A GRAMMAR OF SIGNWRITING

by

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This thesis, submitted by Stuart M. Thiessen in partial fulfillment of the requirements for the Degree of Master of Arts from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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Title	A Grammar of SignWriting
Department	Linguistics
Degree	Master of Arts

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SIGN LANGUAGE ABBREVIATIONS

ASL	American Sign Language
BSL	British Sign Language
BKSL	Ban Khor Sign Language
DGS	Deutsche Gebärdensprache (German Sign Language)
DTS	Dansk Tegnsprog (Danish Sign Language)
KSL	Kenyan Sign Language
LIBRAS	Língua Brasileira de Sinais (Brazilian Sign Language)
LSE	Lengua de Signos Española (Spanish Sign Language)
VGT	Vlaamse Gebarentaal (Flemish Sign Language)

ACKNOWLEDGEMENTS

I would like to express appreciation to Steve and Diane Parkhurst for permission to use the excellent diagrams and illustrations that they used for their book *SignWriting: A complete system for writing and reading signed languages*.

Part of the benefit of writing this thesis is the advice, questions, and suggestions from my advisor and committee members. I learned a great deal from the questions and interaction with the committee. I appreciate the time that you gave to help me hone this thesis.

The SignWriting system is the invention of Valerie Sutton. The system would not be what it is today without her perseverance in the face of opposition and obstacles. Her dedication to requesting, including, and emphasizing the input of Deaf people who use this system is what makes the system one that deserves the attention of Deaf communities worldwide. While the final decision to use or not to use a writing system rightfully remains with each sign language community, the undeniable fact is that they now have the option to write their sign language where before they did not. No longer can anyone say with honesty and integrity: "Sign languages cannot be written."

To the Inventor of language, Whose creativity in designing the intricacies of language never ceases to amaze me and Who models a passion for effective communication.

To my wife, Linda, and my boys, Daniel and Stephen, who put up with a lot of "Dad's going to the dungeon to work on his thesis." Without your patience, it would have been a lot tougher to finish.

To my family (parents, uncles, aunts, parents-in-law, etc.) who have been very encouraging and supportive in my life … especially my parents and Uncle Glenford and Aunt Linda who exposed me early to this fascinating world of linguistics.

To Larry Wilhite, my fifth-grade teacher, whose frequent disappearances to teach Spanish led to a driving curiosity about other languages.

ABSTRACT

Signed languages have not enjoyed the benefits of writing for lack of an effective writing system. Writing systems designed for spoken languages are not easily adaptable to signed languages because signed languages are not based on sound. A successful writing system for sign languages must convey a different set of articulators, namely the configurations and movements of the hands, head, and body to convey meaning. This necessarily means that writing systems for signed languages must find a way to express those articulators, reducing a three-dimensional event to a written representation.

One such writing system is SignWriting, a system developed by Valerie Sutton based on her earlier DanceWriting system. Unlike other attempts at writing sign languages such as Stokoe, HamNoSys, or SignFont which imitate spoken language writing conventions with a largely linear sequence of symbols, SignWriting makes use of the spatial relationships of symbols in a two-dimensional "sign box" to represent a sign. These signs are then written vertically down the page to represent signing.

The selection and placement of these symbols is not unpredictable. Analysis shows that SignWriting has a "grammar", that is, rules that govern how symbols function and how they combine to form whole written signs. The approximately 35,000 symbols are variations of 639 base symbols. I analyzed these symbols to determine the different categories and subcategories, analogous to analyzing the lexicon and grammatical categories of a natural language. Available data in publicly available dictionaries and online SignWriting lessons

provided rules governing how symbols combine to form the representations of whole signs as well as the internal structure of individual symbols, analogous to the syntactic and morphological rules of a natural language.

All symbols fit into a set of seven major categories: hand symbols, movement symbols, a head circle with a set of modifiers, torso and limb symbols, dynamic symbols, punctuation, and SignSpelling notation. Symbols for the hands, head, torso, and limbs represent the active and passive articulators utilized by sign languages. The movement symbols describe how those articulators move and interact with other articulators. The dynamic symbols provide additional information to indicate the manner of the movement or how two-handed signs move. Unlike the other symbols which are composed inside a sign box, punctuation symbols are placed in their own sign box and function much like spoken language punctuation. SignSpelling symbols are not used in everyday writing but are used to store a representation of a sign in a dictionary for collating purposes. Because of the analysis required on the symbol inventory, only preliminary research was possible on the structure and relationships within a sign. The last two chapters present some preliminary rules that govern the placement of symbols and what work remains to determine more specific rules.

Further research along these lines will hopefully open the way for this system to be more easily used with general-purpose software applications and open the possibility for sign languages to take advantage of written forms in an effective and useful fashion. While the decision to use SignWriting (or any written system for sign languages) remains a sociolinguistic matter to be decided by each Deaf community, it is my hope that this research contributes toward the resolution of the technological barriers so that it is no longer a factor in their decision-making processes.

CHAPTER 1

BACKGROUND

1.1 Introduction

Writing has been a tool used by spoken language communities for thousands of years. The use of writing, once limited to a select educated few, has now become an essential tool of communication for everyone in our modern society. Writing gives us a way to develop, record, analyze, and disseminate our thoughts, ideas, and beliefs. Many of our modern advances would not be possible without writing.

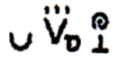
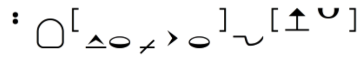
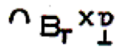
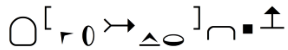
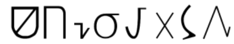
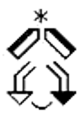
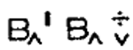
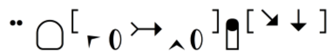
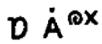
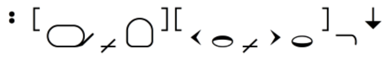
Signed languages have not enjoyed the benefits of writing for lack of an effective writing system. Writing systems designed for spoken languages are not easily adaptable to signed languages because signed languages are not based on sound. To be sure, not all writing systems for spoken languages solely rely on sound. Some writing systems like that used by Chinese or Mayan are largely logographic, and could conceivably be used by sign languages. However, even for spoken languages, writing systems based on sound are typically more easily learned than logographic systems. A successful writing system for sign languages, then, must convey a different set of articulators, namely the configurations and movements of the hands, head, and body to convey meaning. This necessarily means that writing systems for signed languages must find a way to express those articulators in written form.

To date, other than SignWriting (the focus of this thesis), only a few writing systems for sign languages have had wide exposure. These include Stokoe (1976), HamNoSys (Universität Hamburg, 2004), and SignFont (Newkirk, 1987)[1]. These have largely been used in a research context, and only Stokoe and HamNoSys continue to be used on a regular basis. They imitate writing systems for spoken languages in that the symbols are written in linear streams of characters that must be mentally reassembled by the reader into the three-dimensional sign it represents. That imitation does make the writing easier to store on computers and to manipulate within standard software, but it comes at the expense of human readability. Table 1 provides some comparisons between these writing systems and SignWriting.

Both Stokoe and SignFont were designed with ASL in mind. Some people have modified Stokoe to work with British Sign Language (BSL). However, with an estimated 400 sign languages around the world (most of which have yet to be researched), flexibility in a writing system is critical. While both HamNoSys and SignWriting have both extended their systems to support a broad range of sign languages, the extensive public dictionaries and pedagogical materials online shows the SignWriting community has a strong commitment to continually extend SignWriting as needed to write any sign language.

[1] Information on SignFont is out of print and no longer available on the Internet. Linguist Sam Supalla has used SignFont as a bridge orthography to help Deaf children transition to English, and use of the writing system was eventually discarded once Deaf children were reading in English (Supalla & Blackburn, 2004).

Table 1. Comparison of SignWriting with other notation systems[2]

	SignWriting	Stokoe	HamNoSys	SignFont
Snake				
Enter				
Don't Know				
House				
Establish				

First developed in the 1970's by a hearing dancer, and later modified in collaboration with Deaf Community members, SignWriting promises to be one of the more effective ways of writing sign languages. Its value comes from its translation of the three-dimensional signing space to an accurate and readable two-dimensional representation. This two-dimensional representation utilizes both specific symbols and the orientation and arrangement of those symbols to represent the three-dimensional relationships. While the two-dimensional representation poses minimal problems to human readers, and actually helps them to process the written text better, such a representation is more difficult to

[2] Most of these examples came from Martin (2000:11-12) and from a set of pages on the SignWriting website: <http://www.signwriting.org/forums/linguistics/ling002.html>. All of the SignFont examples were written by me, so any errors in transcription are mine. I consulted with Steve Parkhurst to confirm spellings for the HamNoSys examples.

reduce to a one-dimensional string of characters that computers can process. To be usable in modern computer applications, this two-dimensional representation needs a one-dimensional representation, called an 'encoding,' that computers can easily store and use to recreate the two-dimensional representation on the screen or on paper, and which can serve as the basis for other automated processing such as spell-checking, sorting, parsing, and machine-translation.

In order to promote the development of a suitable encoding, this thesis focuses on constructing a "grammar" of SignWriting, that is, an explicit statement of the rules governing how symbols combine to form whole written signs. The system has slightly over 35,000 symbols, most of which are variations on 639 base symbols, and are highly iconic and systematic so they are relatively easy to learn. I analyzed all the symbols to determine the different categories and subcategories, analogous to analyzing the lexicon and grammatical categories of a natural language. I used publicly available dictionaries in several languages (http://www.signbank.org/signpuddle) and lessons available on the SignWriting website (http://www.signwriting.org/lessons) to discover rules governing how symbols combine to form the representations of whole signs as well as the internal structure of individual symbols, analogous to the syntactic and morphological rules of a natural language.

It is important also to note that SignWriting written by hand allows more flexibility in how the various diacritics can interact with one another. However, given that this paper is focused on how the computer renders SignWriting, it does not explore all the variations permitted in handwriting aside from occasional comment about the additional flexibility handwriting may offer.

1.2 Origins of the SignWriting system

1.2.1. MovementWriting

The Center for Sutton Movement Writing (CSMW, 2006a) describes MovementWriting as the entirety of Valerie Sutton's notation system. MovementWriting, as a name, is a fitting description of the approach that Sutton takes. Rather than attempting a writing system based on a specific linguistic analysis, she simply analyzed the available articulators and developed a symbol set that could represent those articulators on either a phonetic or phonemic level depending on the intent of the author. MovementWriting includes five major "subsystems" (illustrated in Figure 1 – Figure 5) with the first two being the most used of the five:

Figure 1. DanceWriting sample (Sutton, 1973:1)

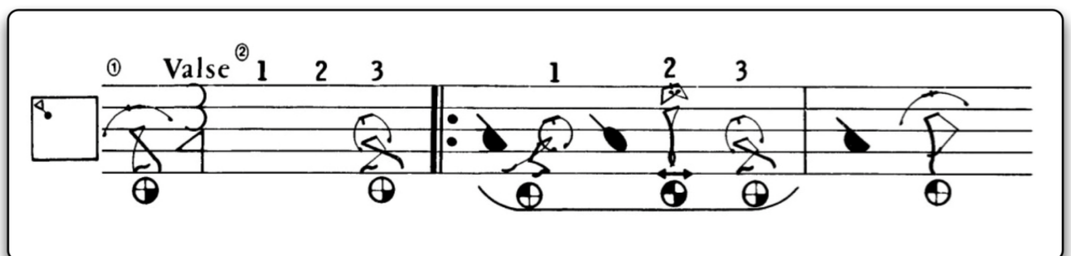


Figure 2. SignWriting sample

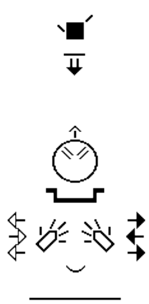


Figure 3. MimeWriting sample (CSMW, 2006a)

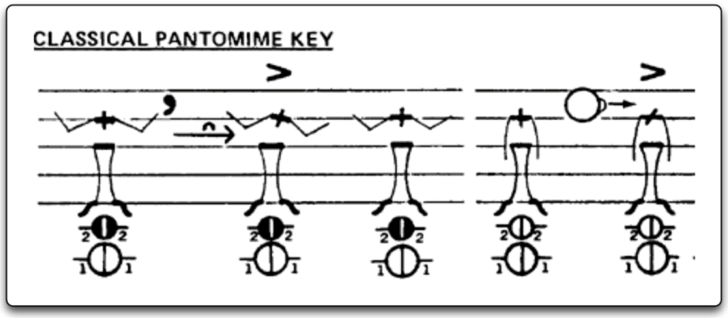
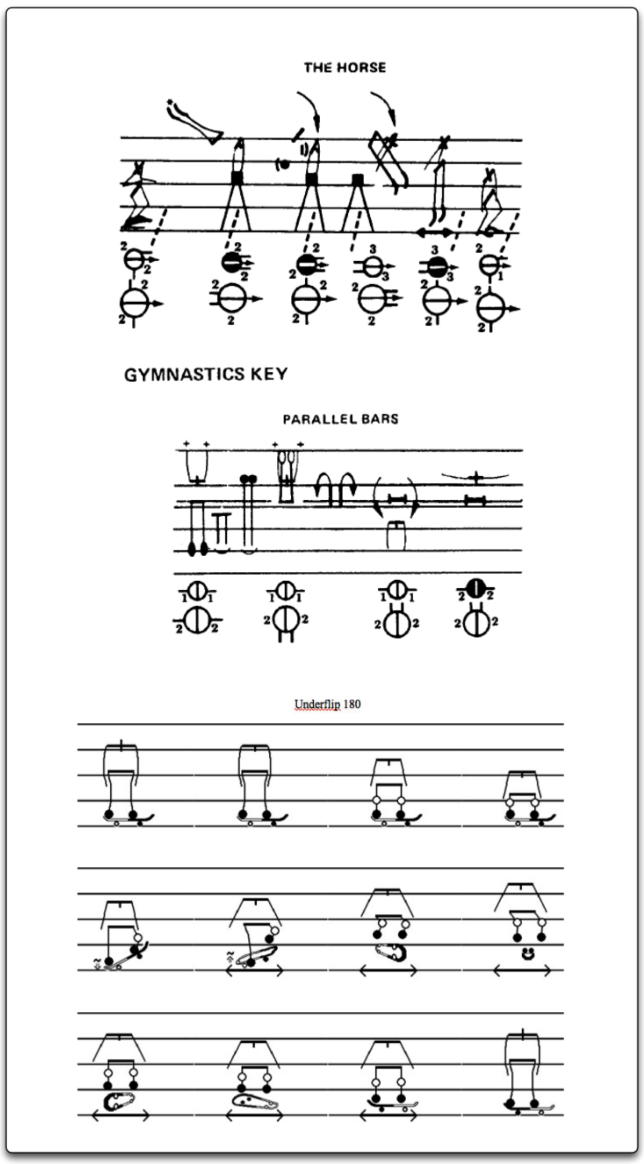
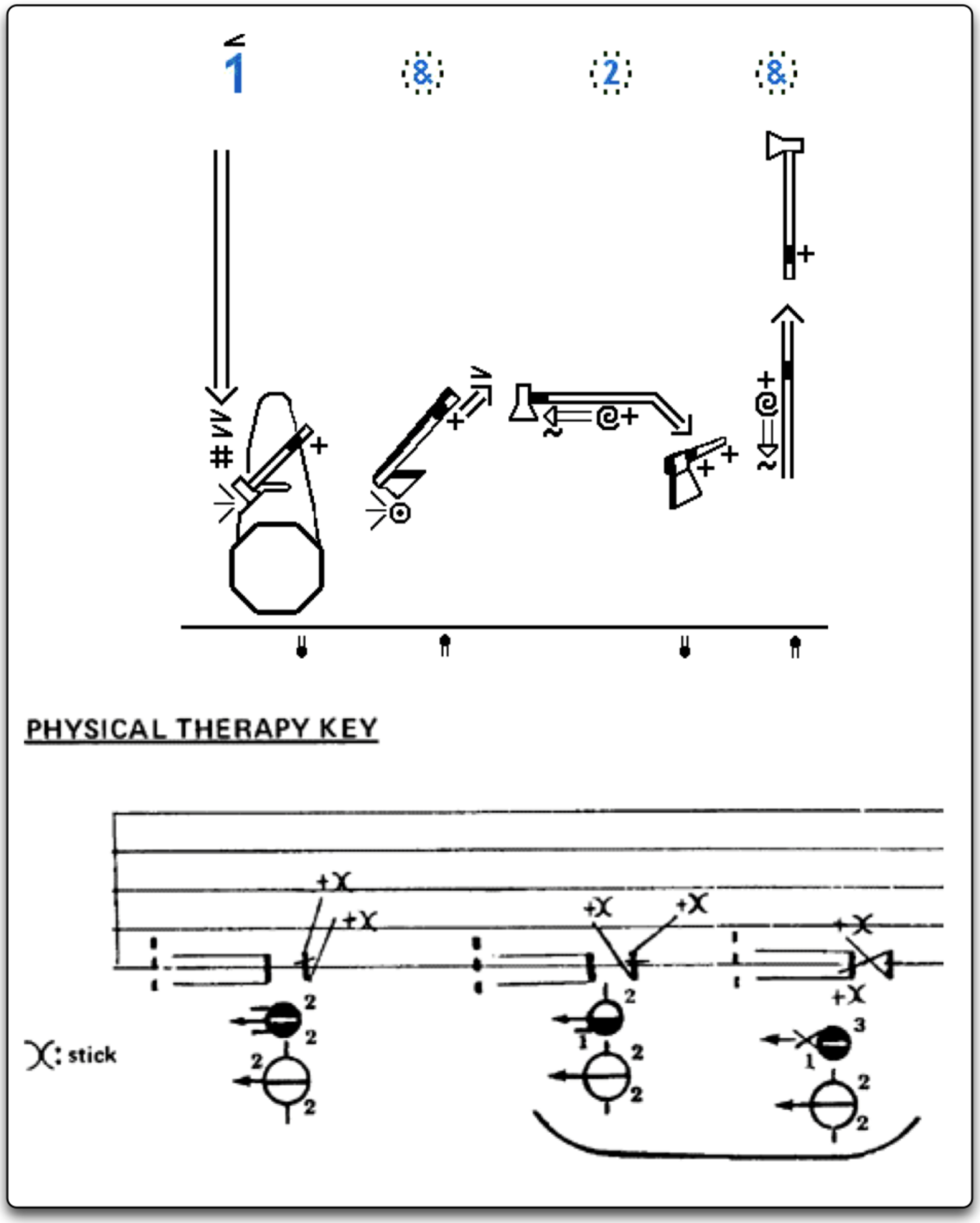


Figure 4. SportsWriting sample (CSMW, 2006a; CSMW, 2007a)



Gymnastics and Skateboarding

Figure 5. ScienceWriting sample (CSMW, 2006c; CSMW, 2006a)[3]



One interesting example of the flexibility of her MovementWriting system relates to craftsman techniques. In October 2005, a Norwegian researcher contacted her about using her notation system for documenting movements of traditional craftsmen. With

[3] The upper diagram is describing log craftsmanship while the lower diagram is describing physical therapy.

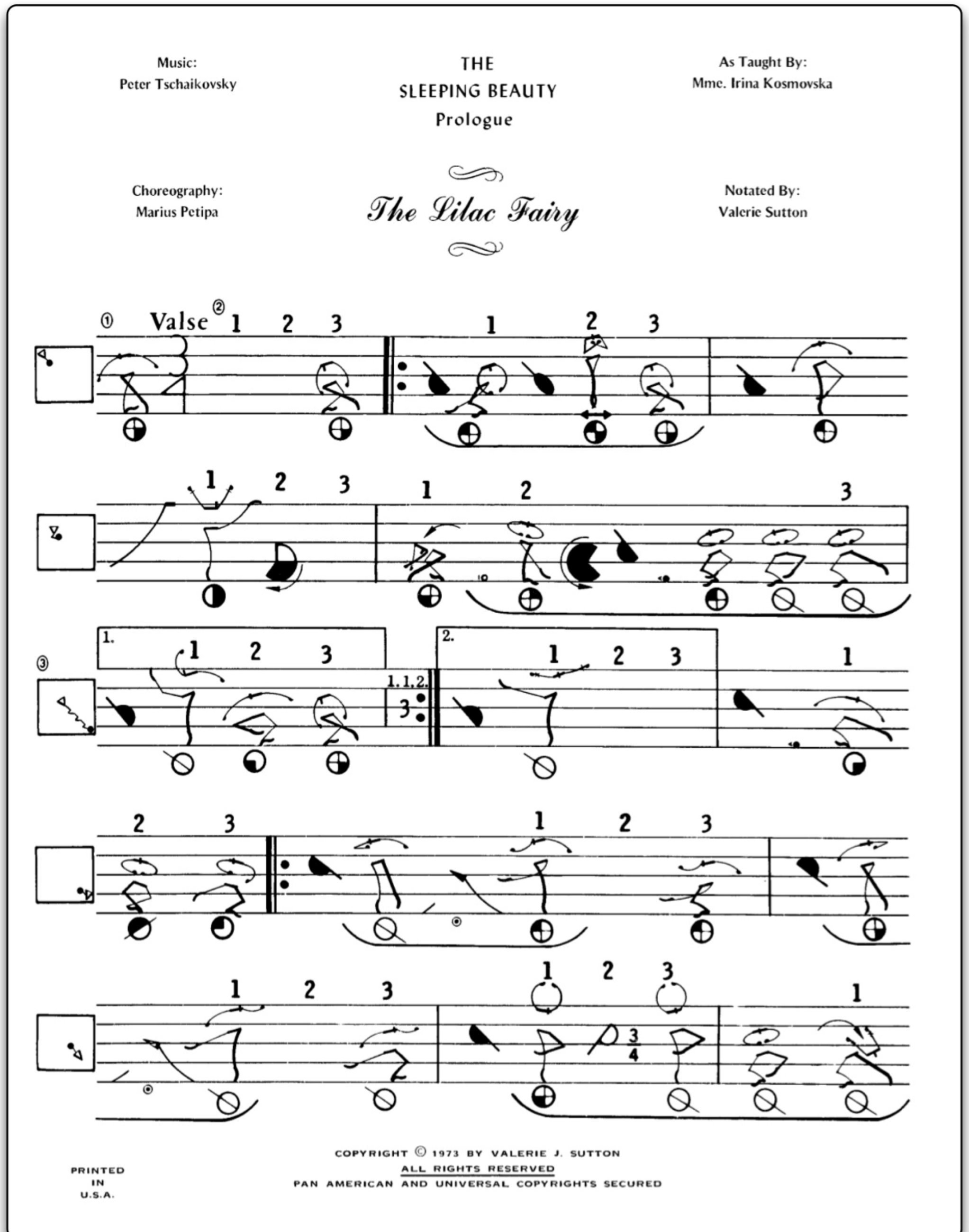
MovementWriting, they were able to describe how these early craftsmen did their work (as illustrated in the top example under ScienceWriting).

The entire symbol set for MovementWriting is called the International Movement Writing Alphabet (IMWA). The symbols are used in generally consistent ways across the various subsystems. This consistency allows each subsystem to borrow from MovementWriting when necessary for more intricate notations.

1.2.2. DanceWriting

DanceWriting (CSMW 2006b) is SignWriting's older sibling and the script that launched the whole MovementWriting system (see Figure 6 on page 9 for an example page of DanceWriting). DanceWriting began as Sutton's personal Dance Notation system in 1966. While training with the Royal Danish Ballet in the early 1970's, she discovered their historic dances were not being recorded so she used her system to preserve those dances. By 1974, she had refined the system and taught it to 30 other dancers with the permission of Ballet Master Flemming Flindt. Today, many symbols included in SignWriting are taken from DanceWriting, especially those that are related to perspective and non-manuals.

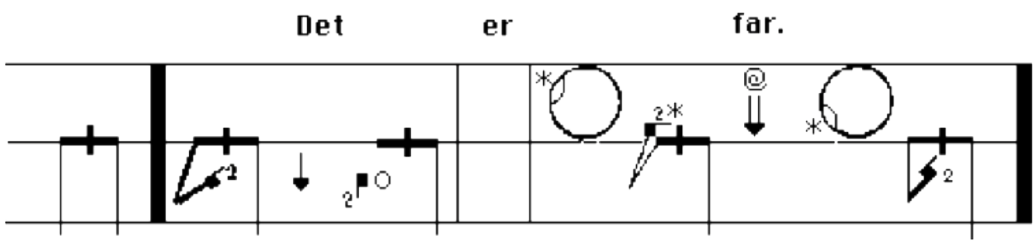
Figure 6. A page of DanceWriting (Sutton, 1973)



1.2.3. SignWriting

SignWriting (CSMW, 2007b) began in 1974 when linguists at the University of Copenhagen led by Lars von der Lieth asked Sutton to use her dance notation system to write Danish Sign Language (DTS). Since 1974, SignWriting has undergone significant changes, mostly as a result of the feedback of Deaf people who use it. Figure 7 through Figure 11 contain examples of SignWriting from 1976 until present time. Over the years, the writing has moved away from a stick figure representation with explicit representation of the arms and shoulders to a more compact representation that only includes limbs when those elements are necessary. In addition, the early hand symbols had no information about the hand's orientation, which is now carried by the rotation and fill of the hand symbols. While some users still use the horizontal direction of writing shown in earlier examples, the system currently encourages a vertical direction of writing. Currently, the International SignWriting Alphabet (ISWA) is the official subset of the symbols in the IMWA that are needed to write sign languages.[4]

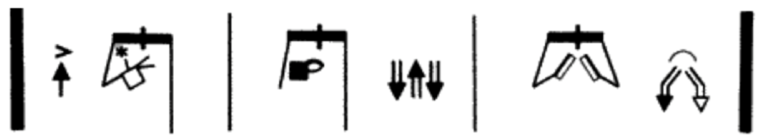
Figure 7. DTS SignWriting example from 1976 (CSMW, 2006d)



'It is Father.'

