# How are signed languages learned as second languages?

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**Abstract**

This review addresses the question: How are signed languages learned by adult hearing learners? While there has been much research on second language learners of spoken languages, there has been far less work in signed languages. Comparing sign and spoken second language acquisition allows us to investigate whether learning patterns are general (across the visual and oral modalities) or specific (in only one of the modalities), and hence furthers our understanding of second language acquisition (SLA). The paper integrates current sign language learning research into the wider field of SLA by focusing on two areas: 1. does 'transfer' occur between the spoken first language and signed second language, and 2. what kind of learning patterns are the same across language modalities versus unique to each modality?

## 1. Introduction

### 1.1 Second language acquisition as a field

Second-language acquisition (SLA) research deals with the process of learning other languages after one's native language (Epstein, Flynn, & Martohardjono, 1996). In addition, SLA research deals with the various strategies that exist for teaching and evaluating language learning in adults. An issue debated in the research on SLA is whether some of the properties or elements that characterize a learner's interlanguage (i.e., developing second language knowledge: Selinker, 1972) can be explained by influence from the first language (L1), or whether they are a by-product of developmental sequences that learners can be expected to move through regardless of different L1 backgrounds (VanPatten & Benati, 2015). This influence is known as language transfer and is argued to occur at all language levels, including phonology, syntax, pragmatics, and even the transfer of gestures from the learner's wider culture (Gullberg & McCafferty, 2008). Transfer can result in errors (negative transfer), facilitation (positive transfer), avoidance (construction infrequency), redundancy or overgeneralization.

SLA research on how learners acquire a new language spans a number of different disciplines (e.g. psychology, linguistics, pedagogy and sociology). Cognitive approaches to SLA research deal with the processes in the brain that underpin language acquisition, for example how language acquisition is related to short-term and long-term memory. Pienemann and Lenzing (2015) argue that second language (L2) learners acquire linguistic structures (i.e., negation, question formation) through predictable stages explained by domain-general processes. According to processability theory, instruction is constrained by these developmental stages as L2 learners follow a rigid route in the acquisition of grammatical structures. This approach

52 defines complexity in relation to language users: what is costly or difficult for language users is
53 seen as complex. Complexity is thus identified with cost and difficulty of processing and
54 learning (Miestamo, 2009). Such theories have uncovered patterns that appear to reveal an effect
55 of universal principles of markedness, with a preference for simplification in the direction of less
56 marked structures. For example, learners often learn a form or construction in one context and
57 extend its application to other contexts e.g. 'She buyed a dress' instead of using a less frequent
58 (more marked) construction 'bought'). Some SLA researchers have argued that simplification
59 and overgeneralization can be used by L2 learners to reduce complexity and cognitive burden
60 (Miestamo 2009). These selected domains of SLA research (transfer and learner patterns) are
61 relatively broad ones that we to use to organise the current research literature on signed language
62 acquisition. However, they are useful ones with which to describe the overall field before
63 carrying out more in-depth studies of specific aspects of adults' signed language acquisition of
64 signed languages.
65
66 1.2 Signed languages
67 Signed languages are fully-fledged human languages (Pfau, Steinbach & Woll, 2012) that
68 emerge naturally in deaf communities all over the world (e.g., American Sign Language: ASL;
69 British Sign Language: BSL, etc.). Signed languages are considered 'minority' languages as
70 deafness is a low incidence condition (1 in 1000 children are born deaf), and only around 10% of
71 deaf children have deaf parents and are thus considered to be native signers (Mitchell &
72 Karchmer, 2004). Signed languages are acquired as first languages by children of deaf adults
73 following well-attested stages (Baker & Woll, 2009; Chamberlain, Morford & Mayberry, 2000;
74 Chen-Pichler, 2012; Morgan & Woll, 2002; Petitto, 1997). In addition, some hearing parents use

a signed language with their deaf children and some hearing children of deaf adults (CODAs) acquire signed languages at a young age (Chen-Pichler, 2012). Signed languages are processed in the brain in traditional language centres, and users of signed languages comprehend and represent signs using similar cognitive processes proposed for users of spoken languages, including networks of lexical representations (Emmorey, 2002; Gutiérrez, Müller, Baus, & Carreiras, 2012; Orfanidou, Adam, Morgan, McQueen (2010).

This review paper addresses a novel question in SLA research: How are signed languages learned by adult hearing learners? While there has been much research on L2 learners of spoken languages there has been less work in signed languages, despite signed languages being popular languages with adult learners. In 2009 in the UK, for example, there were an estimated 190,000 hearing adults who had learned at least basic level BSL (Woll, 2012; for estimates of adult ASL learners see Smith & Davis, 2014). Hearing adults learn a signed language because they start working with deaf people, have a relative or friend who is deaf, plan to train as interpreters, or just develop an interest in learning a new language.

