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Fingerspelling: Beyond Handshape Sequences

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Abstract and Keywords

Fingerspelling has been an object of study for almost as long as sign languages have been studied linguistically. This chapter provides a review of previous literature on fingerspelling, outlining how fingerspelling is (1) implicated in sign language acquisition and bilingual classroom practice, (2) situated within American Sign Language (ASL) phonology, (3) and understood in terms of perception and production. This overview is followed by two recent case studies demonstrating the ways in which fingerspelling is a window into factors of language variation in ASL. The first is a study of the distribution of -E-, which has often been taught using a prescriptive rule, but which has been found to have a distribution based on linguistic context. The second is a case of ulnar digit flexion, which results from a combination of assimilation, plus an important consideration of the basic phonology of the selected fingers of the handshapes involved.

Keywords: fingerspelling, American Sign Language, literacy, variation, handshapes

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At first glance, fingerspelling as a system seems easy to describe: There are a limited number of units (26), and these are just strung together sequentially, one unit after another. However, as with all language phenomena, actual productions of fingerspelling are not just a small number of discrete units strung together completely independent of each other; rather, the units will frequently influence the precise timing and configurations of each other in systematic ways. It is often thought that since fingerspelling in American Sign Language (ASL) is a

representation of English orthography, fingerspelling is solely a language-contact phenomenon. While it is true that fingerspelling is a contact phenomenon, it is also much more than that: It provides a window into the structure of ASL specifically and signed languages broadly.[1]

Fingerspelling Background

Fingerspelling, while not the main method of communication, is an important part of ASL—used anywhere from 12% to 35% of the time in ASL discourse (Padden & Gunsauls, 2003), and more frequently in ASL than in other sign languages (Padden, 1991, p. 199). Fingerspelling is a loanword system that has a form derived from the representation of English words through a series of handshapes and orientations, each of which maps to a letter in the word. Every letter used in English has a unique combination of handshape, orientation, and in a few cases movement path (Cormier, Schembri, & Tyrone, 2008). These are used sequentially to represent an English word. Figure 10.1 shows the handshapes for ASL fingerspelling. The orientation of each handshape is altered in this figure for ease of second-language learning. In reality, all letters (in their citation form) are articulated with the palm facing forward, away from the signer, except for -H-, -G- (in, toward the signer), -P-, -Q- (down), and the end of -J- (to the side).

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Figure 10.1 Letters for ASL fingerspelling.

Fingerspelling is not used equally across all word categories. It generally is restricted to names, nouns, (p. 147) and, to a smaller extent, adjectives. These three categories make up about 77% of fingerspelled forms in data analyzed by Padden and Gunsauls (2003). They analyzed the signing of 14 native signers for one study and 36 native signers for another study. Both studies consisted of subsets of signers from a larger sociolinguistics database that was compiled by Ceil Lucas, Robert Bayley, Clayton Valli, and their associates. Padden and Gunsauls also found that the contrast between signed and fingerspelling versions of the same word for a small set of signs indicates a noun-verb distinction; for example, RIDE (verb) versus R-I-D-E [2] (noun) (Shay, 2002). In early research, many described fingerspelling as a mechanism to fill in vocabulary items that are missing in ASL. On further investigation, it has been shown that this is not the whole story (Padden & Le Master, 1985). Fingerspelling can be used for emphasis as well as disambiguation, mainly in bilingual settings (for example, when the ASL sign for a concept is at odds with the closest English word). Two often cited examples of the first type of use are the use of Y-E-S and G-E-T-O-U-T in a situation where emphasis is needed. An example

of the second type of use is a teacher fingerspelling P-R-O-B-L-E-M—as in a scientific problem in a science class—to clarify that it referred not to an interpersonal problem, but rather the background for a scientific hypothesis. While fingerspelling is an integral part of ASL for all signers, it is used more frequently by signers with more years of education, and by native signers when compared with nonnative signers (Padden & Gunsauls, 2003). Finally, fingerspelling is used more frequently in conversations between deaf signers than it is in conversations of mixed deaf and hearing signers (Battison, 1978).

There has been quite a bit of literature on fingerspelling, stretching back to the 1960s. Much of this work falls into a few major categories: the acquisition of fingerspelling, fingerspelling's connection with reading and literacy, models of fingerspelling, perception of fingerspelling, how fingerspelling fits in with the rest of ASL, and finally variation in fingerspelling—that is, how fingerspelling varies across dialects, communities, and signers, specifically regarding the temporal properties of fingerspelling and properties of handshape.

Terminology

Most people use the terms "word" and "letter" as they are applied to English (and other languages) and their orthographic representations. In this chapter we will use the term "handshape" to refer to the canonical (or typical, phonological) configuration of the hand for each letter. The term "hand configuration" (following others, including Whitworth, 2011) will refer to the actual (phonetic) realization of handshape, which, combined with (phonetic) orientation, forms an individual instance of a letter.

The Acquisition of Fingerspelling

There have been a number of studies of the acquisition of fingerspelling by children as they acquire ASL as a first language from deaf parents (i.e., natively). Studies show that children, when they are learning ASL, will produce imitations of fingerspelling that are not precisely correct but follow specific patterns. First, children start with fingerspelling babbling, where they imitate fingerspelling with finger wiggling (Akamatsu, 1982; Maxwell, 1988). They recognize how fingerspelling is supposed to look from adult signers around them, but they have not yet mastered the motions or system. Akamatsu additionally found that when children produced errors in fingerspelling, they frequently conformed to the overall gestalt of the movement during the word to be fingerspelled, even if the individual handshapes were not exactly correct; this movement pattern is typically opening and closing of the hand. She called this the movement envelope, which will be

discussed in the section on “Models of Fingerspelling.” Padden (1993) as well (p. 148) as Padden and Le Master (1985) proposed that children learn to fingerspell in two distinct stages: The first is where they treat fingerspelled words as whole units that are not made up of individual handshapes. The second stage is where they understand that fingerspelled words are made of up individual handshapes and that those map onto the individual letters in a printed English word.