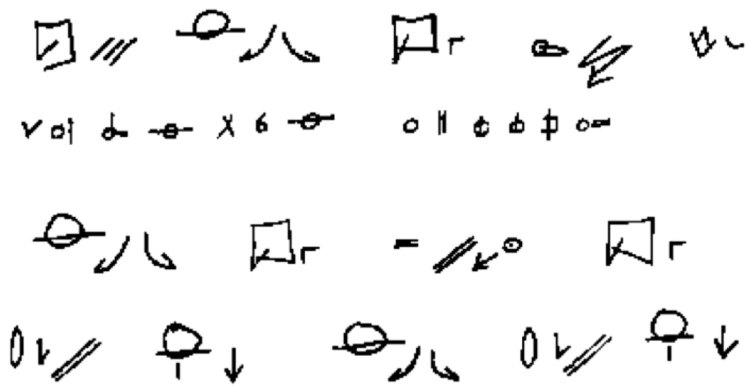
[4] Appendix A and B provide more details regarding the current implementation of the SignWriting system on computers including the numbering of symbols and formats of storing documents. Current documents use the ISWA, but older documents will use one of the earlier symbol numbering systems.

Figure 8. DTS SignWriting example from 1980's (CSMW, 2006d)



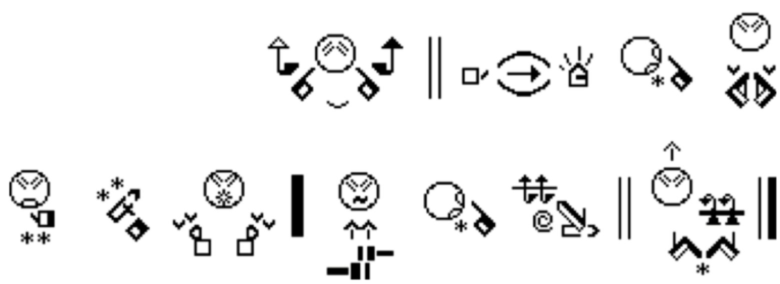
'don't feel-like paint house.'

Figure 9. ASL SignWriting shorthand example from 1980's (CSMW, 2006d)[5]



(no translation available)

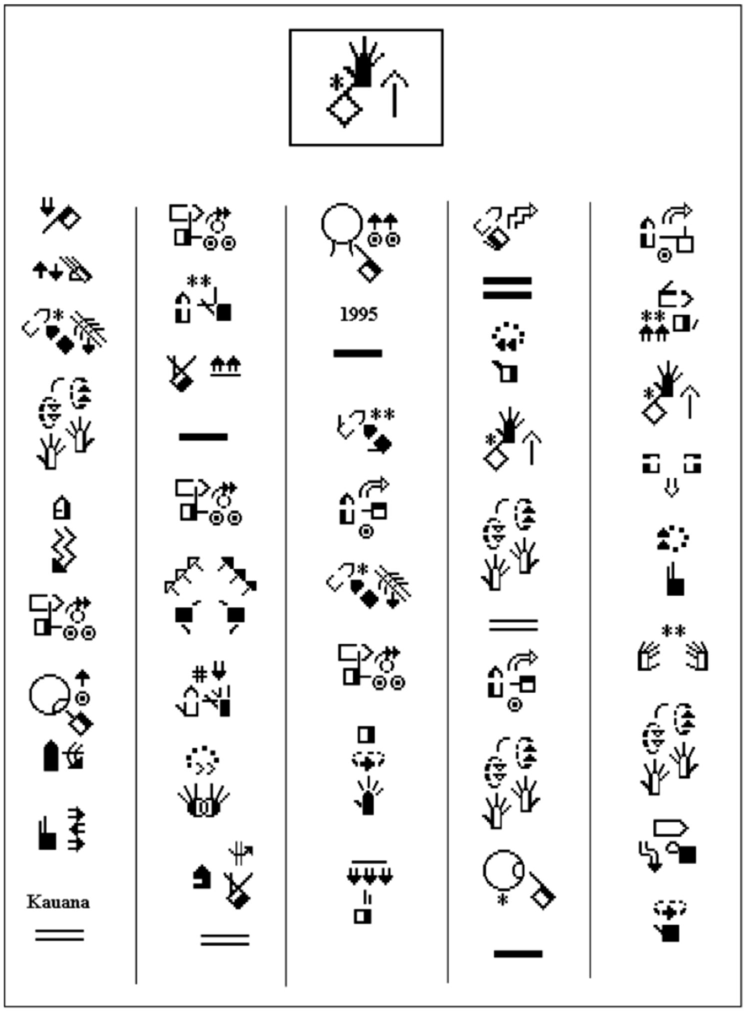
Figure 10. ASL SignWriting example from the 1990's (CSMW, 2006d)



'Finally, a few Deaf met secretly in frustration to discuss what to do and how to support Deaf rights.'

[5] Development of SignWriting shorthand was suspended to focus on refining SignWriting in general. So, very few people other than Sutton can presently read SignWriting shorthand. Even for these people, it is my understanding that one may need to rewrite it fairly soon afterwards to avoid forgetting details omitted to increase speed.

Figure 11. LIBRAS SignWriting example from 1997 (Stumpf & da Rocha Costa, 1997)



First page of a story entitled "Uma Menina Chamada Kauana"

1.3 Overview

Figure 12 through Figure 14 introduce how SignWriting works by explaining three example signs from ASL. In each of these signs there are examples of the various categories of symbols involved in SignWriting. The selection of symbols and their placement is not arbitrary but intended to provide a rule-based, two-dimensional representation of the sign.

Figure 12. ASL 'oppose' using SignWriting[6]

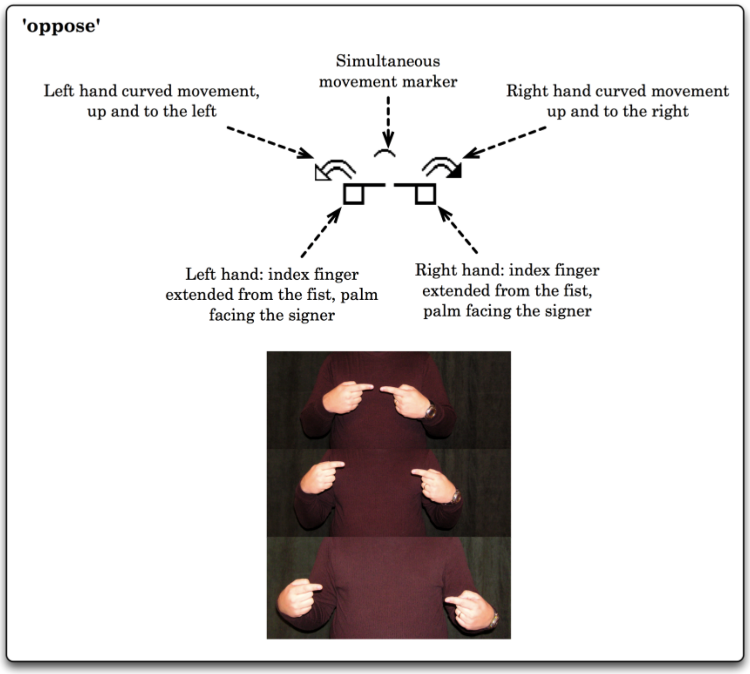
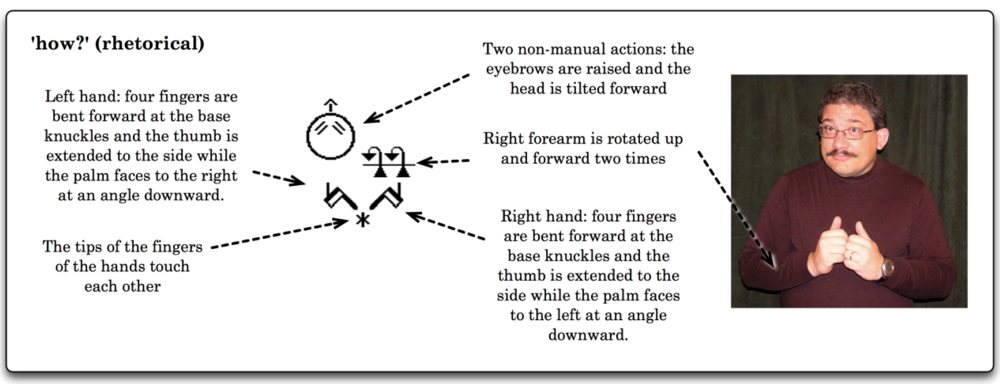


Figure 13. ASL 'how?' (rhetorical) using SignWriting



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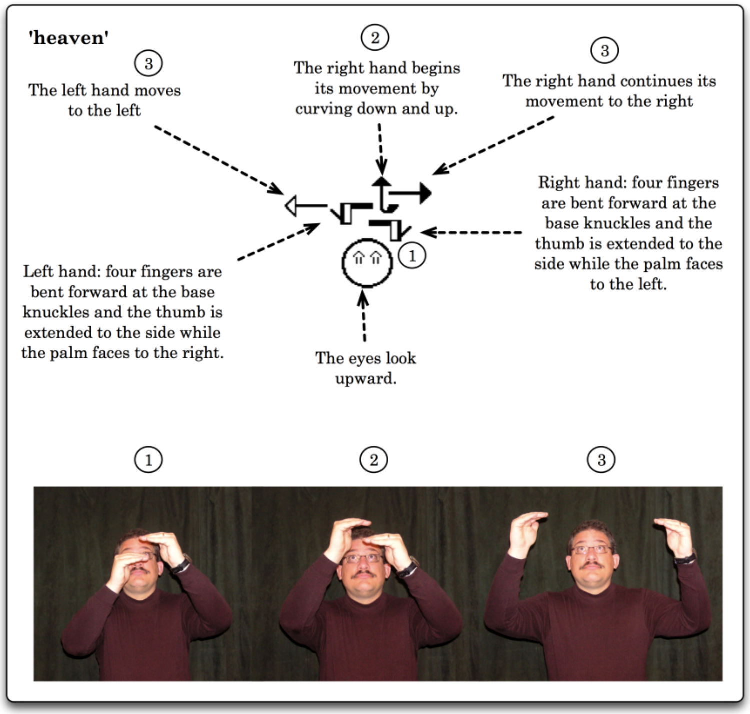
[6] All figures unless otherwise noted were designed by me for this thesis. In some cases, I have borrowed line drawings or other illustrations from others to use in my illustrations and have noted where I have done so. One exception to noting every borrowing of an illustration is the line drawings of hands. These are either from the Parkhursts or from the Gallaudet fingerspelling font. Only one line drawing (the ASL sign 'turtle') is mine.

Figure 14. ASL 'heaven' using SignWriting



Each of the symbols captures an articulator or some aspect of its movement so that the reader can reproduce the sign from the information present in the writing. Like any writing system, SignWriting is not intended to capture every nuance (though symbols exist to provide a reasonably accurate transcription), but rather to capture the necessary elements so that the signing can be reproduced at least intelligibly. As writing becomes more standard, spellings will presumably become conventionalized and less detailed because readers can supply the needed information from their knowledge of the language.

In the next six chapters, this paper covers the symbols used in everyday writing.[7] Chapter 2 describes the symbols that relate to the hands. Symbols for the hands use an **EXEMPLAR** composed of a **BASE FORM** (the nucleus of the hand symbol) and finger symbols

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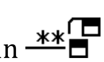
[7] A basic understanding of sign language phonology is assumed in what follows such as that which is covered by Sandler and Lillo-Martin (2006:113-278) and Corina and Sandler (1993).

(symbols that represent the configuration of the fingers). These exemplars then may accept **FILLS** (shadings and other modifications that represent palm facing), **ROTATIONS** (which represent the orientation of the hand in space), and **REFLECTIONS** (which help indicate handedness) to arrive at a depiction of a specific handshape. In the ASL examples above, two hand symbols appear:  (in Figure 12) and  (in Figure 13 and Figure 14). The first hand symbol is from the Fist class, i.e., the  tells us the hand symbol is a variation of the one used to represent a fist configuration (most or all fingers closed into the palm). The lack of shading inside the  tells us the palm is facing the signer. The finger configuration tells us the index finger is extended. The rotation tells us both hands have rotated 90° with each hand's index finger pointing toward the other hand. The reflection indicates one is a left hand and the other is a right hand. The second hand symbol is from the Palm class, using the  form, which represents prominent exposure of the palm from the knuckles to the wrist. The half shading inside the  tells us the palm is facing to the side with the back of the hand on the side of the shading itself. The finger configuration tells us that all four fingers are extended with the thumb extended to the side. In 'how?', the hand symbols are rotated downward 45°. In 'heaven', the hand symbols show no rotation. In both 'how?' and 'heaven', the hand symbols for the left hand are mirror images of the right hand ("reflections" is the term I will use).

Chapter 3 looks at different symbols that describe the movement of hands or other parts of the body. The movement symbols encompass both directional movement and movement that is merely a change of state in one place. In our example signs, directional movement is expressed with arrows. The shaft of the arrows communicates the path and the arrowheads communicate which hand(s) were doing the movement. For instance, straight double-line arrows refer to vertical movement and straight single-line arrows refer to horizontal movement. The curved arrows show movement up and forward or down and forward. Another type of movement symbol are those that express a change of configuration or orientation. For instance, in ‘how?’, there is an example of a contact symbol that shows a state where the hands touch each other.

Chapter 4 looks at the symbols that describe the head along with the various articulators and locations available on it (eyebrows, eyes, nose, mouth, tongue, etc.). Sign languages use the head and its articulators as important elements in the grammatical system as well as functioning as an integral part of certain signs. SignWriting maps all these on a **HEAD CIRCLE**. For instance, the raised eyebrows and head movement forward in ‘how?’ serve to indicate a rhetorical question. The eyes raised skyward in the sign ‘heaven’ is lexically specified as part of the sign ‘heaven’. Some sign languages depend on specific mouthings, which may be derived from spoken languages as a necessary companion of certain signs, or other mouth patterns used to convey adverbial and adjectival meanings.

Chapter 5 covers the symbols used to describe shoulders, hips, arms and legs (not illustrated in the examples thus far). By definition, signs written without torso or limb symbols (or head circles) occur in neutral space, which is the space just in front of the chest. When shoulders, hips, arms, or legs are an important part of the signs (either as a location or as an articulator that is moved), they are represented in the sign. For example, sometimes limb symbols are needed in combination with the simple fist symbol to indicate involvement of the wrist (e.g., in  ASL ‘time’, the finger of the right hand taps the back of the left wrist).

Chapter 6 describes **DYNAMIC SYMBOLS**. Dynamic symbols—with a few exceptions—are modifying symbols; they function in the grammar of SignWriting like modifiers do in languages—modifying the movement symbols to show details of the timing or the manner in which the movement occurs. In 'oppose', the simultaneous dynamic symbol indicates both hands should move at the same time. Related symbols could indicate alternating movement or movement that occurs in opposite directions. Other dynamic symbols can describe the speed or "feel" of the movement.

Chapter 7 concludes our look at individual symbols by examining available punctuation symbols. This includes the equivalent of traditional punctuation such as periods, commas, question marks, etc. It also includes unique punctuation symbols called **PROSODIC BRACKETS** that are used to show non-manuals that spread across a phrase or clause.

Chapter 8 describes symbols not used in everyday writing but available for use with collating sequences for arranging written signs in order, analogous to alphabetizing in a conventional alphabet. These symbols add information that the spatial orientation implied or the writer omitted because fluent signers would naturally supply the omitted information. These collated sequences are presently used by existing software to order dictionaries by the symbols present in a sign. Their usage is limited to this context.

Chapter 9 focuses on describing a preliminary set of rules for composing whole signs out of individual symbols. In order for a computer's rendering engine to be able to place the symbols accurately—interpreting a stream of Unicode characters encoded such that it can recompose the original two-dimensional configuration—it must have an adequate set of rules that govern symbol placement. The rules given there are not exhaustive, but provide a starting place. The ideal encoding would provide sufficient flexibility for the writer to represent all meaningfully distinct arrangements of the hands in space, but no more than that, so as to provide sufficient limits to the amount of variation in spelling so that computer-based searches and sorts would be manageable.

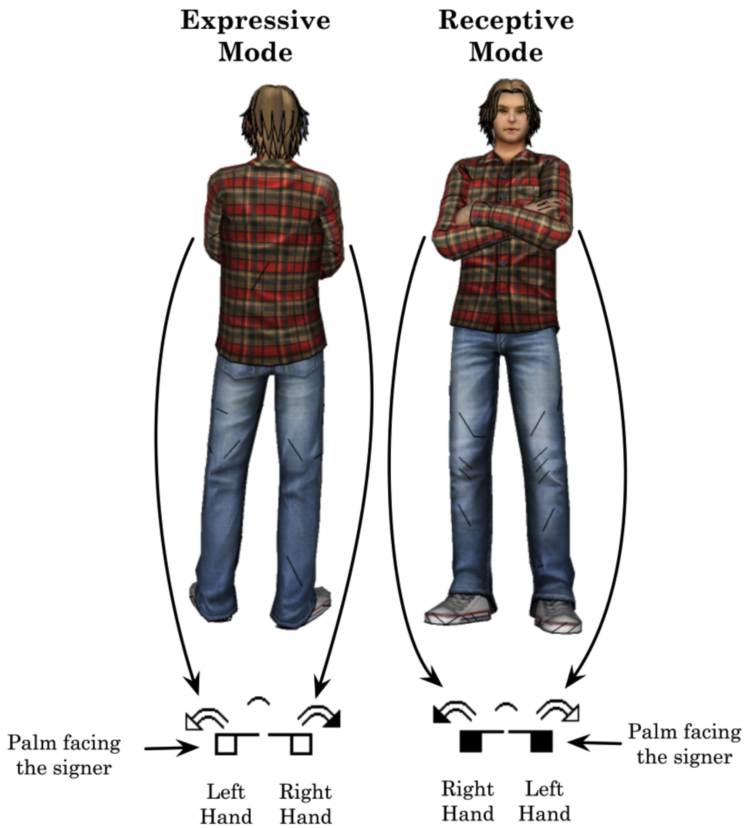
Finally, Chapter 10 concludes with a discussion about some preliminary findings related to key challenges in developing an encoding and how further research could provide more ideas on how to develop a satisfactory encoding. The key challenges involve understanding the structure of a sign, determining adequate **ATTACHMENT POINTS** (points on each symbol with which another symbol may be associated), determining ways to minimally express distance and angle of the symbols in relation to one another, and utilizing this information to encode the sign such that it can be properly reconstituted in a two-dimensional representation.

1.4 Basic underlying concepts in SignWriting

1.4.1. Writing mode and viewpoint

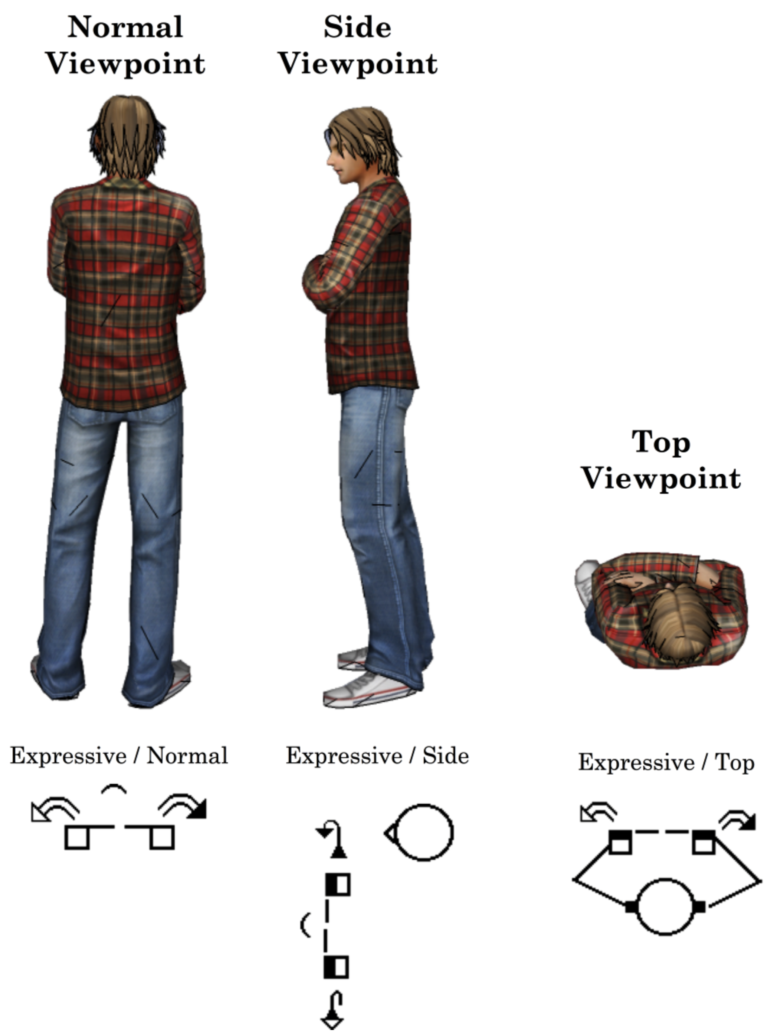
When writing signs, writers need to consider what **MODE** they will use to transcribe the utterance. Typically, SignWriting has one of two modes of writing as illustrated in Figure 15 with the ASL sign 'oppose' (shown earlier in Figure 12) written in both modes. The email archives (Sutton, 1998) show that before 1984, SignWriting was written in the **RECEPTIVE MODE**. In the receptive mode, writers wrote from a third person perspective as an observer. However, with Deaf input, the preferred mode has changed to the **EXPRESSIVE MODE**. In the expressive mode, writers write from a first person perspective as a signer. While some older documents follow the receptive mode, most documents today are more likely to be written from the expressive mode, and in the rest of this paper the expressive mode is assumed unless specified otherwise.

Figure 15. SignWriting modes (illustrated with the ASL sign 'oppose')



Based on the mode of choice, writers then know what viewpoints are available to them. As illustrated in Figure 16, SignWriting can be written from one of three viewpoints: normal, side, and top. Each viewpoint has a point of reference based on the mode being used. In the normal viewpoint, writers write according to the default of the mode they are in (whether expressive or receptive). In the side viewpoint, writers write with the signer facing the Side plane. In the top viewpoint, writers use an imaginary point above the signer's head. SignWriting uses specific symbols to signal these viewpoints as I discuss later in Section 4.10. In particular, the top viewpoint is valuable because some signs (particularly those where the depth of the sign is significant) are more easily written from this viewpoint, providing a better representation.

Figure 16. SignWriting viewpoints (illustrated with the ASL sign 'oppose')

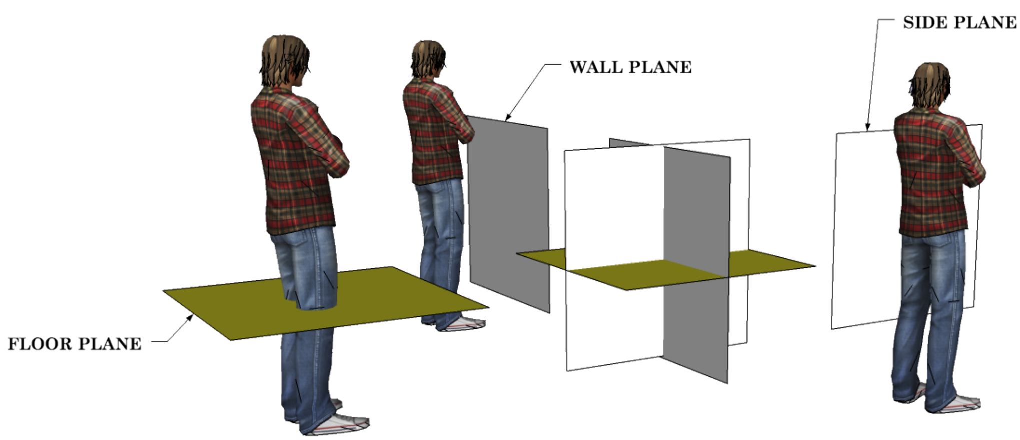


1.4.2. Planes

SignWriting uses the concept of **PLANES** to help describe hand orientation and directional movement. The planes are fixed and do not move regardless of a change in mode or viewpoint. While the SignWriting pedagogical literature typically refers primarily to the Wall and Floor planes with only passing reference to others (suggesting only 2 active planes in use), analysis of SignWriting does show 3 planes—Wall, Floor, and Side with the Side Plane the least emphasized of the three. These are simply alternate names for established anatomical planes. Interestingly, this design decision to limit the significant planes to these three 90˚ planes is an assumption also made by sign language phonologists such as Brentari (1998:34, Fig. 1.20). To date, nothing has contradicted this assumption that all contrastive movement can be represented within one of these planes.