The paper is organised as follows: Section 2 overviews modality issues relevant for sign SLA, Section 3 reviews adult signed language learning with a focus on transfer and the existence of general learning patterns. The motivation for the focus on transfer and general learning patterns is that these represent two central areas of research in the SLA field. The exploration of SLA of signed languages provides a novel learning paradigm (cross-modality SLA) and can provoke new questions in the field. What transfer occurs between language modalities (spoken L1 to

signed L2)? Is SLA of signed languages constrained by domain-general processes or different processes unique to the visual-manual modality? If signed language SLA follows similar stages and evokes similar learner strategies and mechanisms as proposed for spoken language SLA (i.e. modality-similar SLA) it would confirm general patterns of SLA beyond the unitary modality (i.e., observed across signed and spoken languages). Finally, Section 4 draws together some conclusions and offers possible future directions for the field.

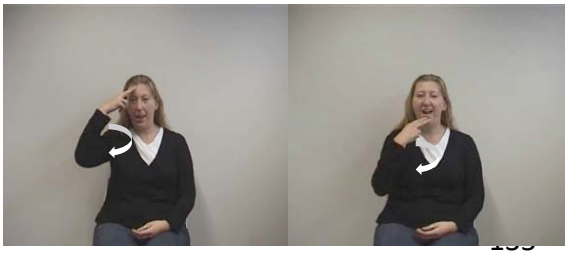
## 2. Modality issues relevant for sign SLA

When learners are exposed for the first time to a new language, they begin to perceive and store the sounds and sound patterns (phonological representations) of the target language. Learners of signed languages need to do the same. In this section we outline the phonological structure of signs, describe aspects of sign language linguistic organisation and the interface with wider communicative systems that are important for hearing second language learners. While some learners are deaf second sign language i.e. within the same modality (M1-L2) the current paper focuses on the L2 acquisition of a signed language by hearing learners thus between different modalities (M2-L2). For these learners, we describe the high amount of iconicity (i.e. motivated links between visual form and meaning) in signs, and how this drives the overlap of signs and gestures. We then document the possibility of expressing several grammatical elements simultaneously on different articulators (i.e. hands, face, and body). This section on signed languages covers several levels of linguistic organisation but is not exhaustive (see Pfau, Steinbach & Woll, 2012 for a comprehensive overview). These aspects are selected as they will be necessary to interpret the results of the signed language SLA research studies reviewed in the following sections.

## 2.1 Sign phonology

Phonology in spoken languages describes the systematic ways in which a limited set of meaningless sounds are combined to create a potentially unlimited set of meaningful words. In contrast to the sounds of language, signs are composed of four main phonological components (handshape, movement, hand orientation, and location - Brentari, 1999). For example, the BSL signs NAME and AFTERNOON (figure 1) constitute a minimal pair. Both have the same handshape, orientation and outwards movement, but differ in the location (the hand moves out from the forehead in NAME and from the chin in AFTERNOON).

Figure 1. Phonological minimal pair in BSL



NAME AFTERNOON

## 2.2 Iconicity

An important aspect of signed languages is the link between the visual form of the sign and its meaning, and this will be relevant for the following section on transfer. In spoken languages, words are traditionally argued to have an arbitrary form-meaning relationship e.g. the sounds in the English word ‘dog’, Spanish ‘perro’ and French ‘chien’ have no link to the concept of what a dog is or does (de Saussure 1983). However, spoken languages do have instances of sound

symbolism e.g. onomatopoeia, and this relationship is implicated in language learning (Deconinck, Boers & Eyckmans, 2017).

Signed language vocabulary is richly influenced by visual properties of sign meanings (e.g. Friedman, 1976; Perniss & Vigliocco; 2015). Bellugi and Klima (1979) first described iconicity as being on a continuum across different signs e.g. in figure 2 the sign BOOK looks like an opening book, the less iconic TO-WORK in BSL looks like hitting your hands together and is related to the concept of making something. Finally, some signs are non-iconic e.g. SISTER in BSL is articulated with a hooked index finger tapping the bridge of the nose. It is also the case that many signs have lost their iconic motivation over time e.g. the index finger moving down the cheek in GIRL in BSL might have originally referred to the strap of a bonnet.

Figure 2. Examples of signs in BSL that vary in iconicity

BOOK WORK SISTER

As a result of this iconicity many signs resemble the conventional gestures used by non-signers. For example, TO-THROW and TO-SMOKE in BSL are visually similar to everyday conventional gestures used in wider British society to express these meanings.

