Measuring language dominance in bilinguals with two sign languages

Dag Johan Lindeberg
The University of Texas at Austin

This study examines whether a multi-faceted construct of language dominance developed for spoken languages applies to signed language bilinguals. Sign languages have been described as highly iconic and relatively similar to each other compared to spoken languages. Attaining fluency in the signed modality might well require considerably less effort, and balanced bilingualism may be more prevalent in the signed modality. Language dominance constructs, as currently understood, might differ in the spoken and signed modality. Forty bilinguals with two sign languages responded to a language dominance questionnaire developed for spoken languages and performed a phonological fluency (sign generation) task. Language dominance levels were found to vary in the signed modality. The correlation between reported dominance levels and the number of signs generated in each sign language was significant, suggesting that the construct of language dominance tested is robust and independent of modality.

Keywords: bilingualism, language dominance, acquisition, iconicity, sign language

1. Introduction

This study examines whether a multi-faceted construct of language dominance applied in spoken languages can predict phonological fluency skills in adults with two sign languages (sign-sign or L2M1 bilinguals). Multi-faceted constructs of language dominance can predict a range of linguistic behaviors in spoken languages and be reliably measured through questionnaires that factor in, at the very least, years of use, current usage patterns, and self-reported proficiency levels (e.g. Bahrick et al., 1994; Dunn & Fox Tree, 2009; Gertken et al., 2014). Phonological fluency as a measure of language dominance in the spoken modality has been reported at least in Shishkin & Ecke (2018). Whether these recent advances

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in research on language dominance in spoken languages, albeit mainly in European and North American contexts (Treffers-Daller, 2019), are distinctive to the spoken modality is a question that has not been addressed.

Signed and spoken languages do not differ only in their modality of use. Lexical similarity ranging from 20% to 40% in unrelated sign languages (Guerra Currie et al., 2002) is attributed to the prevalence of iconicity in sign languages. Signers of distinct sign languages reportedly communicate with each other relatively effortlessly by gesturing (Byun et al., 2018). The visual nature of sign languages, resulting in a prevalence of direct relationships between form and meaning, could indicate that less effort is required to become equally fluent in two sign languages compared to learning two spoken languages.

It is possible that regardless of signers being more dominant in one sign language compared to the other (according to a standardized language dominance questionnaire developed for spoken languages), they may still demonstrate similar phonological fluency skills in both their sign languages. Alternatively, self-reported language dominance levels might predict phonological fluency skills regardless of language modality. This question is addressed with a cohort of adult signers with extensive exposure to a first and second sign language. Participants completed a language dominance questionnaire and participated in phonological fluency tasks for their two signed languages.

The question of language dominance in the signing modality has implications beyond academic settings, in domains such as education, public policy, commerce, and clinical settings (Gertken et al., 2014). Suboptimal interventions for patients and students having two sign languages may be prevented by correctly identifying dominance levels and deploying instruction, treatments, or interventions in appropriate languages.

The next section reviews studies relevant to second sign language acquisition, language dominance, and phonological fluency in the signed modality.

1.1 The prospects of becoming equally fluent in two sign languages

Balanced bilingualism is rare in spoken languages (Grosjean, 1985). Speakers rarely use their two languages for the same purpose in equal amounts in the same domains. Instead, a speaker may use their languages in separate domains, e.g. the home and the work domain, and spend an unequal time in their domains. Typically, the domains differ in topics discussed and type of language registers.

Furthermore, unrelated spoken languages are typically mutually unintelligible. In spoken languages, words and morphosyntactic features are primarily arbitrary (Saussure, 1916/1986). Considerable exposure to a second language is

often required for speakers to become equally fluent in their first and second languages. Even bilinguals who acquire two relatively similar spoken languages early may not perform equally well in their two languages. For example, language dominance predicts early Spanish-Catalan (two related Romance languages) bilinguals' sensitivity to phonological contrasts in Catalan (Amengual & Simonet, 2020).

In contrast, sign languages are noticeably similar in structure (Guerra Currie et al., 2002) and exhibit much iconicity (Desloges, 1779; Klima & Bellugi, 1979: 21). Lexical similarity generally appears to be higher across sign languages than across spoken languages, although measures of similarity and type of lexical items included in crosslinguistic comparisons may differ (Guerra Currie et al., 2002). Greenberg (1957: 37) considered a lexical similarity of 20% or more between two spoken languages "very high," indicating a geographical or historical relationship. Interestingly, the lexical similarity between unrelated signed languages typically hovers above 20%, for example, 23% to 32% similarity between Spanish, Northern Irish, Finnish, and Bulgarian sign languages (Parkhurst & Parkhurst, 2003), 23% similarity between Mexican and Japanese sign languages (Guerra Currie et al., 2002), and 26% similarity between American and British sign languages (McKee & Kennedy, 2000) have been reported. Lexical similarity in related sign languages may range from 38% (Mexican and French Sign Language; Guerra Currie et al., 2002) to 87% (Australian and British Sign Language; McKee & Kennedy, 2000). However, deciding whether a set of "related sign languages" should be considered as separate languages or as dialects of one language is not always straightforward. Seemingly, the pervasiveness of iconicity in sign languages can account for the higher lexical similarity between sign languages compared to spoken languages (Guerra Currie et al., 2002; McKee & Kennedy, 2000; Parkhurst & Parkhurst, 2003).