These studies all provide evidence that, at least at the early stages of learning, children acquire fingerspelling holistically, as words. In this process, they use fingerspelling as an integral part of ASL. They will at least approximate the overall shape of the word as it is fingerspelled even if they cannot (yet) make the precise hand configurations of adult fingerspelling. It is only later, when children become aware of written English, that they map the handshapes in fingerspelled words to letters in written English.

Fingerspelling and English Literacy

Besides being an important part of the acquisition of ASL itself, fingerspelling plays an important role in the life of deaf bilinguals who use both ASL and English in their daily lives. Since fingerspelling is a natural link between ASL and English, for a long time it has been hypothesized that fingerspelling and literacy in English are linked, and that insights might be gained by understanding the nature of fingerspelling in production and perception, per se, and in its use in classroom settings. There have been a number of studies (Emmorey & Petrich, 2011; Haptonstall-Nykaza, 2004; Haptonstall-Nykaza & Schick, 2007; Hirsh-Pasek, 1987) that have correlated fingerspelling ability with literacy in signers. The connection between these has been explored in the classroom, as well as with deaf adults. Emmorey, Bassett, and Petrich (2010) and Emmorey and Petrich (2011) found that there was a correlation between fingerspelling ability and reading ability in a study looking at the effects of segmentation on the perception of fingerspelling, which will be discussed in the section on “Fingerspelling Perception.”

Training in fingerspelling increases children’s ability to recognize written English words (which is a predictor of reading success; Hirsh-Pasek, 1987). Hirsh-Pasek hypothesized that this is because fingerspelling allows for a phonological mapping of written English words onto a fingerspelled (and thus ASL) phonological representation, a process that is known to facilitate word recognition. Haptonstall-Nykaza (2004) showed children who were taught English words with fingerspelling were better able to recognize and write them than when they were taught the same words with print only. The participants in her study were 14 deaf children who were learning ASL at a bilingual school. There were two conditions for teaching English

words: one using neutral fingerspelling and one using printed English. During the experiment, the children frequently added movements that made the fingerspelled words more sign-like (e.g., an up-and-down movement on P-A-I-N-T, as would be seen in the lexical sign PAINT).

This pattern of additional movement was explicitly studied by Haptonstall-Nykaza and Schick (2007). They found that when students were taught explicitly with these types of lexicalized fingerspelling forms they were even better at writing and recognizing English words. The participants in their study were 21 deaf students at an ASL immersion school. There were two conditions: one where an English word was presented with the lexical ASL sign for that English word, and one where an English word was presented along with the fingerspelling for that word including additional movements similar to those that the children used in the previous study. They found that children were significantly better at recognizing and producing English words in the fingerspelling condition than they were in the lexical sign condition.

Ethnographic studies of fingerspelling in classroom settings have been carried out by Ramsey and Padden in the United States (Padden & Ramsey, 2000; Ramsey & Padden, 1998) and Roos (2013) in Sweden, demonstrating that, in addition to the mechanics of production and perception in fingerspelling, there are a number of classroom practices, such as chaining or sandwiching, that are used by teachers and students that could contribute to the effective use of fingerspelling to facilitate a link with the sign language used in the classroom to improve literacy skills. Chaining is a technique that includes multiple repetitions of a word in different languages and modalities; for example, when introducing a new word, a teacher might use fingerspelling, then the lexical sign, and then point to or write out the word in English on a board. Sandwiching is a technique where a fingerspelled word and a lexical sign are alternated without the addition of the written form. Given Battison's (1978) finding that there is more fingerspelling in conversations between deaf signers than in conversations between mixed deaf and hearing, it is not surprising that both of these techniques were used more frequently by deaf teachers and teachers at residential programs than (p. 149) by hearing teachers and teachers at public schools. This is in addition to an overall increase in the amount of fingerspelling by deaf teachers (Padden & Ramsey, 2000).

The study by Roos (2013) found a similar pattern of acquisition for Swedish Sign Language fingerspelling to the one that has been documented for ASL. On top of this, she found that children's productions of fingerspelling were more fluid (and adult-discourse-like) than many of the examples that they saw from the teachers in the classroom. She hypothesized that this fluidness is key to fingerspelling being used as a phonological connection to orthographic representations of written

languages. She also hypothesized that teachers' lack of fluidness in their fingerspelling has a detrimental impact on the children's ability to use fingerspelling as a link to written language. One manifestation of this is that, when a student asks how to spell a word, teachers will frequently offer only one letter at a time while the student writes each letter. A more successful strategy, observed in both ASL by Ramsey and Padden (Padden & Ramsey, 2000; Ramsey & Padden, 1998) and Swedish Sign Language by Roos (2013), is for the teacher to fingerspell the whole word and to encourage the student to practice fingerspelling the whole word as well. Only after the student has mastered the fingerspelling does the teacher move on to the print.

In summary, fingerspelling plays an important role in the language of deaf bilinguals who use both ASL and English in their day-to-day lives. Fingerspelling is a natural link between ASL and English, and there is evidence that fingerspelling ability and literacy in English are directly linked. On top of this link, there are a few studies of the educational setting that show that some specific uses of fingerspelling are better than others at improving literacy.

Models of Fingerspelling

Since nearly the beginning of modern linguistic work on sign languages, and on ASL specifically, there have been a handful of models proposed to account for the production and perception of fingerspelling.

The Cipher model was the first viable model of fingerspelling. It proposed that fingerspelling is simply a cipher for written English (Blasdell & Clymer, 1978). The Cipher model is simple: For each letter in a word, there is a single handshape (and orientation), and these units are combined together sequentially, one after another. The two major predictions of this model (that were subsequently found to be not quite accurate) are as follows: Each letter within a word is executed for approximately the same amount of time regardless of its context or formational properties, and the system can only be understood and learned as a sequence of handshapes (and orientations) that make up a word, as opposed to as holistic production of words.