Indeed, some studies have reported that complete novices can correctly guess the meanings of many signs by using world knowledge and their experience with gestures (Ortega, Schiefner, & Ozyürek, 2019). In this study non-signing hearing adults exploited their implicit knowledge of gestures to guess correctly the meaning of iconic signs in Sign Language of the Netherlands (NGT) they had never seen before. When participants saw signs that had a strong visual overlap with gestural forms, they were able to guess the meaning based on their knowledge of those gestures. The implication of this study was that gestural knowledge can ease the interpretation of the meaning of novel signs. The authors went on to propose that iconic gestures that overlap in form with signs served as 'manual cognates' that help non-signing adults to break into a new language at first exposure (Ortega, Schiefner, & Ozyürek, 2019).

Previous research suggested that the similarities between sign, silent pantomime and co-speech gesture are exploited during sign L2 learning (Casey & Emmorey, 2009; Chen-Pichler & Koulidobrova, 2015; Weisberg, Casey, Sevcikova Sehyr & Emmorey, 2020). In Casey and Emmorey's (2009) study, a group of L2 signers were compared to participants with no knowledge of ASL. In an elicited narrative procedure, the L2 sign learners produced a greater number and type of iconic gestures, as well as a higher rate of such gestures, compared to non-signers. The authors argued that increased iconic gesturing by signers may reflect the iconicity present in lexical, phonological, and spatial aspects of sign languages. The authors further speculated that exposure to ASL influenced signers to visualize the narrative more vividly than non-signers (Casey & Emmorey, 2009).

187

188 2.3 Simultaneous articulation of several linguistic elements in sentences

189 Spoken languages generally express sentence-level meaning through a sequence of words or a
190 sequence of morphemes in a word. Sign languages offer the possibility to express a number of
191 meaningful elements simultaneously. This simultaneity can occur within a single sign (across
192 different articulators); for example, Schönström and Mesch (2014) describe how the signer's
193 mouth is able to function as an independent articulator parallel to the hand, allowing movements
194 to add adverbial information to manual lexical signs. Simultaneity can also occur across multiple
195 signs and articulators, i.e. the two hands, body, eyebrows, mouth, eyes and head (Sandler, 2012).
196 One particular instantiation of the phenomenon is the use of classifiers in signing space.

197

198 An example is shown in figure 3 of a deaf BSL signer recounting a section of a story where a
199 boy mistakenly climbs onto a deer's back and is carried away. The signer's head denotes the
200 deer, his left hand forms the sign DEER and the right hand the position of the boy. The signer's
201 face illustrates the discomfort of the boy.


Figure 3 THE BOY SITS UNCOMFORTABLY ON THE DEER'S HEAD

(example from Gulamani, Marshall & Morgan, 2020)

There is a relatively large amount of research concerning classifiers (see Morgan & Woll, 2007), with the main type investigated in sign SLA being handshapes that represent the shape of a referent class. Classifiers are particularly important as referring expressions. Reference and referring expressions are noun phrases or a surrogate for a noun phrase (e.g. a classifier) whose function in discourse is to identify some individual object. For example, in BSL a G-handshape (an extended index finger) can represent any long thin object e.g. PENCIL, TOOTHBRUSH or even TREE. Once the lexical sign for TREE is signed a subsequent mention of this referent can be tied to the classifier handshape (functioning as an anaphoric pro-form). Signers move or locate the classifier in space so as to express different meanings e.g. 'the tree was next to the river' or 'the tree was at the top of the hill'. Signers can also use classifiers in conjunction with other body parts and the face to express several meaning elements simultaneously. For example,

in BSL the V-handshape in figure 3 represents a person and how it moves and is located. Once the sign for BOY has been signed, a subsequent mention of this referent can be tied as an anaphor to the V-hand classifier handshape. Classifiers have been studied in only a handful of SLA contexts (e.g. Janke & Marshall, 2015) and the findings of this research will be reviewed in section 3.1.

A second issue related to gesture and iconicity is that speakers sometimes move their hands around to express location and movement of objects in their co-speech gesture for referential purposes (Perniss & Ozyürek, 2015). Perniss & Ozyürek (2015) compared German co-speech gesture and German Sign Language (DGS) in this domain and found qualitative similarities and differences between sign language and co-speech gesture for reference tracking in discourse. The authors argued that similiarites were driven by the shared affordances of the visual modality. Thus, the visual modality requires hearing L2 learners to re-use already present communicative resources in order to learn how signed language classifiers function. Up to this point we have described simultaneity as an aspect of expressive language competence. There is an additional role in learning however for receptive competence. When a signer sees a sign produced by another person it is visually reversed from the point of view of their own production of the same sign. For example when perceiving the sign BOOK in figure 2 a signer sees the back of the hands while in production they see the palm of the hands. Shield and Meier (2018) point out that this has implications for how learners represent a sign they have learned. Shield and Meier (2018) showed that sign language learners improved their ability at mentally reversing a visual representation when compared to non-signers suggesting sign exposure has an impact on cognitive visual-spatial skills. Non-signers made significantly more perspective-taking errors in

their imitation of gestures than either intermediate or advanced signers. In a related study, Watkins and Thompson (2017) provided evidence that both left- and right-handed participants identified signs produced by right-handed models more quickly because both left and right-handed signers are required to comprehend right-handed signing more than left-handed signing. Thus sign language learners will require some degree of visual perspective taking ability (Shield & Meier, 2018).