Iconicity may be observed in multiple aspects of the grammar in sign languages, from phonology to morphosyntax. The phonological system of manual signs in sign languages can be divided into handshapes, locations, and movements (Fenlon et al., 2016), and those phonological components often have iconic properties. For instance, the handshape in the sign JUMP in American Sign Language (ASL) resembles a person with two legs, the location is relative to the palm of the other hand, and the movement mimics jumping from the floor (the palm of the hand), as shown in Figure 1. Iconicity is also prevalent in sign languages at the morphosyntactic level, e.g. a signer can repeat JUMP to mark a continuous aspect visually (Rathmann, 2005).

Similar utilization of iconicity may be found across sign languages. For instance, plural concepts may be visually present in two-handed signs, where two hands represent two items or illustrate mass. Östling et al. (2018) found a

Figure 1. JUMP from the ASL Signbank (Hochgesang et al., 2021)

correlation between plurality and two-handed signs in 31 sign languages in North America, South America, Europe, Africa, Asia, and Australia. They also found that those sign languages tended to iconically articulate certain concepts (e.g. *think, say, love*) near specific parts of the body (e.g. head, mouth, and heart). Iconically-based verb agreement and classifier constructions have been attested in virtually all sign languages (Aronoff et al., 2005). Verb agreement is produced by moving a hand representing an action or item from or toward the location of an argument in the signing space, while classifier constructions consist of a handshape representing a referent accompanied by productive movements and locations representing actions of the referent. Aronoff et al. (2005) found highly similar use of verb agreement and classifier constructions in two unrelated sign languages, ASL and Israeli Sign Language, suggesting that verb agreement and classifier constructions are "iconically grounded in spatiotemporal cognition" (2005: p.301) and not products of historical (arbitrary) development.

Considering the crosslinguistic similarities and the prevalence of iconicity, it is not surprising that signers from distinct countries, e.g. the US and France (Clerc, 1852), South Korea, the Netherlands, Uzbekistan, and Hong Kong (Byun et al., 2018), and France, Germany, the US, the UK, Indonesia, Australia, and India (Moriarty, 2020), communicate with each other with relative ease. Before the influential proposition by Saussure (1916/1986) early in the 20th century that arbitrariness is a defining feature of languages, signing intellectuals frequently described all sign languages as parts of the same universal and natural [iconic] language (e.g. Clerc, 1852; Desloges, 1779). Accordingly, with the notion of arbitrariness as a core component of true languages, some of the later linguistic work has focused on arbitrary crosslinguistic differences (e.g. Eccarius & Brentari, 2007; Napoli et al., 2011) and arbitrary components of sign languages (e.g. Frishberg, 1975; Stokoe, 1960). Still, crosslinguistic similarities and iconicity

remain noticeable in sign languages. In an experimental study on mutual intelligibility in sign languages, Jordan and Battison (1976) reported that foreign sign languages are significantly harder to understand than one's own sign language. However, some participants in their study were surprisingly good at detecting the meaning of foreign signed utterances, and the authors commented on the ease of crosslinguistic communication between participants from distinct countries.

Crosslinguistic similarities may facilitate second language acquisition in spoken languages (Ringbom, 2007: 52), suggesting that the observed crosslinguistic similarities in sign languages could be advantageous for signers learning a second sign language. Furthermore, several studies have identified possible facilitation effects of iconicity in sign language acquisition in deaf children (e.g. Caselli & Pyers, 2017; Perniss et al., 2018; but see Meier et al., 2008) and hearing adult novice signers (e.g. Baus et al., 2013; Lieberth & Gamble, 1991; Mott et al., 2020; Ortega & Morgan, 2015). Still, effects of iconicity on the acquisition process tend to show that iconic items are easier to learn but do not provide evidence for subsequent learnability of other aspects of language (Nielsen & Dingemanse, 2021).

The abundance of shared features and iconicity across sign languages could hypothetically result in greater mental connections between two sign languages than in two spoken languages, where similar phonological, lexical, and grammatical features share the same mental resources (Amengual, 2012; Costa et al., 2005). Shared features could advance balanced language dominance. In lexical naming tasks in spoken-spoken bilinguals, the cost of switching from an L1 (dominant first language) to an L2 (weaker second language) is higher than the cost of switching from an L2 to an L1 (Meuter & Allport, 1999). Meuter and Allport (1999) suggested that speech production in L2 requires active inhibition of a stronger L1, while speech production in L1 requires little or no active inhibition of a weaker L2. The inhibition of an L1 may persist when switching from an L2 to an L1 in naming tasks, resulting in significant switching costs from an L1 to an L2. Interestingly, asymmetric switching costs were not found among bilinguals of Irish (L1) and British (L2) sign language in Adam (2016). Instead, the switching costs in both directions (L1 to L2 and L2 to L1) were similar. Adam (2016) suggested that those signers might have become balanced bilinguals or that sign-sign bilinguals might control their two languages differently than spoken-spoken bilinguals. Adam also mentioned that other measures might be more appropriate for evaluating bilingual processes in sign-sign bilinguals.

