I. Phonetics, phonology, and prosody

2. Phonetics

Abstract

Sign and spoken languages differ primarily in their perceptual channel, vision vs. audition. This 'modality difference' has an effect on the structure of sign languages throughout the grammar, as is discussed in other chapters in this volume. Phonetic studies of sign languages typically focus on the articulation of signs. The arms, hands, and fingers form very complex articulators that allow for many different articulations for any given phonological specification for hand configuration, movement, and location. Indeed phonetic variation in sign language articulation is abundant, and in this respect, too, sign languages resemble spoken languages.

1. Introduction

Sign languages are produced by body movements that are perceived visually, while spoken languages are produced by vocal articulation and perceived by the ear. This most striking difference between sign and spoken languages is termed the 'modality difference'. It refers to a difference in communication channel that is often considered to be the ultimate cause for structural differences between spoken and sign languages. Since auditory perception is better targeted at processing small temporal detail than visual perception, and since the manual articulators in signing move slower than the oral articulators in speech, one would for example predict the richness of simultaneous information in sign languages (Vermeerbergen/Leeson/Crasborn 2006).

In all, this chapter aims to characterise the area of sign language phonetics rather than to provide an exhaustive overview of the studies that have been done. The focus will be on the manual component in terms of articulation and phonetic variation. Despite the large importance that is often (intuitively) attributed to the phonetic difference between sign and speech, relatively little research within the field of sign language studies has focused on the area of sign language phonetics, especially in comparison to the phonological analysis of sign languages. This is illustrated by the fact that none of the textbooks on sign language that have appeared in recent years includes 'phonetics' as a keyword (e.g., Boyes Braem 1995; Sutton-Spence/Woll 1999; Emmorey 2002; Sandler/Lillo-Martin 2006; Johnston/Schembri 2007; Meir/Sandler 2008).

In section 2, the modality difference is discussed in further detail. Section 3 will then discuss the relation between phonetics and phonology in sign languages, as it may not be self-evident how a phonetic and a phonological level of analysis can be distinguished in a visual language. Section 4 discusses articulation, and section 5 takes a look at phonetic variation. (Note that perception studies are also discussed in section F of the handbook, see especially chapter 29 on processing. The phonetic transcription and notation of sign languages are covered in chapter 43.)

2. The modality difference

It is attractive to see modality as a black-and-white distinction in channel between spoken language and sign language. One is auditory, the other visual. The deep embedding of writing systems and written culture in many civilisations has perhaps contributed to our view of spoken language as a string of sounds, downplaying the presence of non-verbal communication and visual communication more generally among hearing people (Olson 1994). Yet there is growing evidence for the multimodality of spoken language communication among hearing people. It is clear that visual aspects of communication among hearing people can be complementary to auditory signals. For example, emotional state is often visible in the facial expression while someone speaks (Ekman 1993), and many interactional cues are expressed by a wide variety of head movements (McClave 2000). Manual gestures are known to serve many functions that complement the content of the spoken utterances (McNeill 1992; Kendon 2004).

Moreover, there is also evidence that speech itself is not only perceived auditorily but also visually. McGurk and MacDonald (1976) showed that the visible state of the face can influence the auditory perception of consonants. More recently, Swerts and Krahmer (2008) demonstrated that the perception of manual beat gestures are interpreted as increased prominence of the simultaneously uttered spoken word. However, while hearing people are very skilled at perceiving speech without looking at the speaker (as when communicating by telephone), they are very bad at speech-reading without any acoustic input (Woodward/Barber 1960). Only a small subset of the articulatory features of speech sounds can actually be seen (mainly lip rounding and opening, labiodental contact, and jaw height), while others such as the state of the glottis, velum lowering, and tongue dorsum height are invisible. Thus, for the segmental or syllabic level in speech, it remains fair to say that speech primarily makes use of the acoustic-auditory modality, while there is some visual input as well.