In summary, sign language learning by hearing adults offers a range of opportunities and challenges for the learner related to the switch in modality it entails. On the one hand, sign meanings might be easier to guess and remember because of their close form-meaning relationship and similarities with learners' own gestures. On the other hand, the articulation of language across different parts of the body and in space is very different to how spoken languages are used. This section has highlighted those areas of the linguistic organisation of signed languages which are relevant for interpreting SLA research. As described at the end of section 1, the exploration of SLA of signed languages provides a novel learning paradigm with respect to the existence of transfer and domain-general processes. In the next section we describe a range of studies of signed language SLA in these two domains.

## 3. Sign language learning: transfer and general learner patterns

### 3.1 Transfer

A common feature of SLA is the influence of the native language, i.e. transfer (Gass & Selinker, 2008). How does transfer work in the SLA of signed languages? Hearing L2 learners of a signed language have to master a novel phonological system perceived in the visual and

produced in the manual modality. In comparison, learners of L2 spoken languages adjust their L1 phonological repertoire to include the L2 sounds that partially overlap, as well as master sounds that are not in their language, and this can lead to a foreign accent. Some researchers have argued that because phonology from the L1 cannot transfer across modalities it is not possible for a hearing adult learner of signed languages to have a foreign 'accent' (Rosen, 2004). However, mastering the intricacies of sign phonology will bring to bear other demands, e.g. fine motor control (Mirus, Rathmann & Meier, 2001). More specifically, Mirus et al. (2001) found that sign hearing adult language learners used more proximal joints (i.e. those closer to the body) when attempting to sign and also that they signed more slowly. Thus it is possible that while a sign learner may not have a recognisable foreign (i.e. other) language accent, their difficulties in initial articulation of signs may identify them as being 'hearing' or 'learner' (i.e. non-native) signers.

During the process of learning of sign languages, L2 signers usually adopt certain features, such as word orders of their L1, and even use the spoken L1 and signed L2 at the same time. If the learner's L1 is English then this is known as Sign Supported English (SSE) or 'learner signing' (Chen-Pichler & Koulidobrova, 2015). Signing and speaking at the same time is uniquely possible in sign SLA because each language is articulated in a different modality. While signed languages are independent from the spoken languages used around them, they do borrow from them. For example, many signed languages have a system of manually articulated letters in order to visually 'fingerspell' on the hands a word used in the surrounding spoken language e.g. 'CAR v-o-l-v-o'. Here the BSL sign CAR is followed by the brand word 'Volvo' spelt on the hands of the signer: fingerspelling would be used in a situation where signers lack an agreed sign for this

particular make of car. Thus BSL and English can be used together by learners during attainment of fluency (Sevcikova Sehyr, Giezen & Emmorey, 2018). For example, a beginner hearing adult learner of BSL in Smith et al.'s (2010) study transferred an English expression 'to miss something' (i.e. emotionally long for) by signing this straight into English fingerspelling as YOU m-i-s-s u-s-a ('Do you miss the USA?') rather than using the sign TO-MISS. More research is required that describes the influence of spoken languages on SLA of signed languages both in diverse learning situations and in longitudinal studies.

Another example of transfer in sign learning at the lexical level is the use of 'invented signs'. When a spoken L2 learner has a lexical gap, it is common for them to code-switch back to the L1. This switching is interesting in L2 sign learners, because if the shift meant using their L1 then this would have to happen across modalities (i.e. back to their spoken L1). Smith et al. (2010) showed a group of beginner level BSL learners 40 pictures of objects and actions and asked them to name them with signs. It was expected that beginner learners would have lexical gaps and so would be forced to code-switch to speaking. In fact, the learners stayed in the manual-visual modality (i.e. they did not speak) and code-shifted by using gestures with appropriate meanings for over 80% of the items. These pantomimic gestures were very similar in form to lexical signs in BSL, e.g. for a picture of a CAMERA, all 20 learners demonstrated taking a photograph with a camera. Thus sign language learners transfer co-speech gesture system into pantomimes at the earliest stages of sign learning (Ortega & Özyürek, 2013).