Studies on adult signers as well as children acquiring ASL showed that the Cipher model cannot account for all uses of fingerspelling (Akamatsu, 1982, 1985). Akamatsu showed two major things in this regard: First, the Cipher model cannot account for the way that fingerspelled words are absorbed (i.e., nativized) into the rest of the ASL lexicon as loanwords. Examples of this are #JOB or #EASY. In both cases, some of the fingerspelled handshapes are left out, and in #EASY there is an additional movement added. If fingerspelling is simply a one-to-one cipher, there is

no explanation for the extra movements added or for the letters that are (sometimes) left out. Second, Akamtsu showed that when children are just starting to acquire fingerspelling, they produce whole word chunks that, while not accurate fingerspelling, preserve the overall shape of the fingerspelled words. Akamatsu (1982) named this the “movement envelope.” As discussed earlier in the section on “The Acquisition of Fingerspelling,” the evidence from children (and others) acquiring and perceiving fingerspelling shows that fingerspelling is not simply a string of handshapes representing letters, but rather a system of overall word shapes and patterns as well.

The model of fingerspelling that has been most recently proposed is the Dynamic model (Wilcox, 1992). In the Dynamic model, fingerspelling is composed of not only postures (or holds), which are the typical handshapes (and orientations) that are seen represented on fingerspelling charts, but also of transitions between the postures. The coordination of the holds and the transitions is regulated by the signer’s biomechanical system of articulator coordination, in a fashion that has been used to describe spoken language production in models such as Articulatory Phonology (Browman & Goldstein, 1992).

Perception of Fingerspelling

The accuracy of fingerspelling perception and comprehension varies greatly based on language background, as well as the kind of word that is being fingerspelled. Hanson (1981, 1982) tested 15 native and 2 near-native adult signers of ASL in one (p. 150) study, and 8 native signers of ASL in a second study. She found that native signers are much better at perceiving and comprehending English words (62.9%) than they are pseudowords, words that look like English words but are not actually English words (28.1%) or impossible English words (12.9%). The stimuli were isolated fingerspelled words, produced by a native signer who gave no nonmanual clues as to the word, or their lexical status in English (as a word or nonword). Since even native signers do not recognize fingerspelled words at 100% accuracy, it is not surprising that second-language learners of ASL struggle with fingerspelling perception and comprehension. Learners of ASL frequently claim that fingerspelling comprehension is the hardest part of learning ASL (Wilcox, 1992).

In the description of his Dynamic theory of fingerspelling, Wilcox (1992, p. 59) claimed that the transitions are the most important part of the fingerspelled word for perception:

> If the targets of fingerspelled words are only briefly achieved, then much of the time spent in fingerspelling is in transitional movements. If one must decide which unit is likely to be more salient, the targets or the transitions,

> a reasonable answer would be that the temporally longer transitions may carry a substantial portion of the information in a fingerspelled word. Further, if transitions in fingerspelling are salient and informative this could explain why it is so often noted that proficient fingerspelling comprehension depends on seeing more than just individual letters.

There have been two studies that have looked to test this hypothesis.

The first study used video in which one hold within each fingerspelled word was masked, and native signers were asked to write out the word that was fingerspelled (Schwarz, 2000). This was to test whether the transitions around a hold provide all of the information needed to identify the letter, and subsequently the word. The participants in this study were deaf adults who used ASL as their primary mode of communication for at least 10 years. The responses were scored in three ways: for exact correctness (called the strict approach), for conforming to the overall movement envelope (for example, replacing an -S- with an -N- would produce the same envelope because both are closed handshapes), and finally if the masked handshape was identified correctly but other letters were not (the last will not be discussed in detail here). For the strict approach, signers had a high accuracy with unmasked words (94.7% for short words and 81.3% for long words), but they were much worse at words with one letter masked (60.4% for short words and 53.8% for long words). The results based on signers' responses scored with the movement envelope scoring approach were mixed: Scores for unmasked words using the movement envelope scoring approach were comparable to the scores using the strict scoring approach; scores for masked words were much higher using the movement envelope scoring approach than scores for masked words using the strict scoring (81.3% for short words and 70.7% for long words). Because the strict approach scores were lower for masked words, it is clear that transitions are not the only part of the signal that signers rely on to perceive and comprehend fingerspelling. Additionally, the fact that scores went up when they were scored with the movement envelope method shows that signers do perceive overall movement envelopes, as was suggested by Akamatsu (1982, 1985).

A recent study used a similar approach to test the fingerspelling perception and comprehension among second language learners of ASL (Geer & Keane, 2014). In this study, there were three conditions: all clear, where there was no masking during the fingerspelling; holds only, where all of the transitions were masked; and transitions only, where all of the holds were masked. Masking was accomplished by replacing the frames of video during the period that was to be masked with a neutral gray frame. This process meant that the timing properties of the fingerspelled stimuli were not altered, but there was no visual information during the masked periods. All stimuli were slowed down to half speed, because in initial

pilots the second language learners of ASL were unable to recognize the vast majority of stimuli when the videos were played at regular speed. We expected second language learners of ASL to perform differently from the native signers of the Schwartz (2000) study, but the overall direction of the effects was similar to that reported by Schwarz (2000). When learners had the full video, they were more accurate (53% accuracy) than when they had only transitions (38% accuracy). When the learners were presented with the holds only (with the transitions masked), they were significantly more accurate (65% accuracy) than when they were presented with the transitions only (again, 38% accuracy). This contributes to the findings from the Schwarz study that shows that although transitions provide some perceptual information, they are not sufficient for full perception and comprehension of fingerspelling, which is counter to the claims made by Wilcox (1992).

