1 Introduction

This chapter addresses the particular importance of the handshape parameter in sign language phonology, using evidence from a variety of sources: psycholinguistic and cross-linguistic, as well as system-internal evidence from phonological operations. The chapter is organized as follows. In §1, by way of introduction to this topic, some of the ways that handshape behaves differently in gesture and sign languages will be described. In §2 portions of basic handshape structure will be presented, the terms that will be used throughout the chapter will be defined and some descriptive generalizations concerning handshape will be outlined. Further elaboration of the features of handshape is discussed in §3. A description on how handshape interacts with the other parameters of signs will be discussed in §4. In §5 several examples of the role of handshape at the grammatical interfaces will be described, and §6 will consist of some concluding remarks on the topic of handshape.

1.1 Handshape in gesture and sign language

Handshape includes the form that the hand(s) assume during the articulation of a sign or gesture; however, handshape has been shown to behave differently in gesture and in sign languages in several important ways.

One notable difference concerning handshape in gesture and sign is the greater range of forms used by signers in comparison with gesturers. This has been demonstrated in a number of psycholinguistic studies using tasks in which signing and non-signing (gesturing) participants were asked to describe events using only signs or gestures (Singleton et al. 1993; Goldin-Meadow et al. 1996; Emmorey & Herzig 2003; Schembri et al. 2005). I will describe just one of these studies, that of Schembri et al. (2005). In this study the gesturers did not use their voices. A test that consisted of animated video stimuli of objects moving in space was used to elicit productions from three groups (Supalla et al. 1995): non-signing hearing gesturers from Australia, signers of Australian Sign Language, and signers of Taiwanese Sign Language. Properties of handshape, place of articulation (where the sign is articulated), and movement (displacement of the hands in space) were
Diane Brentari counted for each subject and each group. I will describe only the results comparing the Australian gesturers and signers. The largest difference occurred in the hand-shape parameter. There was a 76% match on movement and place of articulation vs. a 44% match on handshape. The difference consisted in the greater number and complexity of the handshapes used by signers.  

Categorical perception is a second way that handshape in gesture and sign languages behaves differently; that is, native signers of American Sign Language (ASL) exhibit categorical perception for handshape (Emmorey et al. 2003; Baker et al. 2005), but gesturers do not. In Fig. 9.1, 11 equal intervals between two handshapes are shown; static images were used in this study. These two handshapes are contrastive in ASL, and are seen here in the minimal pair PLEASE vs. SORRY. Categorical perception is described in the psycholinguistic literature as being present when performance on an identification task and a discrimination task produces a boundary between the categories that is in the same place along the continuum (chapter 98: speech perception and phonology). In this case the identification task consisted of putting the images shown in Fig. 9.1 into either the PLEASE or SORRY group. The discrimination task consisted of taking images that are two intervals apart and asking participants to judge whether the two forms were the same or different.

In native signers the boundary between the PLEASE and SORRY groups in the identification task and the strongest point of discrimination were in the same place, namely between intervals 4 and 6. Non-signers did not display categorical perception for these handshapes. Moreover, the native signers showed categorical perception for only the pairs of handshapes known to be contrastive; other pairs of stimulus handshapes that are not contrastive in ASL did not yield results indicating categorical perception. Handshapes that are considered allophonic and contrastive are described in detail in §2. The phenomenon of categorical perception does not demonstrate conclusively that a phenomenon is phonological in nature (Harnad 1987), but the example of categorical perception is used here to show that signers

1 A greater range of handshape forms is also seen in signers when compared with those of homesigners (Singleton et al. 1993; Goldin-Meadow 2001). Homesigners are deaf individuals who have not been exposed to a language model for a variety of reasons, and who have invented their own system of gestures to communicate with their family and acquaintances.
behave differently towards handshape than non-signers (gesturers) do. To date, no categorical perception effects have been reported for place of articulation or movement properties of signs.²

A third way that handshape has been shown to be different in gesture and sign is in making segmentation judgments of manually articulated words (signs). A study was conducted in which video clips of one- and two-movement nonsense forms were used as stimulus items, controlling for changes in movement, place of articulation, and handshape, based on the phonotactics of signed words in ASL (Brentari et al., forthcoming). These handshape phonotactics are explained in detail in §2. The experimental design involved “cue conflict,” by putting the cues to word segmentation involving handshape, movement, and place of articulation into conflict with one another. This allows for a ranking of the strategies used from most resilient to least resilient (see Cutler et al. 1986, Jusczyk et al. 1993, 1999 and Suomi et al. 1997 for the use of this design in spoken languages). Signing and gesturing participants from three countries (Croatia, Germany, and the USA) were presented with the stimulus clips and asked to decide if they were one sign or two signs (see the example stimulus item in Fig. 9.2). Overall, there was no significant difference in performance between the signing and non-signing groups; however, if each parameter is analyzed separately, the effect on handshape was significant for signers, but not for gesturers. In other words, the gesturers largely ignored handshape in making sign segmentation judgments, while the signers used handshape in determining whether a form was one sign or two.

Taken together, these results show that handshape is treated differently in gesture and sign by the users of these systems: it has greater range of form in signers, categorical perception is present in native signers, and it is used by native signers in making signed word-segmentation judgments. Notice that all of this work crucially relies on detailed descriptions of handshape, and in some cases knowledge of the phonology of handshape in sign languages. The first study (Schembri et al. 2005) relies on a shared system of description of form that can be used for both gesture and sign. The second study relies on knowledge of

² See Poizner (1983) for a different type of perceptual analysis with movement, one of triadic comparisons.

Figure 9.2 A sample stimulus from Brentari et al. (forthcoming), consisting of a nonsense form containing a handshape sequence that is prohibited according to ASL word-level phonotactics.
contrastive handshapes that create minimal pairs for ASL, and the third study relies on the word-level phonotactics of ASL. In the next sections of this chapter, some of the work that has established these areas of the phonological structure of handshape are described in detail, i.e. how contrasts are expressed and how the system is constrained.