In sum, crosslinguistic similarities, the prevalence of iconicity, and the ease of crosslinguistic communication suggest that becoming equally dominant in two sign languages might require significantly less effort than in spoken-spoken bilingualism. There is, however, no existing evidence supporting firm conclusions.

1.2 A multi-faceted construct of language dominance in spoken languages

When researchers refer to language dominance at the individual level as an explanatory or independent variable, the construct of language dominance must be defined and testable to preserve consistent results across studies (Treffers-Daller, 2016). So far, research on language dominance in spoken languages has mainly been conducted in spoken languages in European and North American contexts (Treffers-Daller, 2019), limiting generalizations of previous results to other language contexts.

Based on previous research on language dominance, researchers have developed questionnaires indirectly measuring the multi-faceted construct of language dominance affected by psychosocial factors, including years of exposure, frequency of use, proficiency levels, and language identity (Birdsong et al., 2012; Dunn & Fox Tree, 2009). Typically, a language dominance questionnaire, e.g. the Bilingual Language Profile (Birdsong et al., 2012), establishes scores based on linguistic background data from each language and compares the scores. If the aggregate scores are higher in language A than B, a person is considered dominant in language A. The questions reflect myriad external factors that influence language dominance levels in spoken languages. For instance, questions about years of use typically span from 0 to around 20 years or more, and current use may cover daily or weekly exposure (e.g. Birdsong et al., 2012; Dunn & Fox Tree, 2009; Marian et al., 2007).

Questionnaires assessing language dominance in the spoken modality have been validated with a range of objective linguistic tests. Bahrick et al. (1994) included direct measures of category fluency, vocabulary recognition, lexical decision, and oral comprehension. Other tests in the literature include the Peabody Picture Vocabulary Test in English (Dunn & Dunn, 1997), lexical translation tasks (Dunn & Fox Tree, 2009), translating sentences (Flege et al., 2002), and naming speed tasks (Gertken et al., 2014). Among a battery of tasks, tasks specifically targeted at lexical access were most closely associated with overall self-reported language dominance status in Bahrick et al. (1994). Birdsong (2006: 47) provides a psycholinguistic definition of language dominance wherein stronger processing skills, including greater speed, accuracy, and automaticity, are observed in dominant languages on a battery of language tasks. For the purpose of this study, Birdsong et al.'s (2012) Bilingual Language Profile (BLP) questionnaire was adapted for use with sign-sign bilinguals (further details below); language dominance scores serve as the independent variable for each of the participants.

1.3 Phonological fluency tasks in the signed modality

Verbal fluency tasks that tap into lexical access and processing skills have been shown to correlate positively with language dominance levels in spoken languages (e.g. Bahrick et al., 1994; Shishkin & Ecke, 2018). The phonological fluency task is a type of verbal task where participants are asked to generate words starting with a given phonological cue, often a letter. Shishkin and Ecke (2018) used a phonological fluency task to attest language dominance levels by asking participants to generate, in each of their languages, as many words as possible starting with a specific letter within one minute. The participants generated words in Russian and English using three cues in each language (3 separate one-minute generation sessions per cue in each language). Older Russian immigrants in the US generated fewer words in English than younger Russian immigrants, while both groups performed similarly in Russian despite similar length of residence in the US. According to Shishkin and Ecke, the difference in performance reflected continuous language dominance in Russian for older immigrants, while dominance levels were more balanced in younger immigrants who reportedly also used English in more domains. Category fluency (generating as many words within a semantic category within one minute) and naming speed tasks (naming a set of pictured items as fast as possible) may also correlate with language dominance (Bahrick et al., 1994; Gertken et al., 2014). For the present study, a phonological fluency task was chosen mainly for two reasons.

First, in categorical fluency tasks in the signed modality, where participants are asked to name concepts within a semantic category (Marshall et al., 2014; Sehyr et al., 2018; Yoel, 2007), identifying the respective language membership of fingerspelled concepts (where each letter in a word is represented by a manual sign) may be problematic. Fingerspelling is commonly used by signers to communicate certain concepts. If the same word is frequently fingerspelled in a sign language, the fingerspelled sequence may be considered lexicalized (Padden & Gunsauls, 2003), but often fingerspelled sequences are novel or infrequent representations of a spoken word. Thus, when a signer is fingerspelling, the language membership (a signed or a spoken language) of the "word" may be unclear because it can be difficult to discern whether a fingerspelled sequence is a lexicalized sign or if a signer is switching to a representation of a spoken word.

Second, in naming speed tasks, signers may express a pictured concept that does not have a lexicalized sign with non-lexicalized gestures. For instance, the concept 'airplane' may be expressed without a conventional sign by extending the arms as if flying (Yoel, 2007). The use of both conventional (lexicalized) and non-lexicalized gestures in sign languages inevitably raises questions about the

lexical status and language membership of the elicited form by a signing participant engaging in a naming task (Yoel, 2007).

In signed phonological fluency tasks, participants are asked to generate as many signs as possible in their sign language with specific cues, such as handshapes, movements, and locations (Marshall et al., 2014; Morere et al., 2012). The nature of this sign generation task inherently discourages non-lexicalized signs and fingerspelling, thus reducing the language membership scoring issues.