So as a starting point, it should be emphasised that the 'modality difference' appears not to be a black-and-white contrast in phonetic channel. While sign languages are exclusively perceived visually by their core users, deaf people, spoken languages are perceived both auditorily and visually. Ongoing research on spoken language communication is exploring the role of visual communication among hearing people more and more, including the role of gestures and facial expressions that are exclusively expressed visually. Hearing users of sign languages can in principle also hear some of the sounds that are made, for instance by the lips or the hands contacting each other, yet

ACTION		SIGNAL		PERCEPTION
Hearing communication				
bodily actions	→	sound	→	auditory perception
		light	→	visual perception
Deaf communication				
bodily actions	→	light	→	visual perception

Fig. 2.1: The modelling difference

this is unlikely to have a substantial phonetic impact on the linguistic structure of sign languages given the fact that the core users of sign languages only have little residual hearing, if any. The modality difference is summarised in Figure 2.1.

Where researchers have made significant progress in the acoustic analysis of the speech signal and in the study of auditory perception, we have very little knowledge of the signal and perception components of the communication chain of sign languages. Yet these are important to study, as general human perceptual abilities form the framework within which linguistic perception takes place. The phonetic research that has been done has focused almost exclusively on the articulation of sign languages (but see Bosworth 2003 for a notable exception). Therefore this chapter will also be primarily devoted to sign language articulation. The reason for this may be that visual perception is extremely complex. While there are only a few parameters of a small section of the electromagnetic spectrum that the human visual system can exploit (luminance and wavelength), these parameters constitute the input to a large array of light-sensitive tissue (the retina) of the two eyes, which themselves move with our head and body movements and which can also move independently (together constituting 'eye gaze'). The human brain processes this very complex input in highly intricate ways to give us the conscious impression that we see three-dimensional coloured objects moving through space over time (Zeki 1993; Palmer 1999).

At a high level of processing, there are abstract forms that the brain can recognise. There have been very few if any sign language studies that have aimed to describe the phonetic form of signs in such abstract visual categories (see Crasborn 2001, 2003 for attempts in that direction). It is clearly an underexplored area in the study of sign languages. This may be due to the lack of a specialised field of 'body movement perception' in perceptual psychology that linguists can readily borrow a descriptive toolkit from, whereas anatomical and physiological terminology is gratefully borrowed from the biological and medical sciences when talking about the articulation of finger movements, for example.

Two generalisations about visual perception have made their way into the sign language literature in attempts to directly link properties of visual perception to the structure of sign languages. First, Siple (1978) noted that the visual field can be divided into a 'centre' and a 'periphery'. The centre is a small area in which fine spatial detail is best processed, while in the relatively large periphery it is motion rather than fine details that are best perceived. Siple argued that native signers perceiving ASL focus their eye gaze around the chin, and do not move their gaze around to follow the movements of the hands, for example. Thus, someone looking at signing would see more details of handshape, orientation, and location for signs near the face than for signs made lower on the body or in front of the trunk. This distinction might then provide an explanatory basis for finer phonological location distinctions near the face area as compared to the upper body area. Irrespective of the data on phonological location distinctions, this hypothesis is hard to evaluate since the face area also includes many visual landmarks that might also help perceivers distinguish small phonetic differences in place of articulation and categorise these as phonologically distinct locations. Since 1978, very few if any eye tracking studies have specifically evaluated to what extent eye gaze is actually relatively immobile and focused on the chin in sign language perception. Also, we do not know whether this differs for different sign languages, nor whether there are differences in the perceptual behaviour of early versus late sign language learners. A related hypothesis that has not yet been tested is that there are more and finer handshape distinctions in the lexicon of any sign language for locations at the face than for lower locations.

The second generalisation concerns the temporal processing of sound versus light. Auditory perception is much better suited to distinguishing fine temporal patterns than visual perception. This general difference is sometimes correlated to the sequential structure found in spoken language phonology, where a sequence of segments together can constitute one syllable, and in turn sequences of syllables can be the form of single morphemes. In sign language, morphemes typically do not show such temporal complexity (van der Kooij/Crasborn 2008). The phonological structure of signs is discussed in the next chapter in this section. While the perceptual functional explanation for the difference in phonological structure may well be valid, there is an equally plausible explanation in terms of articulatory differences: the large difference in size between the arms, hands, and fingers that are mostly involved in the realisation of lexical items and the oral articulators involved in the production of speech sounds leads to a difference in the speed of movement given, assuming a constant energy expense. The mouth, lips, and tongue are faster than the fingers and hands, and we thus correctly predict more fine-grained temporal articulations in speech than in sign. As for the first generalisation about the influence of language modality on structure, very few if any concrete studies have been done in this area, for example allowing us to disentangle articulatory and perceptual influences.

