Learning ASL as a Late Second Language Depends on the Strength of the First Language Foundation

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1. Introduction

Parents of deaf[1] children typically receive two competing sets of recommendations about how they should support their child's language development (Humphries et al., 2012; Napoli et al., 2015; Mauldin, 2016). One approach advocates for exposure to both a signed and a spoken language, or *bimodal bilingualism* (Emmorey, Giezen, & Gollan, 2015). The other approach advocates for exposure to a spoken language only, or *oralism* (Meristo et al., 2007). While proponents of both approaches are in agreement that deaf children benefit tremendously from early exposure to language in some form (Napoli et al., 2015; Hall, Hall, & Caselli, 2019; Fulcher, Purcell, Baker, & Munro, 2012; Geers & Nicholas, 2013), they disagree about the role of sign language in a deaf child's early language environment. This disagreement is compounded by the fact that most deaf children are born to hearing parents (Mitchell & Karchmer, 2004) who are unlikely to know a sign language, highlighting a need to better understand which approach is most beneficial for deaf children's long-term language development. Two major areas of debate, critical periods for language acquisition and bilingualism in one versus two modalities for deaf children are reviewed, followed by results from the current study, which investigated the benefits of early bimodal bilingualism versus oralism on language comprehension outcomes in adulthood. Results suggest that an exclusive focus on spoken language may leave deaf children at risk for poor language acquisition outcomes in their first language, as well as when learning a signed second language as a fallback. Early bimodal bilingual experience seems to mitigate this risk.

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[1] While it is convention to indicate cultural/linguistic affinity to a local deaf community with an uppercase 'D' and denote audiological status with a lowercase 'd', here we use the lowercase form as a broadly-encompassing term (Ruiz-Williams, Burke, Chong, & Chainarong, 2015; Kusters, De Meulder, & O'Brien, 2017; Pudans-Smith, Cue, Wolsey, & Clark, 2019).

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1.1. Are critical periods different for spoken and signed languages?

Supporters of bimodal bilingualism often refer to the critical period hypothesis (Lenneberg, 1967), which claims that the first few years of a child's life are crucial for language development and that delays in exposure to language will negatively affect a person's ability to fully acquire a linguistic system (Newport, 1990; Mayberry, 1993). Evidence from critical period studies has been used to identify the negative effects on cognitive, social, and neural development from late or limited exposure to early language, or *language deprivation* (Pénicaud et al., 2013; Hall, 2017; Hall, Levin, & Anderson, 2017). Those in favor of providing deaf children with sign language input argue that early exposure to an accessible visual language reduces the risk of language deprivation (Humphries et al. 2012; Napoli et al., 2015; Hall, Hall, & Caselli, 2019).

Interestingly, oralists also leverage critical period theories, even though they advocate against the early use of sign languages. Sugar & Goldberg (2015) state that "[t]he window for a deaf child to acquire LSL [Listening and Spoken Language] is much shorter than the window in which ASL [American Sign Language] can be acquired." Further, Madell (2017) advises parents that "[l]earning sign language later is always an option but learning it early destroys possibilities." In other words, the belief is that there is a shorter, modality-specific critical period for spoken languages, and therefore early spoken language acquisition must be prioritized over early sign language acquisition.

The belief in modality-specific critical periods also suggests that sign languages can be learned effectively later in life, since the window is thought to be open longer for sign languages. This belief makes learning a sign language "an individual choice" that deaf children can make when they are older (Madell, 2016), or a "fallback option" for deaf people for whom spoken language interventions were unsuccessful (Hall, Hall, & Caselli, 2019). This belief also suggests that a parental decision to defer a deaf child's acquisition of a sign language to an unspecified and uncertain time in the future does no harm.

However, the claim of a single later critical period for sign languages is not supported by existing research. In particular, it has been shown that critical periods apply equally to language in either the spoken or the signed modality (Mayberry & Eichen, 1991; Mayberry, 2010; Mayberry, Chen, Witcher, & Klein, 2011). Furthermore, we now know there is not just one but multiple critical periods over the first two years of life. Even a difference of a few months in a child's access to language input can impact the number of critical periods that close before they are able to attain the language sensitivities controlled by those early critical periods (Werker & Hensch, 2015; Kuhl, 2004). Still, there are gaps in the literature that make it difficult to respond directly to oralist claims that sign language exposure can be delayed without impacting acquisition. For example, many critical period studies with deaf participants have focused on late *first* language exposure to a sign language, rather than critical period effects for later second language learning of a sign language. For instance, Mayberry & Lock (2003) enrolled participants who were exposed at a late age to both English and

ASL, so who had two late first languages, or who had English (not ASL) as their second language.