2 The phonological nature of handshape in sign languages

Thinking in terms of phonological representation, the handshape might function within the system of contrasts (chapter 2: contrast) as a single unit, in which case the whole hand could be represented by a single symbol. In the earliest accounts of sign language phonology handshape was treated in this way (Stokoe 1960). A single basic symbol with diacritics was assigned to each handshape, in much the same way as symbols with diacritics were assigned to phonemes during phonological theory of the structuralist era (e.g. Bloomfield 1933; chapter 11: the phoneme). Alternatively, various subclasses of properties of handshape might be autonomous and contribute independently to the system of contrasts, forming natural classes that capture phonological generalizations in one or more sign languages. In other words, handshape might consist of distinctive features, and sets of these might be organized within a feature geometry based on articulatory similarity and phonological behavior (chapter 27: organization of features). This has been shown to be the case in subsequent work on handshape both within and across sign languages (Liddell & Johnson 1989; Brentari 1998; Sandler & Lillo-Martin 2006; Brentari 2010). Three important classes of features are: selected fingers, unselected fingers and joints. Let us look at each of these in turn, using the example in Fig. 9.3: the Hong Kong Sign Language (HKSL) sign SPECIAL (Tang et al. 2007) and the labeled handshape beside it. Mandel (1981) was the first to observe that the fingers of a sign should be divided into two different groups based on their phonological behavior: the “selected fingers,” defined as those fingers that can change their aperture (open–close) during the articulation of a sign and appear to be foregrounded, and the “unselected fingers,” which must remain in one position during the articulation of a sign and appear to be in the background. The selected fingers can also assume one of seven different configurations of joints (Brentari 1998), while the unselected fingers can assume only a fully extended (open) or fully flexed (closed) joint configuration, and in many cases this is predictable (Corina 1990). We can determine that in SPECIAL the index finger and thumb are the selected fingers, since they change while articulating the sign and the other fingers do not. The distinction of selected and unselected fingers is at the level of articulatory structure, in much the same way that the velum and lips are articulatory structures in spoken language feature geometry.

3 A single basic symbol with diacritics is still a useful technique to use for notation systems, such as the IPA for spoken languages (Ladefoged 1993) and systems for sign languages currently under development (see van der Hulst & Channon 2010 for an overview).

4 Some details of these arguments are left aside for exposition purposes. For example, some of the operations discussed here behave differently within different sets of vocabulary, such as numbers, forms with a relationship with English, and in some classifier forms. The generalizations described are those that hold for lexemes in the ASL dictionary; that is, the core lexicon, described in §5.
The selected fingers also participate in an internal division involving two types of features: those that specify which fingers are selected (finger features) vs. the position of their joints (joint features). The joints of the hand relevant for phonological specifications are also shown in Fig. 9.3 (right): the metacarpal or knuckle joints are referred to as the base joints, and the intraphalangeal joints (both the one in the middle of the finger and the one at the tip) are referred to together as the non-base joints.

2.1 Selected fingers

Many different sets of selected fingers are used in sign languages to create minimal pairs, but not all possible contrasts are used, and there are language-particular differences among them (Eccarius 2008; Fischer & Dong 2010). A selected finger contrast in ASL is seen in Fig. 9.4a: NERVE vs. APPLE. In both forms there is an identical movement (i.e. a twisting motion of the wrist), identical place of articulation (i.e. the cheek), and identical position of the joints (i.e. bent). Only the number of fingers in the two signs is different. This makes the number of selected fingers a distinctive property in handshape. Some additional selected finger groups are shown in (1).

(1) 

There are also constraints on the distribution of selected fingers: (a) only the selected fingers may change their joint position within the same sign, as we have seen in HKSL SPECIAL, and (b) the precise group of selected fingers remains the same throughout a sign. For example, a change in the selected finger group from to \(\overrightarrow{\text{a}}\) to \(\overrightarrow{\text{c}}\), as shown in Fig. 9.4b, would not be grammatical in ASL for a single sign.

---

5 The term “contrast” in this chapter will be used to refer to minimal pairs, and also, following Clements (2001), to those structures or features used in the creation of a phonological rule/constraint (active contrasts) and those used to capture a particular morphological distinction (prominent contrasts).

6 The handshape images used in this chapter are from Eccarius and Brentari (2008).
In concrete terms, a change of selected finger group indicates a word boundary, and this was one of the cues manipulated in the sign-segmentation experiment discussed in §1. These generalizations have been subsequently formalized in several ways (Sandler 1989; Brentari 1998). The Selected Finger Constraint on Prosodic Words is given in (2), which expresses both of the generalizations just discussed. Given their role in creating minimal pairs and their use in word-level phonotactics, selected fingers are clearly a phonological class of features in sign languages.

   a. Aperture changes affect only selected fingers.
   b. Core lexemes consist of one set of selected fingers.

2.2 Joints

It is possible to make a similar case for the contrastive phonological status of joints, which are also responsible for minimal pairs. The ASL signs CANDY and APPLE have the same group of selected fingers, the ”1” handshape, yet the handshape

---

7 Additional evidence for this constraint comes from compound formation (Liddell & Johnson 1986) and cliticization (Sandler 1999).
is different because of the joint configuration of that finger: in CANDY it is straight; in APPLE it is bent (Fig. 9.5). As mentioned in §1.2, unselected fingers allow only extended and flexed specifications, but selected fingers allow for several more. The seven different positions that are contrastive in ASL are defined in (3) and shown in (4).


a. Fully open: no joints of the hand are flexed.
c. Flat-open: base joints flexed less than 90°.
d. Flat-closed: base joints flexed more than 90°.
e. Curved open: base and non-base joints flexed without contact.
f. Curved closed: base and non-base joints flexed with contact.
g. Fully closed: base and non-base joints fully flexed.