Marshall et al. (2014) reported that signers produce phonological and semantic clusters in the phonological fluency task (that is, the subsequently generated sign may be related to the previous sign by phonological or semantic features not specified in the task instructions). The neural connections between phonological, lexical, and semantic components could be optimized relatively early in signers compared to speakers. If that were the case, a bilingual signer who scores as unevenly dominant in two sign languages on a language dominance questionnaire could perform evenly on a phonology fluency task in their two languages.

For the purpose of this study, the dependent variable *phonological fluency* is assessed through a cued sign generation task, described in detail below, and serves as a measure of fluency capturing speed, accuracy, and automaticity.

2. Method

This section discusses the participant characteristics and the recruitment procedure for this study before describing the measures used: a language dominance questionnaire and a phonological fluency task.

2.1 Participant criteria and recruitment

Participants had to be 18 years of age or older and familiar with ASL as either a first or second language. To ensure substantial exposure to a second sign language and a minimum of fluency, immersion for at least one year was also required, in both sign languages, either by exposure within a family or by residence in a country. Hearing status was not included as a criterion of exclusion in the current study because any hearing threshold might appear arbitrary given the wide range of hearing levels present in the signing population (Kusters & De Meulder, 2013).

Forty participants (16 m, 24 f) used the 16 following sign languages in addition to ASL (participant numbers in parentheses): Arab (1), British (2), Danish (1), Finnish (1), French (5), Hungarian (1), Israeli (3), Japanese (7), Mexican (1), New Zealand (1), Norwegian (1), Russian (7), South African (2), Swedish (4), Thai (2), and Ukrainian (1) sign language. Most of the participants were native signers

who acquired a sign language from birth from at least one deaf parent ($N=23$). The mean age was 40.55 ($SD=10.60$), ranging from 25 to 72. Education levels ranged from compulsory education to PhD. Twenty-six participants were located in the US. One participant confirmed that they were hearing (and native). The rest indirectly confirmed they were deaf or hard of hearing by reporting attending educational settings for deaf people.

Participants were recruited randomly by snowball sampling. Both balanced and unbalanced bilinguals within the US and abroad were encouraged to participate. A description of the research in written English or in ASL was given to the participants, followed by a request for consent in accordance with the Institutional Review Board's policies at the University of Texas at Austin. Data collection started in October 2019 and lasted until April 2020. All interactions with the participants occurred online using videoconferencing and survey technologies.

2.2 Data collection

Bilinguals of two sign languages were assessed using a language dominance questionnaire and a phonological fluency task in the signed language modality.

2.2.1 *Language dominance questionnaire in ASL*

The language dominance questionnaire used in the current study was an adaptation of the Bilingual Language Profile (BLP, Birdsong et al., 2012) into ASL, labeled the ASL-BLP (see Appendix for an English version). The BLP aims at being a tool that accurately identifies language dominance levels in spoken languages while keeping the number of questions to a minimum and being efficiently administered. Like in the BLP, the ASL-BLP asks the same questions for each of the two languages in four sections: language history, current language use, language proficiency, and language attitude. In both the BLP and the ASL-BLP, scores from the four sections are given equal weight to avoid subjective or arbitrary judgments about how much specific sections should be weighed. An index of language dominance is obtained using a difference score created by subtracting one language's total score from the other. The difference score ranges from −218 to +218, representing a continuum from strongly dominant in language A to strongly dominant in language B. The same dominance scores in both languages will result in an index value of zero. A positive index represented dominance in ASL, while a negative index represented dominance in a non-ASL signed language.

The questions in the BLP were translated to ASL in the form of video clips, but also provided in written English (Appendix). When necessary, questions were altered slightly to accommodate situations typical for sign languages that may differ from spoken languages. For example, a question in the original BLP

asks about years spent in a classroom. However, for deaf students, access to sign language in classrooms may be inconsistent (Hill et al., 2018: 196). Despite restricted access to sign language in classrooms, researchers have observed that not much prevents deaf students from signing to each other outside classrooms (Polich, 2005: 64). The question about the school domain was altered to focus on use with other students at a school instead of language use inside classrooms, to capture how sign languages are often acquired at schools by deaf students.

The two last questions addressing writing and reading skills in the proficiency section in the BLP were replaced with questions about production and perception during signed monologues. Known sign languages do not have conventional writing systems, but oral traditions in sign languages have been documented (Bahan, 2006). Webster (2006) points out that both orality and literacy have different connotations in different languages and that orality and literacy can overlap. Questions about literacy might not necessarily involve the same skills even for two spoken languages, and aspects of orality can replace aspects of literacy. For the purpose of the ASL-BLP, I made the assumption that the skills needed to produce and perceive monologues in sign languages depend on knowledge of oral traditions in those sign languages; and for that reason, questions about producing and perceiving signed narratives/monologues replaced BLP questions about literacy skills in the bilingual's languages.

2.2.2 *Phonological fluency task*

The phonological fluency task was based on the phonological fluency tasks used in Morere et al. (2012) and Marshall et al. (2014), where participants were asked to generate as many signs as possible that include a specific phonological cue. The following cues were used in the current study: a Five handshape, a One handshape, a U handshape, the Chest location, and Repeated movement. The Five, One, and U handshapes, shown in Figure 2, were identical to the three cues used in the phonological fluency task conducted in ASL in Morere et al. (2012). Marshall et al. (2014) used location and movement cues based on phonological parameters in British Sign Language, in addition to handshape cues. The Chest location and Repeated movement cues used in this study differed from those in Marshall et al., aiming for easily explained cues that work crosslinguistically.