Further, while deaf children are the focus of recommendations to learn a sign language as a potential later second language, the vast majority of the literature on those who do learn a sign language as a second language focuses on hearing individuals (Chen Pichler & Koulidobrova, 2015; Marshall, Bel, Gulamani, & Morgan, 2020). There exists very little research on late second language acquisition of sign languages by deaf people. What happens if we take the oralists at their word, and ASL can serve as a reliable fallback language? Can the ASL outcomes of deaf people who started learning ASL as teenagers really look just as good as those who acquired ASL earlier?

The few previous studies of deaf people who acquired a sign language as a second language either include postlingually deaf people who started to sign after becoming deaf in late childhood (Mayberry, 1993; Mayberry, Lock, & Kazmi, 2002), or they focus on prelingually deaf people but did not factor measures of their spoken or written first language into their analysis (Mayberry, Fischer, & Hatfield, 1983; Mayberry & Fischer, 1989; Mayberry & Eichen, 1991). Cormier, Schembri, Vinson, & Orfanidou (2012) measured the English reading skills and British Sign Language (BSL) skills of prelingually deaf people who learned BSL as a late second language. Cormier et al. did not explicitly report a relationship between the signers' English skill and BSL skill, however they do report that English skill negatively correlated with their age of BSL acquisition and, for those who learned BSL after eight years of age, the age of BSL acquisition did not correlate with BSL skill. It is still a question as to how or whether deaf people's skill in a signed late second language might relate to the strength of their first spoken or written language.

Given this body of literature, the first aim of this study is to test the oft-repeated claim that sign languages can be effectively learned at any age as a "back-up" language for deaf children (e.g., Madell, 2016), based on the claim that sign languages are subject to an extended critical period (e.g., Sugar & Goldberg, 2015).

1.2. Effects of (bimodal) bilingualism on language development

Another argument made by oralists is the claim that deaf children should not learn a sign language early because it is too difficult for deaf children to attend to more than one modality at a time; bimodal bilingual exposure will inhibit acquisition of one or both languages. As one audiologist put it, "[t]he two languages [English & ASL] have different grammars. Tense is expressed differently, and word order is different. Children can learn both, but not together. We know that." (Madell, 2016). This belief seems to only apply to bilingualism in its bimodal form, as deaf children learning two spoken languages, or *unimodal bilingualism* is not seen as problematic (Guiberson, 2014; Madell, 2019).

Some research appears to support the idea that one or both languages will be negatively impacted when one of the languages is signed, such as a study of deaf children with cochlear implants that found that "children without sign language scored significantly better in reading in late elementary grades compared with children whose families provided early exposure to sign language" (Geers, Mitchell, Warner-Czyz, Wang, & Eisenberg, 2017, p. 7). However, that study has come under fire for a range of methodological design concerns (Hall, Hall, & Caselli, 2019; Corina & Schaefer, 2017; Martin, Napoli, & Smith, 2017). One major issue was the decision to group ASL with several invented manual communication systems under one vague definition of "sign language" (Hall, Hall, & Caselli, 2019). This grouping obscures the empirical conclusions that might have been drawn about the effects of using a natural sign language as part of a bilingual approach to language development in deaf children.

There is thus very little convincing evidence that deaf children are negatively impacted by bilingualism in any of its forms. Studies of deaf bimodal bilingual children with cochlear implants show that they perform similarly to hearing bimodal bilingual children on various measures of English (Davidson, Lillo-Martin, & Chen Pichler, 2014; Goodwin & Lillo-Martin, 2019). Other studies of deaf unimodal bilinguals found benefits, or at the very least, no harm caused by their bilingual language exposure (McDaniel, Benítez-Barrera, Soares, Vargas, & Camarata, 2019; Bunta et al., 2016; Waltzman, Robbins, Green, & Cohen, 2003). There is little evidence of early bilingualism causing "language confusion" that hinders language development in any other population (Guiberson, 2013; Grosjean & Li, 2013).