(4) Contrastive positions of the joints in ASL
In addition to its ability to create minimal pairs, the joint position can change during the articulation of a single sign, as seen earlier in the HKSL sign SPECIAL (Fig. 9.3). These changes are called aperture changes, and they occur in a predictable fashion. Each joint configuration in (3) is assigned membership to either the open or the closed class, determined by its degree of closure and distribution in the system. If there are two handshapes in a sign, one must be from the open class and the other from the closed class. This was also observed by Mandel (1981) for ASL, first formalized in Sandler (1987) as the Handshape Sequencing Constraint, and further refined by Brentari (1990, 1998) as the Maximize Aperture Constraint. A recent formulation of this constraint is given in (5). This phonotactic constraint was also used in the word-segmentation task described in §1.1.

(5) Handshape Sequencing Constraint (Sander & Lillo-Martin 2006: 154)

If there are two joints positions in a sign, one must be [open] and the other [closed].

Examples of handshape sequences that are and are not permitted in a single sign are shown in (6) and (7). In (6a) the index, middle, and ring fingers change from open to closed, and in (6b) and (6c) all of the fingers change from closed to open in a way that conforms to the constraints in (2) and (5). Consequently, all things being equal, these sequences of handshapes should be perceived as single signs by signers of ASL. In contrast, the handshape sequences in (7) all violate the constraints in (2) or (5) in some way, and, all things being equal, such sequences ought to be perceived as two signs by ASL signers. The sequence in (7a) has a change in selected finger groups, violating the constraint in (2), and the sequence in (7b) and (7c) violate the constraint in (5) because the two handshapes in the sequence are either both closed (7b) or both open (7c). The Prosodic Model Notation System for handshape (Eccarius & Brentari 2008) is employed from now on in this chapter to underscore the differences and similarities among handshapes. This notation is explained in detail in Appendix 9.1.

(6) Permissible handshape changes within a sign

a.  

\[
\begin{align*}
MT;/ & > M@;/ \\
BT@ & > BT^c
\end{align*}
\]

(7) Impermissible handshape changes within a sign

a.  

\[
\begin{align*}
*M@;/ & > BT@ \\
*BTo & > BT@
\end{align*}
\]
The different roles of joint features were formalized by van der Hulst (1995), who divided them into two different classes: those used for aperture change with their limited set of possibilities (i.e. “open” or “closed” variants of the underlying handshape) and joint selection for the seven distinctive joint contrasts.

In addition to selected fingers, unselected fingers and joints, handshape can include other structures that will not be further discussed here due to space limitations. The thumb has the possibility of being a selected finger, and sometimes behaves differently than the other selected fingers in a sign. The arm can sometimes form a part of the larger articulatory structure. And two hands are sometimes used to articulate a sign; the dominant hand (H1) is the hand used to sign one-handed signs in a neutral linguistic context. The non-dominant hand (H2) is the other hand used in two-handed signs. This topic is covered in chapter 10: THE OTHER HAND IN SIGN LANGUAGE PHONOLOGY. In addition, orientation of the hand in space is considered part of the handshape structure; this will be discussed in §3.

Based on the facts just presented, the areas of consensus among current models of sign language phonology about handshape are given in Table 9.1 (see Sandler 1989; Brentari 1990, 1998; van der Hulst 1993, 1995; Uyechi 1995; Channon 2002a, 2002b; van der Kooij 2002; Sandler & Lillo-Martin 2006). The generalizations in Table 9.1 extend to all sign languages studied thus far.

The hierarchical feature structure that includes the characteristics in Table 9.1 is given in (8). Notice the articulatory distinction between selected and unselected fingers, discussed in §2.1, as well as the feature distinction between the joints and fingers, discussed in §2.2.

<table>
<thead>
<tr>
<th>Structural property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature geometry</td>
<td>The internal structure of handshape is best accounted for using a specific hierarchy of features that captures the relationships among the substructures of handshape.</td>
</tr>
<tr>
<td>H1/H2</td>
<td>An articulatory distinction of handshape that captures the roles of the two hands in a two-handed sign: the dominant hand (H1) and the other the non-dominant hand (H2) (see chapter 10: THE OTHER HAND IN SIGN LANGUAGE PHONOLOGY).</td>
</tr>
<tr>
<td>Selected/unselected fingers</td>
<td>An articulatory distinction of handshape that captures which fingers are foregrounded (selected) or backgrounded (unselected). Selected fingers can move during the articulation of a sign, and also can assume a larger range and more elaborate configurations of joints. Unselected fingers can assume only two joint configurations: fully open or fully closed.</td>
</tr>
<tr>
<td>Selected fingers/joints</td>
<td>A feature distinction within selected fingers capturing which fingers are selected and the disposition of their finger joints.</td>
</tr>
</tbody>
</table>
3 Consequences and further elaborations of handshape structure

3.1 Consequences of the selected–unselected fingers distinction

As mentioned above, selected fingers form a natural class of handshapes, because they generate minimal pairs and are used in word-level phonotactic constraints. One important consequence of establishing selected fingers in this way is that rather different looking handshapes sometimes belong to the same selected finger group, as shown in (9) and very similar handshapes can belong to different selected finger groups, as shown in (10) and (11). In (9) all of the handshapes have the same selected fingers, i.e. the index finger and thumb, the same as those in the HKSL sign SPECIAL in Fig. 9.3. Notice that the selected fingers are not always the extended fingers, and in the notation below each handshape the same basic symbol “1” is indicated.

(9) Representative handshapes with the same selected and unselected fingers

a. HKSL: SPECIAL
   ASL: ASK 1 To;#

b. HKSL: HAWKER
   ASL: LOLLIPPOP 1o1#

c. HKSL: NOT-HAVE
   ASL: BUTTON 1To;/

d. HKSL: MOTHER
   ASL: THINK 1;#

The handshapes in (10a) and (10b) belong to different selected finger groups, as do those in (11a) and (11b). In each case, the selected fingers assume a more refined joint specification, and the unselected fingers assume a position that is an unmarked open or closed position. Notice the careful contact between the selected fingers in (10a) and (11a) and the careful spread of the selected fingers in (10b) and (11b). The thumb and pinkie are selected in (10a) – ASL SIX, and HKSL LITTLE – but the index, middle, and ring finger are selected in (10b): ASL WEIRD, and
HKSL SUCCEED. In (11a) – HKSL NOT-HAVE and ASL INTERPRET – the index and thumb are selected, but in (11b) – HKSL NAME – the middle, ring, and pinkie fingers are selected.

