a variety of cognitive tasks.

Because bimodal bilinguals have additional switching options available to them that are not available in a unimodal bilingualism context, they offer unique insights for teasing apart the respective contributions of language inhibition and activation to switch-costs. As mentioned earlier, it is possible to code-switch between a spoken language and a sign language, and doing so incurs a switch-cost similar to what has been observed for unimodal bilingual switching (Dias et al., 2017), but this type of unimodal switching is not common among bimodal bilinguals. Much more common is switching between unimodal production of one language (either signed or spoken) and code-blending. This option of switching between unimodal and bimodal production is unavailable to unimodal bilinguals and offers a unique opportunity to distinguish whether switch-costs are incurred due to language inhibition or language acti-

vation. Kaufmann and Philipp (2017) reported that German bimodal bilinguals who were learning German Sign Language (DGS) as an L2 showed higher switch-costs when switching from bimodal code-blending to unimodal German or DGS than the other way around, suggesting that turning a language off is cognitively costly. Emmorey et al. (2020) corroborated and further refined this finding, observing that highly proficient ASL-English bilinguals showed a significant cost for switching from bimodal to unimodal production, but no cost for switching from unimodal production to bimodal production. These findings raise the interesting possibility that bilinguals do not need to expend cognitive effort to switch from lexical retrieval in one language to simultaneous lexical retrieval in two languages, although this effect may only apply to the non-dominant language (i.e., the sign language, for most hearing bimodal bilinguals).

The limited research on bimodal bilinguals' switching behaviour summarized above suggests that they typically do not experience the long-term, repeated cognitive switch-cost that has been associated with enhanced cognitive control, hence we would predict that they also do not display the cognitive advantages observed for unimodal bilinguals. To date, we know of only two studies that directly compare bimodal bilinguals' cognitive control to that of monolinguals and unimodal bilinguals. Emmorey et al. (2008) reported that unlike their unimodal (spoken language) bilingual comparison group, native bimodal bilingual ASL-English users (all Codas) showed no advantages over monolingual English users on a Flanker task, a test of inhibition and selective attention. Giezen et al. (2015) also reported a lack of advantage for a mixed group of Coda and L2 signing bimodal bilinguals performing a spatial Stroop task, a measure of inhibitory control. Both studies are consistent with the proposal that because bimodal bilinguals have (and greatly prefer) the option of activating both of their languages simultaneously, they do not engage in the repeated inhibition required for unimodal code-switching. There is some neuroanatomical evidence to support this account from Olulade et al. (2016), who hypothesized that enhanced cognitive control should correlate with greater grey matter volume (GMV) in the brain. Accordingly, they reported greater GMV in the brains of adult unimodal (Spanish-English) bilinguals compared to English monolinguals, but no difference in GMV between English monolinguals and adult bimodal bilinguals (Codas).

While the existing research suggests that bimodal bilinguals do not share the enhanced cognitive control reported for spoken language bilinguals, it is important to remember that the relevant literature is still quite small and focused mainly on inhibition. Research on a broader range of cognitive tasks is needed for a comprehensive understanding of the cognitive advantages (and disadvantages) displayed by bimodal bilinguals. Furthermore, the bilingual cognitive advantage has recently become a subject of contentious debate even for unimodal spoken bilinguals (e.g., Paap et al., 2017; van den Noort et al., 2019), who do not consistently out-perform monolingual controls on cognitive control tasks. Researchers are just now beginning to discover how cognitive control may be impacted by individual variations in code-switching habits (Hofweber et al., 2020), professional training (Macnamara & Conway, 2014), and multiculturalism (Treffers-Daller et al., 2020). Failure to control for these and other sociolinguistic factors in the existing literature may partly explain the variability in findings across bilingual groups, and future research (re-)examining bimodal bilingualism should be conducted with such variables in mind.

5. CONCLUSION

Our selective review has shown that people who are exposed to input in both a natural sign language and a spoken language can develop as bimodal bilinguals. Like other bilinguals, their languages are 'on' at all times, even in apparently monolingual contexts. Evidence for this comes from their use of words and structures from the two languages, and from studies of language processing. However, bimodal bilinguals are usually in a context in which their sign language is not the dominant community language; in this case, they display characteristics like other heritage language users, including variable proficiency in their sign language, which is greatly affected by the num-

ber and variety of interlocutors they have the opportunity to sign with. While bimodal bilinguals are similar to unimodal bilinguals in many ways, there are also important differences. One major difference comes from the use of two modalities: bimodal bilinguals are not required to always suppress (inhibit) one of their languages, because the modality affords the option of code-blending. Although code-blending is not observed in unimodal bilinguals, it obeys similar grammatical constraints as unimodal code-switching. However, the decreased pressure for inhibiting one language and using code-switching may lead bimodal bilinguals to perform more like monolinguals than unimodal bilinguals in tests of cognitive control, where years of practice with suppression and switching may lead unimodal bilinguals to exhibit a cognitive processing advantage.

In our discussion, we focused on those participants who were fortunate enough to experience a rich bimodal linguistic environment from an early age. Unfortunately, this is not the case for many DHH children. Only about 5% of children born deaf or hard of hearing have parents who already knew a sign language when they were born (Mitchell & Karchmer, 2004). For the others, access to linguistic input depends on decisions made by their caregivers: whether or not they will start to learn a natural sign language and have their child exposed to it; whether or not they will use some form of hearing technology, such as cochlear implants and/or hearing aids. In either case, there is usually some period of time in which regular linguistic input is not accessible to the child, during which the child experiences language deprivation (Hall, 2017). If the family chooses an approach that is limited to the oral/spoken language, it may take quite a while for the use of hearing technology and accompanying training to allow the child to learn a substantial linguistic system (Levine et al., 2016).

If the family chooses to use a bimodal bilingual approach, the child will be able to access the linguistic input that is presented in the form of a natural sign language, which can then provide a linguistic base for the possible subsequent development of a spoken language. It is important to bear in mind that especially when the parents are beginning signers, input to the child from a variety of sources will be invaluable. In some ways, DHH children who sign can be compared to heritage language users, since their home language is not the same as the community language. In this context, the number of interlocutors (of different ages) and the amount of time spent with opportunities to use their sign language will be crucial. By interacting with the local Deaf community, the family can increase the quality of sign language input for their child, and the entire family can feel the benefits of Deaf Community Cultural Wealth (Listman et al., 2011).

Our overview is necessarily limited, and there is a lot of research about bimodal bilingualism that we were not able to cover. Nevertheless, we want to point out that there are many areas in which future research would be welcome. More studies in all the domains we discussed would provide scientific advances in understanding. Importantly, most of the research on bimodal bilingualism concerns a fairly small population: usually, the research concerns hearing Codas, and much of this research is with adults within a fairly narrow demographic range. Much more extensive research with a broader group of participants is needed. In particular, more research looking at DHH bimodal bilinguals in all of the areas listed above would be an important contribution. When we discussed the comparison between heritage language and deaf bimodal bilinguals, we brought up an important point. Most deaf children experience a degree of language deprivation, making them different from unimodal heritage speakers in that the latter generally experience full input in the dominant community language, at least by the time they enter schooling, as we discussed. For DHH children, exposure to fluent providers of accessible linguistic input in any language is sadly often delayed for an extended period, if it occurs at all. How factors such as this affect the comparison between DHH bimodal bilinguals and HL users remains to be seen; alternatively and preferably, these delays should be reduced or eliminated, by ensuring that DHH children receive accessible linguistic input at as early an age as possible.

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