While recent studies of deaf bimodal and unimodal bilinguals have not found negative effects caused by bilingualism (Davidson et al., 2014; Goodwin & Lillo-Martin, 2019; McDaniel et al., 2019; Bunta, et al., 2016), it is still unknown if differences arise later in life. The second aim of this study is to test the claim that early bimodal bilingual language exposure negatively affects English acquisition (Peterson, Pisoni & Miyamoto, 2010; Geers et al., 2017).

2. Hypotheses

This study aimed to test three hypotheses:

Hypothesis 1 addresses whether deaf adults' English reading comprehension is affected by early bilingual exposure to ASL in tandem with English. Given previous studies showing that deaf and hearing bimodal bilingual children perform similarly on measures of English (Davidson et al., 2014; Goodwin & Lillo-Martin, 2019), Hypothesis 1 states that: deaf adults who were raised as bimodal bilinguals and hearing adults who were raised monolingually will perform equally well on an English reading comprehension task. If claims of language deficits from early bimodal bilingualism are accurate, we would expect that deaf adults who used English monolingually to outperform deaf adults who used English and ASL bilingually. However, if studies reporting no language deficits for young bimodal bilinguals are correct, and their early gains continue on into adulthood, then early bilinguals should not be outperformed by early monolinguals.

Hypothesis 2 addresses whether ASL can be learned at any age without deficits related to the age of acquisition. Given strong evidence of a relationship between age of acquisition and language proficiency (Mayberry & Eichen, 1991; Mayberry, 1993; Mayberry et al., 2002; Hartshorne, Tenenbaum, & Pinker, 2018), Hypothesis 2 states that: individuals who learn ASL early in life should outperform those who learn it as a second language (L2) on an ASL receptive comprehension task. If claims of a single, later critical period for sign language acquisition are accurate, we would expect that individuals who learn ASL later in life should score no differently from those who learned ASL earlier in life. However, if the other critical period studies are correct, those who learned ASL earlier in life should outperform those who learned ASL later in life.

Hypothesis 3 addresses whether there is a relationship between the strength of a first language (L1) foundation in English and later L2 acquisition of ASL. Given studies of other languages that show a relationship between individuals' L1 and L2 performance (Ganschow, Sparks, & Javorsky, 1998; Koda, 2007; Sparks, Patton, Ganschow, Humbach, & Javorsky, 2008), Hypothesis 3 states that: for those who learn ASL as a late L2, performance on the ASL receptive comprehension task should be commensurate with performance on the English reading comprehension task. If ASL is an effective fallback for those who learn it later in life, we would expect not to find a relationship between their English and their ASL skills. However, if studies of other languages that found a relationship between skill in the L1 and in the L2 are correct, then those who are weakest in English should also be weakest in ASL.

Hypothesis 1 was tested using Task 1, Hypothesis 2 was tested using Task 2, and Hypothesis 3 was tested by considering performance on Task 2 given performance on Task 1.

3. Participants

Participants were recruited from college campuses in large metropolitan areas on the East Coast of the United States. Prior to invitation, all participants were screened to ensure they had no knowledge of languages other than English and ASL and had no known intellectual or learning disabilities that might affect their ability to acquire language. Once enrolled, participants completed informed consent, a video release form, and a demographics questionnaire online. The questionnaire collected information about the quality and quantity of participants' early language experience and included questions about their hearing levels and use of audiological aids, as well as the hearing status and language competencies of their parent(s).

Participants were placed into one of three groups based on their deaf/hearing status and language experience (Table 1). Deaf L2 signers (DL2) consisted of eleven deaf or hard of hearing individuals who reported English as their sole L1 ($M_{age/start}$=2.2$_y$, range=0-6$_y$; M_y=19.7$_y$, range=15-27$_y$) and reported learning ASL as a late L2 ($M_{age/start}$=18.5$_y$, range=15-25$_y$; M_y=3.5$_y$, range=2-6$_y$). They all reported being prelingually deaf or hard of hearing – nine from birth and two before one year of age. They ranged from being mildly hard of hearing to profoundly deaf. Six reported having two hearing parents, and five reported one deaf or hard of hearing parent. Those with a deaf or hard of hearing parent reported that their parent has no knowledge of ASL and that they communicate with their parent using spoken English. Hearing L2 signers (HL2) consisted of nine hearing individuals who reported English as their sole L1 ($M_{age/start}$=0$_y$, range=0-0$_y$; M_y=23.3$_y$, range=19-26$_y$) and learned ASL as a late L2 ($M_{age/start}$=17.7$_y$, range=15-22$_y$; M_y=4.5$_y$, range=2-8$_y$). Finally, deaf early bilinguals (DEB) were seven deaf individuals who all reported early ASL exposure ($M_{age/start}$=0.4$_y$, range=0-3$_y$; M_y=24.1$_y$, range=22-26$_y$) with English as a concurrent L1 ($M_{age/start}$=0.9$_y$, range=0-4$_y$; M_y=23.7$_y$, range=21-26$_y$). They all reported being profoundly deaf from birth. Two reported having deaf signing parents; the other five reported having two hearing parents[2]. None reported having one hearing and one deaf parent.