(p. 151) Emmorey, Bassett, and Petrich (2010) and Emmorey and Petrich (2011) studied the effects of segmentation on the perception of fingerspelling and compared it to parsing printed text. Words were presented using the Basic Orthographic Syllable Structure (BOSS) syllable boundaries and Phonological syllable boundaries. Using the BOSS method of dividing a written word into syllables, the first syllable of a word is all of the consonants before the first vowel, the first vowel, and all of the consonants after that first vowel but before the next vowel. For example, the word MUSTANG has a BOSS syllable boundary between the T and A: MUST.ANG. The phonological syllable boundary follows the phonological patterns of English speech, and the break in mustang would be between the S and T: MUS.TANG. For printed English words, the authors found that both hearing and deaf participants had better performance on a lexical decision task if words were segmented orthographically rather than phonologically. For fingerspelled words, however, deaf signers had better performance on a lexical decision task when the fingerspelling was segmented phonologically. This shows that signers are sensitive to English phonological syllable breaks rather than simply orthographically based syllable breaks (i.e., BOSS syllable breaks) when they are using fingerspelling.

The work on fingerspelling perception and comprehension, in general, thus supports the Movement Envelope model developed by Akamatsu (1982). It is still an open question as to the precise amount of salience that either transitions or holds have for perception; however, the two studies of fingerspelling perception described here suggest that holds are indeed important for fingerspelling perception even more so than the transitions, which has been a widely held assumption after Wilcox (1992). Additionally, this work on perception could impact the way that ASL fingerspelling is taught to second-language learners of ASL through the development of new tools and techniques for students to practice fingerspelling perception. These might include videos with signers that show a variety of speeds

and videos with and without holds or transitions as a way to train students to not look for individual handshapes but rather use context clues and the overall movement envelope to determine the word that is being fingerspelled.

Fingerspelling in the ASL Lexicon

There are numerous distinct parts that come together to form the whole lexicon of ASL (Brentari & Padden, 2001; Padden, 1998). The ASL lexicon has at least three components: classifier predicates, which are spatial predicates generally used to show motion, location, size, shape, and arrangement of objects; the core lexicon, which are arbitrary lexical signs; and the foreign or nonnative vocabulary, which includes fingerspelling. Differences in how words are formed physically (their phonetics and phonology), how they are changed in meaningful ways (their morphology), and how they are put together with other words (their syntax) vary systematically across these three parts of ASL vocabulary, all of which can be tested.

The part of the lexicon that includes fingerspelling is not monolithic, but rather includes a number of categories, some of which were first described by Battison (1978). There are initialized signs, which look much like signs from the core lexicon but have a handshape that matches the letter of a closely related English word (typically the first letter). Examples include WATER, PINK, FAMILY. There are abbreviation signs, which take a 1–2 letters from a word to fingerspell in one sequential movement (typically letters at the start of the two stems—for example, FEEDBACK, FACEBOOK, WORKSHOP). There are fingerspelled letters in some name signs (called arbitrary name signs; Supalla, 1992), which are those that use a letter from a person's English name in their sign name. There are loan signs, which are signs that have been restructured from their fingerspelled form in some way to be more like core ASL signs (e.g., #SAY-NO, #JOB, #EASY). And finally there is neutral fingerspelling, where each letter of the word is (more or less) articulated in the typical fingerspelling position, which is in neutral space, at around shoulder height, on the ipsilateral side of the signer.

The boundaries between these groups are not completely solid. Some words have situated themselves stably in one of these groups; other words show up in different forms depending on the context. One clear example of this flexibility is local lexicalization (Brentari, 1998). In local lexicalization, a fingerspelled word is gradually reduced during a stretch of discourse, from the full neutral fingerspelling version to a reduced version that looks more like an abbreviated sign or a loan sign. Which letters are preserved and which letters are omitted is not random: The transitions between letters that preserve the largest movements are kept, first

those with a nondefault orientation or movement, and then those that preserve an overall alternation of open and closed handshapes. This pattern has been linked to sonority, which is the relative strength (or (p. 152) salience) of a specific sound or syllable in spoken languages or of a specific movement or syllable in sign languages (Brentari, 1998). For example, when the word S-Y-N-T-A-X is being locally lexicalized, the output is S-Y-T-X, with an additional movement of the wrist downward between the -S- and -Y-, and an additional movement of the wrist sideways between -T- and -X-. The -N- and -A- are deleted because both N-T and T-A are transitions between closed handshapes, adding no salient twisting movements of the wrist or opening/closing movements of the fingers.

Fingerspelling can be used in compounds that are borrowed from English, when there is a conflict of iconicity; for example, EYE+#BALL has fingerspelling for the word BALL, because the sign BALL is iconically based on a ball one typically uses in games or sports. Expanding on this work, Shay (2002) showed how closely fingerspelling can be integrated into ASL discourse. Fingerspelled forms can be used as referents for classifier constructions, which shows that fingerspelling interacts not only with the core lexicon but also with classifier constructions. Additionally, Shay used the local lexicalization proposed by Brentari (1998) as an explanation for why younger signers fingerspell fewer words with full (as opposed to reduced) fingerspelling, which could be an indication of a historical change in progress. Finally, Cormier et al. (2008) expanded this work on nativization to the two-handed system used in BSL and related languages (British, Australian, and New Zealand Sign Language, BANZSL), which shows that ASL is not alone in having a process to nativize fingerspelled words that makes them more like the core lexicon of signs.

To conclude the section, fingerspelling is not only a distinct part of the ASL lexicon, and the process by which fingerspelled forms are changed to become more like the signs that are in the core lexicon shows some of the constraints on the forms of typical signs in ASL core vocabulary. Of course, fingerspelled words typically have more handshapes than do core lexical signs, which violates the phonological constraint of ASL requiring that signs only have at most two different handshapes that are phonologically distinct (Brentari, 1998; Sandler, 1989). The process of lexicalization usually involves the reduction of letters (whether this is local lexicalization or more standard lexicalization as described earlier). The letters that are omitted are chosen to make the fingerspelled words more similar to core signs in terms of their phonological shape, often with alternating open-close handshapes or exploiting larger, more salient orientation changes. The patterns seen in the nativization process of fingerspelled words are one window into the linguistic structure of ASL, and sign languages broadly, as we have seen in the similar work on this topic in BANZSL.