It has been argued that iconicity also influences the accuracy of sign production in L2 learners through transfer of iconic gestures from the larger culture of the L1. Ortega and Morgan (2015)

used a sign repetition task in which beginner learners had to imitate as accurately as possible a set of iconic and non-iconic signs (viewed with English translations and balanced for sign language phonological complexity). Contrary to expectation, it was found that iconic signs were articulated less accurately than arbitrary signs. For example, after seeing the sign TO-WRITE learners repeated the sign but changed the handshape and movement and instead articulated what they did when they actually write (See figure 4).

Figure 4 Iconic sign repetition

Target: TO-WRITE Learner: Handshape and movement error

(example from Ortega and Morgan, 2015)

Ortega and Morgan (2015) argued that iconicity afforded learners direct access to the meaning of a sign, which led them to focus less on the exact phonological form. The beginner learners still produced a sign with the same meaning (via its iconic motivation) but not necessarily with the same phonological form as the target. In contrast, when they repeated non-iconic signs, learners had to focus more on forms, because they could not be linked to meanings via iconicity, and this led to increased accuracy. An alternative but not mutually exclusive explanation is that learners

produced iconic signs less accurately because of their access to gestures. As iconic signs and iconic gestures often resemble one another, learners may have retrieved the gesture rather than the sign.

Other researchers have reported similar negative effects in sign articulation where some of the learners' errors can be traced back to their gestures (Ortega & Özyürek, 2013). There is general consensus among researchers that spoken language transfer is more likely to occur at lower levels of proficiency (Odlin, 1989; Poulisse & Bongaerts, 1994). Following this assumption, presumably once further sign learning has taken place, iconicity can be used but without it transferring via gestures. Nevertheless, as Odlin (1989) points out, certain types of transfer in spoken language, such as cognate vocabulary use, occur even at high levels of proficiency. Although evidence of this type of transfer comes from spoken language data, we cautiously suggest that even learners with good command of a signed language might transfer gestures when attempting to describe constructions that involve elements of both sign and gesture (for example, the classifier system; Marshall & Morgan, 2015).

A final example of transfer is seen in the acquisition of classifiers signs where both Woll (2012) and Janke and Marshall (2017) argue that beginner L2 learners may recruit gesture and pantomime. Smith et al. (2010) reported many errors in the selection and orientation of handshapes to denote objects by BSL learners in spontaneous conversation involving classifiers. Learners were able to produce hand formations to stand in for objects in space (i.e., a fist for a car, a flat hand for a person) which looked 'sign-like' but not the accepted handshapes for these referents in BSL.

Marshall and Morgan (2015) measured experimentally the difficulties that intermediate-level learners (1-3 years of exposure) face with classifiers and also asked whether learners' pre-existing repertoire of gesture and ability to understand iconicity could, as Woll (2012) suggested, facilitate their acquisition. Marshall and Morgan (2015) focused on spatial relationships, which in sign languages are represented in a very iconic way using the hands, and which one might therefore predict to be easy for adult learners to acquire. In a test of matching classifier sentences in BSL with pictures, learners were indeed highly accurate in understanding handshape, location and orientation information. More surprisingly, Marshall and Morgan (2015) reported the same pattern of high comprehension in sign-naïve participants (adults with no prior knowledge of a signed language). The authors argued that the sign-naïve participants were able to bring their general visuo-spatial abilities to the task of understanding BSL classifiers. This type of transfer would not be available to assist understanding grammatically complex constructions in spoken languages.

As Smith et al. (2010) had suggested, Marshall and Morgan (2015) went on to ask whether visual-spatial skills aid the production of classifiers. The same intermediate level learners were asked to describe spatial arrays in pictures using BSL, and their productions were compared to those of native deaf signers. The question was whether the different components of the classifiers – handshape, location and orientation – would be produced equally well. Hearing intermediate level learners produced an interesting set of constructions. This group of learners knew that they should use their hands to represent objects and were highly accurate at signing location and orientation information, but they had more difficulty choosing the same handshapes as the native

signer targets. Marshall and Morgan (2015) concluded that gesture knowledge was partially used by sign learners to produce classifier sentences but lengthy exposure to BSL was required in order to go beyond this first stage and acquire the full complexity of the language. Some authors have indicated that for any pre-existing experience to transfer it is important that the learner goes through a reanalysis stage in which previous gesture knowledge is processed as being linguistically meaningful (Taub, Galvan, Piner & Mather, 2008).