DL2 and HL2 were not significantly different in their age of reported ASL exposure (DL2 $Mdn_{age/start}$=18$_y$, HL2 $Mdn_{age/start}$=18$_y$, Mann-Whitney U=42.5, p=0.624), or number of years of ASL experience (DL2 Mdn_y=4.0$_y$, HL2 Mdn_y=4.0$_y$, Mann-Whitney U=64, p=0.2891). DL2 and DEB were also not significantly different in their age of reported English exposure (DEB $Mdn_{age/start}$=0$_y$, DL2 $Mdn_{age/start}$=2$_y$, Mann-Whitney U=22, p=0.142).

	Deaf L2 Signers (n=11)	**Hearing L2 Signers (n=9)**	**Deaf Early Bilinguals (n=7)**
Hearing status	Mild-to-profound	Hearing	Profound
Age	22.0; 19-29	22.3; 19-26	24.6; 23-26
English exposure (age)	2.2; 0-6	0; 0-0	0.9; 0-4
English experience (years)	19.7; 15-27	22.3; 19-26	23.7; 21-26
ASL exposure (age)	18.5; 15-25	17.7; 15-22	0.4; 0-3
ASL experience (years)	3.5; 2-6	4.5; 2-8	24.1; 22-26

Table 1. Participants were placed into one of three groups

4. Task 1: Peabody Individual Achievement Test - Revised (PIAT-R)

Task 1 addresses Hypothesis 1: DEB will perform as well as HL2 on an English reading comprehension task, despite the former's bimodal bilingual experience and the latter's English monolingual experience. DL2 also participated in Task 1 as an exploration of their adult reading scores, given reports of deaf

[2] The language demographics questionnaire did not ask about parents' knowledge of sign *prior* to the child's birth, however three of the five DEB with hearing parents report their parents use "Signed English," and the other two report that their parents use "Spoken English with little to no accompanying sign."

children's variable reading scores (Kyle & Harris, 2010; Visual Language and Visual Learning Science of Learning Center, 2011).

4.1. Method

It was important to choose a measure of English that all participants would theoretically have equitable access to, regardless of hearing status. Assessments of spoken English comprehension were ruled out because perceptual access to speech is subject to variables such as hearing level and efficacy of assistive technology (Lederberg, Schick, & Spencer, 2013). Since deaf people are able to access spoken language through its written form (Grosjean, 2008; Humphries et al., 2014), the Reading Comprehension subtest of the revised Peabody Individual Achievement Test (PIAT-R; Markwardt, 1989) was chosen to assess reading skills rather than listening comprehension skills (Keenan, Betjemann, & Olson, 2008).

The PIAT-R Reading Comprehension subtest measures academic reading achievement between 5 and 18;11 years (Markwardt, 1989) and has been used with deaf individuals in previous studies (Bélanger, Slattery, Mayberry, & Rayner, 2012; McQuarrie & Abbott, 2013; Hirshorn, Dye, Hauser, Supalla, & Bavelier, 2015). Although all participants tested were over the age of 18;11 (range=19-29$_{y}$), and therefore above the maximum age for use of the PIAT-R, the test was judged appropriate to use because the average reading level of deaf eighteen-year-olds had previously been reported to fall between a third to fourth grade level (Visual Language and Visual Learning Science of Learning Center, 2011).

The PIAT-R is administered using a printed booklet with 85 English sentences each paired with four pictures (with three practice items). The sentences and their corresponding answer choices are presented on separate, consecutive pages. Participants silently read the sentences, then pointed to the picture that best matched the meaning of the sentence. Per PIAT-R instructions, they read the sentence only once, and could not look back at the sentence once they had seen the four possible answers. The initial sentences are simple, then gradually increase in length and complexity (Markwardt, 1989), with incorrect answers including phonological and semantic foils. Due to the onset of the COVID-19 pandemic, DEB completed the PIAT-R with adaptations for remote administration using videoconferencing software.