Fingerspelling in the Context of Language Variation

Language variation is important in its own right, but beyond that, it provides an excellent test for theories of how languages are structured, and fingerspelling offers an excellent context within which to study language variation. There is already some work on variation in sign languages (e.g., Bayley, Lucas, & Rose, 2002; Fenlon, Schembri, Rentelis, & Cormier, 2013; Lucas, Bayley, Rose, & Wulf, 2002; McCaskill, Lucas, Bayley, & Hill, 2011; Schembri, McKee, McKee, Pivac, Johnston, & Goswell, 2009). Studies in variation start with a known process in the language and look for factors that might influence its application. For example, it is well known that ASL signs produced at the forehead are sometimes lowered. Younger, male, mainstream city dwellers use the lowered form more often than older, female, African American, rural signers. In BSL this phenomenon was tied to sign frequency as well—more frequent signs are lowered more; less frequent signs are lowered less.

Variation in fingerspelling was not explored systematically until relatively recently. Fingerspelling is in an ideal area to look for variation in handshape because (1) fingerspelling has a large number of individual handshape tokens; (2) these tokens are in a wide variety of contexts (in principle, any handshape can precede or follow any other); and (3) fingerspelling uses 72% of the possible handshapes in ASL (Brentari, 1998). As such, fingerspelling is a good phenomenon to analyze handshape variation in ASL generally. Language variation is one way to discover the underlying linguistic structure of languages generally, and ASL is no different. Additionally, variation in handshape during fluent fingerspelling presents second-language ASL learners with a problem: They are looking for the canonical, static handshapes they learned from a fingerspelling chart, but sometimes the handshape used is quite different from what they are taught, which makes perception for them difficult. Knowledge of this variation can give teachers of ASL the tools needed to teach common variants and the environments where they show up.

One previously known aspect of handshape is called coarticulation of pinky extension; namely, there is pinky extension in fingerspelling more (p. 153) often if it is surrounded by an -I-, -J-, -Y-, -B-, -C-, OR -F- (Keane, 2013, 2014; Keane, Brentari, & Riggle, 2013). This coarticulation has been shown to be systematic, following predictions made by articulatory phonology and theories of phonetic implementation. In ASL, as well as many other sign languages, handshapes are not indivisible wholes, but rather are made up of different components of features. One division that has been proposed, and accepted by many sign language linguists, is the division between selected or nonselected fingers in handshapes (Brentari, 1998; Eccarius, 2002; Liddell & Johnson, 1989; Mandel, 1981; Sandler, 1989; Sandler & Lillo-Martin, 2006; van der Hulst, 1995). The selected fingers are those that are

more prominent and active: They touch the body when there is contact, and they are the set of fingers that can move within a single sign (Brentari, 1998). The coarticulation observed in pinky extension in ASL fingerspelling is specifically constrained. Pinky extension spreads onto handshapes where the pinky is not a selected finger and not those where the pinky is selected. This is independent evidence that the distinction between selected and nonselected fingers has an impact on the linguistic structure of ASL, in a domain of ASL that has not been explored in detail before. Understanding the factors that influence variation in fingerspelling is a window on the linguistic structure that makes up fingerspelling and ASL as a whole.

On top of linguistic factors like the ones described earlier and in the sections to follow, there are also nonlinguistic factors that affect fingerspelling. Although there has not been large-scale systematic study of these, various sociolinguistic factors also generate variation in fingerspelling. There is variation based on dialect region, social status, age, gender, and even individual signer.

The Timing Properties of Fingerspelling

Anecdotal reports hint that different signers have individual styles—both in signing and in fingerspelling. Timing properties could contribute to this overall impression, and there is evidence that fingerspelling shows variation in its timing properties; namely, the factors that influence the duration of a given letter. There have been quite a number of studies about the timing of fingerspelling. Although these studies vary greatly, timing all fall between 2.18 and 6.5 letters per second (154–459 msec/letter), with a mean of 5.36 letters per second (187 msec/letter). An overview of the previous studies can be found in Table 10.1. It is worth investigating what factors are responsible for such a wide range in duration because understanding the timing properties of the duration of fingerspelled letters will be useful in developing automatic fingerspelling recognition tools, as well as automatic fingerspelling production (avatar) tools. Beyond these direct links, temporal information is important as a secondary predictor in other linguistic analyses of fingerspelling of perception and production.

Table 10.1 Previous Reports of Fingerspelling Rate

Publication	**Rate—Fastest**		**Rate—Slowest**	
	letters/sec	**msec/letter**	**letters/sec**	**msec/letter**
Bornstein, 1965	5	200	5	200
Zakia & Haber, 1971	6.17	162	1.9	527
Hanson, 1981	6.15	162	5.65	177
Hanson, 1982	5.58	170	5.26	190
Wilcox, 1992	3.33	300	3.33	300
Jerde, Soechting, & Flanders, 2003	4.46	319	2	500
Quinto-Pozos, 2010	8	125	5	200

One study showed that word medial letters are held for shorter times than initial or final letters (Reich & Bick, 1977), although that study was looking at Visual English in an educational setting. Visual English is spoken English accompanied simultaneously by fingerspelled words, sometimes known as the Rochester Method. The fingerspelling system used is the same in Visual English and in ASL discourse; however, because of the simultaneous language production during Visual English, the timing properties might differ substantially. For this reason, data from this study cannot be assumed to be representative of ASL broadly, and it is especially unlikely that it will be representative of the fingerspelling produced by native signers of ASL.

Recent work involving four ASL signers has replicated many of the previous findings, and it additionally found that there are large differences among (1) letter types; (2) positions within a fingerspelled word; (3) individuals; (4) the types of word being fingerspelled; and (5) the ratio of holds to transitions among signers (Keane, 2014). Most previous studies used fairly small data sets, measured rate by measuring the duration of a fingerspelled word, and (p. 154) then divided by the number of letters in the word. This work is unique compared with previous work

because it used a large set of words for each signer, which allowed for analysis of within-individual variation as well as overall rate. Keane found a mean rate of 5.84 letters per second, a finding that falls in the middle of the range of values from the previous literature (anywhere from 2.18 to 6.5 letters per second).