3. Phonetics vs. phonology

The phonetic study of sign languages includes the low-level production and perception of manual and non-manual signals. It is much less evident how such phonetic analysis of language relates to the phonological structure. As chapter 3 on phonology makes clear, we have a good understanding of the phonological characteristics of several sign languages and of sign languages in general. However, one cannot directly observe the categorical properties and structures in sign language phonology: they have to be inferred from the gradient phonetic form. Perhaps the impression that we can *see* the articulators in sign languages has made it self-evident what the phonological form looks like, and in that way reduced the need for an accurate phonetic description.

The first description of the manual form of signs that was introduced by Stokoe (1960) in his groundbreaking work was clearly targeted at the lexical phonological level. It used explicit articulatory terms in the description of the orientation of the hand, even though it aimed to characterise the distinctions within this 'minor' parameter at a phonological level. Orientation was characterised in terms of 'prone' and 'supine', referring to the rotation of the forearm around its length axis. There has never been a phonetic variant of Stokoe's system that has been commonly used as a phonetic notation system. Phonetic notation systems such as HamNoSys (http://www.sign-lang.uni-hamburg.de/projects/hamnosys.html) are sometimes used in lexicography. HamNoSys itself is based on the linguistic analyses initiated by Stokoe, describing the handshape, location, and movement for a manual sign, but it allows for the transcription of finer phonetic detail than a phonological characterisation would require, and like the International Phonetic Alphabet (IPA) for spoken languages it is not designed for one specific language (see chapter 43 for details). Another ongoing effort to describe phonetic events insign languages aims to describe American Sign Language (ASL) at a fine articulatory level of detail, yet still incorporates categories (similar to 'movements' and 'holds') that cannot be directly observed in a video recording of sign but that derive from a specific phonological analysis (Johnson/Liddell, 2010, 2011a,b, to appear).

What we consider to be 'phonetic' and 'phonological' descriptions and how these two interact depends on our model of these different components of language form. Different types of spoken language models have been applied to sign languages, from rule-based formalisms of the SPE (Chomsky/Halle 1957) type to modern constraint-based models (e.g., Sandler 1989; Corina/Sandler 1993; van der Hulst 1993; Brentari 1998). Irrespective of the specific model that is used, such models can help us to get a better grip on what we talk about when we describe a phonetic form in sign language. As an example, Figure 2.2 presents an overview of the Functional Phonology model developed by Boersma (1998, 2007) for spoken languages that was adopted by Crasborn (2001) for the description of a sign language.

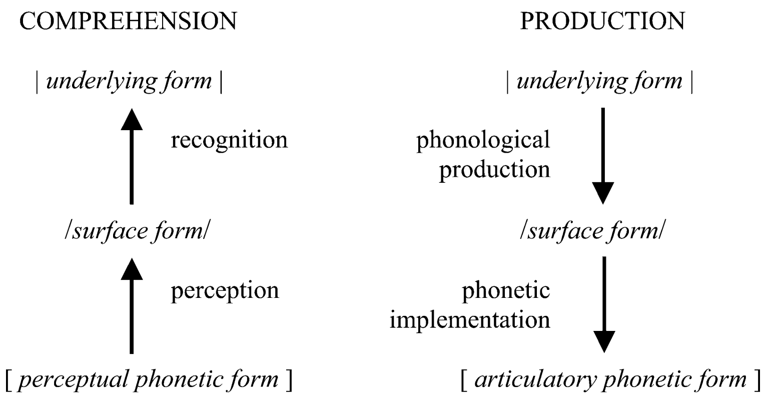


Fig. 2.2: The Functional Phonology model

For example, take the sign PROOF from Sign Language of the Netherlands (NGT) as illustrated in Figure 2.3. The underlying form of this sign specifies that the dominant hand touches the non-dominant hand repeatedly, and that the shape of the two hands is flat with all fingers selected. By default, signs that are specified for a location on the non-dominant hand are realised with both hands in the centre of neutral space. This predictable aspect of the phonological form is added to form the phonological surface representation in the phonetic implementation, and it may be impacted by the phonetic context, showing coarticulation effects (Ormel/Crasborn/van der Kooij 2012). Likewise, the phonological characterisation of the form of signs does not contain any details of how the movement is executed: whether it is the elbow, wrist, or even the fingers that extend to realise the contact with the other hand, or both, is left to the phonetic implementation. It is not fully predictable by phonological rules alone as the phonetic form of a word or sign is also determined by all kinds of sociolinguistic and practical factors (see Crasborn 2001 for extensive discussion). In the instance of the sign PROOF in Figure 2.3, all three joint types appear to participate in the downward movement. This specific type of phonetic variation will be further discussed in section 5.5.