(10) Phonetically similar handshapes
    \textit{Thumb + pinkie vs. index, middle and ring selected}
    
    \begin{itemize}
    \item a. thumb+pinkie selected
    \item b. index, middle and ring selected
    \end{itemize}

    HKSL: \textit{LITTLE}
    ASL: \textit{SIX}

    HKSL: \textit{SUCCEED}
    ASL: \textit{WEIRD}

(11) Phonetically similar handshapes
    \textit{Thumb + index selected vs. middle, ring and pinkie selected}
    
    \begin{itemize}
    \item a. thumb+index selected
    \item b. middle, ring and pinkie selected
    \end{itemize}

    HKSL: \textit{NOT-HAVE}
    ASL: \textit{INTERPRET}

    HKSL: \textit{NAME}
    ASL: \textit{D\textsuperscript{^\#}}

3.2 Secondary selected fingers

The distinction between selected and unselected fingers is sufficient to capture the majority of handshape contrasts in most sign languages, but there are a number of handshapes that require a third level of fingers, which has been called “secondary selected fingers” and can be distinguished from the “primary selected fingers” when necessary (Eccarius 2002). In such cases, the unselected fingers assume an unmarked open or closed joint position as described earlier, but the selected fingers have two different sets: one that is more marked, requiring the more elaborate specification (i.e. the primary selected fingers), and one that is less marked, but which still requires more specification than the unselected fingers (i.e. the secondary selected fingers). Cross-linguistic work – particularly from the sign languages of Asia – has demonstrated the need for this structure (Eccarius 2002, 2008; Fischer & Dong 2010). Some examples are given in (12)–(13). In (12), all three levels are represented: primary selected fingers, secondary selected fingers, and unselected fingers. The handshape in (12a) is from HKSL; (12b–12d) are from ASL. The primary selected fingers are: the index finger in (12a), the thumb (12b), the middle finger in (12c), and the index and middle fingers in (12d). The unselected
fingers are those that are flexed. But in each case there is an extended finger as well, different from the selected and unselected fingers: the middle finger in (12a), the index finger in (12b) and (12c), and the pinkie and thumb in (12d); therefore, a third level of finger structure is needed.

(12) Handshapes with primary and secondary selected fingers, as well as unselected fingers

The HKSL examples in (13) have primary and secondary selected fingers and no unselected fingers. Either group of fingers can move during the articulation of a sign, so both sets of fingers are considered selected; one set with the more elaborate joint specification is the primary set of selected fingers. Both handshapes in (13a) and (13b) are morphologically and phonologically complex forms. In (13a) – FOX – the index and pinkie represent the animal’s ears and the middle and ring fingers represent the animal’s face; the middle fingers can open and close, as in a biting motion, or the ears can move in a wiggling fashion. The example in (13b) means WATER CLOSET, and is a borrowing (CHAPTER 95: LOANWORD PHONOLOGY) from British Sign Language (BSL). The thumb and index fingers represent the “C” and the middle, ring and pinkie fingers represent the “W.”

(13) Handshapes with primary and secondary selected fingers and no unselected fingers

3.3 Further classifications of finger and joint features

Both the finger and joint nodes in (8) require further elaboration to capture all of the contrasts found within and across sign languages. Some earlier models assigned a feature to each finger – [thumb], [index], [middle], [ring], [pinkie] (e.g. Sandler 1989) – but more recent approaches have specified the selected finger groups

8 The handshapes of the classifier system are iconic, as we will see in §4, but they are not typically any more complex to represent phonologically than other handshapes in the system.
using two sets of features that are simpler and more elegant. These are the "quantity" and "point of reference" features, first proposed in Brentari *et al.* (1996) and later refined in Brentari (1998), van der Kooij (2002), and Sandler and Lillo-Martin (2006). The number of fingers is specified as quantity, using the features [all] and [one]. The feature [all] is used for handshapes with all four fingers selected; the [one] feature is used when just one finger is selected, and groups with two and three fingers are captured by a dominance-dependency relation. [All] over [one] is used for three-finger handshapes, and [one] over [all] for two-finger handshapes.

In addition, the location on the hand closer to the selected fingers is specified as the "point of reference" (POR): the index finger side [radial], which is the default specification, the pinkie finger side [ulnar], or the middle finger [mid]. Some examples are given in (14). The handshapes in (14a) have a different number of fingers selected: one finger (i) vs. three fingers (ii). In (14b) the handshapes reference different sides of the hand as a point of reference: (i) references the radial side (index finger side) of the hand, while (ii) references the ulnar (pinkie finger side).

(14) Examples of quantity and point of reference handshape features

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. one vs. three fingers selected (quantity)</td>
<td>b. radial vs. ulnar (point of reference)</td>
</tr>
<tr>
<td>(i) 1;#</td>
<td>(i) M^;#</td>
</tr>
<tr>
<td>(ii) M^;#</td>
<td>(ii) D^;#</td>
</tr>
</tbody>
</table>

The joint selection node in (8) also requires some elaboration to capture a number of relatively common handshapes within and across sign languages. These features are [stacked], [crossed], and [spread], and are widely accepted across models. A [spread] joint configuration is one where the fingers are purposefully spread apart within the same plane in space. A [stacked] joint configuration has an extended index finger, and each successive finger becomes increasingly more flexed, moving toward the pinkie (Johnson 1990). In other words, the fingers are progressively spread apart from each other in a plane perpendicular to the palm. A [crossed] configuration is one in which the fingers are crossed over one another. Examples of these features used in four- and two-finger handshapes are given in (15).