In addition to the overall rate data of whole words discussed earlier, Keane also analyzed the individual holds associated with each letter in each fingerspelled word, which allowed for an analysis of individual letter durations. Although this analysis is stretching current technological capabilities because fingerspelling is so quick, and current, nonspecialized video cameras do not record faster than 60 fps, a number of effects on hold duration were found. First, as expected, the rate of fingerspelling has a large effect on the duration of holds: The faster the rate, the shorter the holds. Although this is not surprising, it has not been documented before. In addition, the durations of individual letters provide cues to word position. The first and last letters are held for much longer than word-medial letters, in agreement with findings of Reich and Bick (1977). Of the word-medial letters, holds tend to be the same duration with only slight differences between them. Letters with movement are held for longer. Letters with orientations that are down or to the side might be held for longer, although this is complicated by the alignment of handshape changes with orientation changes. Additionally, there is a large amount of variation among signers for the overall duration of their holds. This variation is just one aspect of individual differences in signing style that has heretofore not been recognized. It may be due to sociolinguistic factors, such as age, gender, race, or region of the country, but since each of the individuals in this study represented a different set of such factors, this will be for future work.

Transition durations vary more due to the orientation or movement of the previous letter than the following letter. This could be evidence that orientation and handshape changes are aligned to only the beginning of the holds for letters, as opposed to both the beginning and ends of holds. Transitions get considerably shorter in later positions in words. Finally, there is a large amount of variation among transitions as well. Strikingly, the intersigner variation for holds and transitions does not follow the same pattern: Signers with long holds do not necessarily also have long transitions. Rather, there is considerable variation in the ratio of holds to transitions among different signers. This is counter to what has generally been assumed in the past (Wilcox, 1992). Some signers do have fingerspelling that has relatively shorter holds and longer transitions, but other signers have fingerspelling with relatively longer holds and shorter transitions. This variation may be one of the features that people are (subconsciously) aware of when they describe different individual styles of fingerspelling (or signing more generally). This variation might also explain the huge range of rates reported in the literature. Since most studies included only a few signers, it is not surprising, given

the huge amount of variation, that there is a wide range of rates reported.

In summary, the anecdotal reports hint that different signers have individual styles both in signing and in fingerspelling that could be the result of factors in the timing of holds and transitions between signs, as well as between the letters in fingerspelling. This temporal variation is just one property that would make up an individual style or regional variety of ASL. In addition to the sociolinguistic importance of variation, understanding the range of variation and structure of variation will be useful in developing automatic fingerspelling recognition tools and automatic fingerspelling production (avatar) tools. An understanding of these timing properties could also help prepare ASL students for the kinds of variation they will see when they see signers fingerspelling.

Coarticulation in Fingerspelling

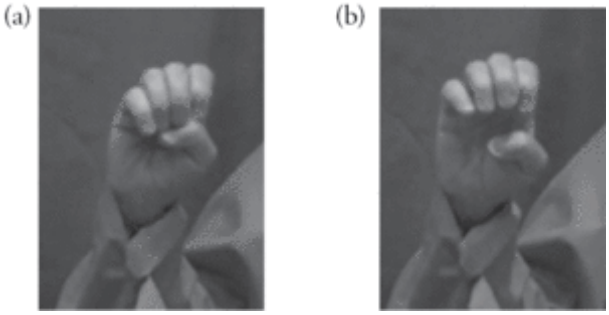
As noted earlier, variation of handshape is a central theme of work in variation in fingerspelling, and such variation can come from a number of different sources (e.g., individual signer variation, dialect, register). A handshape is not typically articulated alone (in fingerspelling or ASL generally), but rather there is a handshape that is articulated before and after it. When handshapes (or any motor action) are articulated in quick succession, there will be overlap of articulatory gestures, and changes based on what is articulated before and after. This phenomenon is frequently called coarticulation, and it has been studied in spoken languages for nearly as long as people have been studying them (Farnetani & Recasens, 1999, for a review). One source of variation is this context that surrounds a handshape, and one way to understand what causes the different phonetic hand configurations seen for a given phonological handshape is to investigate the surrounding context for coarticulatory effects. Recall that the (p. 155) term “handshape” refers to the canonical configuration of the articulators for each letter, and the term “hand configuration” refers to the actual realization of handshape for a specific letter.

We have already noted that handshapes used in the manual alphabet that are seen in textbooks are not always what are produced in fingerspelling encountered in daily life. Some of the earliest studies note that only a small proportion (20%) of handshapes have identical forms to the ones that would be expected from charts of the fingerspelled alphabet (Reich & Bick, 1977). That study, described earlier in this chapter, was based on Visual English, which is a significantly different communication phenomenon than fingerspelling in ASL discourse. Because these are two distinct systems of communication, one cannot assume that the variation found in the production of Visual English will be the same as the variation that is found in ASL fingerspelling. In the next two sections, coarticulation will be

addressed in two case studies. One concerns the variation in the fingerspelled letter -E-, and the other concerns the spread of ulnar flexion in fingerspelling. Both are phenomena previously documented in the literature, and because these coarticulatory phenomena are constrained by (among other things) the phonetic and phonological properties of language, studying these cases are a window on the linguistic structure of ASL. The variation of handshape in fingerspelling that has been found is not random. It conforms to linguistic rules and structures that govern ASL, signed languages, and all languages in general.

-E- Contact

Handshapes for the letter -E- (among others) were found to vary based on how many fingers are extended in pervious and following handshapes (Armstrong, Stokoe, & Wilcox, 1995, Jerde et al., 2003; Keane, 2014; Tyrone, Kegl, & Poizner, 1999).



Click to view larger

Figure 10.2 An example of a closed-E- (a) and an open-E- (b).

What has been described as the traditional or canonical handshape for the letter -E- is controversial. Some people insist that the fingertips must touch the thumb, and that if they do not this is an inaccurately articulated -E-.[3] This so-called mistake is often attributed to learning to sign (and fingerspell) as a nonnative signer. The two types of -E- are illustrated in Figure 10.2. From here on, the -E- with the fingers touching the thumb is called closed-E-, and the one with the fingers and thumb not touching will be called open-E-. In the following study we investigate whether the open variant is indeed a mistake or a case of principled variation.