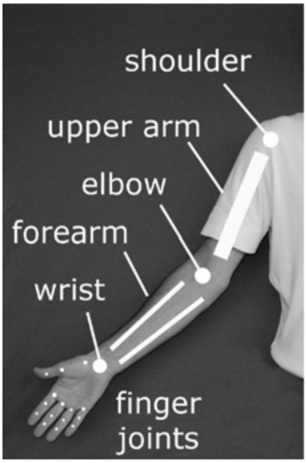
Fig. 2.3: PROOF (NGT)

In the Functional Phonology model, the form of signs that is stored in the lexicon is a perceptual target, whereas the concrete phonetic realisation at a given point in time needs to be characterised at both an articulatory and a perceptual level in order to be properly understood. Most phonological models of sign languages aim for the characterisation of the underlying form of signs, yet this can be viewed as clearly distinct from the phonetic form that is generated by the phonetic implementation in the model above. Section 5 of this chapter will discuss studies on phonetic variation, and we will see how these different articulations (phonetic forms) relate to a single underlying representation. First, section 4 will discuss in some detail how the articulation of signs can be described.

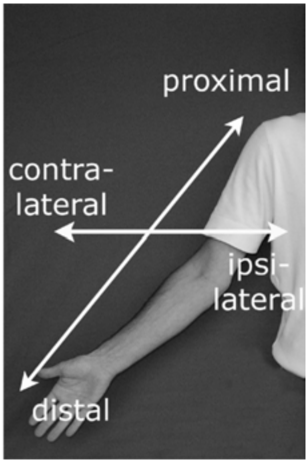
4. Articulation

4.1. Levels of description

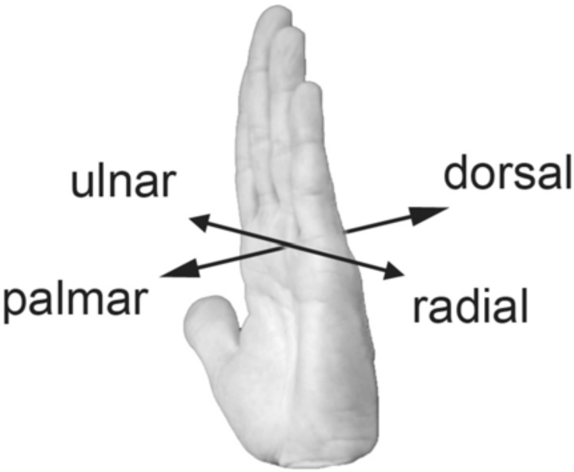
The articulation of manual signs can be characterised in different ways. Figure 2.4a presents an overview of the parts of the upper limb. We can describe the location and orientation of the various *body parts* (fingers, whole hand, forearm, upper arm) in space or relative to the upper body or head, for example. In the sign language literature, we mostly find descriptions of the whole hand or of one or more of the fingers with respect to a body location or in the 'neutral space' in front of the body. Such descriptions rarely describe in detail the location and rotation of the upper arm, for example. It is the 'distal end' of the articulator that realises the phonologically specified values for location and movement in almost all lexical items in sign languages studied to date. The anatomical terms 'distal' and 'proximal' refer to the relative location with respect to the torso, following the line of the arm and hand (see Figure 2.4b). An additional pair of terms displayed in Figure 2.4b is 'ipsilateral − contralateral'. These are similar to 'left − right', yet take the side of the active articulator as a basis: ipsilat-