(15) Spread, stacked and crossed handshapes with four- and two-finger selected finger groups

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4-fingers</td>
<td>[spread]</td>
<td>[stacked]</td>
<td>[crossed]</td>
</tr>
<tr>
<td>BT</td>
<td>Bt-^</td>
<td>BTk</td>
<td>BTx</td>
</tr>
</tbody>
</table>
If the elaborations of handshape structure described in §3 are added to the basic structure in (8), the full handshape structure is as in (16).

(16) The structure of handshape with elaborations

4 The role of handshape with respect to other parameters

The handshape structure in (16) is part of a larger feature hierarchy that includes Movement (M; see Chapter 24: The Phonology of Movement in Sign Language), Place of Articulation (POA) and Orientation (OR). Models differ on how handshape should be represented with respect to the other parameters. Because of space, only three representative models are mentioned: the Hand Tier model (Sandler 1989; Sandler & Lillo-Martin 2006), the Prosodic Model (Brentari 1998), and the Dependency Model (van der Hulst 1995; van der Kooij 2002). Also because of space, only two points that bear on the issue of handshape (HS) and other phonological structures are raised: aperture change (ApChange; already discussed above) and orientation. A full discussion of the arguments for these structural differences is beyond the scope of this chapter, so the purpose of the representations below is simply to indicate where aperture change and orientation are represented in these different models. The differences arise from trying to best determine the simplest and most elegant analysis that can account for specific sets of forms. In addition, the Hand Tier Model adheres to the view that articulatory relatedness should
motivate the structure when possible, following Sagey (1986), while the Prosodic Model adheres to the view that phonological behavior should take precedence over articulatory relatedness (Goldsmith 1976; Clements 1985; Clements & Hume 1995). Schematized versions of the three models are given in (17) below; in order to make the differences clear, the representations of the models are schematized in a similar way, with the root node represented as “°”.

(17) a. **Hand Tier Model**

    ![Hand Tier Model diagram]

b. **Prosodic Model**

    ![Prosodic Model diagram]

c. **Dependency Model**

    ![Dependency Model diagram]

With regard to aperture changes, the Hand Tier Model argues, in part, that since they are articulated by the hand, they should be represented with handshape. The Prosodic Model argues, in part, that since aperture changes behave phonologically like other movements in the system they should be represented with movement. The Dependency Model argues that movement is predictable (redundant) in most cases (but see Chapter 24: The Phonology of Movement in Sign Language). This is one reason why aperture changes are placed in the handshape structure in this model: there is no movement structure per se.

The representation of orientation is different in these models as well. In earlier accounts of orientation, it was expressed in terms of the direction of the palm of the hand; that is, a property of the hand in space. We see such an account in Liddell and Johnson (1989) and Sandler (1989), where the orientation features ae [up], [in], [prone], and [contra]. More recent work has shown that orientation indicates one of eight parts of the hand (not just the palm) and how it is oriented towards a particular place of articulation (Crasborn & van der Kooij 1997). These eight places are shown in Table 9.2 for ASL and are depicted in Fig. 9.6 (Brentari 1998).

### Table 9.2

<table>
<thead>
<tr>
<th>Role in orientation in ASL</th>
<th>Role in two-handed signs in ASL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. finger fronts</td>
<td>LABEL</td>
</tr>
<tr>
<td>2. palm of hand</td>
<td>MY</td>
</tr>
<tr>
<td>3. back of palm</td>
<td>LOVE (a thing)</td>
</tr>
<tr>
<td>4. back of fingers</td>
<td>CHERISH</td>
</tr>
<tr>
<td>5. radial side of fingers</td>
<td>OLD</td>
</tr>
<tr>
<td>6. ulnar side of fingers</td>
<td>BROKE (‘no money’)</td>
</tr>
<tr>
<td>7. tip of fingers/thumb</td>
<td>COMPLAIN</td>
</tr>
<tr>
<td>8. heel of hand (wrist)</td>
<td>SLIP</td>
</tr>
</tbody>
</table>

* There is one more contact discussed by Liddell & Johnson (1989), known as ‘web’ (e.g. FOOTBALL, in which the fingers are interlaced). It is treated here as a sub-class of ‘ulnar’.
These same eight places are also needed to specify the places on the non-dominant hand that can be contacted in a two-handed sign. The current version of the Hand Tier Model (Sandler & Lillo-Martin 2006) utilizes six of these – the back of hand and back of fingers are not included – the Prosodic model uses all eight. The Prosodic Model and Dependency Model are also compatible with additional insights by Crasborn and van der Kooij (1997), showing that orientation is derivable from other elements already specified; hence, in these models, “OR” is in parentheses in (17b) and (17c).

5 Handshape at the grammatical interfaces

Handshape has received a great deal of attention on purely phonological grounds, as we have seen in the previous sections. It has also been used to describe phenomena at the grammatical interfaces between phonology and other components of the grammar. Here we address handshape phenomena at the phonology–phonetics, phonology–morphology, and phonology–syntax interfaces. Each of the phenomena addressed in §§5.2–5.4 involves one or more of the phonological structures discussed earlier in this chapter. In order to understand how these phenomena are manifested in a sign language grammar, some background on the architecture of a sign language lexicon is needed.