Each phonological cue is a prompt for participants to spontaneously express specific signs using that cue. For the handshape cues, flexions (bending fingers), adductions (bringing together fingers), and abductions (spreading fingers) were accepted. The flexions, adductions, and abductions were allowed because signers may not always present a particular sign with the same handshape consistently due to phonemic or phonetic factors (e.g. the fingers are not necessarily entirely straight, spread together, or spread out in natural settings). For example, the

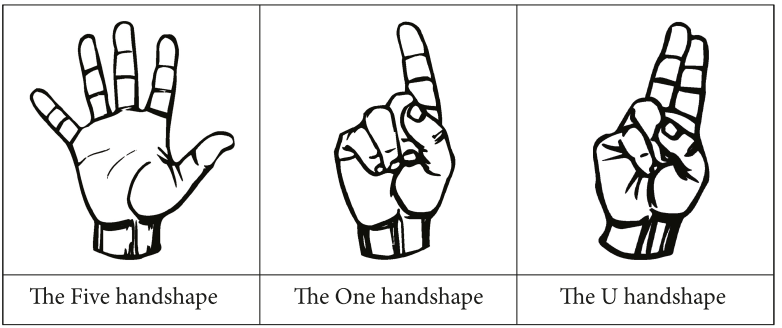

Figure 2. Illustrations of the Five, One, and U handshape

sign THINK in ASL typically occurs with a straight index finger in dictionaries, but signers may use a bent (flexion at the interphalangeal joints) index finger in natural settings. Another reason to include a range of flexions, adductions, and abductions was that the task was intended to depend on the signer's own categorical (phonological) perceptions, which may be language-specific. Whether a range of flexions, adductions, and abductions are permissible for a given handshape in a sign depends on particular signs' lexical features.

The Chest location cue elicited signs related to the chest either by touching it or by an implied relationship (e.g. the sign for *me* in ASL may be performed by pointing at the chest, but not necessarily touching the chest).

The Repeated movement cue elicited signs with repeated movements without restrictions on handshapes or locations. The Repeated movement is commonly used to express ranges of aspects by using continuous and repeating movements in ASL (Rathmann, 2005) and likely occurs in other sign languages as well (e.g. Mosand & Malmquist, 1996).

The generated signs could be any type of construct; no judgments were made about whether a construct was a lexical sign or mainly consisted of 'paralinguistic' gestures. Signs that deviated from the phonological cues or were identical replications of previous signs within the same cue were removed from the data. Randomly selected signs generated in the non-ASL languages were verified by sign language dictionaries and other signers. Constructions deviating from the lexicon of non-ASL languages were not found, confirming that non-lexicalized gestures were not an issue.

A non-native bilingual signer, fluent in ASL, counted all the signs generated in the phonological fluency task following the inclusion criteria described above. A second rater, a native signer of ASL who was also a sign-sign bilingual, counted a random subset of the sample (10 participants × 5 cues × 2 languages) using the same criteria. In the form of Spearman's correlation, the interrater reliability between the non-native rater and the native rater was high, $r_s = .97$, $p < .001$.

2.3 Procedure

The ASL-BLP was given first to determine language dominance levels prior to initiating the phonological fluency task. This step was to ensure that half of the participants started this task with their dominant language while the other half started with their less dominant language. The ASL-BLP was offered to the participants through an online survey tool (Limesurvey GmbH) or a face-to-face interview through video conferencing, depending on the participants' preferences.

The phonological fluency task was carried out during a screen recorded video conference. The task was described by displaying a handshape representing the letter K in ASL and generating three signs with the K handshape, "plant," "king," and "kindergarten" (Morere et al., 2012). The participants first generated signs in either ASL or a non-ASL, starting with the Five handshape, followed by the One handshape, the U handshape, the location of the Chest, and Repeated movements, respectively.[1] A one-minute generation time limit was set for each cue. After completing these five one-minute sign generation tasks in one language, the same phonological cues were again given in the same order for the other sign language not used in the first run. Right before giving out the phonological cues for the non-ASL, I asked the participants for the signs for "cat," "brother," "sister," and "breakfast" in the non-ASL to minimize an abrupt transition from the language of instruction, ASL, to the phonological task in the non-ASL.

2.4 Statistical models

Researchers have identified significant correlations between language dominance indices (the independent variable) obtained from a BLP questionnaire and linguistic behavior (the dependent variable) with mixed effect models (e.g. Baird, 2021; Shen et al., 2020). The same statistical approach was used in this study, with count data from the phonological fluency task as the dependent variable and language dominance indices from the ASL-BLP as a continuous independent variable.

The data was sent to a generalized mixed-effects model with a Poisson distribution and an interaction between language dominance and language (the number of signs generated in ASL and a non-ASL language). If signers with lower dominance scores in a second sign language relative to a first sign language generate about the same number of items in both languages in the phonological fluency

1. Early in the study, two participants started with Chest, followed by Repeated, Five, One, and then the U cue (see Result section), but the Chest and Repeated cues required additional clarifications when given out first. The number of signs generated by those two participants remained within 1.5 times the five cues' interquartile ranges of the other participants who started with the Five handshape.

task, the interaction effect between language dominance indices and language should be weak or non-significant.