A corpus of productions from four Deaf adult signers was used for this study—three native ASL users, and one early learner (ages 65, 58, 51, and 32 years). English words were presented to the signers on a computer screen. The signers were told to fingerspell the word, and then press a green button to advance; each word was repeated twice. The corpus included approximately 3 hours of video, based on 300 unique words (1,200 tokens of words) and approximately 7,868 letters. The period of hand configuration and orientation stability for each letter was determined (i.e., where the instantaneous velocity of the articulators approached zero). This point was the period where the hand configuration most closely resembled the canonical handshape, although in normal speed the hand configuration was often very different from the canonical handshape. Still images of every letter were then

extracted for analysis; for a more detailed description of the annotation process, see Keane (2014).

Every example of the letter -E- in the corpus was annotated for finger-thumb contact. For finger-thumb contact, the annotation metric is easy: If there is a visual gap between the tips of the finger and the thumb, the letter is an open-E-; if there is none, it is a closed-E-.

Using a hierarchical logistic regression to analyze the possible factors that contributed to the -E- being open or closed, the following results were obtained. First, the percentage of open-E- variants ranged among the signers from 12% to 52%. Additionally, there were more closed-E- variants when the fingerspelling is slower. Some signers use more open-E- variants than others (12% versus 52%). There were more open-E- variants when they immediately preceded handshapes that were completely closed (-A-, -O-, -N-, -M-, -T-, -S-, or -X-). There were also more open-E- variants at word edges (the first or last letter of a word) when the fingerspelling speeded up. In addition, there were more open-E- variants at the end of the word, when the immediately preceding handshape was closed.

(p. 156) In the resulting statistical model, open-E- was associated with:

- faster fingerspelling
- when the immediately previous handshape is closed
- when the letter is at the beginning or end of a word

Signers' use of more open-E-s before closed handshapes serves to enhance the contrast between the -E- and the following letter through dissimilation of the joint configuration, supporting the Maximize Aperture Change constraint proposed by (Brentari, 1998). This constraint prefers handshape changes from open to closed (or vice versa), rather than closed-closed or open-open. Thus, the variation in -E-s makes fingerspelled sequences more compatible with the phonology proposed for the core ASL lexicon. Similar phenomena have been documented for fingerspelled loan signs (Battison, 1978; Brentari & Padden, 2001; Cormier et al., 2008). This newer work showed that this phonological constraint is not limited to loan signs, but puts pressure on fingerspelling generally to conform to more native ASL-like parts of the ASL. This study also demonstrated that the prohibition of the open variant of -E- is not supported by the ASL fingerspelling use by native signers. Based on the findings of this study, one might indeed take the closed -E- as the basic or citation form, and the open variant as a principled alternate form rather than an error or mistake.

Ulnar Digit Flexion

Click to view larger

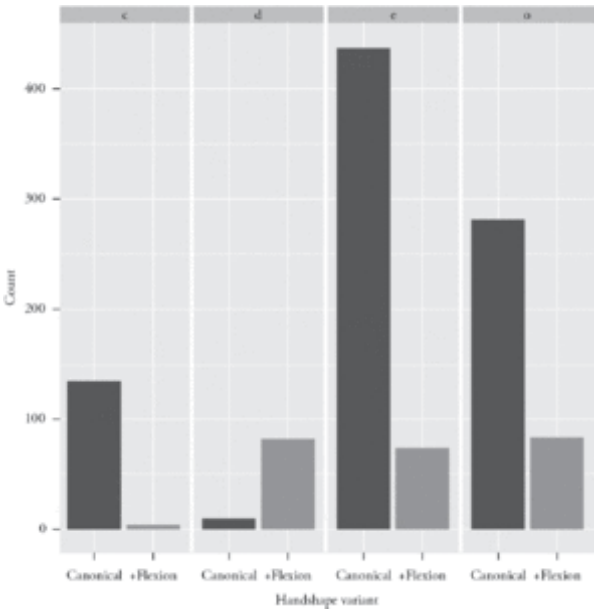
Figure 10.3 (a) a flexed and a canonical variant of -d-; (b) a flexed and a canonical variant of -E-; (c) a flexed and a canonical variant of -O-.

Using the same set of data, ulnar digit flexion variation (also known as baby handshapes) was annotated for letters -C-, -D-, -E-, and -O-. The two sides of the hand are called the radial (the index finger) side and the ulnar (the pinky finger) side, respectively. The baby handshapes are so-called because they present with more ulnar digit flexion of the pinky, ring, or middle fingers than the other fingers. They are called baby handshapes because at rest the hand of a baby is more flexed than that of an adult. For -D-, only the pinky and ring fingers were used because the index and middle always maintain close to the canonical configurations. See Figure 10.3 for examples of ulnar digit flexion and canonical variants for D-, -E-, and -O-, respectively.

Looking at raw counts of the canonical and baby variants, there are three clear patterns (see Fig. 10.4). -C- letters are almost all canonical, with very few ulnar digit flexion variants. -D- letters are almost all ulnar digit flexion variants, and very few are canonical. For -E- and -O- letters there is much more variation, both have more canonical variants, but they have 1/8 and ¼ flexed variants, respectively. Because they are nearly all either canonical or ulnar flexed variants, letters -C- and -D- will be set aside, and the rest of this section will focus on letters -E- and -O-.

A hierarchical logistic regression was used to analyze the factors that contributed to the ulnar digit flexion variants for handshapes -E- and -O-. This model found that if the previous or the following letter has less than all of the fingers selected and extended, the ulnar flexion variant is more likely to be used. In other words, there are more ulnar digit flexion variants in letters -E- and -O- when they are surrounded by letters that have the ulnar fingers flexed, and radial fingers extended, but not when all of the fingers are either extended or flexed. This includes handshapes where there is one finger selected and extended: -G-, -L-, -Q-, -T-, -X-, and -Z-; where there are two fingers selected and extended: -H-, -K-, -N-, -P-, -R-, -U-, and -V-; and where there are three fingers selected and extended: -M- and -W-.