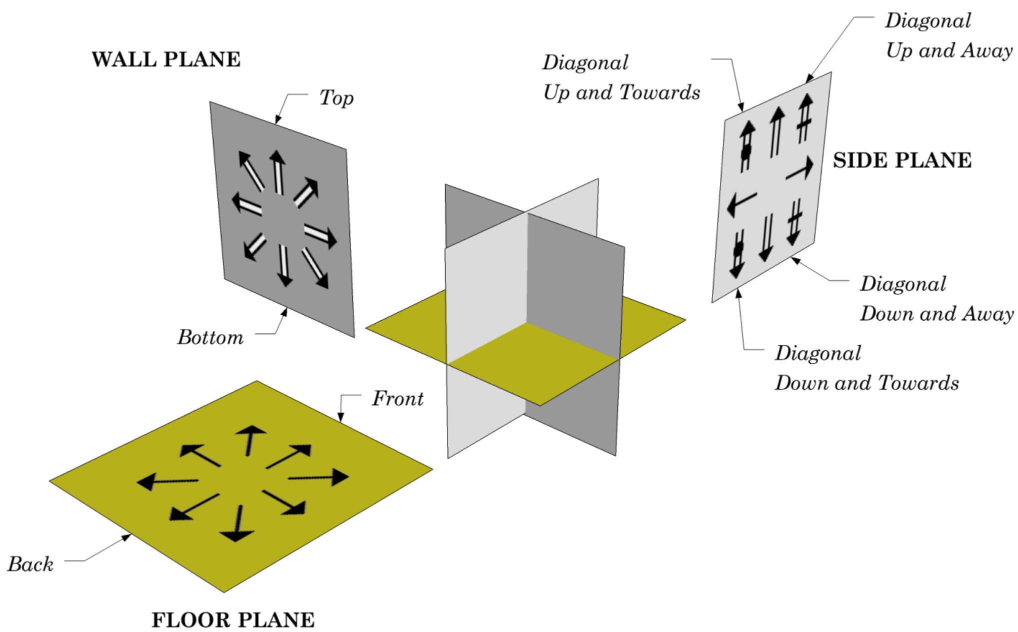
Figure 17 shows the three planes. In anatomical terms, the **WALL PLANE** corresponds with the frontal or coronal plane (the ventral, frontal, or x-plane for Brentari). The **FLOOR PLANE** corresponds with the transverse or axial plane (the transverse, horizontal, or y-plane for Brentari). The **SIDE PLANE** corresponds with the lateral or sagittal plane (the midsagittal or z-plane for Brentari).

Figure 17. Planes in SignWriting



These planes are important when discussing movement. Movement that travels up, down, or side-to-side parallel to a wall facing the signer is said to be movement "on the Wall plane". Movement that travels backwards, forwards, or side-to-side parallel to the floor is said to be movement "on the Floor plane". If one imagines a "wall" that cuts through the middle of the body from back to front, then movement that occurs parallel to this "wall" is said to be movement on the Side plane. Symbols representing straight movements are illustrated in Figure 18, but Chapter 3 will provide more details on these and other movement symbols.

Figure 18. Motion on the three planes



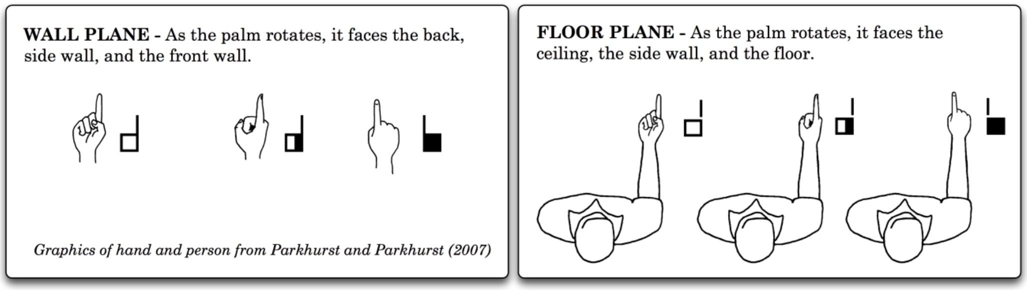
To keep writing simple, most writers only choose Side plane symbols when the movement cannot be represented by a symbol on the Wall or Floor plane. Typically, the Side plane is invoked to represent diagonal straight movements or curved movements that go up or down **and** forwards or backwards; circular movement in the Side plane involves all four directions, of course. In certain cases, one may find some overlap where planes share similar movement (such as side-to-side movement which can be written on either the Wall or Floor planes). Those instances are examples of **SYNOGRAPHS** (see Section 1.4.5) and writers typically select the most visually simple symbol. Throughout this paper, I refer to these planes when discussing orientation or movement.

1.4.3. Fills

A **FILL** is a term used to refer to shadings and other modifications that occur within the symbol, serving as a type of diacritic that modifies its interpretation. Fills are limited to hands and arrowheads. In Sections 2.3.4 and 3.3, I explain the use of fills in more detail. The following is a brief summary.

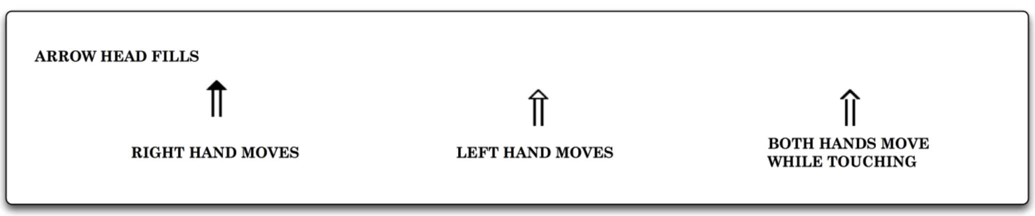
As shown in Figure 19, the fills for hands describe the orientation of the palm with respect to the Wall and Floor planes. Looking at the row of hands on the left, a black fill corresponds to the back of the hand whereas a white fill corresponds to the front of the hand. Therefore, a partial fill represents the hand facing to the side (with the portion shaded in black representing the back of the hand). By default, a hand symbol assumes the Wall plane (i.e., a line running from the wrist to the knuckles is parallel to the Wall plane). The row of hands on the right illustrates the strategy used to represent hands on the Floor plane. A gap where finger or thumb symbols attach to the hand symbol or a gap placed in the body of the hand symbol indicates a switch from the expected Wall plane to the Floor plane. This provides us with six fill positions for each hand symbol (the first three for the Wall plane and the second three for the Floor plane).

Figure 19. Fills for right hands



As shown in Figure 20, the fills for arrowheads have a different purpose in that they represent handedness. A black arrowhead represents movement by the right hand. A white arrowhead represents movement by the left hand. A neutral arrowhead (consisting of two sides of a triangle) means both hands are touching while they move together along the same path. Aside from fills for hands and movement arrowheads, fills are not used for other symbols in the system.

Figure 20. Fills for arrows



1.4.4. Rotations and reflections

Many symbols have an inherent directionality and, thus, can be rotated on the page. **ROTATIONS** are usually in 45° increments.[8] The left illustration in Figure 21 illustrates how rotation shows the alignment of the hands. This, coupled with the fill, can often imply which hand is represented. On the right, rotated arrows show the direction of the movement.

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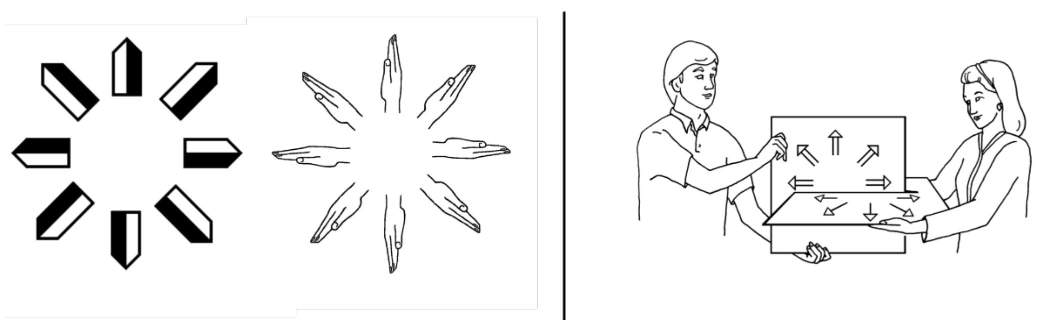
[8] Some combinations of rotation and fill are seldom used, since they represent orientations that are anatomically difficult or impossible.

Figure 21. Illustrations of hand and arrow rotations[9]



Rotations by the hands | *Rotation of directional movement arrows*

In many cases, the SignWriting symbol lists include a set of rotations and then a set of reflected rotations of the same symbol. **REFLECTIONS** are a function of the body's symmetry since articulators from both halves of the body participate in conveying separate but equally important information. For hands, the reflections serve as an additional indicator of handedness (discussed later in this section). For arrows, particularly with more complex arrows, the reflections show the set of opposite movements from the first set of rotations.

1.4.5. Synographs and homographs

A common challenge in SignWriting is dealing with synographs and homographs. **SYNOGRAPHS** are symbols that are visually distinct, but represent the same articulator or movement. For instance, the hand symbol (see 'oppose' in Figure 12) could easily have been written in the Floor Plane as . This is one ambiguity introduced by the interaction of rotations and fills with the availability of different planes. A similar issue arises with arrows when there is overlapping movement on different planes. For instance, horizontal side-to-side movements on the Wall and Floor planes are identical movements and so can be written on either plane. With any synograph, the writing convention is to use the less

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[9] Illustrations in this figure came from Parkhurst and Parkhurst (2007).

complicated symbol where possible. That is why, for instance, the sign ‘oppose’ is written with  instead of .

Homographs, on the other hand, are hand symbols that are visually similar, but represent distinct hand orientations that may need context or additional symbols for clarification. For instance, hand symbols with no additional finger symbols (such as ) are ambiguous when they are filled and unfilled as to whether the symbol represents the right or left hand. Visually, the same symbol can represent either hand. While handedness is usually clear when a symbol is half-filled, in these instances, additional context or clarification may still be needed. This visual ambiguity can be challenging when other tasks such as searching or sorting expect us to know the actual underlying representation. Methods of inputting SignWriting may need to take homographs into consideration, allowing ways to input and store disambiguating information that is not visible on the page, to ensure that these other types of language processing do not run into problems.

1.4.6. Handedness

While much of the sign language literature recognizes that sign language structure is independent of left- vs. right-handedness (and thus uses terminology such as strong versus weak hand), SignWriting tries to maintain a close phonetic connection to actual signing. By convention, writers write what they sign even if they sign left-handedly, so that a left-handed signer’s writing is reversed from a right-handed signer’s writing. There is limited anecdotal data that readers typically interpret what they read according to their own handedness even if it does not match what was written. In other words, the reader, not the writer, typically adjusts for differences between left-handed and right-handed signing—parallel to what happens in real-time use of the language.[10]

In SignWriting, the hand symbols themselves have no element that definitively shows whether a hand is left or right. However, it is usually possible to determine handedness by a combination of its location in reference to the center of the body, its location in reference to any other hand symbol(s) present, its fill, the placement of the finger symbols with respect to the base, its rotation, and its reflection. Where handedness is significant, yet these clues still leave the hand symbol ambiguous, the attachment of a limb symbol can sometimes help to identify if it is a left or right hand.

The only absolute identifier available is in cases where one or more directional movement arrows are involved. The arrowhead of each arrow must correlate with the handedness of the hand symbol to which it is attached. An exception, of course, exists when both hands are contacting and also moving together in the same movement. In those cases, the neutral arrowhead is used and there is no information from the directional movement arrows to distinguish left or right hands. However, handedness is not likely an issue when both hands are functioning as a unit.

1.4.7. Script directionality

Unlike the written conventions for most spoken languages, the current convention is to write signs in vertical columns from top to bottom. Until the 1990's, SignWriting followed the typical Western convention to write horizontally from left to right. Feedback from Deaf users indicated that it felt more natural to write in columns. Since the body itself is

[10] Indeed, experienced signers sometimes do not even notice whether another person signs left-handed or right-handed.

symmetrical across a vertical plane, a stream of signs written vertically appears to fit the flow of signing more naturally. Chapter 9 covers this in more detail.

1.4.8. Symbol opacity

A unique characteristic of SignWriting is its use of **OPACITY**. While usually the symbols are transparent, some symbols include opaque white areas in their definition. This use of transparency and opacity is particularly significant when symbols are stacked, in that opaque white areas hide black portions of the lower symbols. Their order of stacking (**Z-ORDER**) is significant in that it can determine which elements of the composed symbol actually come through.

The head circle is a good example. Normally, the diacritics for the head circle are either completely inside or completely outside of the symbol like one would normally expect. However, some diacritics are inside the head circle, but break outside. Such diacritics have some opacity defined so that it covers up the overlapping curve of the head circle. For instance, , , or  exhibit this. From time to time, I will mention where opacity is also involved with these symbols.

1.4.9. Use of diacritics

The ensuing discussion frequently mentions the use of diacritics. For most writing systems, diacritics are separate small symbols written near or attached to another symbol (e.g., á, å, ü, ñ, ç, etc.). In this analysis of SignWriting, I likely stretch the usual understanding of diacritics, but the analogy appears to be helpful.

Essentially, SignWriting has two classes of diacritics: regular diacritics and ligating diacritics. Regular diacritics follow expected patterns where a symbol is added to another symbol without changing the appearance of the first symbol. Ligating diacritics, on the other hand, induce a change in the form of the symbol to which they attach, i.e., the two symbols form a ligature. Instances of ligating diacritics will be noted as they occur.

CHAPTER 2

HANDS

2.1 Introduction

The most obvious articulators in sign languages are, of course, the hands. An accurate description of the hands is essential because they are the primary means of establishing contrast between signs. A description of the hands must take into consideration important elements such as the configuration of the hands and fingers, the position of the hands relative to the body, and the orientation and palm facing with respect to the floor or the wall. This chapter begins with the traditional way that SignWriting has described hand symbols. However, in trying to analyze the hand symbols, I have chosen a different analysis, which I describe in the remainder of the chapter. Further, I begin my discussion focusing on symbols used primarily for the right hand. Later in the chapter, I introduce the left hand.

2.2 Traditional SignWriting description

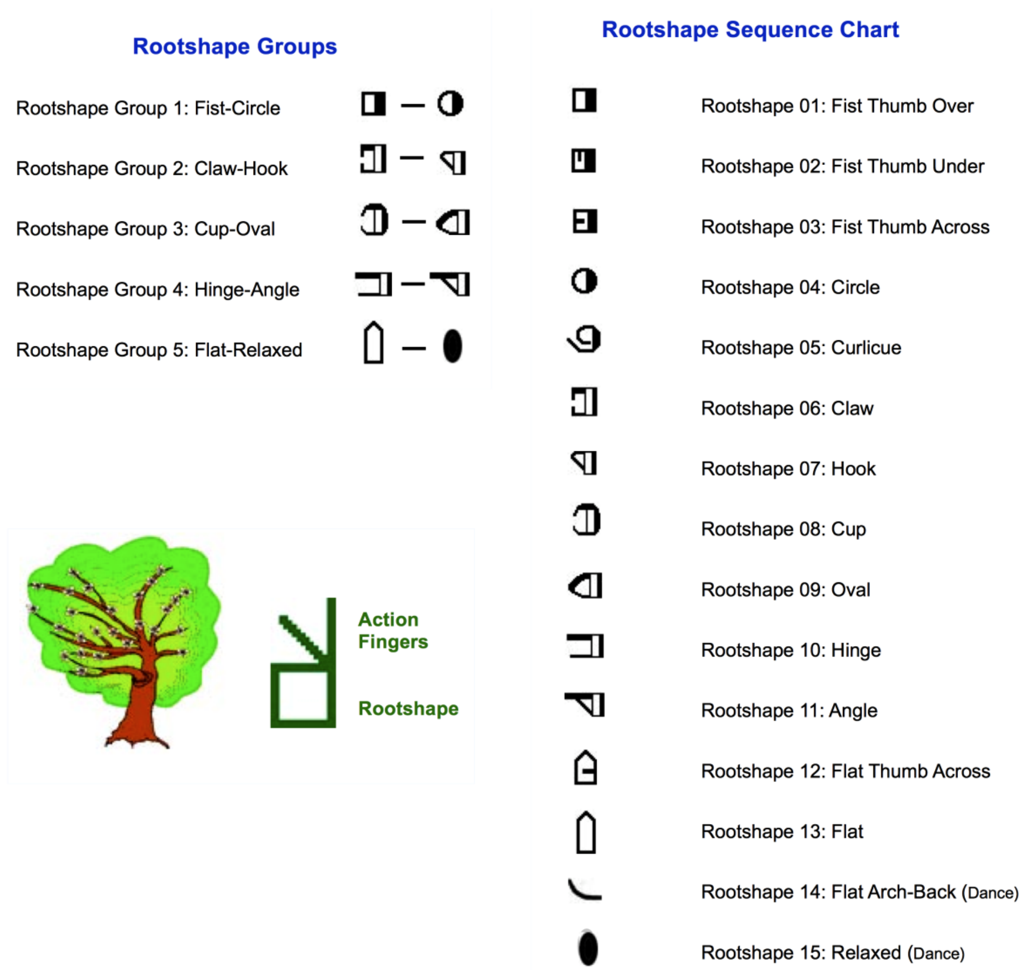
Sutton uses the concept of **ROOTSHAPES** to describe the basic forms of SignWriting hand symbols. She writes:

> SignWriting handshapes are built like a tree. Just as a tree has roots, each handshape has a root, or foundation shape, called the Rootshape. There are 15 Rootshapes in the International Movement Writing Alphabet. Most signed languages use around seven.
>
> The Rootshape is determined by the shape of the LOWEST finger in the handshape. Once the Rootshape is established, the lines for the fingers are attached. The finger lines are like the branches of the tree. They are called the Action Fingers.

Signers tend to focus on Action Fingers, since they give meaning to the handshape (Sutton, 2004b:72).

She developed the list of RootShapes in Figure 22 (taken from Sutton, 2004b:72-73). Of these Rootshapes, only numbers one through thirteen are actually used in SignWriting. Fourteen and fifteen are only used in DanceWriting. The RootShapes are organized into groups showing a general theme of open to closed. The construction of a specific hand symbol is a function of the Rootshape that best fits that handshape (which may include specification of one or more fingers) plus the addition of zero or more finger symbols to result in an accurate depiction of that handshape.

Figure 22. Sutton RootShapes and RootShape groups (Sutton, 2004b)



Sutton's description of SignWriting hand symbols using the concept of Rootshapes is meant to assist the user in creating a new hand symbol from scratch when the existing inventory of hand symbols does not yet include it. Using the Rootshapes, a user can decide which Rootshape comes closest to describing the configuration of the hand, and then add the Action Fingers to end up with a new hand symbol to depict the new handshape.

Unlike Sutton, the purpose of my analysis is to look at how the symbols in the system relate visually to each other, not only at their real world origin. As a result, my analysis of SignWriting handshapes is different than her description. To explain my analysis, I have adopted slightly different terminology to distinguish my analysis from her explanation of the system. The remainder of this chapter explains my analysis.

Before looking at the elements of a hand symbol, I should comment on an important aspect of Sutton's design for the hand symbols, its extensibility. Though SignWriting already contains an impressive inventory of hand symbols, certainly more than any one sign language would use, she has deliberately designed the system so that adding newly discovered handshapes is possible following the rules of composing a handshape. I will not go into further detail about composing new handshapes, however; my focus will be on the handshapes already present in the system.

2.3 Elements of a SignWriting hand symbol

2.3.1. Basic elements

Each hand symbol, conceptually, has an **EXEMPLAR** that represents a specific handshape independent of its palm facing, orientation, or handedness. An exemplar is a composite of two elements: the **BASE FORM** and finger symbols.[11] Usually, the representation for an

[11] I have chosen the term *base form* to avoid confusion with RootShapes.

exemplar is the symbol for the right hand where the palm faces the chest and is parallel to the wall.[12] The base form (Section 2.3.2) assumes a default configuration for the fingers and palm. Based on the definition of the base form, specific slots become available for finger symbols (Section 2.3.3) to attach. Those finger symbols describe the configuration of the fingers in the depicted handshape.

Simply specifying the base form and the finger symbols to arrive at an exemplar is not enough for the full specification of a handshape. Handshapes within a sign also contrast with one another based on the orientation of the palm. Hand symbols represent this orientation through fills (a combination of shadings and other modifications), rotations, and reflections. Fills (Sections 2.3.4 – 2.3.5) primarily describe 90˚ changes in palm facing and some information about orientation. Rotations (Section 2.3.6) describe orientation in 45˚ increments. Finally, reflections (Section 2.3.7) primarily help us distinguish between hands, but it should be remembered that some reflections could represent either hand. Now, with these modifications to the exemplar (fills, rotations, and reflections), the specific configuration of a handshape can be accurately depicted. So, to summarize, an exemplar is a combination of base form and finger symbols irrespective of its fill, rotation, or reflection. Fills, rotations, and reflections modify exemplars to arrive at a depiction of a specific handshape with a specific orientation.

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[12] An exception is the Heel base form, discussed below under the Palm Class. The Heel base form has only one fill, so exemplars for the Heel base form use that fill plus zero or more finger symbols.

2.3.2. Base form

Explanation of the analysis

In my analysis, I grouped exemplars whose basic form was similar. In turn, I found these base forms could be grouped into three major classes: the Fist class, the Palm class, and the Cup Class. The base forms are what I will describe in this section. I also found that each base form accepts only a limited set of finger symbols at designated locations. Some base forms may assume certain fingers are already in a given configuration, thus limiting the number of slots where finger symbols may attach.

To represent the various possibilities for each base form, I developed a base form diagram that illustrates the various possible finger slots. Table 2 illustrates two examples of a base form diagram. Since fills sometimes impact finger and thumb slots, base forms that manifest changes in finger and thumb slots—such as the example in (a)—have three forms shown in brackets. Each of the forms represents one of the first three fills (on the Wall plane). The fourth through sixth fills (on the Floor plane) use the same finger and thumb slots as the first through third fills, the only difference usually being the small gap within the base form or between the base form and the finger and/or thumb symbols. A subscripted number after the letter for the finger or thumb slot identifies which the fill is being represented (for instance, slot A in the second/fifth fill is noted as A_2).[13] Base forms whose finger and thumb slots remain the same through all fills—such as the example in (b)—have a single diagram and no subscripted numbers by the finger and thumb slots.

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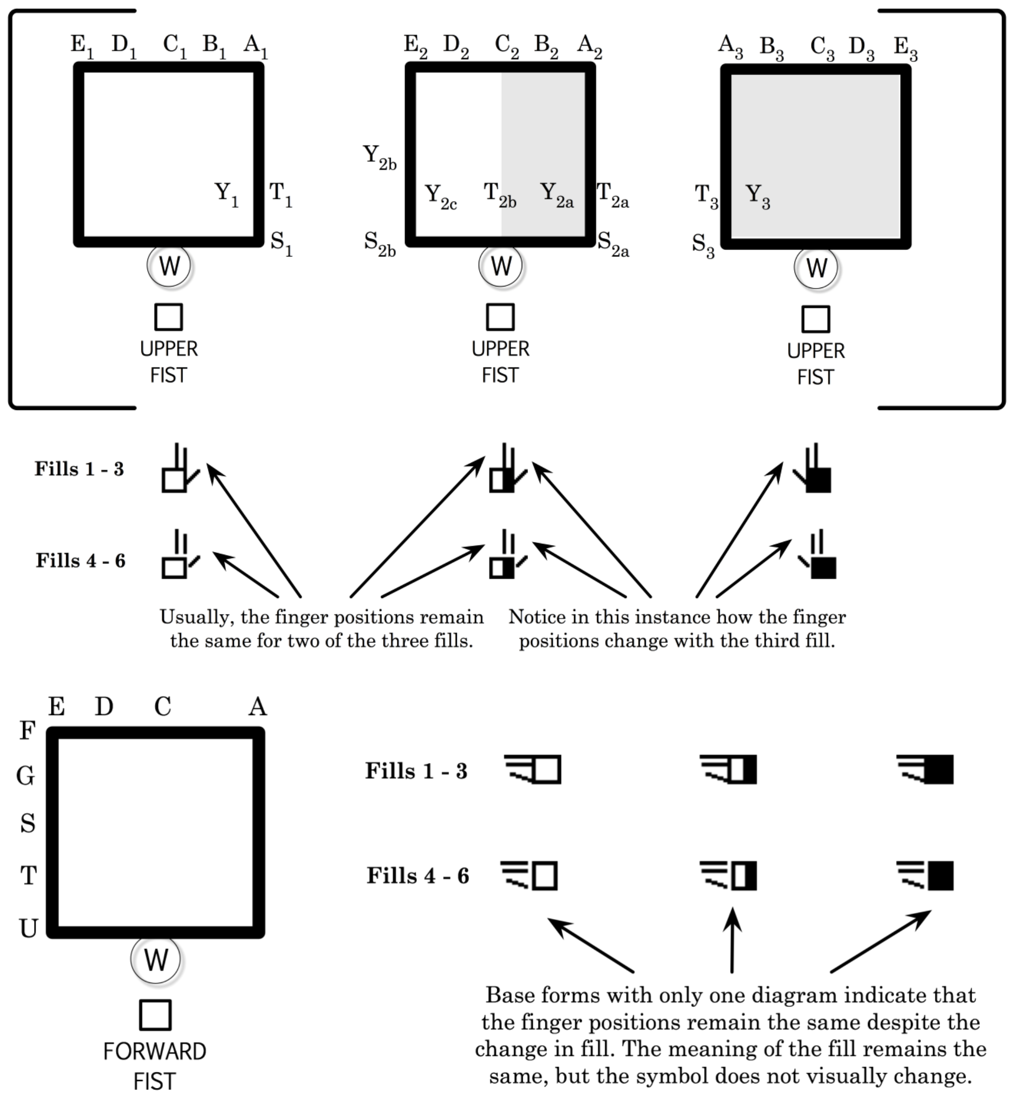
[13] The interactions between the fills and the finger symbols will be explained in greater detail in Section 2.3.5. For now, I am noting the positions so that the discussion will be clearer later.