3. Results

Main findings from the ASL-BLP survey are presented first, followed by a description of the correlations between the ASL-BLP and the phonological fluency task. The dominance scores and the results from the phonological fluency task by each participant in this study are publicly available (Lindeberg, 2022).

3.1 Results from the ASL-BLP survey

On average, the participants used 13.17 minutes ($SD = 6.92$) to complete the ASL-BLP. The mean of the dominance indices was 5.60 ($SD = 68.30$, range −149.33 to 115.72), which illustrates that ASL dominant signers were slightly better represented. The participants were divided between those dominant in ASL ($N = 22$) and those dominant in a non-ASL language ($N = 18$). The distribution of dominance indices is illustrated in Figure 3.

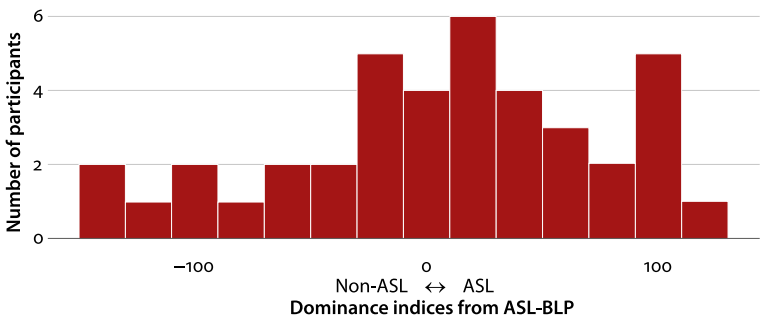

Figure 3. The distribution of ASL-BLP dominance indices of 40 participants
Note. An index above or below 0 indicates dominance in ASL or a non-ASL, respectively. Dominance levels of ASL and a non-ASL are more balanced for participants with indices closer to 0.

The maximum score possible for age of acquisition or years of use in the ASL-BLP questionnaire was 20, reflecting a non-linear impact of age of acquisition where early exposure contributes more to language dominance. As illustrated in Figure 4, the age of acquisition of a first sign language ranged from 0 to 17 ($M = 3.32$, $SD = 5.53$). When the age of acquisition of the first sign language was higher than 0, it means that a signer acquired another signed or oral language

beforehand or was exposed to a first language later than birth. Thirteen participants acquired their second language between the ages of 8 and 19, and the rest at 20 or later.

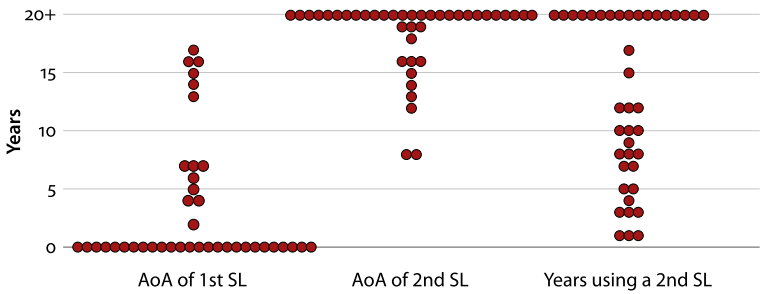

Figure 4. The age of acquisition of the first sign language, the age of acquisition of the second sign language, and years using a second sign language

3.2 Correlations between the phonological fluency task and the ASL-BLP

More signs were generated in ASL ($M = 61.60$, $SD = 17.76$) than in the non-ASL languages ($M = 52.40$, $SD = 18.75$).

A dot plot illustrating the language dominance indices and the number of items generated in ASL and a non-ASL language is shown in Figure 5. Each participant has one dot in ASL and one in non-ASL, representing the number of generated signs in each sign language, but their language dominance index is unchanged in both plots. For instance, the rightmost participant on the language dominance axes (who would be considered highly ASL-dominant based on their ASL-BLP index) generated 40 signs in the non-ASL language and 121 signs in ASL.

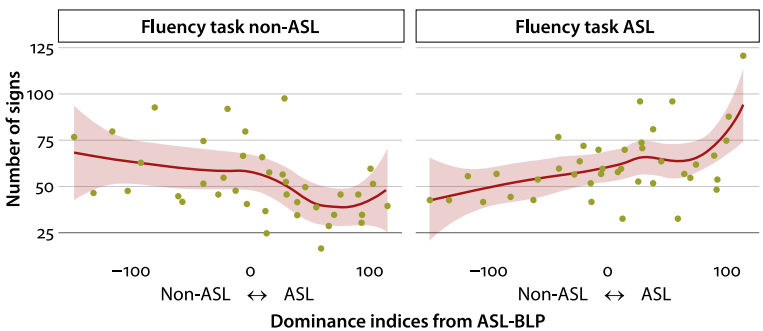

Figure 5. Plots of the number of signs generated in each sign language in the phonological fluency task

Note. The y-axis shows the number of signs generated (non-ASL languages in the left plot and ASL in the right plot).