Janke and Marshall (2017) subsequently argued that learners have to converge on the conventionalised classifier system that forms part of the grammar of the language being learned by selecting from all the handshapes they are physically able to articulate. In this study 30 sign-naïve hearing adults were tested on Marshall and Morgan's task. All used some handshapes that were different from those used by native BSL signers and the intermediate learners, but there was a lot overlap also. However, the sign-naïve hearing adults had much less consistency e.g. using 4-5 different handshapes to represent the same object across the different trials in the task, whereas fluent signers used just a single handshape. The findings suggest that a key challenge when learning classifiers might be reducing from a very large set of gestural resources, rather than supplementing a restricted one. An interesting observation on the use of classifiers and potential transfer effects is that if we distinguish between production and comprehension there seems to be a negative transfer (e.g., wrong handshapes) in production and a positive transfer of gesture knowledge in comprehension.

The studies reviewed in this section report transfer from L1 to L2. Much more research is required on transfer as this is an important process in SLA of signed languages. Similarly, it will

be necessary to carry out studies on larger numbers of learners, as well as combine observational and experimental data. There is an additional area of research which should be pursued, namely that acquisition of a new language (L2) affects the first (L1). Casey, Emmorey and Larrabee (2012) reported that learning a signed language influenced co-speech gesture that accompanied the learners' spoken L1. Learners of ASL felt that they gestured more when they were speaking English, and a longitudinal study confirmed this perception. The sign learners produced more iconic gestures in their co-speech gesture, and they also used a greater number of differing handshapes when gesturing.

### 3.2 Domain generality

In investigating how signed languages are learned as second languages we turn to general learning patterns seen across modalities. In the general SLA literature difficulties can occur for learners because of proposed processing costs (Miestamo, 2009) that lead to errors, as well as conscious/intentional strategies on the part of the learner. Two important aspects which can be studied in SLA of signed language are the following:

- Simplification: Learners often use simpler forms and constructions instead of more complex ones. E.g. the use of simple present 'John eats' instead of the present perfect continuous 'John has been eating' (Trudgill, 2011).
- Over-redundancy: Learners can over-use a lexical form or construction to avoid ambiguity or decrease cognitive load e.g. 'The lady bought a dress. The lady bought some shoes' (Sorace, Serratrice, Filiaci, & Baldo, 2009).

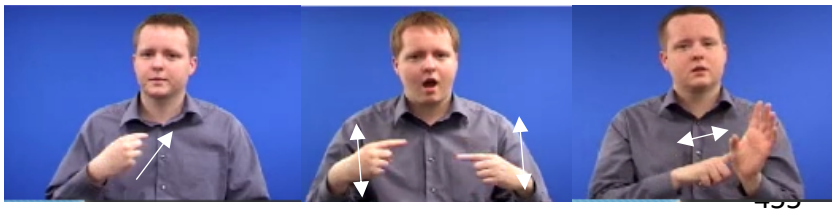
Documenting how sign languages are learnt might reveal similar general L2 learner patterns.

A well-documented feature of SLA is phonological simplification processes. For example, marked sounds like [θ, ð] are replaced by more common ones like [t, d], and consonant clusters are reduced. In sign learning this is can be seen in changes made to the sub-lexical organisation. For example, the handshape required in the BSL sign SHEEP involves a fist with an extended pinkie finger. Adult L2 learners often produce this sign with a fist but omit the pinkie finger, thus simplifying the articulation. In seminal work, Mirus, Rathmann, and Meier (2001) and Rosen (2004) examined production errors in ASL phonology made by beginning L2 adult learners due to poor motor dexterity. Although adults have a fully developed motor system to perform complex movements with their arms and hands, the particular types of movements required for signing are initially unpractised and lead to errors (Woll, 2012). These were proximalisation (making signs with joints closer to the body than in the target), substitutions of handshapes, displacements of signs to the wrong locations, additions of extraneous 'practice' movements and deletions of movements. Production errors were also tied to difficulties in visually perceiving signs, include the mirroring of hand movements (producing signs as perceived in the input i.e. on the wrong side of the body), addition and deletion of parts of the sign difficult to see (e.g. on top of the head).

Smith et al. (2010) reported one of the few examples of longitudinal data for BSL sign phonology in L2 acquisition. Learners were asked to articulate a list of 20 signs at the beginning of the BSL course (after 2 hours of exposure) and at the end (after 24 hours of exposure). Beginner learners found handshape most difficult to produce accurately, followed by movement and location, and during learning accuracy across all these parameters improved from 36% to 79% (Smith et al., 2010). A second methodology used in the sign language learning literature is

to ask learners to copy signs with different levels of phonological difficulty and observe what errors they make. Signs are not all equal in phonological complexity e.g. in the number of hands with which they are articulated (1 or 2), the number of movement components they include, and the motoric complexity of the handshape (Brentari, 1999). See figures 5 and 6 of BSL signs with the simplest to the most complex phonological structure

Figure 5.