When the Reading Comprehension subtest is administered as part of the full series of PIAT-R subtests, the starting point is determined by performance on the previous subtest in the sequence, Reading Recognition. Here, participants started with the first item on the Reading Comprehension subtest and continued until they responded incorrectly to five out of seven consecutive responses. Responses were later assessed to determine raw scores.

4.2. Results

DEB were not significantly different from DL2 or HL2 on the PIAT-R (DEB Mdn. 95, range=75-97, DL2 Mdn. 75, range=50-100, Mann-Whitney U=53.5, p=0.19; HL2 Mdn. 96, range=78-99, Mann-Whitney U=20.5, p=0.267). However, HL2 performed significantly better than DL2 (Mann-Whitney U=77, p=0.04; Fig. 1).

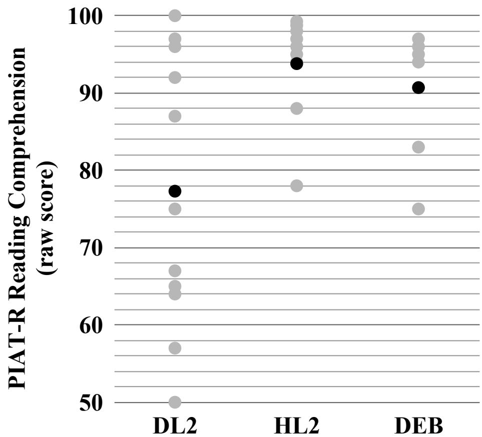

Figure 1. PIAT-R Reading Comprehension results for deaf L2 signers (DL2), hearing L2 signers (HL2), and deaf early bilinguals (DEB). The mean score for each group is indicated in black.

5. Task 2: American Sign Language Comprehension Test (ASL-CT)

Task 2 addresses Hypothesis 2: DEB should outperform DL2 and HL2 on an ASL receptive comprehension task.

5.1. Method

All participants took the ASL Comprehension Test (ASL-CT; Hauser et al., 2016). The ASL-CT was chosen because it is normed to native deaf signers, yet is sensitive enough to discriminate between non-native deaf, native hearing, and non-native hearing signers[3]. The test focuses on various depictive constructions

[3] Hauser et al. (2016) defined their native signers as deaf or hearing individuals with deaf signing parents. On average, their non-native deaf signers were first exposed to ASL at age 6.6, which is much younger than the mean age of exposure reported by DL2 in this study. Hauser et al. (2016) did not report the mean age that their non-native hearing signers were first exposed to ASL, but seeing as they were recruited from college ASL courses, it can be reasonably assumed that their mean age of exposure is comparable to HL2 included here.

in ASL (i.e. constructed action, list buoys, use of space). It is externally validated with other measures of ASL proficiency, such as the ASL-Sentence Reproduction Task (ASL-SRT; Hauser, Paludneviciene, Supalla, & Bavelier, 2008).

The ASL-CT consists of 33 multiple choice questions (with 3 practice items), hosted online as part of the VL2 Online Assessment Portal (Allen & Fernandez, n.d.). For each question, participants select one of four potential answers shown on screen. DL2 and HL2 were tested in person. DEB were assessed remotely on their own computers and were observed by the experimenter using videoconferencing software. Responses were scored automatically by the VL2 Assessment Portal.

5.2. Results

DEB performed significantly better than DL2 on the ASL-CT (DEB Mdn. 25, range=21-28, DL2 Mdn. 18, range=10-23, Mann-Whitney *U*=74.5, *p*=0.001). DEB were not significantly better than HL2 (Mdn. 23, range=16-26, Mann-Whitney *U*=49.5, *p*=0.064), though this study was understandably statistically underpowered and we suspect this difference could reach significance with a larger sample. HL2 performed significantly better than DL2 (Mann-Whitney *U*=78.5, *p*=0.03; Fig. 2).

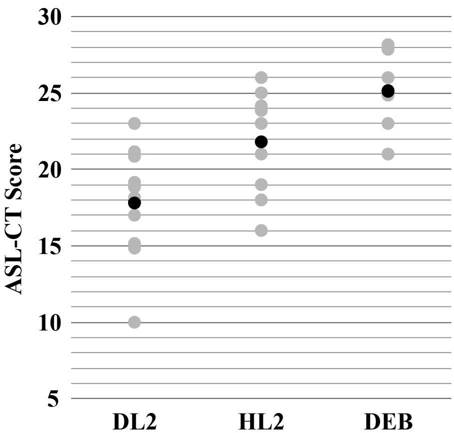

Figure 2. ASL-CT results for deaf L2 signers (DL2), hearing L2 signers (HL2), and deaf early bilinguals (DEB). The mean score for each group is indicated in black.