Table 2. Example base form diagrams taken from the Fist class

(a)

(b)



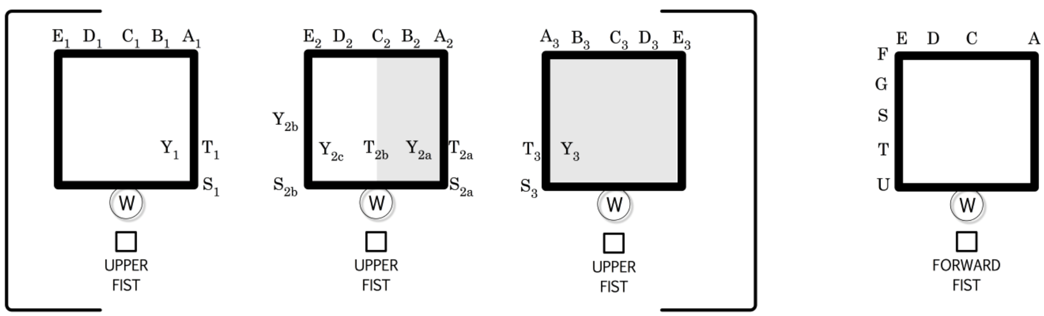
In both (a) and (b), a circled W in the diagram represents the implicit location of the wrist. On the base forms, I tag the available slots where finger/thumb symbols can be placed. The letters A-G represent finger slots and the letters S-Z represent thumb slots.

Fist class

The Fist class (containing four base forms) describes handshapes whose configuration is or approximates a fist. □ is the prototypical form for the closed fist hand symbols (such as is used for the ASL 's' handshape ). I list these base forms in Figure 23 and Figure 24.

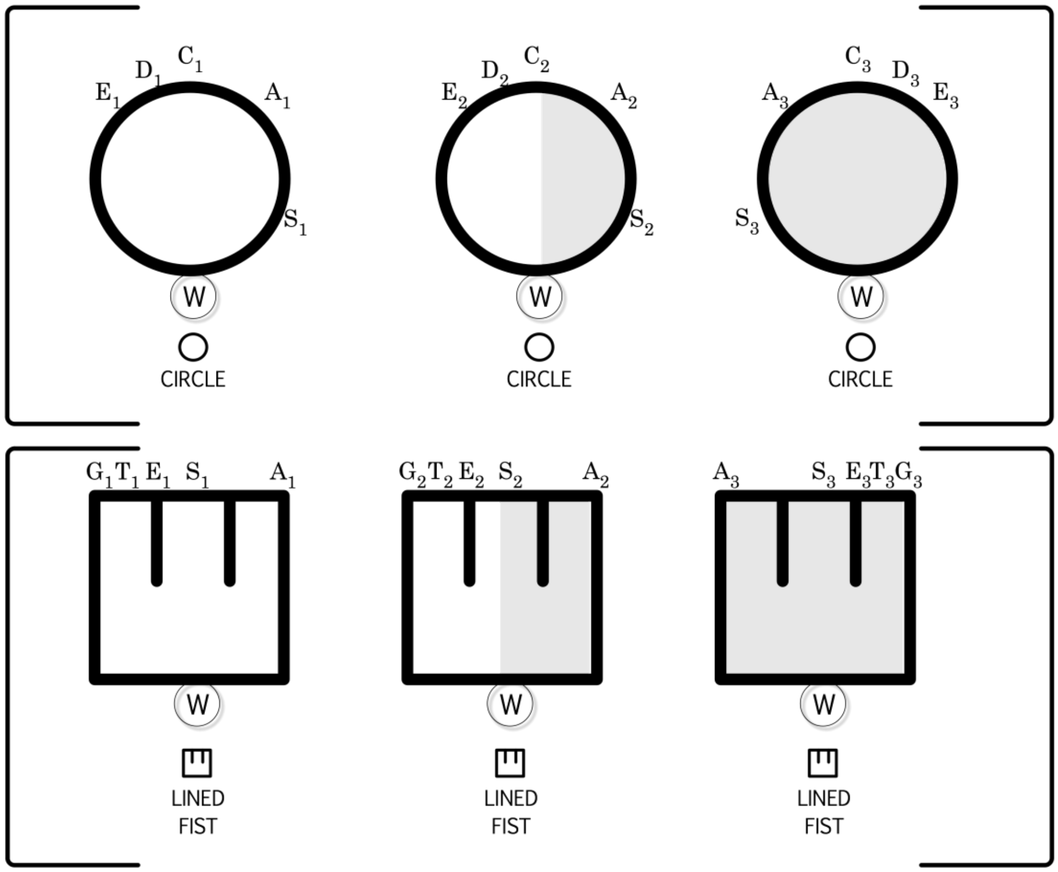
Exemplars using the □ can be divided into two base forms: Upper and Forward (Figure 23). Although they are visually identical (□), they attach the finger symbols and apply the fill rules differently. Upper □ represents handshapes where 1-3 fingers project upwards from the fist, i.e. fully extended. Some thumb symbols occur on the sides or inside the □. Forward □ represents handshapes where the fingers usually project forward from the fist, i.e. flexed at the first knuckle. For reasons discussed later, the finger slots for the Forward □ do not move in different fills, a design decision that does reduce the iconicity of this base form. It also does not accept any thumb symbols inside the □.

Figure 23. Fist Class: Upper and Forward Fist base forms



The other two base forms of □ are the CIRCLE (○) and LINED fist (□) (Figure 24). ○ represents open fist handshapes (such as the ASL 'o' handshape). ○ has a number of forms that are parallel to □. □ represents the thumb under one or more fingers (such as the citation form of the ASL 'm' handshape). This inherently limits the number of fingers that can be up, thus decreasing its productivity. In the exemplars below, only the index, ring, and little fingers are used with □. Neither of these two forms are as productive as □.

Figure 24. Fist Class: Circle and Lined Fist base forms

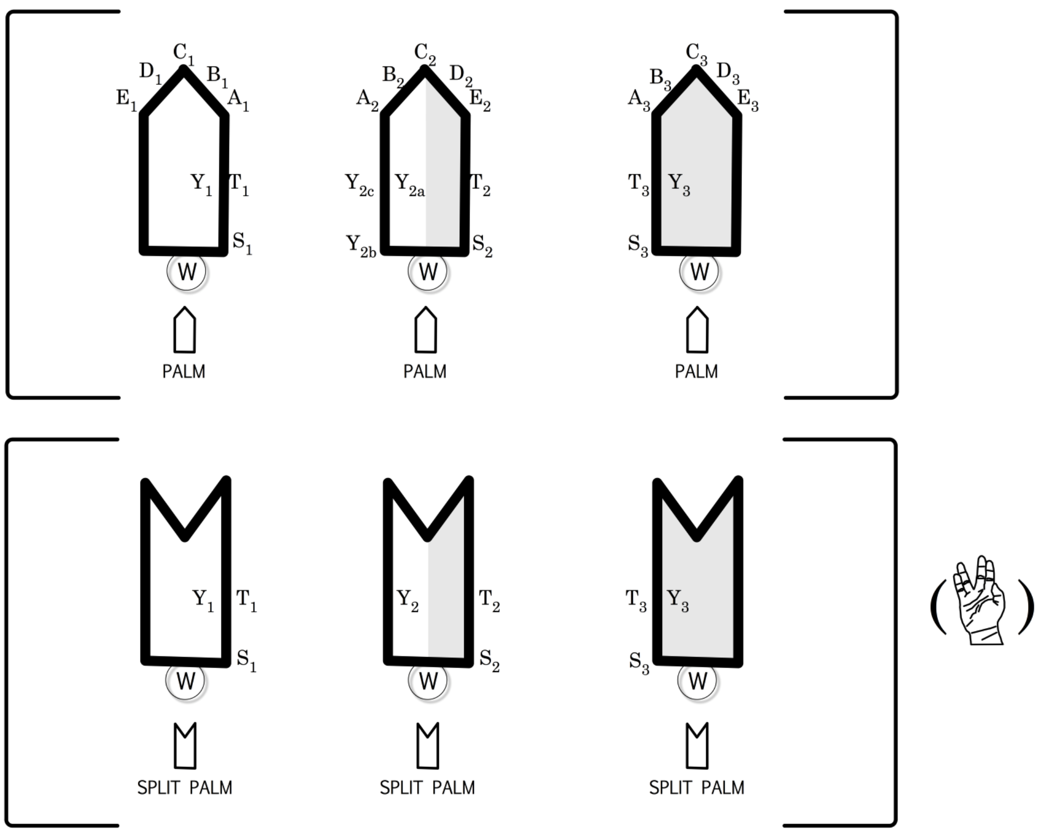


Palm class

This class represents handshapes based primarily on a flat hand viewed from the palm, i.e. with all four fingers partially or fully extended. Five base forms exist in this class. Similar to what we observed with the Upper and Forward □, two base forms in the Palm class (Mirrored and Static) use the same visual shape (▯), but attach finger symbols and apply the fill rules differently.

▯, which represents a flat palm, accepts finger symbols on the top of the symbol with the thumb allowable either on the one side inside or outside the symbol. ▯, the Split Palm, represents the hand with the fingers spread in two groups. It only accepts the thumb outside or inside the symbol, and no other finger symbols, since the two peaks at the top of the symbol represent the four fingers as two groups of two. Both of these shapes are illustrated in Figure 25.

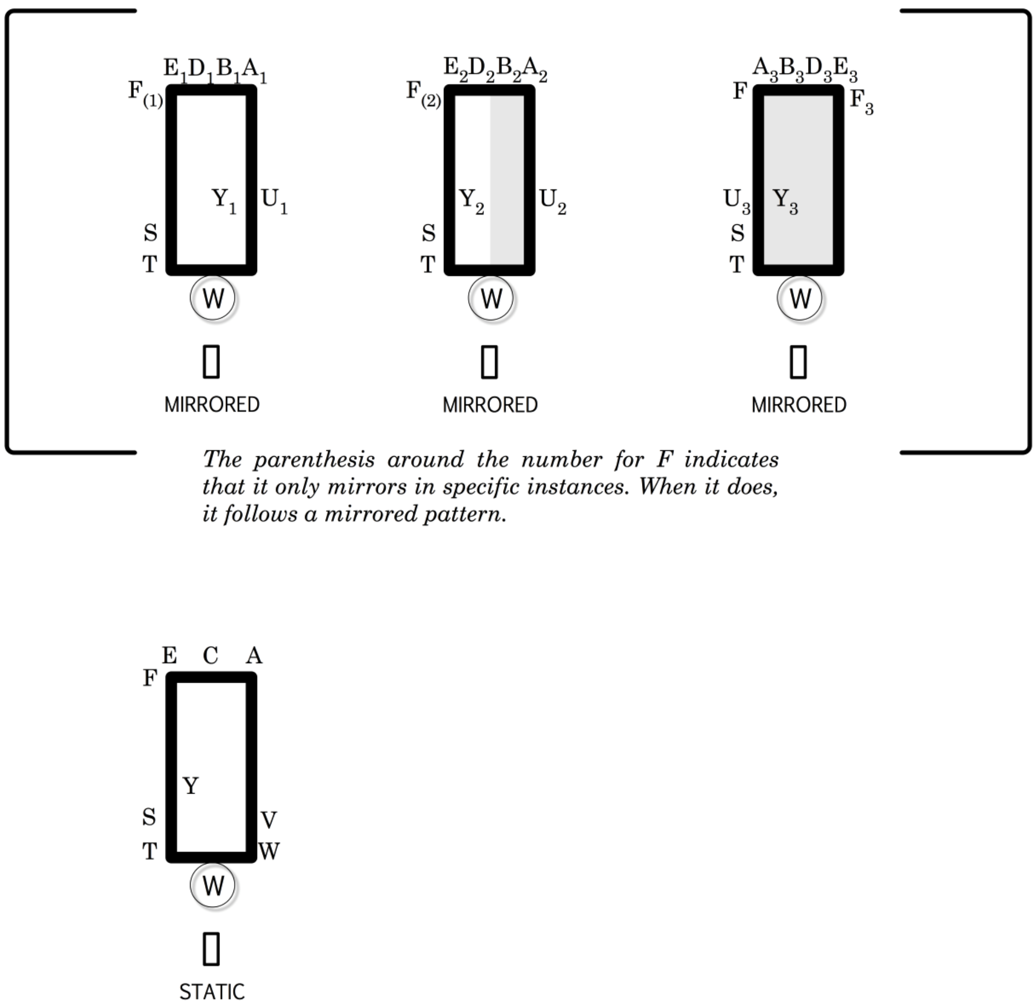
Figure 25. Palm Class: Palm and Split Palm base forms



The unmarked rectangle (▯) shown in Figure 26 is used for handshapes where all the fingers are away from the palm but not all extended or hooked (Parkhurst & Parkhurst 2008:61). I have grouped these rectangle forms under two base forms, Mirrored and Static, to reflect whether their finger slots move or not in different fills. In this way, the Mirrored and Static Rectangles follow a similar pattern as the Upper and Forward Fist symbols. While Upper Fist and Mirrored Rectangle have finger slots that move, Forward Fist and Static Rectangle do not have finger slots that move.

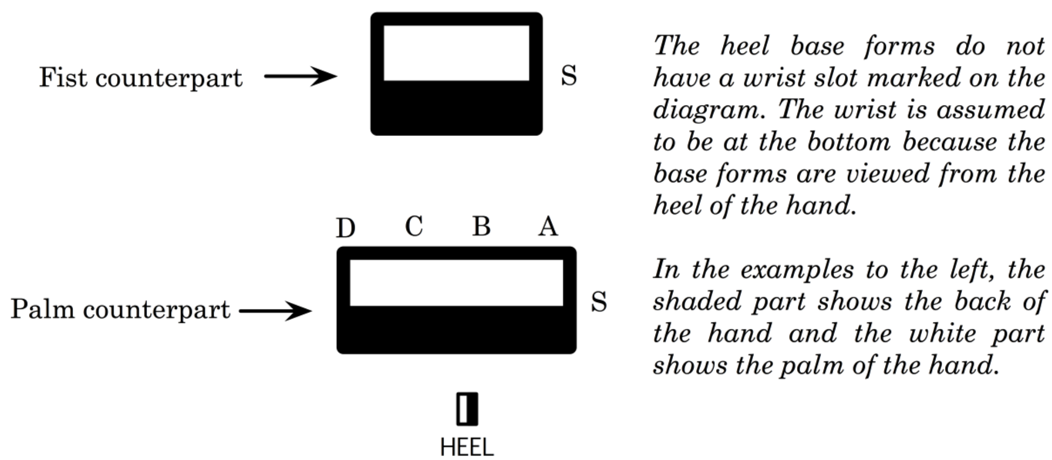
The two Rectangle base forms attach finger symbols to the hand as if the hand was viewed from the side, but the fill alters the visual implication to show the hand facing toward or away from the reader. These base forms can accept one or more of the four fingers along the top of the symbol and one or more fingers facing forward at an angle. The thumb can be placed inside the palm, as a forward thumb, as a side thumb, or not at all.

Figure 26. Palm Class: Mirrored and Static Rectangle



Finally, the heel base forms, as shown in Figure 27, represent the heel of the hand. These two unique base forms have no palm facing toward or away from the body. Rather, they are designed to handle instances where the hand is best viewed from the heel of the hand. The challenge in transcribing some signs can be resolved by using these base forms.

Figure 27. Palm Class: Heel



Perhaps, an example will make things clearer. The ASL sign 'boat', shown in Figure 28, has hands facing each other at a 45˚ angle. None of the normal fills handle a 45˚ angle palm facing. This left two choices: additional fills to handle 45˚ palm facings (adding more complexity to the system) or the addition of a set of simple corresponding exemplars under one of the Heel base forms that can handle most (if not all) those cases through rotation. Between the two baseforms, only seven exemplars have been precomposed.

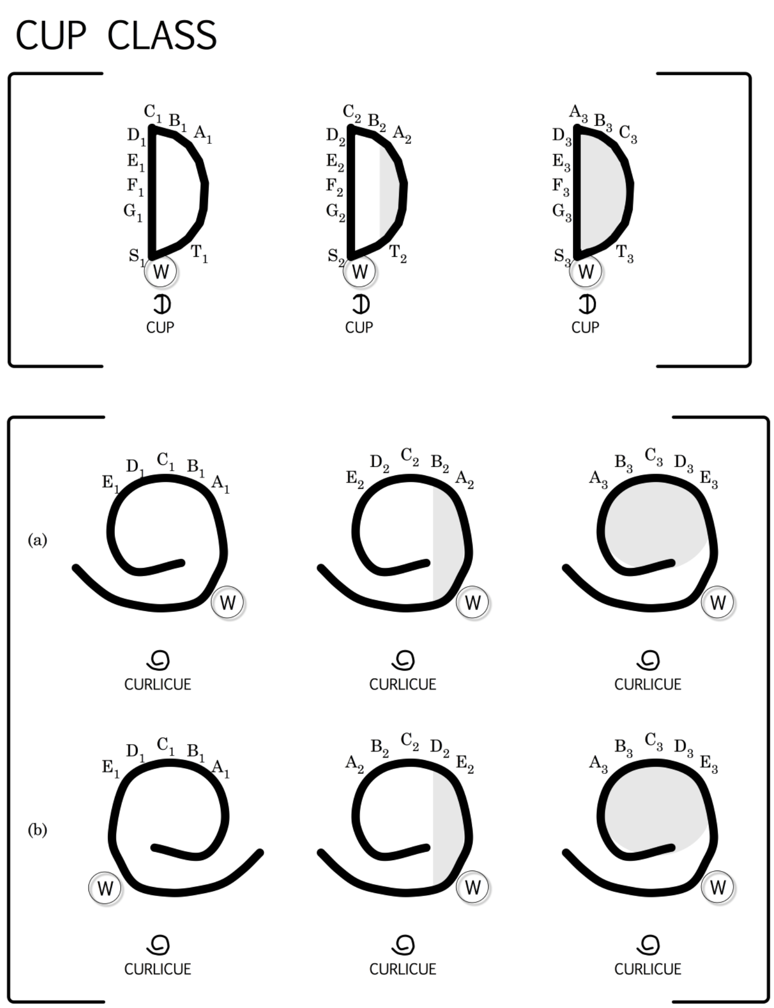
Figure 28. Heel base form example (ASL sign 'boat')

Cup class

Symbols in the Cup class focus on the cupped hand. They represent the hand when forming variations like holding a cup or forming a ‘C’ with the hand ( ). Two base forms exist in this class with the Curlicue base form only including a few exemplars. I list these two base forms in Figure 29.

The Cup base form focuses on the cup shape and is slightly more productive. The second base form, , represents a curlicue handshape with the index and/or other fingers tightly closed against each other with a space between them and the base of the thumb.

Figure 29. Cup Class: Cup and Curlicue base forms



2.3.3. Finger symbols

Each of the base forms accepts finger (or thumb) symbols that attach in specific slots on the base forms. Each finger symbol expresses a specific configuration of one or more fingers. By far, the greatest variety between handshapes lies in the variation of finger configurations. While SignWriting contains an impressive inventory of precomposed hand symbols, flexibility in the system requires a way to manually compose a new hand symbol. This section presents my analysis of finger symbols used in existing hand symbols.

Finger symbols can be grouped into three categories as follows:

- **INDEPENDENTS**: Independents appear regularly alone and/or with other symbols and do not change appearance when different fills are suggested.
- **POLYMORPHS**: These finger symbols can change appearance and/or location depending on which fill is selected (e.g.,  which follows this paradigm: , , , , , and ). In this section, I simply list the initial finger symbol for a polymorph (the form that is used in the exemplar). I defer the discussion of the actual changes that occur until Section 2.3.5.
- **LIGATURES**: These are symbols that represent multiple fingers and can attach at one or more slots (e.g.,  in ). Some ligatures include polymorphs, which I note in the charts with an asterisk (*). Sometimes, fingers may spread into adjacent slots. Some symbols within a ligature may change slightly when they appear in combination with other symbols. Other ligatures occur when one or more symbols typically occur as a group.

To represent these different ways that fingers attach in the chart, I have expressed them formally using one of the following patterns[14]:

---

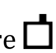
[14] The syntax of my patterns is as follows: Items in italicized brackets represent choices between types of symbols. The vertical bar (|) represents an "or". Bolded brackets represent a list of finger slots to explain where the fingers attach. Any polymorphs in the ligature

- *symbol:* a finger symbol that attaches at one slot
- *polymorph*:* a finger symbol that changes appearance when fills are applied
- *[polymorph* | symbol]* **[***list of slots***]**: a finger symbol (whether independent or polymorph) that attaches at more than one slot
- *[polymorph* | symbol]* **[***list of slots***] &** *[polymorph* | symbol]* **[***list of slots***] …**: a set of finger symbols that appear visually distinct but typically appear together.

Because the set of finger symbols available to each base form varies, each base form has two tables. The first is a table of possible finger symbols arranged by available slots. The second table lists exemplars for all precomposed hand symbols currently in the ISWA 2008.

In each listing of precomposed exemplars for a base form, columns represent thumb slots and rows represent finger slots. Each exemplar has a reference to its **BINARY SIGNWRITING CODE.**[15] My analysis does not assign a specific ordering to finger symbols, but rather focuses on the slots on the base form that the hand symbol uses. Column or row headings referring to symbols that depict the thumb are shaded in grey.

Finger symbols for the Upper Fist

Table 3 describes the finger symbols for the Upper Fist base form, and Table 4 lists the precomposed hand symbols that belong to this base form. Symbols that attach to slots S, T, Y, and Z are symbols that depict the thumb. The only exceptions are  and  where the finger symbol in slot B actually represents the thumb.

---

column have an asterisk (*) following the slot specifications (if any). Finger symbols joined by an ampersand (&) are visually discrete but tend to appear together as a group.

[15] Appendix A explains in more detail. SignWriting assigns a code to each glyph in the system. The more familiar code has a series of numbers separated by dashes (e.g., 01–01–001–01–01–01). However, to save space, I use the integer-based Binary SignWriting code in this chapter and in the following charts.

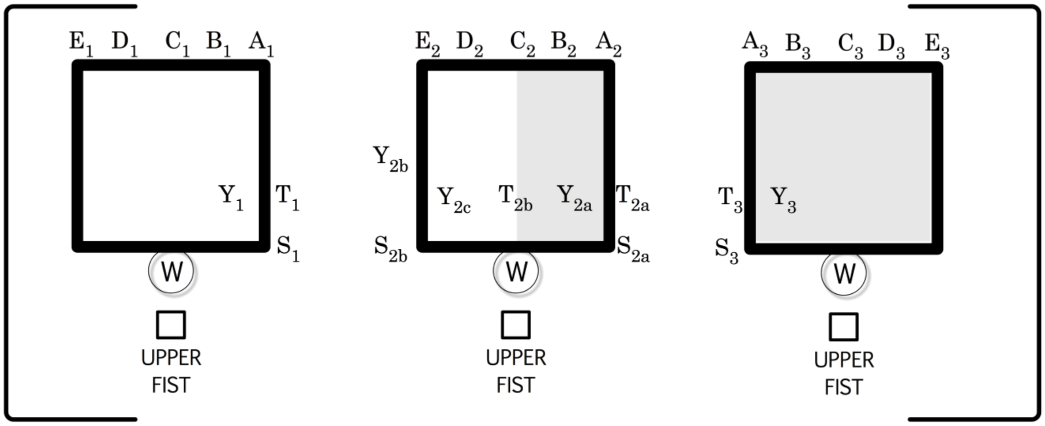
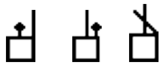
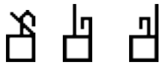
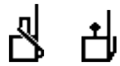
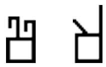
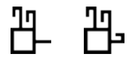
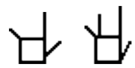


Table 3. Upper Fist finger symbols

□	Independent	Polymorph	Ligature
A	▌, ꟸ, ⌐	●, •	* [AC], [AC] [A] & [D] [C] & [A]*
B	▪		[BD]
C	▌	•	[CS], [CDE]
D	╲		
E			[ES]
S			
T		▬	
Y	▪	•	

Table 4. Upper Fist precomposed hand symbols

□	Ø	S	T	Y
Ø	24064	23008 23104 23200	22816	7168 23296
A	256 832 1120 1216 1312 1504 1792	20608 20704 20800 2944 3424	20512 20896 21088 20992 3136	21184 21280 3808
B	23392 2080 2368 2464	4480	4384 4864 4576	5056
C	18592 2848 16960 12928 13408	18784 13600		
D	16480 17056	17248		
E	13984 14464 16576	14560 14656		

□	Ø	S	T	Y
AC	 1888 1984 2560  2752 2176 2272	 4672 3616	 4960 3520 3712	
AD	 1696 17152	 13792	 3232 3328	
AE	 15232 15616 17440	 14848 18400		
CE	 19072	 18976		
BD	 18880			
BE		 16192		
ACE	 16000			
CDE	 19168			

Finger symbols for the Forward Fist

Table 5 describes the finger symbols for the Forward Fist base form, and Table 6 lists the precomposed hand symbols that belong to this base form. Symbols that attach to slots S, T, and U are symbols that depict the thumb.