An example of a word with this phenomenon (T-E-A-C-H-E-R) can be seen in Figure 10.5. Here, the second -E- in the word is an ulnar digit flexed variant. This is in line with the predictions from the model: The -E- has conditioning letters on either side (and the first has two: -H- and -R-). The configuration of the ulnar fingers (here, the pinky and ring finger) match that configuration of the nonselected fingers of the conditioning letters on either side. (As an aside, the first -E- is an open -E-, as predicted by (p. 157) the analysis described in the previous section on the open and closed -E-.)



Click to view larger

Figure 10.4 Counts of canonical and ulnar digit flexion variants for letters of letters -C-,-D-, -E-, and -O-.

Although this has not yet been measured quantitatively, which ulnar fingers are more flexed varies. In some variants only the pinky is more flexed; in others it is the pinky and ring fingers; and in others it is the pinky, ring, and middle fingers. Impressionistically, which of these three occurs depends on the conditioning handshapes. In general, which fingers are nonselected in the conditioning handshapes dictates which fingers have increased flexion in the -E- or -O- letter. For example, if an -E- is flanked by a -G- and an -L- (both of which have the pinky, ring, and middle fingers nonselected and flexed), it will frequently show up as an ulnar digit flexion variant with the pinky, ring, and middle fingers flexed. This is evidence that ulnar digit flexion is the result of transferring the members of the selected fingers group from the conditioning handshapes to the -E- or -O-. This can be added to the list of phenomena that support the phonological existence of selected versus nonselected fingers (Mandel, 1981).

Click to view larger

Figure 10.5 Still images at letters for the word T-E-A-C-H-E-R.

In summary, the variation of handshape in fingerspelling that has been found is not random. It conforms to linguistic rules and structures that govern ASL and signed languages, and it provides (p. 158) evidence for which is the more basic or citation form. From the first study we see that signers' intuitions are correct that closed -E- occurs more frequently, but open -E- is not a mistake; it is a conditioned variant that occurs less frequently, hinting that this is not the citation form. Moreover, its appearance conforms to a rule created for the core vocabulary of ASL—namely the Maximize Aperture Change constraint—showing that this phenomenon in fingerspelling is behaving similar to typical signs. The same reasoning can be used with the baby handshape variants in the second study. They appear in specific environments when flanked by handshapes with fewer than all of the fingers selected. These phenomena therefore have provided us with a window on the structure of ASL. There is still more to learn about the sociolinguistic factors that influence these phenomena, but these studies have laid

the groundwork for that future work.

Conclusion

Work on fingerspelling has shown that there are numerous ways that fingerspelling is integrated into ASL. Understanding fingerspelling is important in a number of ways related to first-language acquisition of ASL, second-language acquisition of English by deaf children, and second-language acquisition of ASL by hearing people. Fingerspelling acquisition by native signers has been well documented, and it is clear that children learn to fingerspell in two stages. Deaf children who learn to sign from their deaf parents start with a holistic approach that is based on the overall gestalt of fingerspelled words, and only later do they learn fingerspelling as a system that is comprised of a handshape-orientation combination for each letter used to write English. Fingerspelling has been linked with reading proficiency, but the specific factors about fingerspelling that drive this link are yet to be determined. Finding how this connection works could give educators tools needed to enhance literacy among deaf children.

The literature on fingerspelling has developed models of fingerspelling production and perception, some of which are still being tested and used today. Fingerspelling itself represents a part of the ASL lexicon that obeys slightly different linguistic rules than other parts (namely the core-lexicon and the spatial/classifier construction components), but these three groups are not impermeable: There is ample evidence that fingerspelling can and does undergo a process of nativization over time and even, in some instances, within a discourse. This process alters the phonological and phonetic formulation of the fingerspelled word to make it more core-lexicon-like.

Although the fingerspelling system seems simple on the surface—there are 26 handshape-orientation combinations that map onto the letters used to write English—fingerspelling as used by native signers is much more complicated. There are numerous ways that fingerspelling varies from signer to signer, from situation to situation, from word to word, and even from letter to letter. This variation is not random, but rather is constrained by linguistic principles that govern fingerspelling, ASL, and sign languages generally. Fingerspelling is one gateway to fully understanding the linguistic structure of handshape and other aspects of sign languages. Additionally, understanding this variation is important for progress in a few other areas. First, automatic fingerspelling recognition systems and automatic fingerspelling production systems will benefit greatly from understanding what the possible and likely variation is in naturalistic fingerspelling. Second, fingerspelling is an especially difficult skill for second-language learners of ASL. One aspect of

this difficulty, it has been noted, is the variation that students see when they see fingerspelling in the world. Understanding this variation, and dispelling myths about it, can allow teachers of ASL to explicitly teach this to their students, which might help further their ability to produce and perceive fingerspelling.

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(1.) Most of this chapter looks at the relationship between American Sign Language fingerspelling and its relationship with spoken and written English. For the purposes of this chapter, because the focus is on ASL, the word “English” is used frequently, although it is a stand-in for spoken and written languages generically.

(2.) This chapter adopts the typographic conventions of Brentari and Padden (2001). Fingerspelled forms are written in small caps (an adaptation from Cormier et al., 2008), with hyphens: A-T-L-A-N-T-I-C and ASL native signs are written in only small caps: GROUP. Single fingerspelled letters will be flanked by hyphens on either side (e.g., -T-). Additionally, signs that have been clearly borrowed from fingerspelling, but have been adapted to be more like lexical signs (what are often called fingerspelling borrowings or loan signs), are glossed with a hash mark before them (e.g., #SAY-NO, #JOB, #EASY). A detailed discussion of this process can be found in the section on “Fingerspelling in the ASL Lexicon.”

(3.) This prescriptive rule can be seen in numerous sources; one example is https://www.youtube.com/watch?v=pDfnf96qz_4

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