6. Discussion

6.1. Hypothesis 1

The PIAT-R results support Hypothesis 1, which predicted that deaf adults with early bimodal bilingual experience should perform equally as well as hearing adults who were raised as English monolinguals on an English reading comprehension task. DEB performance did not differ significantly from HL2 performance, and also did not differ significantly from DL2 performance. These results suggest that early English and ASL exposure does not lead to long term deficits in English abilities.

Notably, the range of DL2 PIAT-R scores is twice as wide as for the other two groups, the only group with such variable results. This wide range, while not surprising (Visual Language and Visual Learning Science of Learning Center, 2011), is especially striking since DL2 were not recruited based on their English skills, only their report of English as their sole L1.

This initially led to concerns that the PIAT-R was measuring something other than English ability. Because DL2 reported a wide range of hearing levels, we suspected that the PIAT-R might have actually measured access to sound-based phonology (Buchanan-Worster et al., 2020, Perfetti & Sandak, 2000), rather than decoding of print. A reanalysis of scores based on hearing levels did not support this concern, suggesting that the PIAT-R likely does measure reading achievement independent of auditory access to spoken English.

It is also possible that DEB and DL2 performance on the test might be affected by other factors tied to being deaf. Such factors, as will be discussed in section 6.3, consider possible reasons why HL2 performed significantly better than DL2 on the PIAT-R, but DEB did not. At this point, however, we are confident that parental hearing status and ASL fluency can be ruled out as potential contributing factors given that five out of the seven DEB report having hearing parents who either do not sign or only use “Signed English.” In short, the results suggest that deaf children with hearing parents who choose a bimodal bilingual approach can become proficient in reading English.

6.2. Hypothesis 2

The ASL-CT results partially support Hypothesis 2, which predicted that individuals who learn ASL early in life should outperform those who learn it as an L2 on an ASL receptive comprehension task. As expected, DEB, who learned ASL as an L1, performed significantly better than DL2, who learned ASL as a late L2. However, while it was expected that DEB would also perform significantly better than HL2, this was not the case. This lack of significance may be due to insufficient statistical power and a larger study might reveal a significant difference.

Interestingly, HL2 also significantly outperformed DL2 on the ASL-CT, suggesting that learning ASL as a late L2 is possible, but – as demonstrated by DL2 performance – not because sign languages are a priori easier to learn than spoken languages (Brown, 1978), but because HL2 had the benefit of early L1 development (for a similar take on this, see Mayberry, 1993). This result suggests that hearing college students are succeeding more at learning ASL than deaf college students.

6.3. Hypothesis 3

Hypothesis 3 predicted that skill in ASL as an L2 depends on skill in English as an L1. As the only group with a wide range of PIAT-R scores, DL2 were divided based on their PIAT-R scores, allowing for group-wise analyses. Inspection of DL2 PIAT-R scores suggested a bimodal distribution: those below an 8th grade level (raw score ≤ 75) and those above a 12th grade level (raw score ≥ 87). These clusters were used to split DL2 into two groups: deaf weak readers (DWR; n=6)[4] and deaf strong readers (DSR; n=5; Table 2). DWR and HL2 scores did not overlap. HL2 and DEB were not subdivided because their score ranges were narrower than the score range for DL2.

	Deaf L2 Signers (n=11)			**Hearing L2 Signers (n=9)**	**Deaf Early Bilinguals (n=7)**
	whole group	DWR (n=6)	DSR (n=5)		
Hearing status	Mild-to-profound	Moderate-to-profound	Mild-to-severe	Hearing	Profound
Age	22.0; 19-29	22.2; 20-29	21.8; 19-23	22.3; 19-26	24.6; 23-26
English exposure (age)	2.2; 0-6	2.5; 0-6	2.0; 0-4	0; 0	0.9; 0-4
English experience (yrs)	19.7; 15-27	19.7; 15-27	19.8; 15-23	22.3; 19-26	23.7; 21-26
ASL exposure (age)	18.5; 15-25	18.8; 15-25	18.0; 17-19	17.7; 15-22	0.4; 0-3
ASL experience (yrs)	3.5; 2-6	3.3; 2-6	3.8; 2-5	4.5; 2-8	24.1; 22-26
PIAT-R	77.3; 50-100	63.0; 50-75	94.4; 87-100	93.8; 78-99	90.7; 75-97

Table 2. Updated participant groupings with deaf L2 signers split into deaf weak readers (DWR) and deaf strong readers (DSR) based on their PIAT-R scores (white columns). Grey columns duplicate the information from Table 1, with the addition of the PIAT-R score (bottom row).