5.1 Handshape in the core–periphery framework

Many sign languages have multiple origins, resulting in a lexicon divided into sub-components according to the historical origins of signs, as well as their morphological and phonological behavior. For a model addressing similar facts for spoken languages, see Itô and Mester (1995a, 1995b); the sign language model is presented in Brentari and Padden (2001). The sign language lexicon consists of three different components: core, foreign, and spatial, as represented in Fig. 9.7a. The structure with overlapping ellipses is based on overlap in the distribution of constraints that affect forms in the three components (see Brentari & Padden 2001 for details).
Handshape, the focus of this chapter, has a different morphophonological status in the three components of a sign language lexicon. In the core lexicon, handshape is purely phonological, and combines with other elements to form stems; i.e. the handshape is meaningless and completely arbitrary. In the foreign lexicon, handshape has an association with the surrounding spoken or written language, or with another sign language (chapter 95: loanword phonology). One set of foreign forms that is discussed in §5.2 consists of initialized forms. The handshape of these signs corresponds to the first letter of the English word (e.g. WATER, CAFETERIA, BACHELOR, and DIVORCE are all initialized signs). The spatial lexicon consists primarily of the classifier constructions, which are used to express

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**Figure 9.7** (a) The three sub-components of a sign language lexicon. (b) Examples of the same three handshapes (“O,” “C,” and “F”) used in each component.
events of motion and location. Classifier constructions are polymorphemic verbal complexes with a root – the movement – and affixes that involve place of articulation and handshape. The classifier morphemes that refer to the arguments of the predicate are the handshapes (Janis 1992; Benedicto & Brentari 2004). In classifier predicates, parts of the handshape structure can carry information about the size and shape of the object that may be phonological, morphological, and iconic at the same time. In Fig. 9.7b examples of signs in each of the components using the same handshapes are shown: “F” \( \text{\textsuperscript{\textdegree}} \), “O” \( \text{\textsuperscript{\textcircled{\textdegree}}} \), and “C” \( \text{\textsuperscript{\textcircled{\textbullet}}} \) handshapes.

5.2 The phonology–phonetics interface and joint features

A recent study was conducted to address whether the phonetic targets for joints were the same across the three lexical components described above (Eccarius 2008; Eccarius & Brentari, forthcoming). The stimuli consisted of video clips of core vocabulary, initialized signs from the foreign component and classifier forms from the spatial component. Three handshape groups were tested (“O,” “F,” and “C”). Each item included three variants of the handshape (round, intermediate, and flat) at the same place of articulation using the same movement. The variants were designed to address the stability of joint specifications throughout the lexicon. A foreign item using the “C” handshape is given in Fig. 9.8, with the round, intermediate, and flat forms. The round form is the sign for CAFETERIA and the flat form is the sign for BACHELOR (a minimal pair); the intermediate form could be interpreted as either sign or neither of them. Twelve Deaf signers who were native or early learners of ASL participated in this experiment.

A total of 154 randomized stimulus video clips, balanced across lexical component (core, foreign, spatial), handshape group (O, F, C) and variant (round, intermediate, flat) were shown to each participant. Participants were asked to watch each clip and to respond to two questions presented immediately afterwards on the computer screen: “What is the best English meaning for this sign?” and “Please rate the handshape of this sign,” from very bad to very good, on a five-point scale.

Figure 9.8 The round, intermediate, and flat variants of “C” used with the target signs CAFETERIA (left), BACHELOR (right), and an intermediate form (middle).

\( ^9 \) A “native signer” is someone with two Deaf signing parents; an “early learner” is defined here as someone who learned ASL before age 5.
One hypothesis considered in this experiment was that contrasts are the same throughout the lexicon; i.e. if a contrast is present in one part of the lexicon, it should also be present in all other parts. If true, signers’ responses to tasks involving the same sets of handshapes across lexical components should also be the same. This proposal has been made for spoken languages by Allen and Miller (2001). Based on constraint asymmetries discussed by Itô and Mester (1995a), Brentari and Padden (2001), and Eccarius (2008), we predicted that the results of this experiment would disprove the “uniform lexicon hypothesis”; i.e. that participants’ responses would differ between one or more parts of the lexicon.

There were two significant effects (p value < .05; Fischer’s Exact Test). The first effect was that the number of joint contrasts varied across components. For example, in classifier handshapes, the “C” handshape group showed a contrast between the intermediate and flat variants, as well as a contrast between the round and intermediate variants. This result suggests that there are two contrastive differences in classifier handshapes of the spatial component and just one contrastive difference in the foreign and core forms. The other significant effect was that the phonetic targets were different in the foreign and core components. In initialized signs of the foreign component the round variant was preferred for the “C” and “O” groups, while in core lexical items the intermediate variant was preferred.

These results disprove the “uniform lexicon hypothesis”; both the number of targets and the targets themselves can vary across components. The motivation might be due to either the historical origin of the signs or the synchronic morphophonological differences among components. On the basis of these results, the joints structure of the model presented in (16) could perhaps be simplified in the representation of core forms, but further research is needed to know whether this would be warranted.

5.3 The phonology–morphology interface and selected finger complexity

A morphophonological phenomenon is described in this section, demonstrating that generalizations can be formulated concerning the participation of handshape in both phonological and morphological components. The data come from a large corpus of cross-linguistic study of classifiers collected on 12 sign languages, three of which were included here: ASL, Swiss German Sign Language (DSGS), and HKSL (Eccarius 2008; Brentari & Eccarius 2010). Recall that classifier constructions are included in the spatial component of the lexicon (see Fig. 9.7). Two types of classifiers are “whole entity” classifiers, which express an entire class of object – e.g. ‘vehicle’, ‘upright being’, ‘small animal’ (Engberg-Pedersen 1993) – and “handling” classifiers, which represent how an object is handled or manipulated (Supalla 1982). Examples are given below in Fig. 9.9 for “flat-object” and “handle-flat-object.”

In this analysis of ASL, DSGS, and HKSL the finger complexity of the handshapes used by these two types of classifiers was analyzed. The analysis involved the selected finger features, primarily the quantity and point of reference features given in (16) and discussed in §3.3. Handshapes can be classified into three levels

10 This work was funded by NSF grant BCS 0112391.
of selected finger complexity. Low-complexity handshapes have the simplest phonological representation (Brentari 1998), are the most frequent handshapes cross-linguistically (Hara 2003; Eccarius & Brentari 2007) and are the earliest handshapes acquired by native signers (Boyces Braem 1981). These three criteria converge on the set of handshapes represented in (18a): all fingers , index finger , and thumb . These three handshapes have also been found to be frequent in the spontaneous gestures that accompany speech (Singleton et al. 1993) and in child homesign (Goldin-Meadow et al. 1995). Medium-complexity handshapes include one additional elaboration of the finger representation of a one-finger handshape. The elaboration indicates that the single selected digit is not on the “radial” (thumb) side of the hand (the default specification) – e.g. in the finger is on the [ulnar] “pinky” side of the hand and is [mid] “middle” – or that there is an additional finger selected, as in where two fingers are selected rather than one. High-complexity handshapes include all other handshapes, e.g. and .