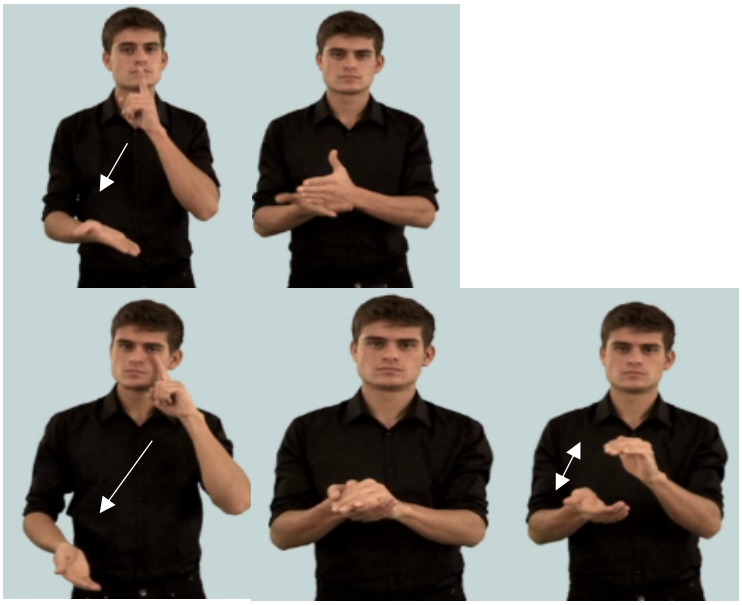
I/ME ALLOW YEAR

I/ME, one- handed sign, one handshape, one location, no movement;

ALLOẄ, double-handed sign, symmetrical, one handshape, one location, movement in both hands;

YEAR, two-handed sign, two different handshapes, movement in the dominant hand.

Figure 6.



PROMISE

LOOK-AFTER

PROMISE, two-handed sign, two different handshapes, one handshape change in the dominant hand, movement in the dominant hand;

LOOK-AFTER, one handed sign to start with then changes to double-handed, two different handshapes occur during the production of the sign, handshape change in the dominant hand, movement in the dominant hand: movement is different in the one-handed compared to the double-handed sign.

Ortega and Morgan (2015) asked sign learners to copy different signs. They found that two-handed signs (ALLOW, YEAR, PROMISE & LOOK-AFTER) were articulated less accurately than one-handed signs (I/ME), and two-handed signs in which both hands have symmetrical movements (ALLOW) were executed more accurately than two-handed signs in which both move independently (PROMISE & LOOK-AFTER). Furthermore, and with respect to location, signs that were performed in the signing space in front of the learner were articulated less accurately than signs which make some contact with the body. It is possible that the

proprioceptive feedback of a sign that requires contact on the body eased learner cognitive load when producing the location parameter. The authors concluded that the more phonological constituents a sign has, the more difficult it will be for learners to process and articulate accurately, and this findings follows patterns reported in the wider SLA literature (Epstein, Flynn, & Martohardjono, 1996).

Williams and Newman (2016) reported differences in ASL phonological accuracy based on both learners' proficiency and input variability (input from a learner or a native signer). This study adds another level of complexity to previous accounts of accuracy in learners by describing some differences, especially for handshape perception (described as the most difficult parameter to master in previous research), based on learner and target properties. Learners made more movement errors for sentences signed by other learners relative to those by the native signer. An innovative study, building on the earlier studies of learner errors carried out by Mirus et al. (2001) and Rosen (2004), attempted to calculate learners' ability to produce accurate ASL signing using an instrumentation methodology. Hilger, Loucks, Quinto-Pozos and Dye (2015) investigated production variability and the development of motor control. Production variability was characterized through a Spatio Temporal Index (STI - Smith et al., 1995) which is a measure of stability and variability in kinematic movements. Motion capture apparatus was used to acquire wrist displacement data across eight target signs embedded in carrier phrases. The STI values of deaf fluent signers and beginner hearing learners at three different ASL experience levels were compared. As predicted, deaf fluent signers showed significantly lower STI values than the hearing learners and stability increased with increased language use as in spoken language accuracy measures. Future research using combined naturalistic and instrumentation

methods is required to add to these interesting initial studies. Future studies should control elicitation procedures and tasks, both from the production and comprehension perspectives.