Dividing DL2 based on their PIAT-R performance did not result in differences in their language experience demographics. DSR and DWR did not differ significantly in their age of exposure to English (DSR $Mdn_{age/start}=3_y$, DWR $Mdn_{age/start}=2_y$, Mann-Whitney U=13.5, p=0.8572). In fact, there were no significant differences in years of ASL experience across the three L2 groups (DWR $M_y=3.3_y$, range=$2\text{-}6_y$, DSR $M_y=3.8_y$, range=$2\text{-}5_y$, HL2 $M_y=4.5_y$, range=$2\text{-}8_y$, Kruskal-Wallis, H(3)=1.6, p=0.449). There also was no significant difference in their ages of exposure to ASL (DWR $M_{age/start}=18.8_y$, range=$15\text{-}25_y$, DSR $M_{age/start}=18_y$, range=$17\text{-}19_y$, HL2 $M_{age/start}=17.7_y$, range=$15\text{-}22_y$, Kruskal-Wallis, H(0.36)=2, p=0.835). DWR reported hearing levels ranging from moderate to profound and DSR reported

[4] Even though they are labeled as DWR here, it should be noted that the majority performed above the third or fourth grade reading level, the reported average reading level of deaf eighteen-year-olds (Visual Language and Visual Learning Science of Learning Center, 2011). This is possibly a selection effect arising from the fact that they were all college students and may represent a different distribution than reported in previous studies about deaf people's reading scores.

hearing levels ranging from mild to severe. Recall that no relationship was observed between PIAT-R scores and hearing level.

DSR did not differ significantly from HL2 on the PIAT-R (DSR Mdn 96, range=87-100, HL2 Mdn. 96, range=78-99, Mann-Whitney *U*=22, *p*=1). DWR scored significantly lower than DSR (DWR Mdn 64.5, range=50-75, Mann-Whitney *U*=30, *p*=0.008) and HL2 (Mann-Whitney *U*=0, *p*=0.008; Fig. 3).

Given group differences in PIAT-R scores, Hypothesis 3 predicted that DWR should score lower than DSR and HL2 on the ASL-CT, and DSR and HL2 should perform similarly. DWR scored significantly lower on the ASL-CT than HL2 (DWR Mdn. 16.5, range=10-23, HL2 Mdn. 23, range=16-26, Mann-Whitney *U*=8.5, *p*=0.034). DSR were not significantly different from DWR (DSR Mdn. 19, range=17-21, Mann-Whitney *U*=21, *p*=0.317) or HL2 (Mann-Whitney *U*=12, *p*=0.184; Fig. 3).

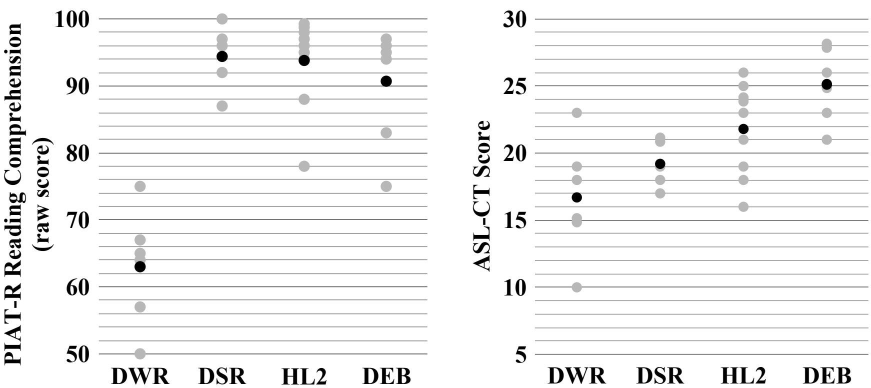

Figure 3. PIAT-R and ASL-CT results with deaf L2 signers (DL2) split into deaf weak readers (DWR) and deaf strong readers (DSR). The mean score for each group is indicated in black.