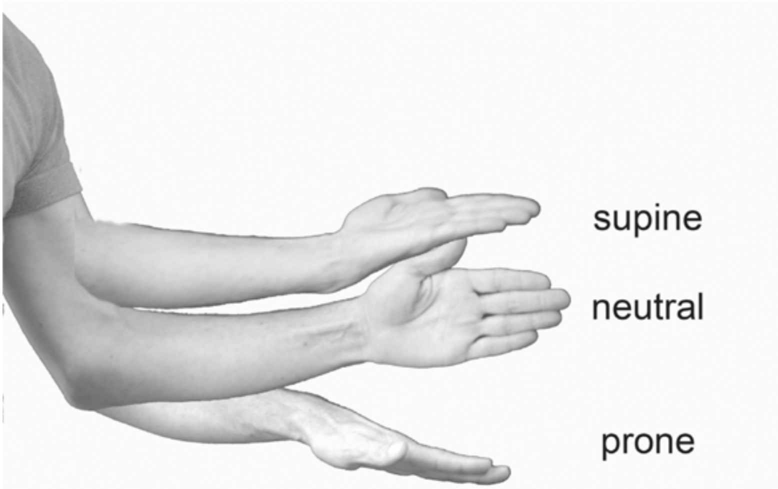
a. Body parts and joints



b. Location terms



c. Sides of the hand



d. Rotation states of the forearm

Fig. 2.4: Terminology used for the description of manual signs

eral refers to the side of the articulator in question, whereas contralateral refers to the opposite side. As such, these terms are better suited to describe the bilaterally symmetric human body than the terms 'left − right' are.

Alternatively, one can also look at manual articulations by focusing on the state of the different *joints*, from the shoulder to the most distal finger joints. For joints like the elbow that have only one degree of freedom, this is very straightforward, while other joints are more complex. The wrist has two degrees of freedom in its movement (flexion-extension and lateral flexion-extension), while the shoulder not only allows movement of the upper arm at the upper body (three degrees of freedom: flexion in two dimensions plus rotation about the upper arm axis), but also shows restricted movement of the shoulder blade and clavicle with respect to the torso, affecting the whole arm plus the hand.

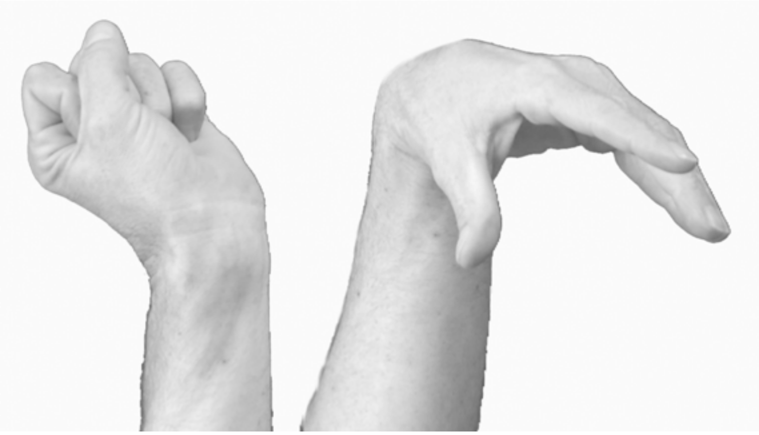
In addition to describing articulation in terms of body part states or joint states, one can look at the *muscles* involved in movements of the arms and hands. There are a large number of muscles involved in the articulation of each sign, and as they are not directly visible, knowledge about the anatomy and physiology of the hand is needed to create such descriptions. Several sign language studies have focused at this level of description in an attempt to phonetically distinguish easy from hard articulations; these will be discussed in section 4.2.

The phonological description of signs typically centres on the hand: its shape, rotation in space, location, and movement are represented in the lexicon. Such a specification does not contain a concrete articulatory specification, irrespective of the level of description. In terms of the model outlined in Figure 2.2, a phonetic implementation is needed to generate a phonetic form from a phonological surface form. Take for example the NGT sign INDIA. Its phonological specification includes the location *forehead*, the *extended thumb* as the selected finger, and a *rotation* movement of the thumb at the forehead. As the state of more proximal joints will influence the location of the end of the extremity, the state of the upper body will also influence the location of the fingertips. Thus, bringing the tip of the thumb to the forehead (in other words, articulating the phonological location) does not only involve a specific state of the shoulder, elbow, wrist, and thumb joints, but needs to take into account the current state of the upper body and head. When the head is turned rightwards, the hand will also need to be moved rightwards, for example by rotating the upper arm outwards. Thus, while the phonological specification of a sign contains global phonetic information on the realisation of that sign, it is quite different from its actual articulation in a given instance.