Here is the first base form that only has a single form in the base form diagram rather than three forms as shown for the Upper Fist base form. The single form indicates that the finger slots **do not** move for this base form when the fills are applied. As a general rule, most handshapes whose fingers extend out from the palm have a baseform that does not use moveable finger slots. The reason is this: look at the palm with one or more fingers extended out from the palm, or turn the hand with palm facing away. The extended fingers cannot be seen easily, or not at all. To deal with this, Sutton's design decision was to let the finger symbols retain a "side view" and indicate orientation only by means of the fills. The discussion on fills and the interaction between fills and fingers will give additional insight.

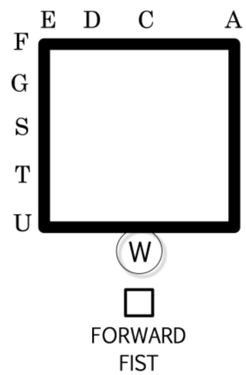
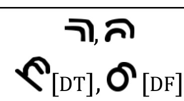
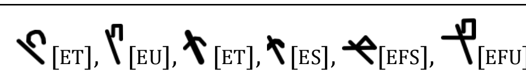
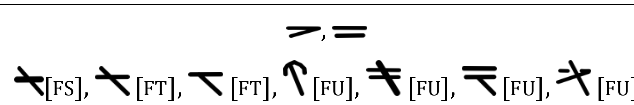
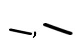


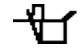
Table 5. Forward Fist finger symbols

	Independent	Ligature
C		 [CDF]
D		 [DT], [DF]
E		 [ET], [EU], [ET], [ES], [EFS], [EFU]
F		 [FS], [FT], [FT], [FU], [FU], [FU], [FU]
S		
T		

□	Independent	Ligature
U		

Table 6. FORWARD Fist precomposed hand symbols

□	Ø	S	T	U
C	13312 13504			
D		5152	4096	
E			21472	21376 21568
F	21856	22624	22336 22432 22528 22720	21760 22048 21952 22144 22240 4192 5920 6016 6112 4288
CE		5728	5632	5344 4768
CF	5824			
DE				3904
DF	4000			
EF	5440 5536	6208 6304	6400 15040 15136	5248 6496

	Ø	S	T	U
CDF	 13888			
AEF			 16384	 16288

Finger symbols for the Circle

Table 7 describes the finger symbols for the Circle base form, and

Table 8 lists the precomposed hand symbols that belong to this base form. Finger symbols that attach to slot S are symbols that depict the thumb.

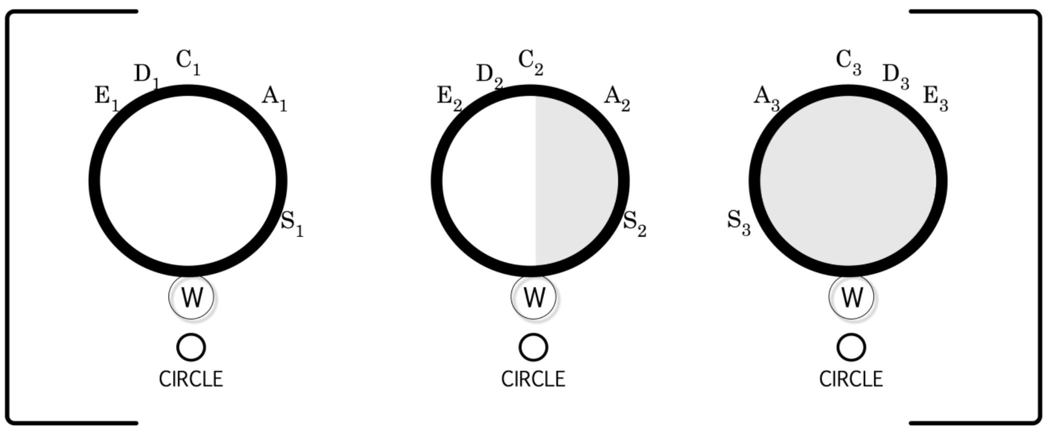


Table 7. Circle finger symbols

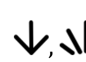
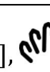
	Independent	Polymorph	Ligature
A			 [AC]
C			 [CDE],  [CDE]
E			
S			

Table 8. Circle precomposed hand symbols

○	Ø	S
Ø	11392	
A	352 928 1408 1600	3040
C	18688 13024	
E	16672 14176	

○	Ø	S
AC	2656	
AE	15328 15712 17536	
ACE	16096	
CDE	19264 19936	

Finger symbols for the Lined Fist

Table 9 describes the finger symbols for the Lined Fist base form, and Table 10 lists the precomposed hand symbols that belong to this base form. has three irregular forms (, , and) where the humps representing fingers over the thumb are not used elsewhere in the system. Since the Lined Fist symbols show the thumb under one or more fingers, it is unique in that the thumb, in slots S and T, can appear above the knuckles where only fingers usually appear for the other base forms. A is used for the index finger, G is used for the little finger, and E is used for the ring finger.

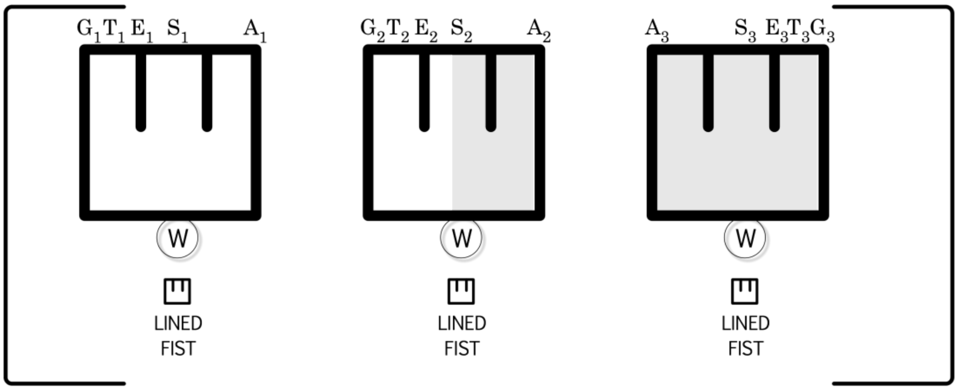


Table 9. Lined Fist finger symbols

	Independent	**Ligature**
A		
G		
S		
T		[TE]

Table 10. Lined Fist precomposed hand symbols

	Ø	S	T
Ø	23968 23680 23872 23776	23488	23584
A	1024		
G	14080		
E			17344

Finger symbols for the Palm and Split Palm

Table 11 describes the finger symbols for the Palm and Split Palm base forms, and Table 12 lists the precomposed hand symbols that belong to these base forms. Finger symbols that attach to slots S, T, and Y are symbols that depict the thumb.  also has a special variant  that represents a 45˚ fill, although, commonly, a Heel base form is used instead. The Split Palm base does not accept any finger symbols except for the thumb.

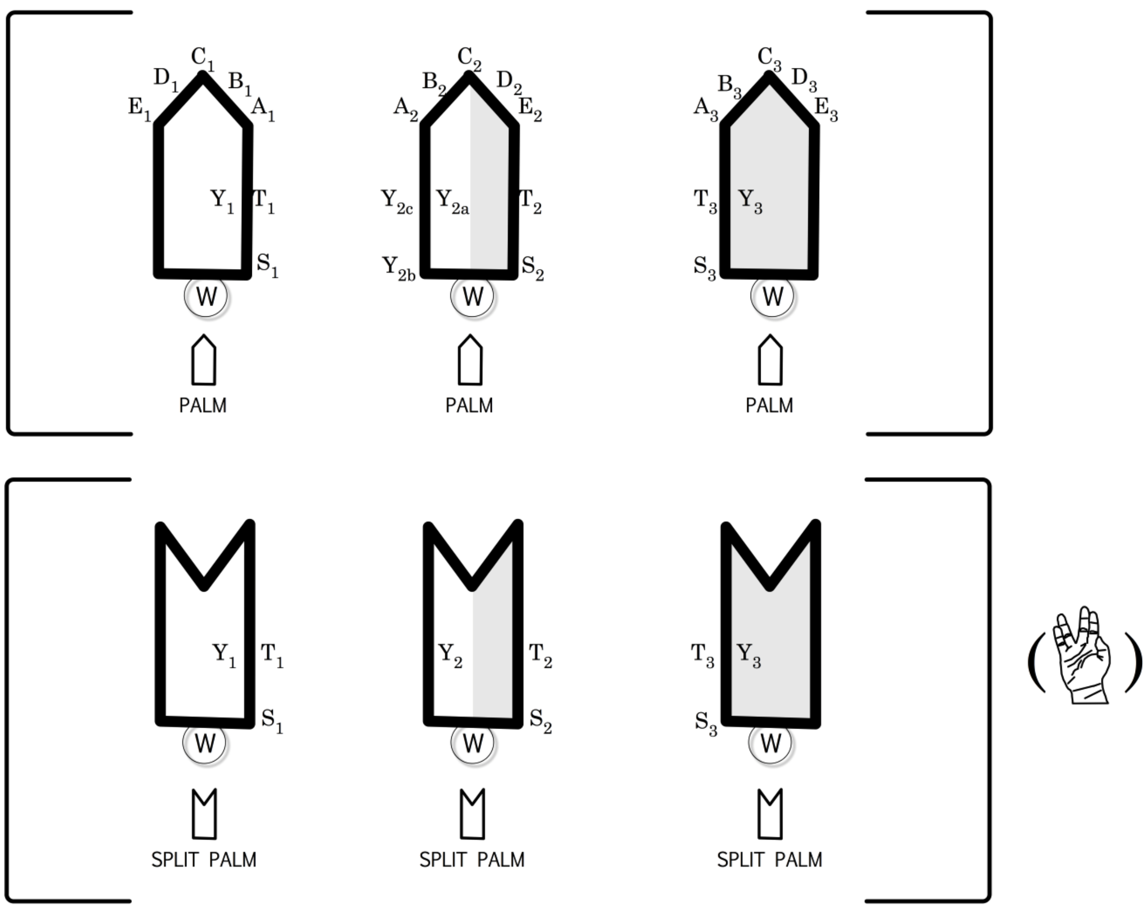


Table 11. Palm and Split Palm finger symbols

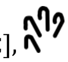
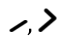
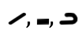
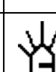
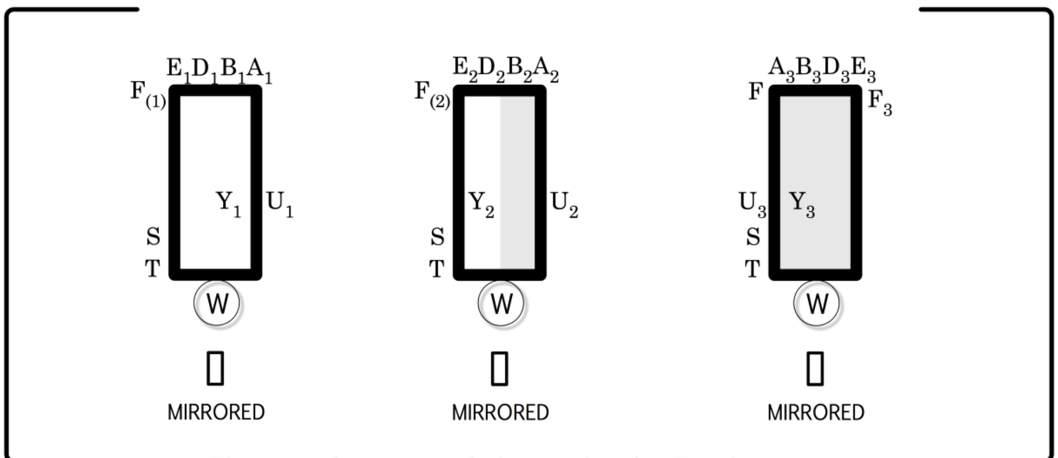
	Independent	Polymorph	Ligature
A			
B			 [BCDE],  [BCDE]
E			
S			
T			
Y			

Table 12. Palm and Split Palm precomposed hand symbols

	Ø	S	T	Y
Ø	 8704  8800  9472	 8992  9184  9664	 9568	 6880  9280  6976
A			 9376	
E	 9760			
BCDE			 7360  7552  7744	 6592  6688  7936

Finger symbols for the Mirrored and Static Rectangle

Table 13 describes the finger symbols for the Mirrored and Static Rectangle base forms, and Table 14 and Table 15 list the precomposed hand symbols that belong to these base forms. Finger symbols that attach to slots S, T, V, W, and Y, are symbols that depict the thumb. The Mirrored base form has two special exemplars where the base form is oblique (and). As the diagram notes, slot F for the Mirrored base form typically does not move, but, in at least one exception, it does. When F does move, F follows the numbered slots in the diagram. The single diagram for the Static Rectangle base form indicates that the finger symbols do not move under different fills similar to what we observed for the Forward Fist.



The parenthesis around the number for F indicates that it only mirrors in specific instances. When it does, it follows a mirrored pattern.

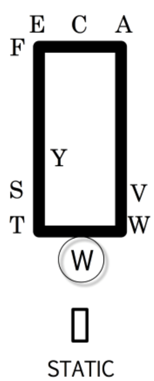


Table 13. Mirrored and Static Rectangle finger symbols

	Independent	Ligature
A	,	[ABDE], [ACE], [A] & [ET]
C		
D		[DEF]*
E	,	
F	[16], , , , , , ,	[FS], [FT], [FS], [FS], [FT], [FT], [FT], [FT], [FT], [FS], [FS], [FS], [F] & [S], [F] & [T]
S	,	
T	,	
V	,	
W		
Y		

Table 14. Mirrored Rectangle precomposed hand symbols

	Ø	S	T	V	Y
F	12448			12256	
AF		736	544 640		
EF		16864 14368	16768 14272		

[16] Only applies to symbols 12448 and 12256.

	Ø	S	T	V	Y
AEF		15520 18112 18208 18304	15424 17728 17824 17920		
ABDE	8608			8512	6784 8416
ADEF				13696	

Table 15. Static Rectangle precomposed hand symbols

	Ø	S	T	W	V	Y
F	10048 10816 11680 12544	10336 11872 10240	9856 10144 10432 11008 11488 11776 11968 12064 12160 12832 12640 12736		9952 10624 11584 12352	7072 7264
AE			21664			
CF		13120 13216				
EF					14752	
AEF		15904 15808			14944 18496	

	Ø	S	T	W	V	Y
ABCD		19552 19648 19744 19840 20416	20032 20224 20320	20128		

Finger symbols for the Heel

The Heel base forms are unique in that they only accept one fill. This correlates with their purpose to mitigate the need for 45˚ fills in other base forms. Exemplars derived from the Heel base forms represent handshapes from the vantage point of the heel of the hand. So far, only 7 exemplars have been precomposed. The corresponding finger symbols and the available precomposed symbols are shown in Table 16 and Table 17.

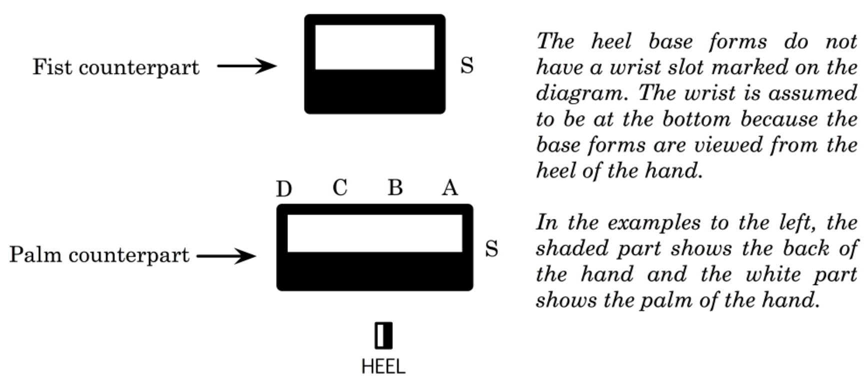


Table 16. Heel finger symbols

	Independent	**Ligature**
A		[ABCD], [ABCD]
S	, ,	

Table 17. Heel precomposed hand symbols

	Ø	s
Ø	8912 24176	9104 22928
ABCD		7472 7664 7856

All of the Heel exemplars have counterparts in the other classes (five from the Palm class and two from the Upper Fist class). Exemplars associated with the Palm base form are more flat and wide; exemplars associated with the Upper Fist base form are slightly taller and narrower. Table 18 shows the seven Heel exemplars with their counterparts.

Table 18. Palm/Fist exemplar counterparts for the Heel exemplars

Heel							
Palm/Fist							

Finger symbols for the Cup

Table 19 describes the finger symbols for the Cup base form, and Table 20 lists the precomposed hand symbols that belong to this base form. Finger symbols that attach to slots S and T are symbols that depict the thumb.

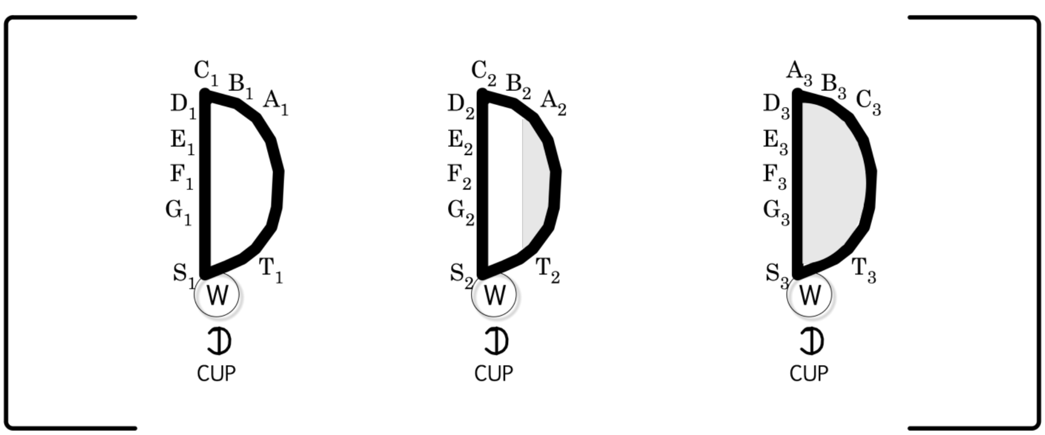


Table 19. Cup Finger finger symbols

	Independent	Ligature
A		[ABC]
C		
D		[DEFG] & [S] [DEFG] & [S] [DEFG] & [S] [D] & [F] & [S]
S	,	
T		

Table 20. Cup precomposed hand symbols

	Ø	S	T
D	10912	10528 11104	10720
AD		448	
DF		8320	
ACD		18016	
ABCD		19456	
DEFG		8032 8128 8224	

Finger symbols for the Curlicue

The Curlicue base form is not very productive. It is restricted to only four exemplars. Two (namely and) are the only exemplars that use additional finger symbols and both follow a different pattern for the fills. follows pattern (a) below while follows pattern (b). Table 21 shows the finger symbols used, and Table 22 shows the four available exemplars.

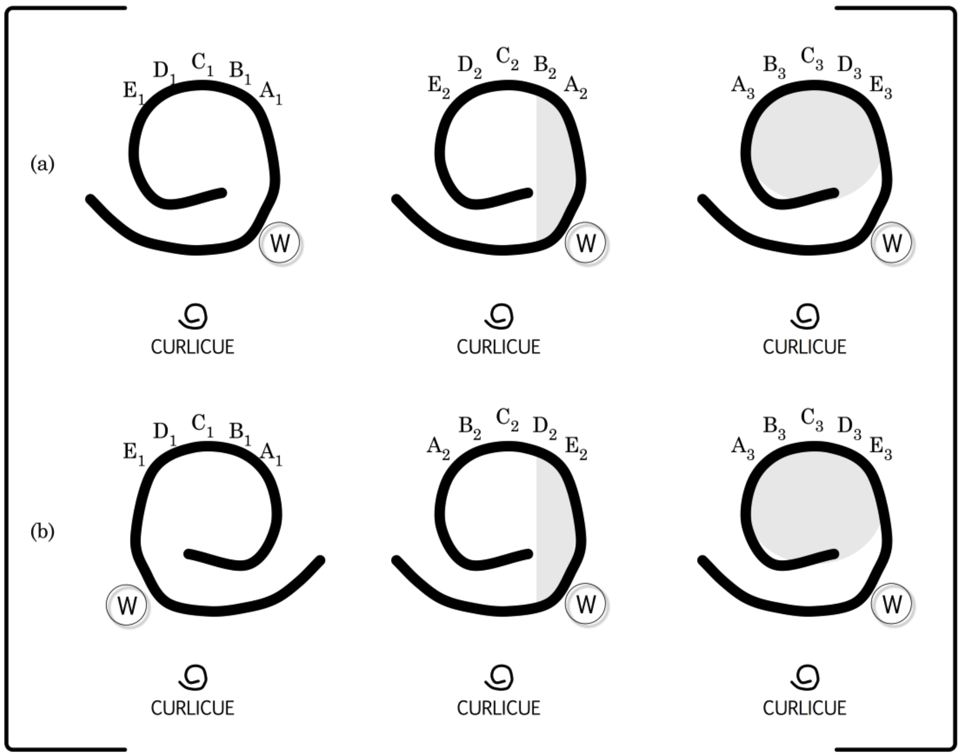


Table 21. Curlicue finger symbols

	Independent	**Ligature**
A	ǀ	
C		ǀ⁄⁄ [CDE]
D	ǀ	
E	\	

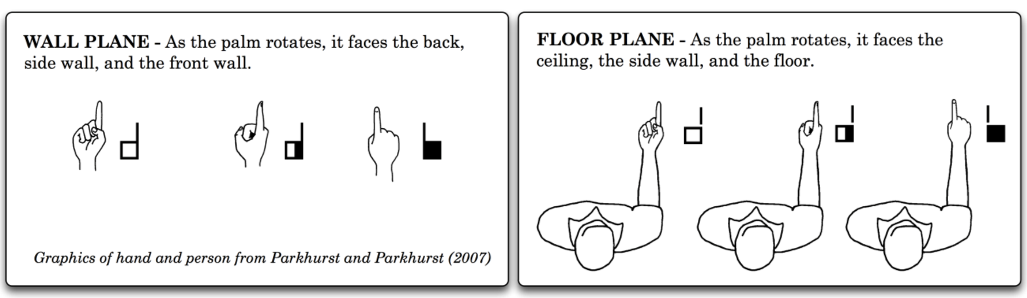
Table 22. Curlicue precomposed hand symbols

	Ø
Ø	 11296 11200
ADE	[17] 17632
CDE	 19360

2.3.4. Fills

Fills refer to the shading or other modifications to the exemplar to indicate the relationship of the palm of the hand to the Wall and Floor Planes. As described earlier in Figure 19 (and reproduced here), black shading corresponds with the back of the hand whereas white shading (actually an opaque white) corresponds with the palm. Therefore, a partial fill represents the hand facing to the side (with the portion shaded in black representing the back of the hand). The use of a gap (either between the fingers or within the symbol) signals that the hand is oriented on the Floor plane.

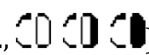
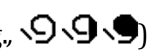
Figure 19. Fills for right hands



Each base form has a specific matrix that determines how the fill is applied. Figure 30 illustrates the matrices for each base form. For the Wall Plane, the back of the hand is

[17] As a side note, the line drawing for the third handshape matches the hand symbol in form, but not in orientation. But this helps to visualize the handshape better.

represented with all cells filled and the palm of the hand with all cells empty. A partial fill occurs when only the even cells are filled. Any fingers (or parts of fingers) that lie within filled (or unfilled) cells take the reverse color (e.g., the thumb being black in  versus the thumb being an opaque white in ).

For the Floor Plane, a visually similar yet distinct pattern is used. The system uses a concept called a "gap" that distinguishes the hand symbols on the Floor Plane as opposed to the Wall Plane. This "gap" usually appears in one of two places in the symbol: separating the fingers from the base form (e.g., ), or through the upper part of the base form (e.g., ), including the bounding lines of the base form (which are normally black). The usual rule is that if finger symbols are present, the gap separates the fingers from the base form. If no finger symbols are present, then the gap appears in the upper part of the base form, occupying cells 3 and 4 for Fist Class base forms (e.g., ) and for Palm and Split Palm base forms in the Palm Class (e.g., ). For the Cup base form, all fingers including those at slots D and S have a gap (e.g., ).[18] For the Curlicue base form, the bottom stroke of the symbol (representing the thumb) takes a "gap" in the middle of the stroke with any additional fingers also exhibiting a gap (e.g., ).