The wider SLA literature describes learners dropping or mis-ordering required elements during acquisition. In signed languages the face is an important non-manual marker of several grammatical functions. For example, one of the non-manual markers of questions is movement of the eyebrows. Research has found that the grammatical use of non-manuals is relatively limited among early and intermediate L2 learners (Schönström & Mesch, 2014). An example from their data is that L2 learners did not raise the eyebrows in order to indicate wh-questions non-manually but instead used the manual question signs WHAT etc. Unfortunately, the authors did not report quantitative statistics for this observation. The authors reported that learners largely focused on how to articulate manual signs while in fact not looking at the teacher. Signing SLA learners have to become familiar with using facial expressions to convey particular grammatical contrasts that in spoken languages would be conveyed by changes in intonation and they have to learn how these non-markers work simultaneously with the manual lexicon. A possible reason why these non-manual elements are challenging is that learners cannot visually perceive their own faces whilst signing. Smith et al. (2010) reported timing difficulties with articulating the manual and non-manual part simultaneously, whereby the non-manual was articulated before the manual part when it should have occurred throughout the whole phrase. Although we have included these as errors of simplification it is also possible that as grammatical markers expressed on the face are not part of the learners' L1 they are thus harder to learn.

Finally, a common pattern in second language learning is the issue of 'redundancy' in the use of referring expressions e.g. 'The lady bought a dress. The lady bought some shoes'.

L2 learners of pro-drop (null-subject) languages even with an advanced level command of the target language will produce overt subjects in contexts where native speakers would not have produced them (Sorace & Filiaci, 2006). There are now a small number of papers examining how hearing adult learners of sign learn to use referring expressions (Bel, Ortells & Morgan, 2015; Frederiksen & Mayberry, 2019; Gulamani, Marshall & Morgan, 2020; Perniss & Özyürek 2015). Bel et al.'s (2015) study involved 13 advanced adult learners of Catalan Sign Language (LSC) who were enrolled on a sign language interpreter training course and had experienced 600 hours of formal exposure to LSC. Eleven deaf native LSC-signers acted as controls. Participants were required to view a three-minute silent film about conflicts at school and were subsequently instructed to tell a new story to camera about a similar experience they knew involving a friend or classmate during their childhood or teenage years. This task was devised to encourage participants to introduce third-person characters in their productions and make use of spatial locations. Bel et al. (2015) found, as has previously reported for spoken language studies, that the L2 signers had a tendency to oversupply overt arguments. Learners used overt pronouns more frequently than their native-signing comparison group, including in contexts of referent maintenance when a null pronoun would have sufficed. Thus Bel et al. (2015) argued that the complexity of the task was resolved by learner signers in modality-similar ways to that argued for spoken language L2 users. The added redundancy, while it seemed to free up cognitive resources, had the effect of reducing the sign learners' fluency as judged by native signers.

## 4. General conclusions and future directions

555 The aims of this review were to describe sign language SLA research and begin to integrate these
556 results into wider SLA theory and literature. We chose to do this by using two general and well-
557 researched topics in SLA: transfer and general learner patterns. Although these domains are
558 broad-ranging, they constitute fundamental topics in SLA research. We see that the sign learning
559 research fits into these topics naturally and provokes several interesting issues worthy of further
560 discussion. In general, we see that the research on SLA in sign is compatible with patterns and
561 data previously reported solely in the spoken modality. While there are modality-specific issues
562 e.g. transfer of gestures rather than phonemes/words, and visual reversals in perception and
563 production of signs, by and large these appear to be about ***how*** general SLA mechanisms are
564 instantiated.
565 The mechanisms we have reviewed in this paper centre around the reduction of processing cost
566 (Miestamo, 2009) by SLA learners of sign through simplifications (Trudgill, 2011) and over-
567 redundancy (Sorace, Serratrice, Filiaci, and Baldo, 2009). This supports our position that SLA
568 across modalities is driven by some of the same language and learner component features.
569
570 This review, while touching on a broad and central range of topics, illustrates that in many
571 domains there is a clear need to carry out much more research to arrive at more informed
572 patterns and mechanisms of signed language SLA. There are several areas of SLA research up to
573 this point less tested on sign language learners. We point out some of these future directions.
574 There is less research devoted to the development of signed language comprehension in adult
575 learners than there has been on signed language production. For example, unlike learning new
576 spoken words, signed language learners are required to use visual perspective-taking skills to
577 perceive new signs as they see the visual reversal when looking at someone else produce a sign

compared to what they themselves produce (Shield and Meier, 2018). Future research in signed language SLA should look more at the relationship between expressive and receptive language in L2 sign acquisition, and how is it influenced by the visual-spatial modality. In other aspects of SLA there is also no work on how different types of exposure or learning setting (classroom versus incidental learning) influence SLA of sign. A similarly unexplored area is the age of the learner. While there is much debate about sensitive periods in the acquisition of spoken and signed languages there has been no work on whether age influences hearing adults SLA of sign language. It is our hope that future interaction between sign language and SLA research on these future topics will enrich both disciplines.

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