Although this section aimed to characterise the articulation of manual parts of signs, a short note on non-manual articulations is in place. The articulations of the jaw, head, and upper body can be described in ways similar to those of the arms and hands. Facial articulations are different in that other than the lower jaw there are no bones underlying the skin of the face that can move. Rather, what we see when we describe facial expressions are the impact that the muscles have on the skin of the face. Psychologist Paul Ekman and colleagues have developed a notation system to analyse these articulations. The system emphasises that there is no one-to-one mapping between muscle actions and visible changes in the skin. In other words, we cannot directly see the muscles, but only their effect on the facial skin. The FACS coding system uses the term 'action unit' for each type of articulation; each action unit can be the result of the action of one or more muscles (Ekman/Friesen/Hagen 2002).

4.2. Ease of articulation

In an effort to explain the relative frequency of some forms over others in the lexicon of sign languages, among other things, several studies have looked at the anatomy and physiology of the upper extremity. In particular, the muscles that are used in the articulation of aspects of signs have been discussed in a number of studies. Mandel (1979) looked at the extensor muscles of the fingers, showing that these are not long enough to fully flex the fingers at all joints when the wrist is also maximally flexed. This physiological fact has an impact on the possible movements of the wrist and fingers. One can easily test this by holding the forearm horizontal and pronated, and relaxing both wrist and finger muscles. When one then quickly forms a fist, the wrist automatically extends. Similarly, when the wrist quickly flexes from a neutral or extended state, the fingers automatically extend to accommodate the new position of the wrist. The slower these movements are performed, the better they can be controlled, although in the end the anatomy restricts the possible range of movement and the resulting states of the different joints in combination. At normal signing speed, we do expect to find a certain influence of this 'knuckle-wrist connection', as Mandel called it: closing movements of all fingers are likely to be combined with wrist extension, which in turn leads to a dorsal movement of the hand. Mandel argues that these dorsal movements are typically enhanced as path movements of the whole hand through space in ASL; conversely, opening movements of the fingers tend to be combined with path movements in the direction of the palmar surface of the hand. Thus, while phonologically, path movement direction and handshape change are independent, there is a phonetic effect that relates the two. This is illustrated by the two configura-



(a) Fingers flexed, wrist hyperextended (b) Fingers extended, wrist flexed

Fig. 2.5: The relation between finger extension and hand position in two articulatory configurations

tions in Figure 2.5: when all fingers are closed (2.5a), the wrist is hyperextended; by consequence, the hand appears more 'backwards' than when all fingers are open and the wrist can flex (2.5b).

The literature on ASL contains several studies on handshape that make reference to the articulation of the fingers, arguing that some handshapes are easier to articulate than others (Mandel 1981; Woodward 1982, 1985, 1987; Ann 1993). Patterns of frequency of occurrence − both within the ASL lexicon and in comparison to the lexicon of other sign languages − were attributed as evidence for the 'unmarked' status of handshapes with only the index, thumb, or little finger extended, or with all fingers extended. Supporting evidence came from the order of acquisition of such handshapes. Such distributional (phonological) patterns were related to articulatory (phonetic) properties. Ann (1993, 2008) was the first to perform a detailed physiological study of the articulation of all handshapes. She argued that many of the patterns that were found could be explained by reference to the anatomy and physiology of the hand. For instance, both the index finger and the little finger have a separate extensor muscle and tendon allowing them to extend independently (viz. the *extensor indicis proprius* and the *extensor digiti minimi*). The middle and ring fingers do not: they can only be extended on their own by employing a shared extensor muscle for all four fingers (the *extensor digitorum communis*) while other muscles simultaneously flex the other fingers.

A different articulatory constraint appears to play a role in the formation of some morphological forms. Mathur and Rathmann (2001) argued that the range of motion of the arm joints restricts the inflection of some verbs in sign languages. Inflections for first person plural objects (as in 'send us') do not occur if their articulation requires extreme flexion or rotation at multiple joints. These articulations are required in combining an arc movement (part of the first person plural morpheme) with the lexical orientation and location specifications of verbs such as INVITE in ASL and German Sign Language (DGS) or PAY in Australian Sign Language (Auslan).