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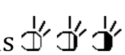
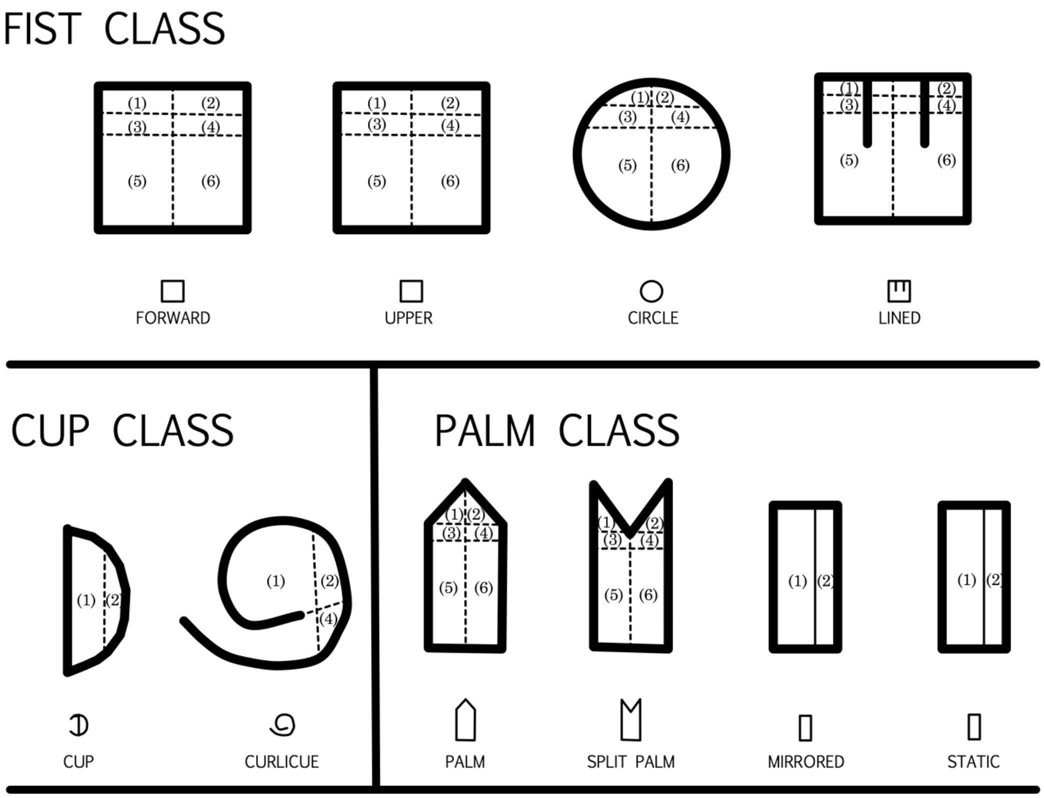
[18] One exception for the Cup base form is  (19456 / 01-09-004-01-01-01).

Figure 30. Fill matrices for each base form

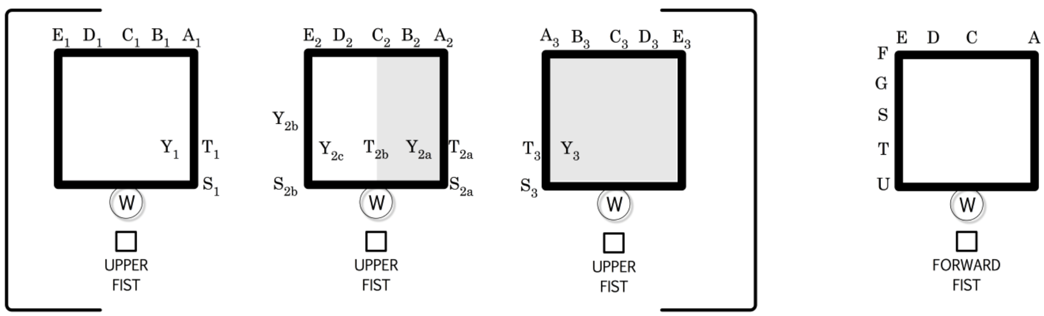


2.3.5. *Interactions of fills and finger symbols*

Initially, the interaction of base form, finger symbols, and fills may appear to result in a seemingly complicated set of hand symbols that can appear at times to be somewhat random. However, there are rules that govern this interaction. This section attempts to enumerate those rules, starting with some general concepts followed by rules for specific finger symbols (in particular, polymorphs and ligatures).

The first rule, shown in (1), describes the attachment of finger symbols. A finger symbol attached to a specific slot remains attached to that same slot, even if the slot "moves" to a different location on the base form because of a change in the fill. Comparing examples (a) and (b) in (1) with the possible slots for the Upper Fist in Figure 23, the finger symbol attaches at the initial slot A_1. Following the paradigm, the finger remains attached to slot A through the successive applications of the fills. The second part of the rule describes the fact that the finger symbol by default keeps the same orientation when attached to that slot.

Figure 23. Fist Class: Upper and Forward Fist base forms



(1) *Fill Default #1* Unless a specific finger or thumb rule states differently, finger and thumb symbols remain attached to their initial slot and maintain their original orientation.

Examples:

(a) 

(b) 

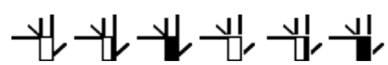
The next rule shown in (2) describes which base forms (or exemplars) tend to move slots and which do not move slots. In general, this is marked at the base form level, but the curlicue base form has some exemplars that move slots and some exemplars that do not. In general, the movement of slots allows the system to preserve iconicity. As a general rule of thumb, if the underlying base form is looking at the handshape as being one in which fingers project forward, it does not tend to move the slots; otherwise, it reorders the slots, usually mirroring them. Examples in (a) and (b) do not represent forward-projecting handshapes and so the slots move between fills, but the examples in (c) and (d) represent handshapes that do project forward and so the slots for all fills are the same.

(2) *Fill Default #2* If an exemplar belongs to a Forward Fist, Static Rectangle or is not either of the two exceptions for the Curlicue base form, the slots for fingers does not move. Otherwise, the slots for fingers will move according to the template for that base form. Slots are moved in order to preserve iconicity.

Examples:

(a) 

(b) 

(c) 

(d) 

	Class	**Class**	**Class**
Slots allowed to move	Upper Lined	Mirrored	[and]
Slots not allowed to move	Forward	Static	[and]

The next rule shown in (3) describes an exception to the rule that a finger symbol keeps the same orientation once attached. Thumb symbols placed on the outer slots typically flip if the slot moves to the other side of the base form. This rule helps preserve iconicity in the appearance of the symbol. In (a), the thumbs flip in fills 3 and 6, which preserve the iconicity of this exemplar.

(3) *Fill Default #3* Rather than retaining their original angle of attachment to their slot, thumb symbols attached to the outer slots always flip if the slot moves to the other side of the symbol.

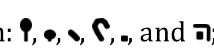
Examples:

(a) 

The next rule shown in (4) describes the usual pattern to have finger and thumb symbols detach from the base form during fills 4-6 as seen in example (a). There are a few observed exceptions as noted in the rule. In (b) – (d), the finger symbol remains attached to the base form in all fills, and a gap is present within the base form instead for fills 4-6.

(4) *Fill Default #4* (a) When finger symbols attach to the base form, they always detach from the base form in fills 4-6.

The only exceptions are as follows:

(b) the following finger/thumb symbols (when they appear alone) place a gap within the base form: ;

(c) when only the thumb attaches to the Palm or Upper Fist base forms;

(d) one exception from the Curlicue base form

The next rule shown in (5) describes another general exception to the rule stated earlier in (1). Straight fingers attached at slots B-E on the Palm base form typically flip. For example, if angled to the upper right when attached on one side of the base symbol, they angle to the upper left when attached to the other side. Again, this is a concession to iconicity. An example is given in (a).

(5) *Fill Default #5* Straight fingers in slots B-E on the Palm base form flip if the slot moves to the opposite side of the peak of the base form.

Examples:

(a) 

The primary challenge for describing finger attachments in different fills involves polymorphs and ligatures. Often they attach differently or they change the way the fills operate. In Table 23, I describe the rules for polymorphs and ligatures that require additional handling beyond the current rules. The first column notes base forms that are affected by the rule. The second column identifies the finger or thumb symbol in question. The remaining columns fill in the paradigm for the finger or thumb symbol in question.

If the letter Q is used to refer to a slot rather than a valid letter for an actual slot, it means the finger or thumb symbol can appear in more than one slot and it remains in whatever slot it is initially placed. If a finger or thumb symbol appears with another finger or thumb symbol, a rule for that combination overrides any default established when the finger or thumb symbol appears alone. Each rule includes an example of a specific finger symbol in use. Some rules are unique to one exemplar; others apply across several exemplars. To save space under the Base form column, these abbreviations are used:

UF = Upper Fist | Ci = Circle | P = Palm | Cu = Cup

FF = Forward Fist | LF = Lined Fist | SP = Split Palm

Table 23. Additional rules for fills for specific finger symbols

Base form	**Sym**	**Fill 1**	**Fill 2**	**Fill 3**	**Fill 4**	**Fill 5**	**Fill 6**	**Note**
UF, Ci		Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	
UF		A_1	A_2	A_3	A_1	A_2	A_3	
UF, Ci		A_1	A_2	A_3	A_1	A_2	A_3	
UF		A_1	A_2	A_3	A_1	A_2	A_3	
UF		C_1A_1	A_2	A_3C_3	C_1A_1	A_2	A_3C_3	

Base form	Sym	Fill 1	Fill 2	Fill 3	Fill 4	Fill 5	Fill 6	Note
UF		D_1A_1	D_2A_2	A_3B_3	D_1A_1	D_2A_2	A_3B_3	
UF, Ci		C_1A_1	C_2A_2	A_3C_3	C_1A_1	C_2A_2	A_3C_3	
UF		C_1A_1	C_2A_2	A_3C_3	C_1A_1	C_2A_2	A_3C_3	
UF		C_1	C_2	C_3	C_1	C_2	C_3	
UF		Y_1	Y_{2B} S_{2B}	Y_3	Y_1	Y_{2B} S_{2B}	Y_3	
UF		B_1S_1	B_2S_2	S_3B_3	B_1S_1	B_2S_2	S_3B_3	
UF		T_1	T_{2A}	T_3	T_1	T_{2A}	T_3	[19]
M		$E_1D_1B_1A_1$	$E_1D_1B_1A_1$	$E_1D_1B_1A_1$	$E_1D_1B_1A_1$	$E_1D_1B_1A_1$	$E_1D_1B_1A_1$	

[19] This rule is unique to only one exemplar (4864 / 01-03-021-01).

Base form	Sym	Fill 1	Fill 2	Fill 3	Fill 4	Fill 5	Fill 6	Note
UF		Y_1	Y_{2C}	Y_3	Y_1	Y_{2B}	Y_3	
P		Y_1	Y_{2C} Y_{2B}	Y_3	Y_1	Y_{2C} Y_{2B}	Y_3	20
P, SP, M		Y_1	Y_{2A}	Y_3	Y_1	Y_{2A}	Y_3	
M		Y_1	S	Y_3	Y_1	S	Y_3	
M		$F_1E_1D_1$	F_2 D_2	$D_1E_1F_1$	$F_1E_1D_1$	F_2 D_2	$D_1E_1F_1$	
UF		D_1B_1	D_2B_2	B_3D_3	D_1B_1	D_2B_2	B_3D_3	
UF, Ci, LF, M		E_1	E_2	E_3	E_1	E_2	E_3	
UF		E_1	E_2	E_3	E_1	E_2	E_3	

[20] For Fills 2 and 6, the rule selects slot Y_{2C} if the base form has other fingers attached, but slot Y_{2B} if the base form has no fingers attached.

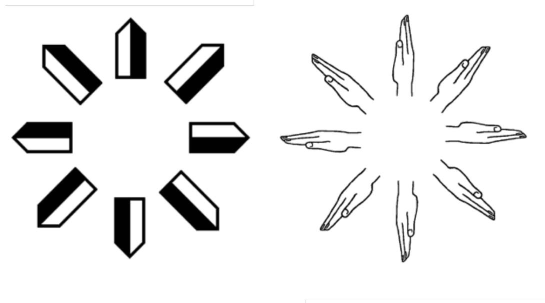
Base form	Sym	Fill 1	Fill 2	Fill 3	Fill 4	Fill 5	Fill 6	Note
UF		E_1T_1	E_2T_{2A}	T_3E_3	E_1T_1	E_2T_{2A}	T_3E_3	
UF, Ci		Q_1	Q_2	Q_3	Q_1	Q_2	Q_3	
UF		C_1	C_2	C_3	C_1	C_2	C_3	
UF, Ci, M		E_1	E_2	E_3	E_1	E_2	E_3	
LF		F_1E_1	F_2E_2	E_3F_3	F_1E_1	F_2E_2	E_3F_3	
UF		D_1B_1	D_2B_2	B_3D_3	D_1B_1	D_2B_2	B_3D_3	
Cu		$C_1B_1A_1$	$C_1B_1A_1$	$C_1B_1A_1$	$C_1B_1A_1$	$C_1B_1A_1$	$C_1B_1A_1$	
UF		T_1	T_{2B}	T_3	T_1	C_2	T_3	

2.3.6. Rotations

Rotations show the actual angle of the specified fill in 45˚ increments (a set of eight rotations). Writers typically choose an exemplar, a fill, and then a rotation that best describes the handshape. Figure 24 illustrates rotation for the flat palm hand symbol.

Rotations and fills work together to provide information on the actual orientation of the hand. Unlike fills, rotations make no other modifications to the symbol itself.

Figure 24. Rotations for the Palm hand symbol (Parkhurst and Parkhurst 2007)



Rotations by the hands

2.3.7. Reflections

Until now, this discussion has focused on the graphemes for the right hand. How does SignWriting handle the graphemes for the left hand? While this is not clearly stated in the literature or in the symbol lists, graphemes for the left hand are the reflections of the graphemes for the right hand. In the ISWA, reflections are handled as another set of rotations that are reflected. For the hands, these are rotations nine through sixteen. Like rotations, reflections do not modify the hand symbols in any other way.

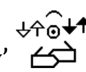
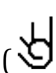
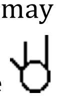
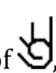
It should be noted that, though I have explained these symbols using right hand/left hand distinctions to this point, that distinction is not cut and dried. The interaction of fill and reflection are generally interpreted to represent the hand that can most comfortably assume that configuration. Some reflections are anatomically possible for both hands (though usually uncomfortable for one of them). For instance, in BKSL, a language from a remote village in northern Thailand with less than 1,000 users, it is possible to have a sign like in Figure 31 where the reflection actually still depicts the right hand. In this case, the writer must add a limb symbol to clarify which hand is being depicted.

Figure 31. BKSL 'foreigner' (Harrison 2007:232-234)

Still, left and right hands are usually discernable after the application of all the available modifications. Limb symbols showing the arm can also be added when the location of the wrist is ambiguous or when movement or contact occurs with the arm. I discuss armlines and other symbols representing the torso and hips itself in Chapter 5 .

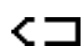
2.4 Principles for selecting a hand symbol

As a general rule, the hand symbols selected in writing signs are no more complex than necessary. Early in their use of SignWriting, most writers tend to err on the side of caution and write as much detail as they can. Over time, experienced writers begin to agree on specific conventions on how to write including how to represent the set of handshapes actually used in their sign language. In some cases, the hand symbol selected may not be phonetically accurate, but it may be acceptable since the readers understand what handshape to produce.

In other cases, the question is more about which exemplar to use. For example, the thumb's extension (such as in the ASL sign 'anyway' ) may or may not be significant for writing. The ASL sign 'anyway' could possibly be intelligibly read without the extended thumbs. Or, for instance, a particular sign language may not make a distinction between  () and  (), so a writer might be able to use  instead of , the former being admittedly more simple to write. In short, any application of SignWriting to a specific language should analyze that language's inventory of handshapes to see which handshapes are truly necessary and which are not. This is analogous to the way English uses the digraph *th* to represent both the voiced and unvoiced 'th' sounds (even though they are contrastive) or the way German uses the digraph *ch* to represent the same phoneme, even though it is phonetically distinct in *ich* and *Buch*.

In other cases, it may not be which exemplar to use, but which fill or rotation to use. Some fills are actually synographs of other fills because of the interaction between planes. Table 25 shows some examples using the basic palm hand symbol for the right hand (obviously, the reflected forms would be true for the left hand). Now, some of these positions may not be anatomically comfortable, but they illustrate how the interaction between fill and rotation can create synographs. In general, symbols without gaps are visually simpler, and so many choose the symbol without the gap over the symbol with the gap unless the symbol with the gap is necessary.

Table 25. Examples of fill synographs

Wall Plane	**Floor Plane**
	
	
	
	

CHAPTER 3

MOVEMENT

3.1 Introduction

The articulators in sign languages are not restricted to the hands and fingers. They also include the head, the eyes, the nose, the mouth, the tongue, the cheeks, the limbs, and the torso. These articulators in motion (or at rest, as the case may be) are a critical element in showing contrast between signs. This category of movement includes movement describing an articulator that moves along a specified path and non-path movement describing an articulator's change in configuration or spatial relation. Movement along a path, or directional movement, is generally written with an arrow to depict a change in location. Directional movement typically assumes two arguments: a specified articulator at the beginning of the movement and a specified articulator at the end of the movement. Often, one of the arguments can be assumed if the articulator does not change during the course of the movement.

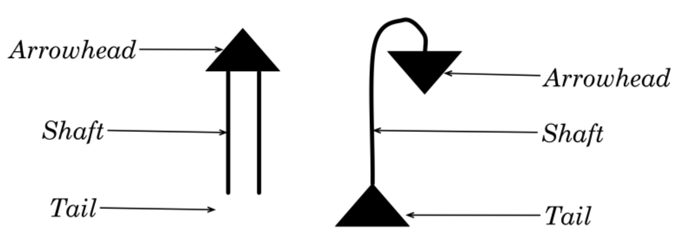
Describing an articulator's change in configuration or spatial relation requires a few different strategies. Obviously, if a handshape completely changes to a different handshape or orientation, then another hand symbol may be simplest. Otherwise, these changes are more often written with a diacritic that associates with the articulator or serves to note a relationship between articulators. Thus, some diacritics only accept one argument, the articulator that changed its configuration, or two arguments, the articulators whose spatial relationship to one another has changed. As I mentioned earlier in this section, it is important to remember that, while movement more frequently relates to the hands, these diacritics can also be used in relationship to other articulators.

3.2 Overview of directional movement symbols

3.2.1. Basic structure

Directional movement symbols describe the path of an articulator (usually the hand or arm) as it moves through space. Arrows take the general form shown in Figure 32. The **SHAFT** represents the path of movement. The longer the shaft, the longer the movement it represents. Some "arrows" used to represent rotation of the forearm do not have an arrowhead, but have the other properties of arrows, so it is appropriate to extend the term "arrow" to describe them. While most arrows have an empty **TAIL** like the first example in Figure 32, some arrows (as we describe later in this chapter) may have an element in the tail position like the second example in Figure 32.

Figure 32. General form of directional movement arrows



The **ARROWHEAD** usually takes one of three forms. The rule in (6) explains the convention for arrowheads. This applies to any arrow in the system. For arrows associated with the hands, the most common arrowheads will be ▲ for the right hand and △ for the left hand. ^ represents movement where both hands touch each other, their individual paths becoming indistinguishable as they take the same exact path in space during that motion.

For arrows associated with the fingers or some other part of the body, the only arrowhead used is ⋀. When writing a sign, the handedness expressed by the arrowhead must agree with the handedness implied by the choice of the hand symbol.

(6) Arrowheads for arrows describing the movement of the entire hand must agree with the handedness of the hand symbol with which it is placed. Arrows associated with the right hand use the **RIGHT ARROWHEAD** (▲). Arrows associated with the left hand use the **LEFT ARROWHEAD** (△).

An arrow referring to movement by the fingers or articulators other than the hands or an arrow referring to movement by two hands that remain in contact throughout the movement use the **NEUTRAL ARROWHEAD** (⋀).

Primary arrows representing the axis for the rotation of the forearm (**AXIAL ARROWS**) have no arrowhead.

Due to the necessity of representing three-dimensional movement on a two-dimensional surface, movement must be differentiated based on the Plane in which it occurs (i.e., the Plane that it is parallel to). Figure 33 provides examples of straight directional arrows. Generally, arrows with a double-lined shaft depict movement on the Wall Plane. Arrows with a single-lined shaft depict movement on the Floor Plane. Diagonal movement on the Side Plane uses a pair of diacritics placed upon arrows from the Wall Plane.[21] The bar through the shaft of the arrow represents motion that moves away from the reader; the large dot on the shaft represents motion that moves toward the reader.

[21] The diagonal Side Plane arrows in Figure 33 are shown from the side to illustrate what they mean, but they are actually used in Normal view. The diagonal movement is either moving up or moving down. As such, they are written straight vertically. The diacritic

Where planes intersect, there may be several synographs to select from. As elsewhere in the system, writers tend to balance consistency with simplicity. If, for instance, other arrows in the sign use the Wall Plane, then the first choice would be a Wall Plane arrow if it accurately depicts the movement. Otherwise, the simplest arrow is usually preferred.

Figure 33. Straight arrows on the movement planes

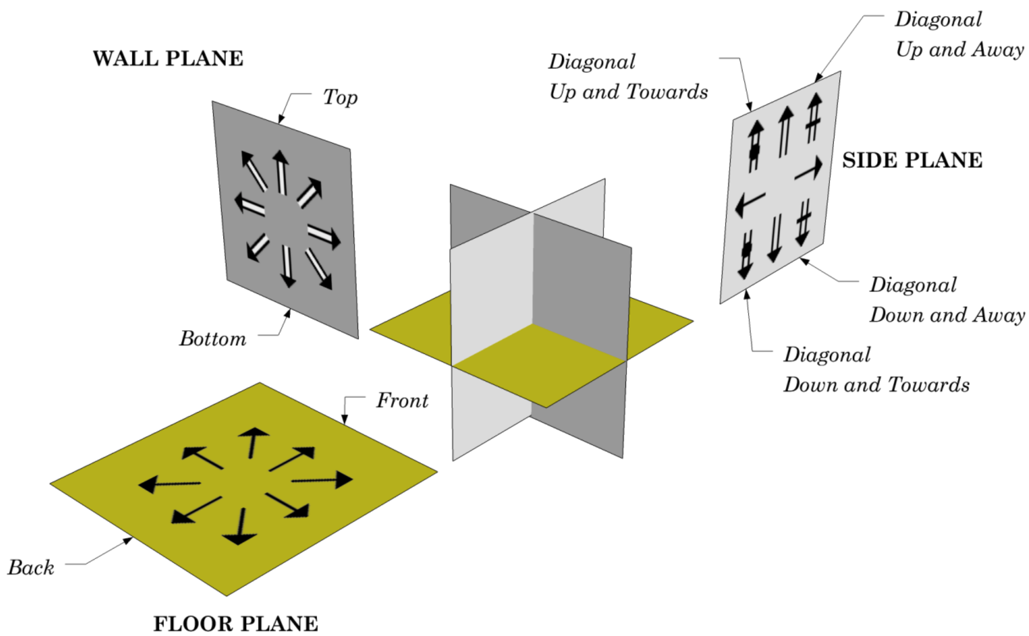


Figure 34 depicts the set of curved arrows. The system maintains a general consistency in the design of the shaft of the arrows. Arrows on the Wall Plane use the double-lined shaft. Arrows on the Floor Plane use the single-lined shaft with an added distinction: thick portions of the shaft imply motion closer to the reader and thin portions of the shaft imply motion further from the reader. Arrows on the Side Plane use either a single-lined shaft or a double-lined shaft depending on whether the curve is (roughly) parallel to the Floor Plane

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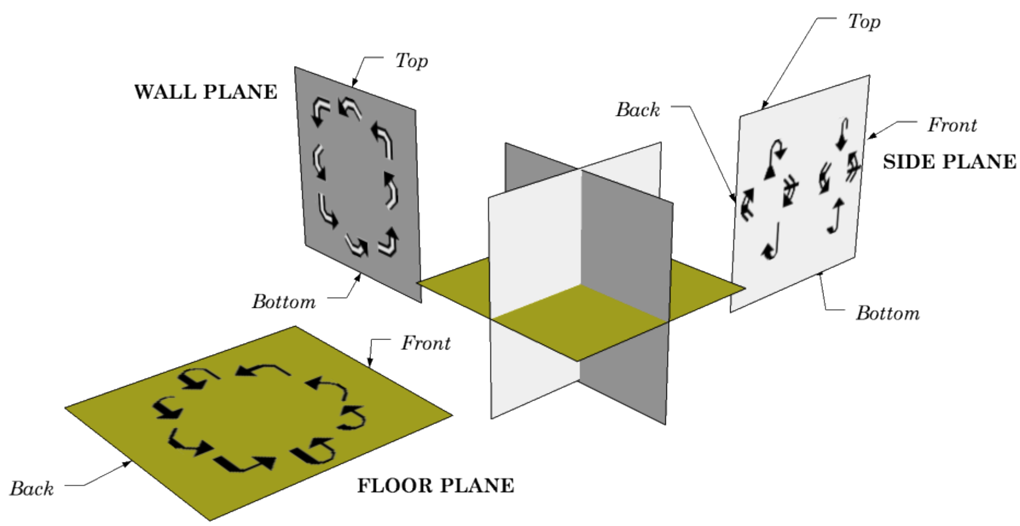
then supplies the information that it is a diagonal path. While this may not seem as helpful for straight arrows, it becomes more helpful when looking at curved arrows.

or Wall Plane, respectively. Arrows representing curves in the Side Plane parallel to the Floor Plane have a specific diacritic associated with the arrowhead or the tail to distinguish them as Side Plane arrows; this can be thought of as a thickening of that end of the shaft that is closest to the reader. Arrows representing curves in the Side Plane parallel to the Wall Plane employ the same Side Plane diacritics used for straight arrows, only now placed on Wall Plane curved arrows.