The data was analyzed with a generalized mixed-effects model using lme4 (Bates et al., 2015) in R (R Core Team, 2020) with the number of generated signs as the dependent variable. The language dominance indices, 'Dominance,' and the ASL and non-ASL language in the phonological fluency task, comprising a two-level categorical variable, 'Language,' were defined as fixed effects, with 'Participants' as a random effect. The interaction effect (Dominance*Language) was significant (Table 1). Increased dominance in ASL resulted in a higher number of signs generated in ASL and fewer signs generated in non-ASL and vice versa for increased dominance in non-ASL.

Table 1. A generalized mixed-effects model with an interaction between ASL-BLP dominance indices and the signs generated in the phonological fluency task

Fixed effects	***B***	***SE***	**95% CI**	***z* score**	***p***
Intercept	3.92	0.04	[3.82, 4.01]	96.37	<.001***
Language	0.16	0.03	[.10, .22]	5.49	<.001***
Dominance	−0.16	0.04	[−.25, −.07]	−3.67	<.001***
Dominance x Language	0.29	0.03	[.23, .35]	9.48	<.001***
Random effects	s^2				
Participants' intercept	0.055				

Note.
* $p<.05$ ** $p<.01$ *** $p<.001$. $AIC = 667.9$, $BIC = 679.8$. Number of observations = 80.

The interaction effect is plotted in Figure 6.

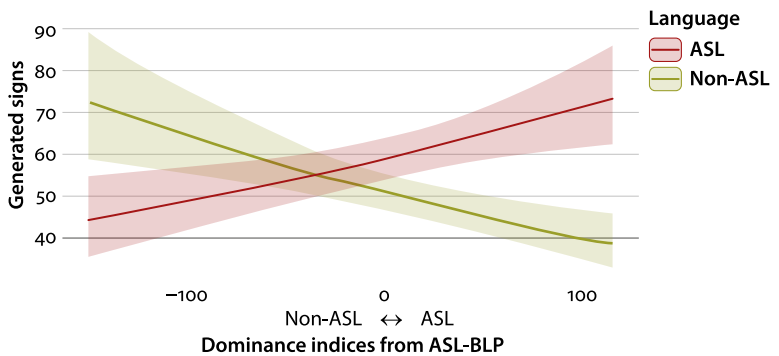

Figure 6. Interaction between Dominance and Language

4. Discussion

For this group of 40 sign-sign bilinguals, language dominance indices obtained from a language dominance questionnaire, the ASL-BLP, correlated with the results from a phonological fluency task in two sign languages. The significant correlation suggests that the relative dominance levels of two sign languages may be successfully identified by using adapted versions of language dominance questionnaires developed for spoken languages. In other words, the construct of language dominance may be considered amodal. Language dominance levels in the signed modality patterned according to a gradient scale, ranging from strongly dominant to balanced, as observed in spoken languages (Flege et al., 2002; Grosjean, 1985). The language dominance indices of many participants hovered around zero (Figure 3) but still varied, illustrating how difficult it can be to determine who is "perfectly balanced." Extensive immersion experience in two sign languages did not typically result in equal phonological fluency skills despite the relative similarity of the languages, the prevalence of iconicity, and the ease of communication between signers of distinct sign languages.

According to Marshall et al. (2014), signers produce phonological and semantic clusters when they generate signs in phonological fluency tasks. A greater dominance in one sign language could indicate more robust neural connections at the phonological, lexical, and semantic levels in that sign language over another. Performance on the phonological fluency task may mirror the strength of the neural connections, and the external factors that advance neural connections between linguistic components may be similar in spoken and signed languages.

The current study did not control for grammatical knowledge, crosslinguistic similarities, or iconicity. It is possible that proficient signers take advantage of crosslinguistic similarities and an abundance of iconicity, acquiring the grammar of a second sign language with relatively little effort. The results in this study may then be explained by a dominant language overall being more entrenched with stronger neural connections (fluency) relatively independent of acquired grammatical knowledge (proficiency). Dissociation between fluency and proficiency levels has been observed in the spoken modality (Bahrick et al., 1994; Birdsong, 2006) and would not be unique to the signed modality. Future studies on sign-sign bilinguals could benefit from including both fluency and proficiency measures.

The demonstrated similarity between iconic signed and arbitrary spoken languages in terms of a correlation between a language dominance questionnaire and an objective measure could indicate that the role of iconicity is negligible in multi-faceted constructs of language dominance. No evident facilitation effects of iconicity appeared in the form of equal access to two mental lexicons being

expected in the signed modality. Still, more research is needed to specifically address the question whether iconicity affects language dominance levels.

On average, balanced bilinguals in terms of the ASL-BLP generated more signs in ASL than in their non-ASL language (see 0 on the X-axis in Figure 6). Two factors might explain this observation. First, ASL was the language of instruction for the task, and some participants expressed that it was hard to generate signs in their non-ASL language without the presence of other non-ASL signers. Secondly, ASL is often used as a lingua franca, and ASL constructions frequently appear in international sign systems used when deaf people from various countries meet (Kusters, 2020). The role of ASL as a lingua franca was not controlled for in the ASL-BLP.

A direct-measure phonological fluency task validated the self-report ASL-BLP; thus, the ASL-BLP can, in some contexts, replace controlled tests requiring specialized training. Evaluating language dominance in a bilingual signer may be important in healthcare or educational settings where the decisions about instruction, interventions, or treatments are optimized by identifying and utilizing an individual's dominant language. For instance, the extent of premorbid language use appears to modify the recovery of the L1 from aphasia (Kuzmina et al., 2019). In the education context, Stewart (1985) found that deaf students, after being told a story in English, primarily recalled details from the story in ASL, which was their dominant language. Sign-sign bilingual students may be able to recall details better in their dominant sign language.