5. Phonetic variation

5.1. Introduction

Studies on the articulation of signs as described above form an important contribution to our phonetic understanding of signs. In most of the studies that were done until now, this articulatory knowledge was related directly to patterns observed in the lexicon. As the model of the relation between phonetics and phonology in Figure 2.2 makes clear, this is a rather large step to make. As the lexicon contains abstract phonological representations that are more likely to be perceptual than articulatory, it is not always self-evident how a sign (or even the handshape of a sign) can be articulated and whether there is a prototypical articulation of a sign that can be taken as a reference point for studies on markedness.

5.2. Handedness

The phonetic realisation of signs, just as for words in spoken language, is in fact highly variable. In other words, there are many different phonetic forms corresponding to a single phonological underlying form. One obvious aspect that leads to variation is handedness: whether a signer is left-dominant or right-dominant for non-sign tasks is the primary factor in determining whether one-handed signs are typically realised with the left or right hand (Bonvillian/Orlansky/Garland 1982; Sáfár/Crasborn/Ormel 2010). There is anecdotal evidence that L2 learners may find left-handed signers more difficult to perceive.

5.3. Hand height

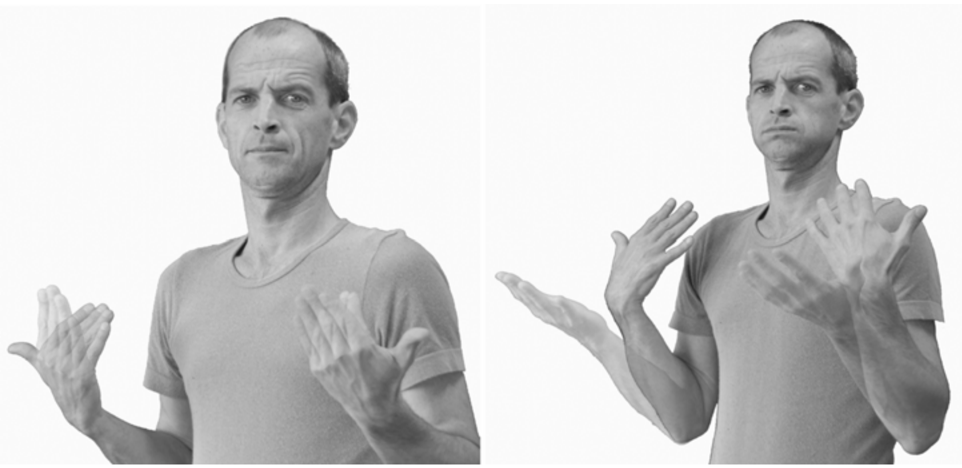
The height of the hand in signs that are lexically specified for a neutral space location has been shown to vary. Coulter (1993) found that in the realisation of lists of number signs ONE to FIVE in ASL, the location is realised higher for stressed items and lower for the initial and final items. In an experimental study of ASL, Mauk, Lindblom, and Meier (2008) found that the height of the hand in the realisation of neutral space locations in ASL is raised under the influence of a high location of the hand in the preceding and following sign. The same has been shown for NGT (Ormel/Crasborn/van der Kooij 2012). For signs located on the body, Tyrone and Mauk (2008) found the reverse effect as well: under the influence of a lower location in the preceding or following sign, a target sign assumes a lower location. These raising and lowering effects in the last two studies are argued to be an instance of coarticulation in sign languages. Similar to coarticulation in spoken language, the strength of the effect is gradual and sensitive to the rate of speaking or signing. It is thus not categorical phonological assimilation that leads to the visible difference in phonetic location, but a case of phonetic variation. This analysis is supported by the fact that the degree of experimentally elicited differences in hand height varies across signers (Tyrone/Mauk 2008).

5.4. Handshape

Similar coarticulation effects for the realisation of handshapes have been described by Jerde, Soechting, and Flanders (2003) for the articulation of fingerspelling (see also Wilcox 1992). They found both progressive and anticipatory influences of fingerspelled letters on each other in ASL; both dissimilation and assimilation were found. Cheek (2001) found that similar assimilation processes also occur in the articulation of handshapes in regular lexical items in ASL. For example, the extension of the little finger needed for the articulation of the -handshape following a -handshape was demonstrated to start before the end of the preceding sign. Again, their gradient nature and dependence on signing rate argues for the interpretation of these findings as instances of phonetic coarticulation rather than phonological assimilation.