Figure 34. Curved arrows on the movement planes



The example sign 'oppose' (Figure 12) uses the Wall Plane curved arrows. 'Heaven' (Figure 14) uses a Side Plane curved arrow and two Floor Plane straight arrows. The hands are placed at the tail of the movement arrows. The association of the hand symbol with the head or the tail of the arrow is important to determine the sequence of the sign's movement.

Figure 12. ASL 'oppose' using SignWriting

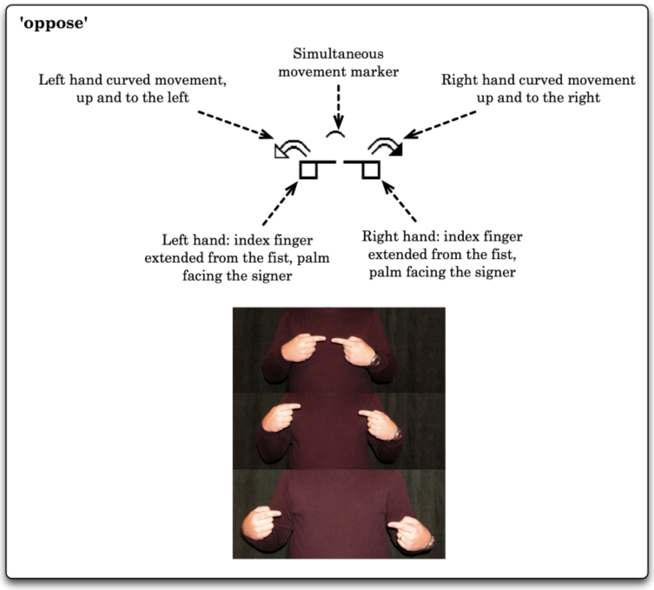
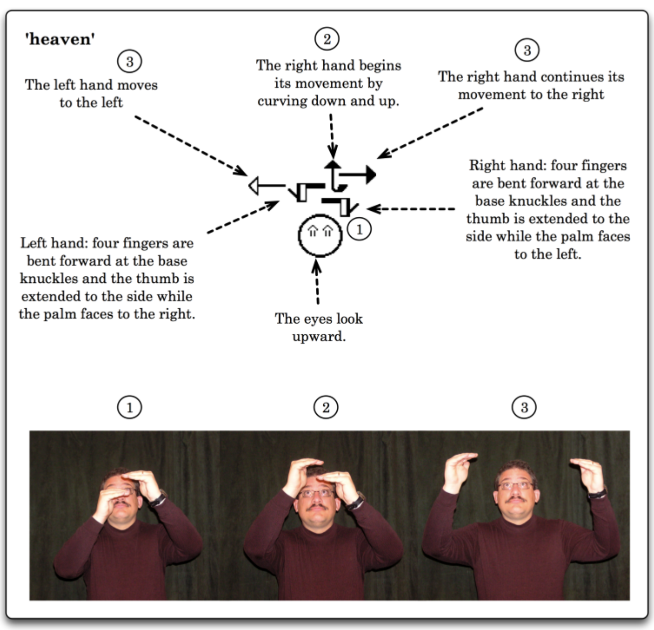
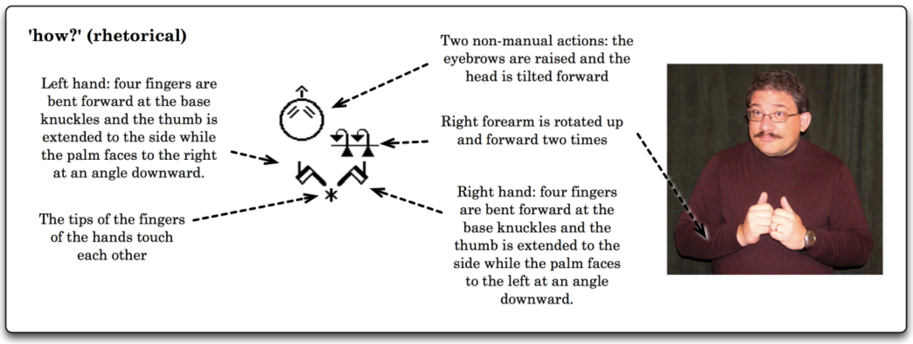


Figure 14. ASL 'heaven' using SignWriting



'How?' uses an axial arrow that includes a Side Plane curved arrow. The axial arrow is an example of a movement described by a **PRIMARY ARROW** (e.g., a headless single-lined arrow) and one or more **SECONDARY ARROWS** (e.g., the two Side Plane curved arrows). **AXIAL ARROWS** are a special category of arrows whose primary arrow is headless because the shaft represents the axis on which the rotation takes place. If the arrowhead is retained, the arrow describes movement along the path of the primary arrow while (usually) simultaneously moving in the path of the secondary arrow (e.g., rotating the forearm).

Figure 13. ASL 'how?' (rhetorical) using SignWriting



3.2.2. Overview of analysis

In this analysis, arrows are grouped by type of movement (usually symbolized by the shaft of the arrow and any diacritics or secondary arrows that it accepts) and by the Plane on which they operate (Floor, Wall, and Side). In the arrow shaft diagrams and rule descriptions below, several slots are defined to show where the arrow symbols combine with diacritics and secondary arrows. The most productive is Ⓜ, which represents the midpoint in the shaft of the arrow. Most diacritics or secondary arrows attach at this point. Some diacritics can actually attach at any point along the shaft of the arrow, but the existing computer implementation only presents precomposed symbols where the diacritic attaches at Ⓜ. Often, diacritics and secondary arrows only work with a specific length of the arrows. These are identified in the discussion below. Further, if the primary arrow has an arrowhead, the arrowheads for secondary arrows must agree with it.

Two other slots are also important. Ⓝ represents the point just below the arrowhead where some diacritics attach. Ⓣ represents the tail of the arrow. Though not depicted on the diagrams below, Ⓗ does appear in the rules to represent the arrowhead.

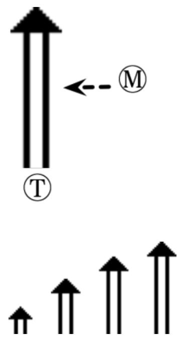
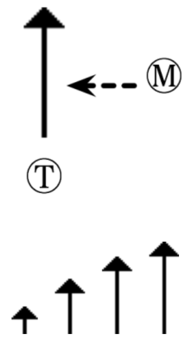
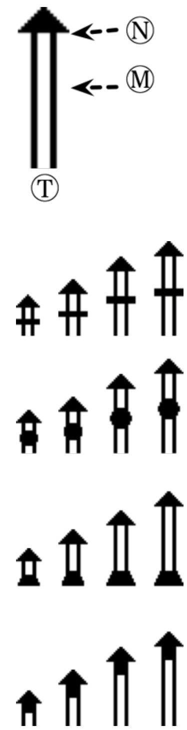
Each set of arrows also varies in the number of shafts for each group and how many lengths the ISWA 2008 has implemented. In each diagram, I illustrate the different possible shafts. For each notational device employed, I define when it can occur and show examples.

Some arrows represent basic motions such as straight or curved motion. But others can be analyzed as arrows that are composites of these basic motions. This gives us insight into the flexibility of the directional movement arrows. The system can represent more complex movements by using combinations of arrows already in the system. From time to time, I will note where some arrows are basic and where some are composites of existing arrows.

3.3 Straight arrows

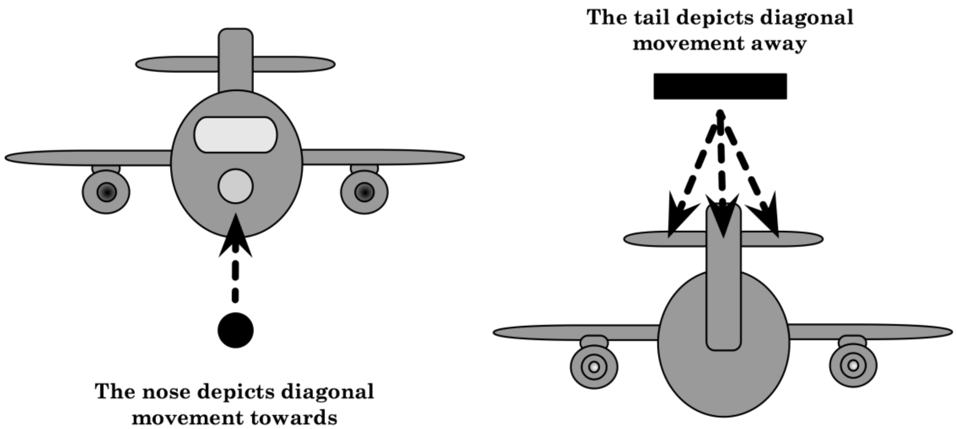
The **STRAIGHT ARROWS** naturally represent straight-line movement. Table 26 illustrates the structure of the straight arrows. Wall Plane straight arrows use a double-lined shaft. Floor Plane straight arrows use a single-lined shaft. Both have 4 possible lengths to choose from. In this table (as well as successive tables), I use the right-hand arrowhead as the exemplar. (Exceptions are noted where they arise.) As Figure 33 indicated earlier, arrows also rotate in 45° increments (with exceptions on the Side Plane).

Table 26. Structure of straight arrows

WALL	FLOOR	SIDE
		

Rather than choosing a different shaft, Side Plane arrows typically use diacritics on Wall Plane arrows to identify the arrow as a Side Plane arrow. The Side Plane straight arrows can be confusing because the seemingly vertical arrows are actually representing diagonal movement at various angles. The first two diacritics were derived from an airplane as described in Figure 35. The dot placed on the shaft of the arrow (•) represents the airplane's nose as it moves diagonally **toward** the reader. The line placed on the shaft of the arrow (▬) represents the airplane's tail as it moves diagonally **away** from the reader. When either is placed at the midpoint of the shaft, it represents motion at a 45˚ angle.

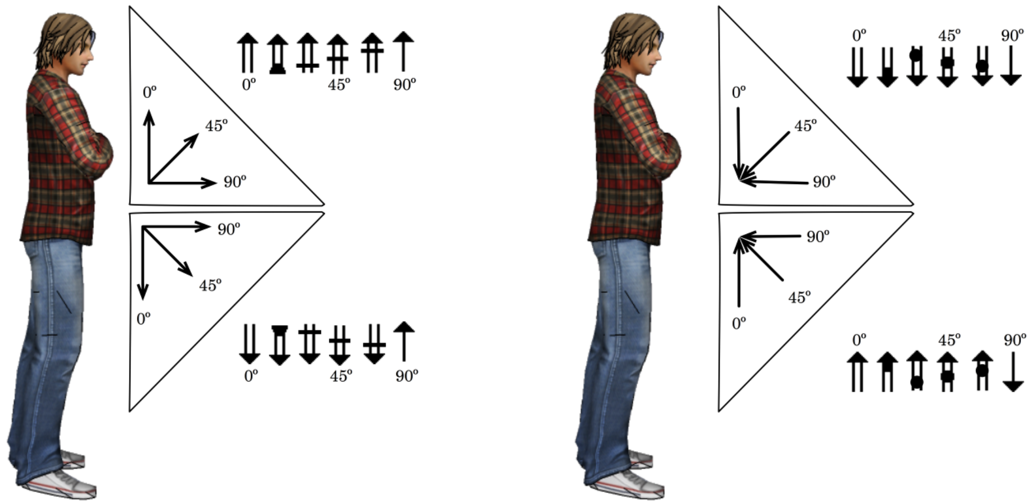
Figure 35. Derivation of Side Plane arrow diacritics



The ISWA 2008 provides the diagonal arrows listed in Table 26 (the first two rows representing a 45˚ angle and the last two rows representing a nearly vertical angle as shown in Figure 36). In the literature, only the 45˚ diagonal is mentioned as a specific angle. The other arrows listed in Figure 36 are simply interpreted to be somewhere between 0˚ and 45˚ or between 45˚ and 90˚, respectively. The system represents angles other than 45˚ by placing the dot or bar diacritic at other points along the shaft.[22] Figure 36 shows examples of the 90˚ progression from the Wall Plane arrows to the Floor Plane arrows for both Side Plane arrows that move away and move toward the reader.

[22] In handwriting, the system allows for the dot or bar diacritics to be placed anywhere between the arrowhead and the tail. The closer the diacritic is to the arrowhead, the closer the movement is to the horizontal. The closer the diacritic is to the tail, the closer the movement is to the vertical.

Figure 36. Angles for Side Plane Arrows

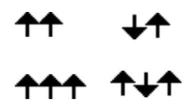


FINGER ARROWS (↑) are a special category of straight arrows that are used to indicate a specific movement by a finger. Because the finger is the focus and not the hand, it accepts a neutral arrowhead. Only the shortest shaft is used for finger movements.

The first general notational device for straight arrows, the use of grouped arrows to show repetitive movement, is described in (7), along with rules for its use. When the arrow is length 1, then one to three arrows can be placed side-by-side as a group. Naturally, such a group must have identical arrowheads since they are attached to the same hand symbol. A group of side-by-side arrows indicates a repetitive motion. This repetitive motion can either be successive motions in the same direction (when all arrows are pointing in the same direction) or successive motions alternating back and forth (when the second arrow is rotated 180˚). A group of three arrows generally means that the signer made that motion more than two times. Movement is only contrastive for singular, dual, or multiple repetitions.[23] Variations in the number of multiple repetitions are usually from non-linguistic factors, so the writing system only needs to track those three.

(7) Arrows may appear in groups of one, two, or three arrows if length == 1.

All arrows in a group must be identical in rotation and size.[24] The only exception permitted is that the second arrow can be rotated 180°.

Wall	**Floor**	**Side**
		

This rule corresponds to observations in actual signing. Shorter, repetitive movements appear to be more common than longer repetitive movements. Also, no repetitive Side Plane movements are precomposed, as repetition of diagonal motion is also rare.

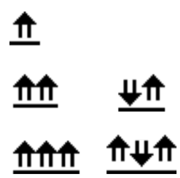
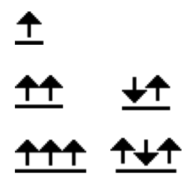
The second notational device for straight arrows, the application of motion to the wrist only, is described in (8), along with a rule limiting its use. When the arrow is length 1, then the tail accepts a **WRIST LINE**. That indicates that the movement will be a bending of the wrist with the hand moving in the indicated direction. This device can co-occur with arrow groups for repetitive movements, in which case one wrist line is used for the whole group. If the bending movement is vertical, the Wall Plane arrows are used; if it is horizontal, the

[23] I find it interesting that the distinctions for repetitive movement are similar to the way some languages show pluralization—singular, dual, or plural.

[24] Based on (6), the arrowheads in a group must match as they refer to the same articulator.

Floor Plane arrows are used. For the bending of the wrist, there is no identifiable movement on the Side Plane that cannot be described by the Floor or Wall Plane arrows.

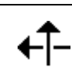
(8) Ⓣ accepts a wrist line if length == 1

Wall	Floor	Side
		

Because movements are often more complex than a simple path, some arrows allow for more than one motion per symbol. The following are some examples. The third general notational device for straight arrows, the chaining of two movements, is described in (9). This combination of two primary arrows at slot Ⓜ moving in a cross-like motion describes sequential action, which is different from the use of secondary arrows (described next) that assumes simultaneous motion.

(9) Ⓜ accepts the following set of secondary arrows if length == 2:

1) a perpendicular secondary arrow of the exact same Plane and length as the primary arrow, and whose arrowhead agrees with the primary arrow.[25]

Wall	Floor	Side
		

[25] This arrow uses opacity: a white strip inside the double shaft and a thin white strip on both sides of the single shaft.

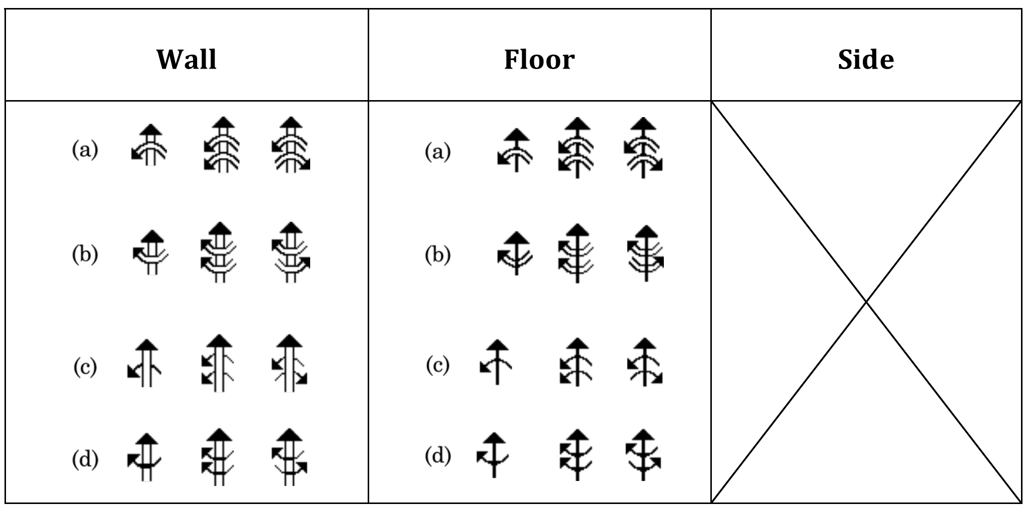
The fourth general notational device for straight arrows, the use of secondary arrows, is described in (10) - (12). These arrows allow for a limited set of secondary arrows that indicate additional movements that occur simultaneously during the straight path. These secondary arrows attach at Ⓜ. In (10), the notational device describes an arrow that moves upward (on the Wall Plane) or forward (on the Floor Plane) while, at the same time, the forearm pronates or supinates.[26] In the SignWriting literature, the choice between the upper or lower curve is subjective, depending upon the writer's intuition whether the thumb or the little finger was the articulator that was performing the arc. For both columns, secondary arrows in (a) and (b) assume that the forearm is oriented on the Floor plane (i.e., horizontal) while secondary arrows in (c) and (d) assume the forearm is oriented on the Wall plane (i.e., vertical). This is not a grammatical rule per se, but a semantic requirement in order to make this combination of hand symbol and arrow coherent.

[26] *Supination* refers to a rotation of the forearm where the palm either ends up facing upwards or toward the body. *Pronation* refers to a rotation of the forearm where the palm either ends up facing downwards or away from the body.

(10) Ⓜ accepts the following set of secondary arrows if length = 2:

1) 1-2 curved arrows of the same plane (either Wall or Floor Plane). If a second arrow is included, it must describe the same arc moving either in the same or the opposite direction as the first arrow.

If the forearm is on the same plane as the primary motion (e.g., both the forearm and the primary motion are vertical), the secondary arrows showing movement further away is placed behind the primary arrow in z-order. Otherwise, the secondary arrow is placed over the primary arrow in z-order.[27]



So, in the Wall column, (a) shows primary movement upward with the forearm horizontal during which the thumb curves over and to the left (pronation), (b) shows primary movement upward with the forearm horizontal during which the little finger curves under and to the left (supination), (c) shows movement upward with the forearm vertical during which the little finger curves outward toward the left (supination), and (d)

[27] Z-order refers to the order in which symbols are stacked on top of one another. Symbols placed over another will cover up overlapping portions of the symbol underneath.

shows movement upward with the forearm vertical during which the thumb curves inward toward the left (pronation). Similarly, in the Floor column, (a) shows primary movement forward with the forearm horizontal during which the thumb curves over and to the left (pronation), (b) shows primary movement forward with the forearm horizontal during which the little finger curves under and to the left (supination), (c) shows movement forward with the forearm vertical during which the little finger curves outward and toward the left (supination), and (d) shows movement forward with the forearm vertical during which the thumb curves inward toward the left (pronation). Naturally, rotations of the primary arrow change the direction of the forward or upward motion, which, in turn, changes the rotation of the forearm. Secondary arrows, however, retain the same form through all the rotations of the primary arrow. Reflections flip the direction of the curve from the left to the right.

In (11), a set of three secondary arrows without arrowheads represents a set of fast alternating forearm rotations, commonly called a shaking movement. In this case, it depicts a shaking movement that occurs while traveling in the direction of the primary arrow. Because the Plane is irrelevant for the shaking movement, the symbol only has a set of single-lined arcs to represent the movement.

Ⓜ accepts a limited set of secondary arrows if length == 2.

3 curved single-shafted arrows with arrowhead Ø and shafts curved toward the arrowhead.

(11)

Wall	Floor	Side
		

In (12), the secondary arrow represents rotation at the wrist during the primary motion, usually resulting in the appearance of a spiral motion of the hands.

Ⓜ accepts a limited set of secondary arrows if length >= 2.

1-3 single-shafted circles surrounding the primary arrow. The arrowhead on the secondary arrow always falls on the circle closest to the tail and must agree with the primary arrow.

(12)

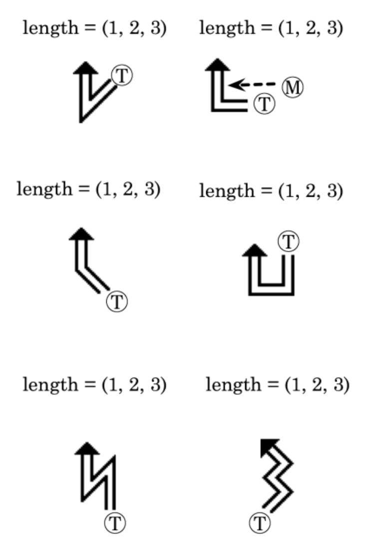
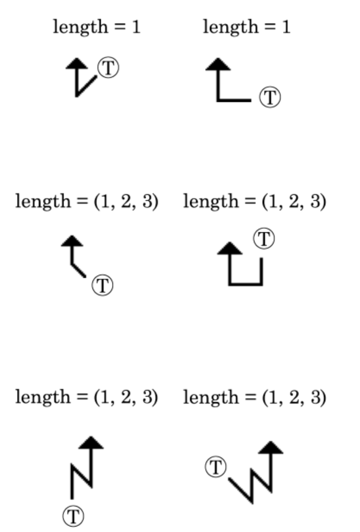
Wall	Floor	Side
		

3.4 Angled arrows

In this and following sections that describe increasingly complex movements, it is worth noting that this discussion is focusing on arrows currently listed in the SignWriting list of symbols. As such, this list is not exhaustive, but it appears to be sufficient to handle the majority of movements needed. Keep in mind that if some unlisted complex movement is needed, it may simply be a combination of existing precomposed arrows or it could be composed following the pattern laid out for the complex arrows that are discussed below.

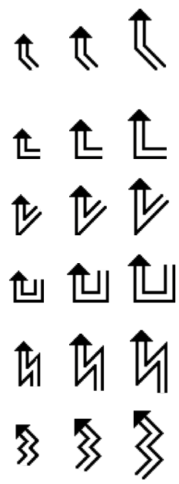
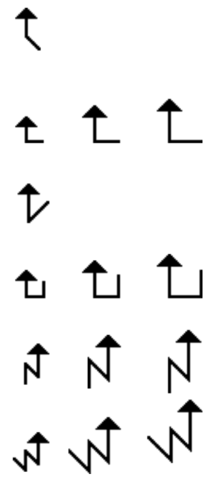
The **ANGLED ARROWS** have a shaft that indicates a path with a sharp change in direction. The angled arrows are actually straight arrows that are appended to one another with no intervening arrowhead. In most cases below, the combining arrows are of equal lengths. In Table 27, the structure of the angled arrows is illustrated. Wall Plane arrows maintain a double-lined shaft, and Floor Plane angled arrows maintain the single-lined shaft. There are presently no pre-composed angled arrows for the Side Plane.

Table 27. Structure for angled arrows

Wall	**Floor**	**Side**
		

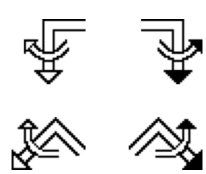
In Table 28, examples of the precomposed complex arrows and their available lengths are listed. All of these arrows are available in three lengths except for two Floor Plane angled arrows.

Table 28. Examples of angled arrows

Wall	Floor	Side
		

Only the right-angled Wall Plane arrow accepts a secondary arrow. If the arrowhead is ▲ or △ and the length is 3, then it accepts a curved arrow representing pronation during the movement. The curved secondary arrow is placed on the segment closest to the primary arrowhead with the curve nearest to the primary arrowhead. A result of this combination is that the rotations of this precomposed form are limited to 2 each for the right and left hand. The rule and examples are shown in (13).