The results show that Hypothesis 3 was only partially correct. There was a relationship between PIAT-R scores and their ASL-CT scores for DWR and HL2. That is, DWR scored low on the PIAT-R and were comparably low on the ASL-CT, and HL2 scored high on the PIAT-R and were comparably high on the ASL-CT. DSR performance on the ASL-CT was a surprising exception, as their scores were significantly higher than DWR on the PIAT-R but not on the ASL-CT. The HL2 results suggest that their stronger L1 foundation supported their late L2 acquisition of ASL, but further clarification is needed to understand why DSR did not demonstrate the same effect.

DWR were the lowest-performing group on both the PIAT-R and the ASL-CT. Stated plainly, those with the weakest L1 foundation in English were also the weakest in their later ASL. This finding is consistent with claims that late L2 learning is supported by a strong L1 foundation, rendering ASL harder to learn for deaf children who begin signing late, after failing to succeed in English. The option of easily acquiring ASL later, as a back-up to English, does not seem to be reliably available.

Given their PIAT-R and ASL-CT results, it seems that DEB had the benefit of early English and ASL bilingual experience. When more than ninety-five percent of deaf children in the United States have hearing parents (Mitchell & Karchmer, 2004), the success of DEB with hearing parents on both language measures suggests that deaf children with hearing parents can succeed in both signed and spoken languages given early bimodal bilingual experience. This is in line with Henner, Hoffmeister, Fish, Rosenberg, & DiDonna (2015), who found that deaf children with hearing parents demonstrated better English and ASL skills the longer they were enrolled in a bilingual school environment.

The results of this study have a number of limitations that should be addressed in future studies. First, the current sample size is small and necessitated the use of non-parametric tests. To increase statistical power, more participants should be included. Second, the ASL-CT and PIAT-R were the sole measures of receptive language skills. Subsequent studies should include expressive measures, such as the ASL-SRT (Hauser et al., 2008) or the ASL-EST (Enns, Zimmer, Broszeit, & Rabu, 2019), and the writing subtests from the WJ III ACH (Woodcock, McGrew, & Mather, 2001) or the WIAT-II (Wechsler, 2001). Additional tests could focus on more complex morpho-syntactic knowledge.

Third, the results may have been affected by group selection effects, such as possible differences in implicit learning skills (Conway, Pisoni, Anaya, Karpicke, & Henning, 2011; cf. Hall, Eigsti, Bortfeld, & Lillo-Martin, 2017). Since many deaf children who are raised without sign language lack access to environments that allow for incidental language learning (Henner, 2016), it seems likely that attainment of English by DSR is the product of explicit language instruction. The emphasis on explicit instruction in English may lead to inflated PIAT-R scores without necessarily reflecting the overall language foundation necessary to acquire a late L2. It is also possible that different university admission requirements for the hearing versus deaf students recruited for this study may have impacted the results, if admission requirements correlate with differential learning aptitude outcomes (Marschark & Knoors, 2013) or ASL skill upon entering. Recruiting beyond college students would help address these limitations and reveal some of the possible causes for the unexpected performance by DSR on the ASL-CT.

7. Conclusion

The data presented here suggests that exposing deaf children bilingually to English and ASL early in life is unlikely to negatively affect their comprehension of written English as adults, and similarly, earlier exposure to ASL is likely to be beneficial to their sign language comprehension, even if they have hearing parents. Albeit exploratory, the current data further suggests that encouraging deaf children to wait to learn ASL until later in life may only benefit those who actually succeed at acquiring English as a first language. For those deaf children whose acquisition of English is weak and who could benefit from early ASL, the lack of a strong first language foundation may eventually lead to further weakness in their second language. In other words, critical periods apply to signed and spoken languages equally, and learning ASL later may not be a reliable fallback option.

In this study, deaf L2 signers underperformed hearing L2 signers on an ASL measure when matched for age and length of exposure to the language. The deaf L2 signers who were identified as having the weakest foundation in English reading were also the weakest in their comprehension of ASL. Deaf early bilinguals were no different from hearing L2 signers on an English reading measure and were the strongest on the ASL comprehension measure, despite five out of seven having hearing parents. While these results warrant further exploration, taken together, they suggest that parents who decide against using ASL with their deaf child are potentially setting them up for failure twice – once in English and again when they learn ASL later. This risk may be mitigated by using a bimodal bilingual approach early, without impeding their child's development of either language.

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