5.5. Movement

In addition to these effects of the sequential linguistic context on the appearance of signs, different articulations are found depending on the distance between the signers. Larger and smaller forms of a sign can be compared to shouting and whispering in speech. Crasborn (2001) elicited such forms by changing the distance between pairs of NGT signers, and found that different articulations of the same sign can invoke movement at different joints. For example, phonologically specified changes in location that in their neutral form are articulated by extension of both the elbow and wrist joint were found to be enhanced by a large movement of the elbow joint alone, and reduced by movement at the wrist and metacarpophalangeal joints (which link the fingers to the rest of the hand). In Figure 2.6 below, this is illustrated for the NGT signs WARM and SAY.



a. Small and large articulations of WARM (NGT)

b. Small and large articulations of SAY (NGT)

Fig. 2.6: Smaller and larger realisations of path movements can involve articulation by different joints in the NGT signs WARM and SAY.

The contribution of various joints to a change in location was also illustrated in Figure 2.3 for the NGT sign PROOF. Rather than the whole hand moving downward as a unit, the movement to contact was articulated by simultaneous extension at finger, wrist, and elbow joints in the instance in the image.

5.6. The nature of the phonological abstraction of phonetically variable forms

On the basis of these movement variation data, it can be argued that even though phonological specifications by definition show a large step of abstraction away from the concrete articulatory detail, one hidden articulatory category that may be too concrete for accurate phonological specifications is the hand itself: phonological specifications typically specify the selected fingers and their state, but in many cases this is done in such a way that there is no distinction anymore between 'finger state' and 'handshape' (Crasborn 2003). Finger configurations such as 'extended' or 'straight' imply not only that the two interphalangeal joints of a finger are extended, but also the metacarpophalangeal joint. Thus, most phonological 'handshape' specifications are just that: a specification of the form of the whole hand, albeit at a certain level of abstraction, not aiming to include the exact angles of all joints in the lexicon. For example, in the characterisation of different types of movement, Brentari (1998) distinguishes path movements from local movements by referring directly to possible articulators: by default, the former are realised by the shoulder or elbow joints, the latter are realised by the wrist or finger joints (Brentari 1998, 130–131). Thus, movement of the hand through space is distinguished from movement that changes the form or orientation of the hand. While it may be the case that the underlying form of some signs does indeed include the activity of the whole hand, it may be more accurate for yet other signs to consider a fingertip or a finger to be the articulator (Crasborn 2003). Such a representation would better account for some of the variations in the data that are found in several sign languages, because it abstracts away further from the concrete articulation and aims for a more perceptual representation. However, Emmorey, Bosworth and Kraljic (2009) found that signers only use visual feedback of their own signing to a limited extent, suggesting that visual representations may not play an important role in language production. This is clearly an area in need of further research.

5.7. Summary

In conclusion, the few studies that have explicitly targeted phonetic variation have looked at articulatory variability in the realisation of categorical phonological distinctions. These studies open up a whole field of investigation for linguists and movement scientists. The few studies that there are show that similar processes are at work as in speech variation. Although for convenience's sake these studies have targeted an articulatory level rather than the level of the visual signal, basic factors like the aim to reduce articulatory effort whenever perceptual demands of the addressee do not prohibit it are not different from the spoken modality.

6. Conclusion

The phonetic variation studies discussed above make clear that indeed there is a phonetic level of description in sign languages that is different from the phonological level, even though it has received relatively little attention in the sign language literature. At the same time, these studies make clear that there is a whole field of study to be further explored: the articulation and perception of sign languages is likely to be just as complex as the phonetics of the vocal-auditory modality. While we primarily expect to find differences between sign and speech due to the unique importance of the gestural-visual modality used in Deaf communication, there are also likely to be similarities between the two modalities at some phonetic level. Both sign and speech are instances of human perception and performance; both take place over time and cost energy to perform. These similarities and their impact on the phonology of human language form an important area for future investigations, just as a deeper understanding of the differences merits much further research.

7. Literature

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