This study has potential limitations. First, the inclusion criteria only defined one common sign language: ASL. Restricting a study to two specific sign languages could let researchers control for the distribution of phonological cues in each sign language, compare semantic and phonological clusters, and analyze intrusions and cognate effects. Limiting the set of languages could also let researchers control for proficiency levels and crosslinguistic similarities. Second, the ASL-BLP was completed before the phonological fluency task. Participants might have realized that they were not equally fluent in both their languages during the phonological fluency task and underperformed according to responses in the ASL-BLP. Last, snowball sampling might have resulted in an oversampling of sign-sign bilinguals with particular characteristics, potentially restricting the relevance of this study's results to other populations of sign-sign bilinguals.

5. Conclusion

A multi-faceted construct of language dominance developed for spoken languages predicted linguistic behavior in the signed modality among sign-sign bilinguals.

A significant relationship appeared between a language dominance questionnaire (based on predictors identified in research on spoken languages) and results from a phonological fluency task conducted in two sign languages. Language dominance is demonstrable despite signers of distinct sign languages reportedly communicating with each other with ease and sign languages being relatively similar and heavily iconic. The construct of language dominance appears to be amodal, and signing bilinguals vary in their language dominance levels just as has been observed in spoken languages. Measuring language dominance in sign-sign bilinguals with the signed adaptation of the Bilingual Language Profile (Birdsong et al., 2012) may be useful in healthcare and educational settings where a clear understanding of a bilingual signer's strongest sign language may be critical for providers as they determine the needs of the situation.

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Appendix

The questions (and response options in parentheses) in the American Sign Language Bilingual Language Profile (ASL-BLP) are shown below. The word "non-ASL" in the questions below did not appear in the online ASL-BLP questionnaire. At the onset of the online questionnaire, the participants typed the name of a sign language they knew in addition to ASL. The survey software replaced all the instances of "non-ASL" with this name, i.e. the participants got questions about ASL and a particular sign language they knew.

Language use

Response options: 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%

1. In an average week, what percentage of the time do you use ASL, non-ASL, and Other Languages with friends?
2. In an average week, what percentage of the time do you use ASL, non-ASL, and Other Languages with family?
3. In an average week, what percentage of the time do you use ASL, non-ASL, and Other Languages at school/work?
4. When you talk to yourself, how often do you talk to yourself in ASL, non-ASL, and Other Languages?
5. When you count, how often do you count in ASL, non-ASL, and Other Languages?

Language history

Response options: 0-20+

6. At what age did you learn to use ASL and non-ASL?
7. At what age did you start to feel comfortable using ASL and non-ASL?
8. How many years have you been a student at a school (primary school through university) where you used ASL or non-ASL with other students?
9. How many years have you spent in countries/regions where ASL or non-ASL are used?
10. How many years have you spent in a family where ASL or non-ASL are used?
11. How many years have you spent in a work environment where ASL or non-ASL are used?

Language proficiency

Response options: Not well at all (0), 1, 2, 3, 4, 5, Very well (6)

12. How well do you express yourself in ASL and non-ASL in conversations?
13. How well do you understand ASL and non-ASL in conversations?
14. How well do you present in ASL and non-ASL?
15. How well do you understand lectures or monologues in ASL and non-ASL?

Language attitudes

Response options: Disagree (0), 1, 2, 3, 4, 5, Agree (6)

16. You feel like yourself when you use ASL and non-ASL.
17. You identify with the ASL culture and the non-ASL culture.
18. It is important to you to use (or eventually use) ASL and non-ASL like someone who grew up using ASL or non-ASL.
19. You want others to think that you grew up using ASL and non-ASL.

Résumé

Cette étude vise à déterminer si un modèle complexe de dominance linguistique développée pour les langues parlées, peut s'appliquer chez les bilingues dans les langues signées. Les langues des signes ont été décrites comme très iconiques et relativement similaires entre elles par rapport aux langues parlées. Atteindre un bon niveau de langue dans la modalité signée pourrait alors demander beaucoup moins d'efforts, et le bilinguisme équilibré pourrait être plus fréquent dans la modalité signée (que dans la modalité parlée). Les concepts de dominance linguistique, tels qu'ils sont utilisés actuellement, pourraient donc être différents selon la modalité envisagée (parlée vs. signée). Quarante bilingues connaissant deux langues des signes ont rempli un questionnaire sur la dominance linguistique conçu pour les langues parlées et ont accompli une tâche de fluence phonologique (avec génération de signes). Les résultats indiquent une variation des niveaux de dominance linguistique dans la modalité signée. La corrélation entre le niveau de dominance déclaré et le nombre de signes générés dans chaque langue des signes est significative, ce qui suggère que le modèle de dominance linguistique testé est robuste et indépendant de la modalité.

Mots-clés : bilinguisme, dominance linguistique, acquisition, iconicité, langues des signes

Author's address

Dag Johan Lindeberg
The University of Texas at Austin
110 Inner Campus Drive
Austin, TX 78712
United States
daglind@gmail.com

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