(18) Low- and medium-complexity handshapes (Brentari 1998; Eccarius & Brentari 2007)

a. low complexity

fingers

quantity

[b][all][u]

fingers

quantity

[b][one][u]

selected

fingers

quantity

[b][one][u]

thumb

b. medium complexity

fingers

quantity

[b][one][u]

POR

quantity

[b][ulnar][u]

fingers

quantity

[b][one][u]

POR

quantity

[b][mid][u]

fingers

quantity

[b][one][u]

all

(B) (I) (T) (I) (8) (U)

11 Joint complexity has been set aside for future analysis and is not considered here.
Using both elicitation methods and grammaticality judgments, Eccarius (2008) and Brentari and Eccarius (2010) found that whole entity and handling classifiers differ systematically in their distribution of finger complexity. Whole entity classifiers have a larger set and a more complex set of finger contrasts than handling classifiers (see (19); the level of complexity is shown beneath each handshape). Both types of classifier handshapes have the potential to use selected fingers to show the size and shape of an object, yet only whole entity classifiers do this extensively.

(19) Number of finger contrasts for classifier handshapes in ASL, HKSL, and DSGS, with the finger complexity given for each

<table>
<thead>
<tr>
<th>Finger contrasts</th>
<th>Object CL-HSs</th>
<th>Handling CL-HSs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fingers</td>
<td>1 1 1 2 2 3 3</td>
<td>1 1 1 2</td>
</tr>
</tbody>
</table>

This distribution is a part of the phonology–morphology interface for several reasons. First, the morphological categories for whole entity and handling classifiers are associated with a corresponding phonological pattern, but this state of affairs is not obligatory. For example, if a hypothetical morphological classifier type in a sign language were comprised of the following handshapes – \( \text{wB2TP} \) – the set would also form a phonological class, because the handshapes in the set share a phonological property (their joints are all fully extended). New handshapes that enter the set would be predicted to be fully extended as well. If, instead, the hypothetical classifier type is comprised of this set handshapes – \( \text{w<&L} \) – the set would not form a phonological class as there is no common property that the handshapes share. In this event, the handshapes would constitute a morphological class, but not a phonological one. In the case discussed here, finger complexity provides a unifying phonological property associated with whole entity and handling classifiers; high complexity is associated with whole entity classifiers and low complexity with handling classifiers. New forms entering the system are therefore expected to conform to this pattern. Second, the phenomenon is morphophonological because it is tied to specific morphological classes, similar to the way that Trisyllabic Laxing is tied to English words having specific Class 1 affixes (Chapter 94: Lexical Phonology and the Lexical Rule Syndrome). And third, this phenomenon is phonological because selected fingers are phonological throughout the system, as has been discussed earlier in this chapter, and whatever iconicity might exist in classifiers is subject to phonological pressures on the system as a whole, such as ease of articulation and ease of perception (Eccarius 2008).

This work expands the range of generalizations possible in sign language phonology, specifically with regard to handshape, which is important in its own right. In addition, it provides a new way to consider the emergence of phonology as it has evolved from gesture to homesign and from homesign to a sign language.

Handshapes in (19) are abstract classes, so, for example, the handshape \( \text{wB} \) with or without the thumb, represents any handshape with one selected finger, i.e. one finger active, e.g. \( \text{wL} \). The thumb is ignored in our analysis, except when it is the only finger selected.
homesigners, and signers (Brentari et al. 2010). In sign languages iconicity is shaped by the phonology; Frishberg (1975) demonstrated this in a general way, but there are many specific interactions between iconicity and the grammar that have yet to be explored.13

5.4 The phonology–syntax interface and orientation features

The final example of handshape at the interfaces concerns the phonology–syntax interface, again in handshapes that occur in classifier predicates. Benedicto and Brentari (2004) demonstrated that the same two classifier types discussed above – whole entity and handling classifiers – exhibit a transitive–intransitive distinction, following observations by Shepard-Kegl (1985), Schick (1990), and Janis (1992). Four syntactic tests were created to establish this for ASL, and two of these tests have been applied cross-linguistically to HKSL, DSGS and, more recently, to Italian Sign Language (LIS) (Mazzoni 2008). Two of these tests are described here.

The first syntactic test is sensitive to subject/agents. The sign languages we have investigated have a form for the “negative imperative”; namely, [verb], STOP/FINISH! In sentences such as those in (20), we begin with verbs from the core lexicon, so that the effects of this test can been seen clearly. MELT in (20a) is an unaccusative verb, which subcategorizes for an object/theme only, and in such sentences adding the sign FINISH is ungrammatical. LAUGH in (20b) is an unergative verb, which subcategorizes for a subject/agent only, and in such sentences adding FINISH is grammatical. Sentences containing classifier predicates, such as those in (21), express the same minimal difference in meaning, and also in form (i.e. those shown in Fig. 9.9, in both cases a book is moving onto its side). The form in (21a) uses a whole entity classifier (i.e. the one in Fig. 9.9a) and the form in (21b) uses a handling classifier handshape (i.e. the one in Fig. 9.9b). The sentence containing the object handshape in (21a) is ungrammatical with FINISH; therefore, it does not contain a subject/agent. The sentence with the handling handshape in (21b) with FINISH is grammatical; therefore, it contains a subject/agent.

(20) Negative Imperative Test applied to core lexical verbs

a. *MELT FINISH
   ‘Stop melting.’

b. LAUGH FINISH
   ‘Stop laughing!’

(21) Negative Imperative Test applied to predicates containing classifier handshapes

a. *BOOK (B)/+/MOVE FINISH
   book object classifier + move stop
   ‘Book, stop falling on your side!’

b. BOOK C/+/MOVE FINISH
   book handling classifier + move stop
   ‘Stop putting the book on its side!’

13 See also Padden et al. (2010) for another example of iconicity and grammar concerning iconicity and the system of verb agreement of sign languages.
The second diagnostic syntactic test is sensitive to object/themes. The sign languages we have investigated have a form for the “distributive,” with the meaning ‘... to each’. As above, sentences with verbs from the core lexicon are tested first (22). The sentence in (22a) with MELT, an unaccusative verb, is grammatical with the ‘to-each’ form. The sentence in (22b) with LAUGH, an unergative verb, obtains an ungrammatical result for the intended meaning ‘Each woman laughed.’ The only interpretation of this sentence that is acceptable is ‘The woman laughed at each [of them].’ As above, the sentences in (23) express a minimal difference in meaning and form (i.e. in both cases each book is moving onto its side). The form in (23a) contains the whole entity classifier and the one in (23b) contains the handling classifier, the same two forms discussed above. The results of this test determine that the sentences in both (23a) and (23b) are grammatical; therefore, both the whole entity classifiers and handling classifiers contain an object/theme. The whole entity classifiers are therefore intransitive since only an object is present, and the handling classifiers transitive because both an object and subject are present.

(22) The Distributive Test applied to core lexical verbs
   a. BUTTER MELT + ‘to-each’
      butter melt DISTRIBUTIVE
      ‘Each butter melted.’
   b. WOMAN LAUGH + ‘to-each’
      woman laugh DISTRIBUTIVE
      # ‘Each woman laughed.’
      ‘The woman laughed at each of them.’

(23) The Distributive Test applied to classifiers
   a. BOOK B/+ MOVE + ‘to-each’
      book OBJECT CLASSIFIER + move DISTRIBUTIVE
      ‘Each of the books fell down (on its side).’
   b. BOOK C/+ MOVE + ‘to-each’
      book HANDLING CLASSIFIER + move DISTRIBUTIVE
      ‘Each book was put on its side.’

This transitive–intransitive alternation concerns the phonology because it can be captured by a phonological analysis specifying which nodes of the feature tree are associated with this syntactic distinction. The phonological element involved in the transitive–intransitive alternation concerns the differential use of orientation of the hand.14 In whole entity classifiers orientation is purely phonological and does not interact with the syntax. In handling classifiers, the parts of the hand shown in Fig. 9.6 can be used morphologically, and these alternations also interact with the syntax to express an agent.

The studies presented here provide a few examples of how phonology interacts with the phonetic, morphological, and syntactic components. In the phonology–phonetics example, it was the joint features that were used. In the phonology–morphology example, it was the selected fingers that allowed for the generalization

14 As stated in §4, orientation is represented differently in the phonological models available; however, these handpart features are part of the handshape structure in all models.
about finger complexity to be expressed, and in the phonology–syntax example, it was the features involved with orientation (parts of the hand) that were essential in capturing the syntactic transitive–intransitive distinction. All of the generalizations in this section crucially depend on structures of handshape, and without a clear and detailed phonological description of handshape, none of this work would be possible.

6 Conclusion

Close attention has been paid to handshape since the 1960s, and a great deal of progress has been made in its description; therefore, existing handshape structures can capture the distinctions observed when large corpora or other grammatical components are involved. The handshape structure as described in this chapter has also been extremely useful in widening the scope of sign language investigations to other grammatical components and to other disciplines. In the case of psycholinguistic experimentation, discussed in §§1 and 5.2, stimuli that use handshape were able to be constructed that are well controlled only because so much is known about its structure.

In this chapter I have presented the handshape structure by describing its phonological nature in terms of its formal representations and constraints. The tools of Autosegmental Phonology and Feature Geometry have been fundamental in the current description of handshape in sign languages, and these advances in general phonological theory have enhanced the study of sign language phonology as well, particularly in the area of handshape. In addition, because theoretical work on handshape has been able to directly use and adapt theoretical notions used in spoken languages, understanding the literature on handshape is a good way for a linguist who studies spoken languages to gain access to the field of sign language phonology.

APPENDIX 9.1: PROSODIC MODEL NOTATION SYSTEM FOR HANDSHAPE

There are several systems for transcribing handshapes. The one presented in Stokoe et al. (1965) was the first, followed by several others: SignWriting (e.g. Sutton 1981), HamNoSys (Prillwitz et al. 1989), ASL-phabet (Supalla et al. 2008), SignPhon (Crasborn et al. 2001), and SignTyp (van der Hulst & Channon 2010). Until now none have (a) incorporated the phonological generalizations needed to find natural classes of handshapes easily within a corpus or (b) used a system that exploits a keyboard compatible with Excel spreadsheets. Eccarius and Brentari (2008) have developed such a notation system, based on the Prosodic Model. Each of the terminal features is assigned a diacritic, and the hierarchical structure of handshape within the feature tree is maintained. The fingers are divided as shown below; the primary selected, secondary selected, and unselected fingers are separated by semi-colons. The primary selected fingers have five designated slots corresponding to the different branches of the feature tree in (16). The first slot is for the base symbol, which incorporates quantity and point of reference information; the next two are for the thumb; and the last two are for joint specifications. The secondary selected fingers have only one slot for joints rather than two. The unselected fingers have just one slot. Natural classes of handshapes based on any of the handshape features of the Prosodic Model can
be searched for. This notation also captures the case of two handshapes that are very similar phonetically, but which belong to different handshape groups because of differences in their selected fingers, such as examples (10) and (11) in the text. A complex handshape meaning SPACE-SHUTTLE is transcribed below:

1. finger base symbol
2. thumb base symbol
3. thumb joint symbol
4. spread ‘stacked’ and/or ‘crossed’ joint symbol(s)
5. remaining joint symbol
6. secondary selected fingers symbols (4 are possible)
7. unselected fingers symbol

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Handshape in Sign Language Phonology