(13) Ⓜ accepts an upward curving arrow if the length of the primary arrow is 3, and the arrowhead is ▲ or △. The acceptable rotations are limited to the two for each hand:



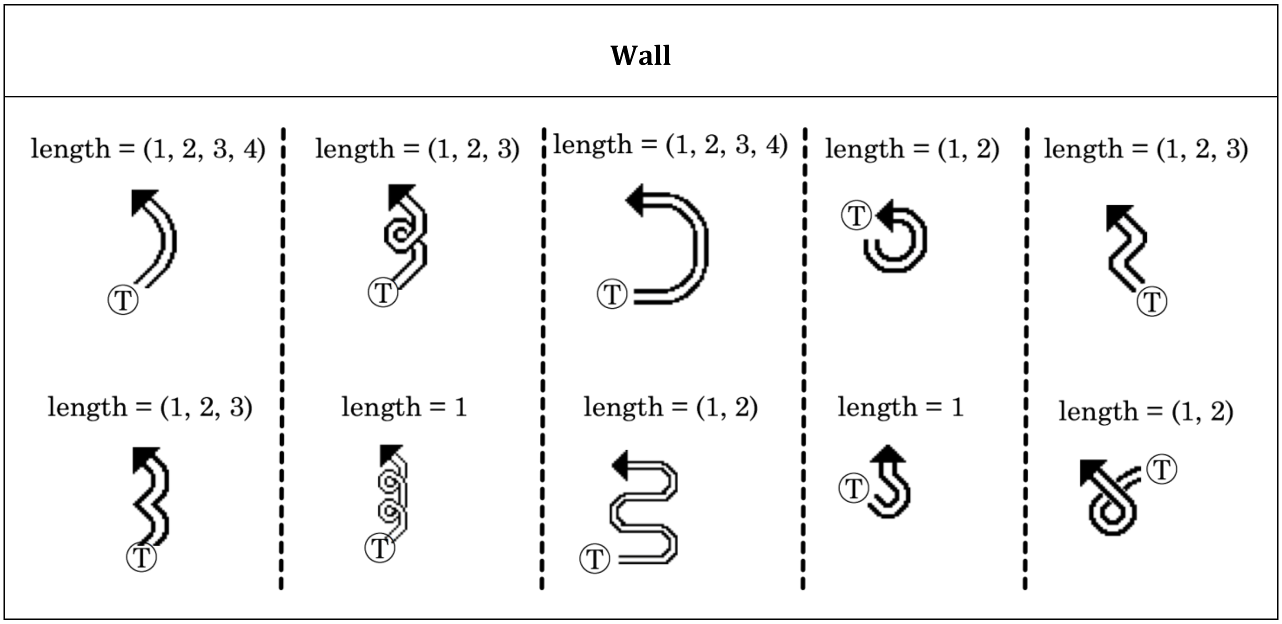
3.5 Curved arrows

The **CURVED ARROWS** have a shaft that indicates a curved path. Unlike angled arrows, not all the curved arrows in the ISWA can be analyzed as precomposed arrows established for the writer's convenience. Some curves are basic motions. The curved arrows exhibit more visual irregularity than the other arrow classes, particularly when rotated. So, the presentation of the curved arrows differs slightly from the other classes. Rather than presenting all three planes at once, the presentation looks at them in order from more regular to least regular.

3.5.1. Wall Plane curved arrows

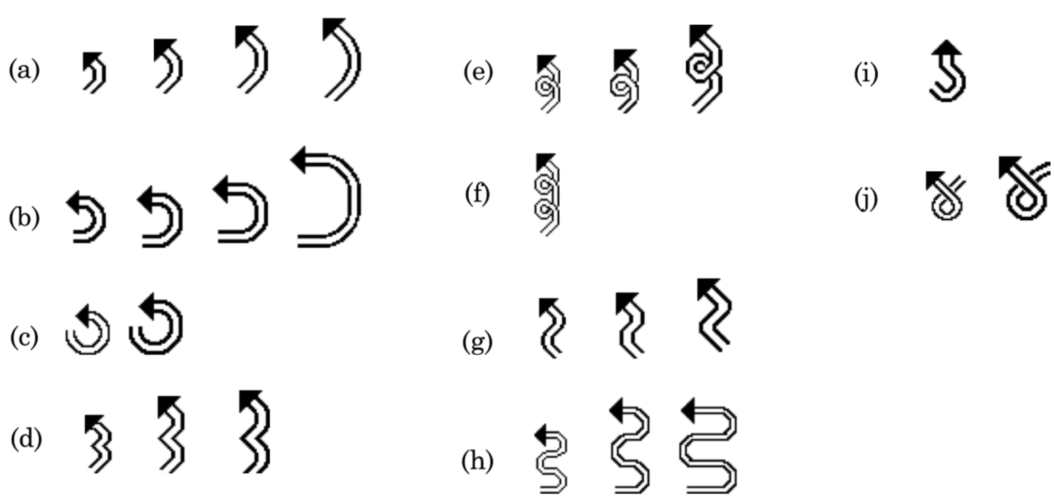
The most regular of the curved arrows are in the Wall Plane. In Table 29, the structure of the Wall Plane curved arrows is illustrated. These Wall Plane arrows maintain the motif of a double-lined shaft. Wall Plane curved arrows rotate as expected unlike their counterparts on the Floor and Side Planes. In each column except the last one, the bottom arrow can be analyzed as a complex arrow that contains the top arrow connected with another top arrow or some another arrow. In the first two columns, the bottom arrow is a repetition of the top arrow. In the third column, the bottom arrow is actually a composite of three top arrows with the middle top arrow flipped. In the fourth column, the bottom arrow is the composite of the top arrow plus a straight arrow. The fifth column has two unique arrows that are not clear composites of other arrows.

Table 29. Structure for Wall Plane curved arrows



The variations of the Wall Plane curved arrows are in Table 30. The variations are not simply limited to the size of the arrows. They also vary in the sharpness of the curves as in (g) or extend the length of the straight segments as in (b) and (h). Again, this list is not exhaustive; other possible variations in segment length or sharpness of the curve could potentially be written. Finally, the curved arrows that function as secondary arrows are limited to those in row (a).

Table 30. Wall Plane Curved arrows



3.5.2. Floor Plane curved arrows

In Table 31, the structure of the Floor Plane curved arrows is illustrated. These Floor Plane arrows maintain the motif of a single-lined shaft. Floor Plane curved arrows have mostly irregular forms for each rotation. Thin segments within the shaft represent portions of the path that are farther away from the reader. Thick segments within the shaft represent portions of the path that are closer to the reader. The first row shows how this convention is applied when complex arrows are derived from simpler ones. The first arrow is a simple curve. The second arrow is a composite of two repetitions of the first arrow. The third arrow is a composite of three repetitions of the first arrow with the second repetition flipped. The second row contains arrows that are not clearly composites of other Floor Plane curved arrows.

Table 31. Structure for Floor Plane curved arrows

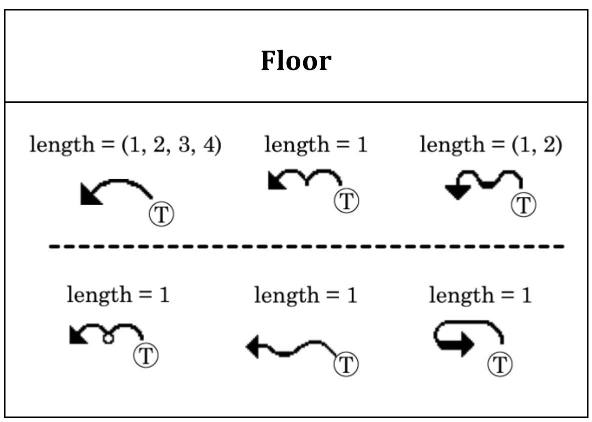
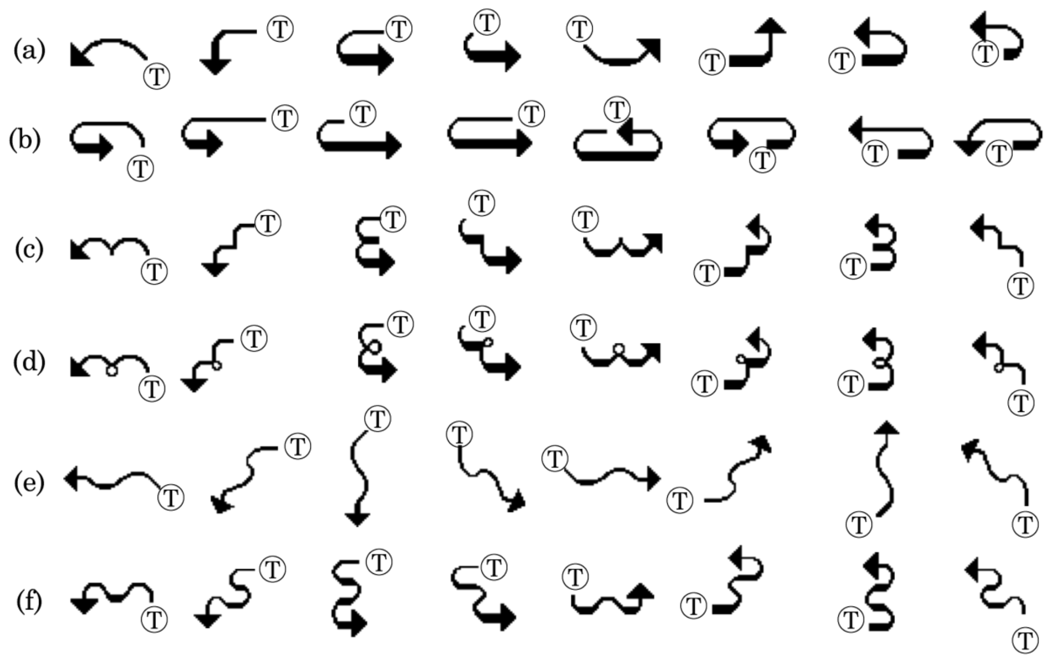


Table 32 shows the irregular rotations for the Floor Plane curved arrows. The arrow in (b), the three-quarter curve, is a good example of the visual irregularity. Despite their visual irregularity, the rotations intend to show the same curve at 45° increments: forward, forward-left corner, left, back-left corner, backward, back-right corner, right, and forward-right corner. Thick and thin segments serve as visual reminders of which segments are further or closer to the reader. Finally, the curved arrows that function as secondary arrows are limited to those in row (a).

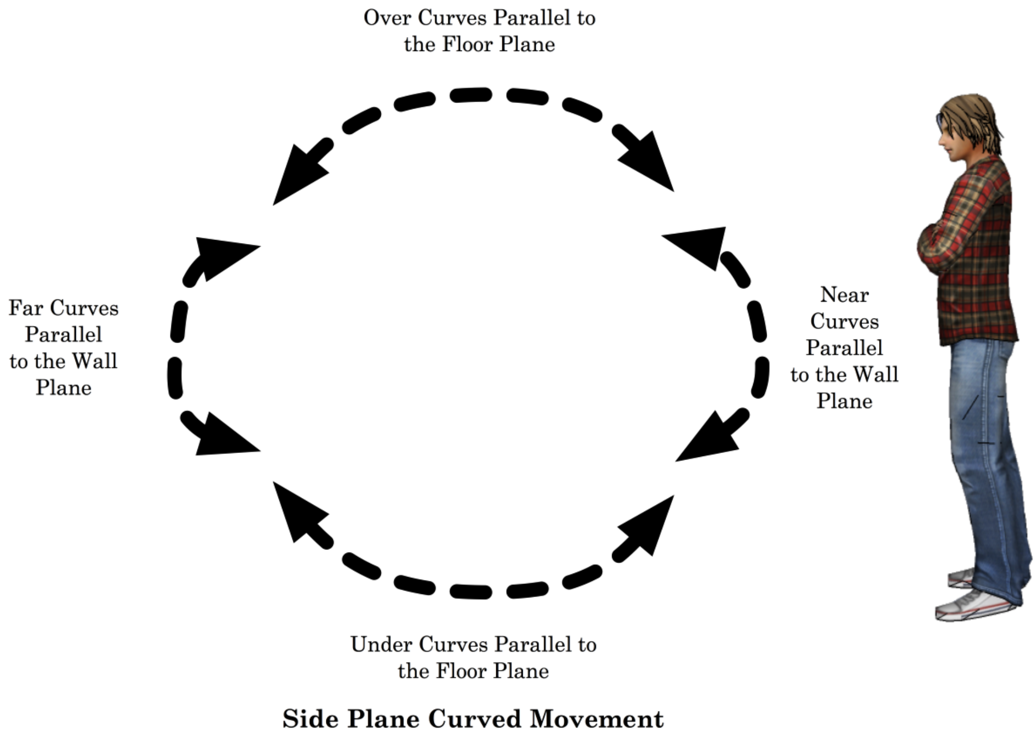
Table 32. Irregular rotations of the Floor Plane Curved arrows



3.5.3. Side Plane curved arrows

Side Plane curved arrows can be confusing to understand. Figure 37 shows the curved movement that these arrows depict. There are four curves in view: two curves that run roughly parallel to the Floor Plane moving over and under the Floor Plane and two curves that run roughly parallel to the Wall Plane and curve nearer and further from the reader.

Figure 37. Side Plane curved movement



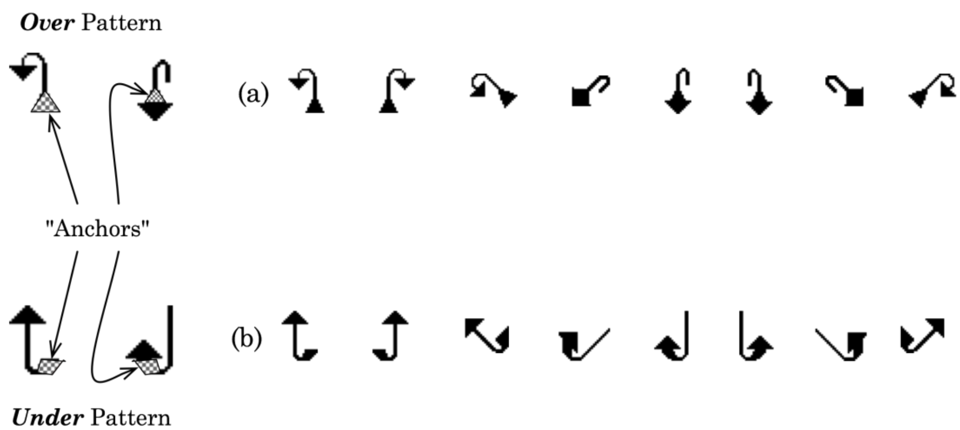
Unlike the Floor Plane or Wall Plane curved arrows, the Side Plane curved arrows vary in the shafts they select. The selection is based on its parallel plane. Side Plane curved arrows that run parallel to the Floor Plane choose single-lined shafts. Side Plane curved arrows that run parallel to the Wall Plane choose double-lined shafts. While some irregularities exist, there is still a systematic nature to it. They also have less than the usual number of available rotations and reflections: those running parallel to the Floor Plane only have two rotations that are reflected and those running parallel to the Wall Plane have two or three rotations that are reflected.

Curved arrows on the Side Plane parallel to the floor

As illustrated in Figure 38, arrows that curve parallel to the Floor plane are single-lined. Like Floor Plane curved arrows, Side Plane curved arrows that curve parallel to the Floor

Plane carry the thick/thin distinction that the Floor Plane arrows used to show near/far movement, although conventionalized further using diacritics. The Over pattern uses ▲ in slot Ⓣ or Ⓝ to mark the portion of the path that is closest to the reader.[28] Likewise, the Under pattern uses a thick shaft.

Figure 38. Pattern for Side Plane curved arrows parallel to the Floor Plane



The symbols follow the basic rotational pattern shown in (a) and (b). Based on the pattern, if the first and fifth forms are known, the writer can extrapolate the others. There are actually only four unique symbols (the first, third, fourth, and fifth); the other four are simply reflections. The first and second symbols and the fifth and sixth symbols are synographs, representing the same movements. Sometimes, visually, one is a clearer representation of that movement than the other.

These arrows combine with each other as illustrated in Figure 39. The first three pairs of over/back and under/back arrows show single, double, and triple curves forward and back. The next two pairs show a looped path. The last pairs depict alternating curves over and under.

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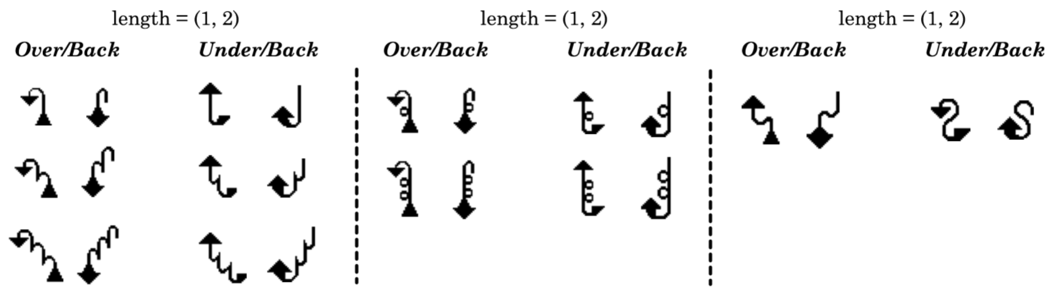
[28] In this case, the ▲ is not acting like an arrowhead, but serving as an anchor.

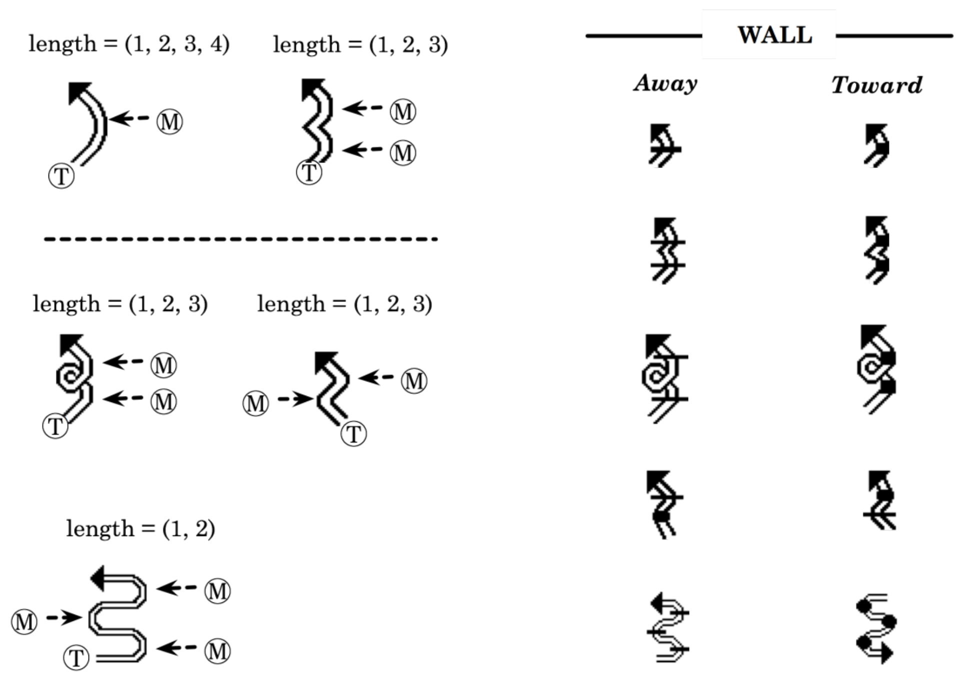
Figure 39. Examples of Side Plane curved arrows parallel to the Floor Plane



Curved arrows on the Side Plane parallel to the wall

Figure 40 shows the arrows that curve parallel to the Wall Plane, which have double-lined shafts plus the same two diacritics used for diagonal straight movement in the Side Plane. This represents movement that curves toward the reader (a dot in slot Ⓜ) and movement that curves away from the reader (a line in slot Ⓜ). With the diacritic placed on the curve(s), the curve does not represent motion moving from side to side as it appears to be doing, but motion near and far on the Side Plane. These curves only have an upward form and a downward form and a reflection of each. Semantically, the reflections are synographs, available when one might be clearer.

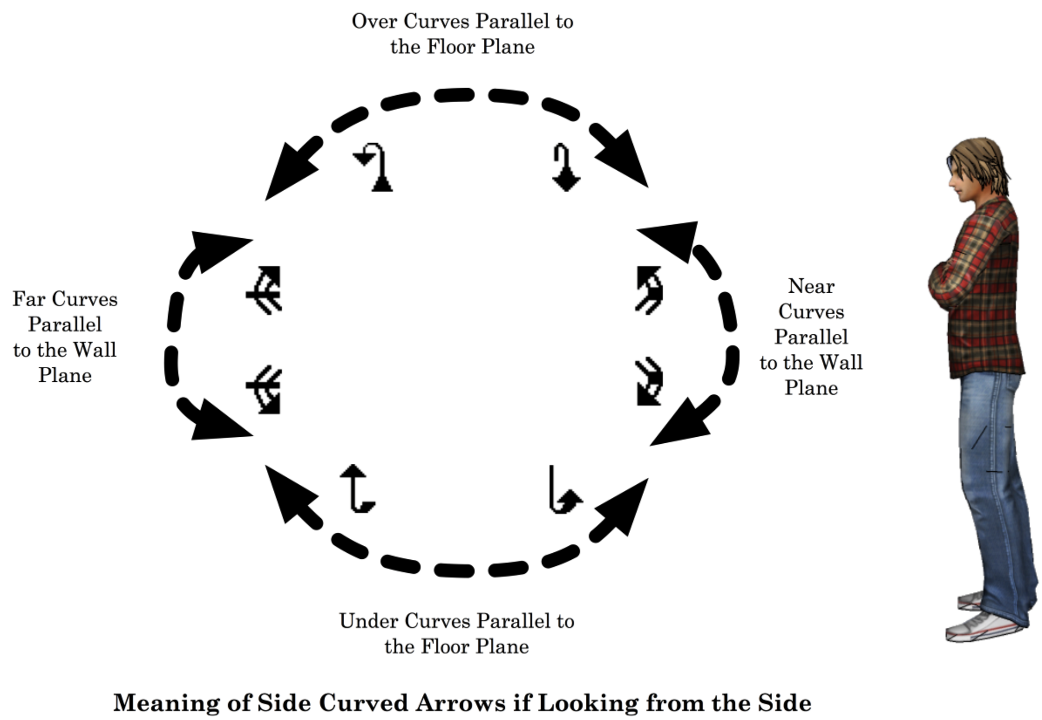
Figure 40. Side Plane curved arrows parallel to the Wall Plane



One exception (/) does appear. These do not follow the same pattern as the other arrows of its class. Each symbol has only 3 forms, and a reflection of those three forms. has and . has and . The portion of the arrow that moves to the side does represent side movement. The curve represents either movement away or movement towards the reader depending on the diacritic in place. There does not appear to be any reason for them not to have the vertical opposites in the precomposed version (i.e., /), but they are not present in the ISWA 2008.

Perhaps the diagram in Figure 41 can serve as a helpful summary of the Side curved arrows. If a side camera is placed alongside our reader as he/she signed these arrows from the normal viewpoint, the diagram matches the curved movements to the respective arrows.

Figure 41. Summary of Side Plane curved arrows



3.6 Axial arrows

AXIAL ARROWS describe rotational movement when the arm remains stationary and the forearm supinates and/or pronates. Table 33 utilizes line drawings used by Parkhurst and Parkhurst (2007) and some example signs to illustrate these movements. In all three cases, the arm is stationary, and the forearm rotates.

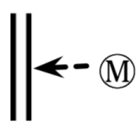
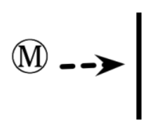
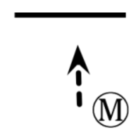
Table 33. Examples of axial movements

	Movement	**Symbol**	**Example Sign**
Wall			 ASL 'blue'
Floor			 ASL 'to share'
Side			 ASL 'kid'

Essentially, they are similar to the secondary movements on straight arrows described in (10) earlier, but without any primary movement because the main shaft has no arrowhead. Like the regular movement arrows, this movement describes a path, a path of rotation in this case. The basic structure of axial arrows is illustrated in Table 34. Rather than indicating primary movement, the shaft for the axial arrow indicates the orientation of the forearm: a double-lined shaft for the Wall Plane, a vertical single-lined shaft for the Floor Plane, and a horizontal single-lined shaft for the Side Plane.

Note, however, that the shaft of the axial arrow is **not** a limb symbol directly representing the forearm, but merely serves as an anchor providing a clue as to the orientation of the forearm. Three arguments that the shaft of the axial arrow is not a limb symbol but rather truly an arrow shaft are (a) the shaft never accepts a hand symbol like a limb symbol would, (b) a limb symbol never appears as a double line like the Wall Plane arrows do, and (c) the tail of the axial arrow is placed with respect to the hands like the tail of a movement arrow rather than appearing near the wrist like a limb symbol.[29] The curved arrows that attach to Ⓜ indicate the path of the rotation.

Table 34. Structure for axial arrows

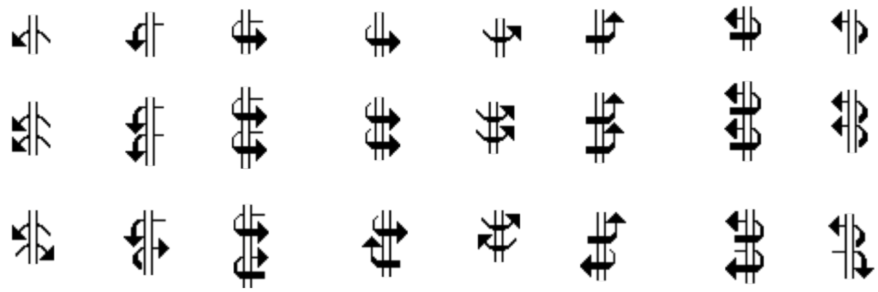
Wall	**Floor**	**Side**
		

Wall Plane axial arrows

Examples of the Wall Plane axial arrows are shown in Table 35. The Floor Plane curved arrows attach to Ⓜ. The shaft indicates the orientation of the forearm, which is the Wall Plane, and the forearm then rotates in the direction(s) indicated by the secondary arrow(s). Unlike the Floor or Side Plane axial arrows, the shaft itself does not rotate. Instead, the secondary arrows rotate around the shaft.

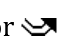
[29] Chapter 9 provides more details about the placement of movement arrows with hand symbols. Suffice it to say, the axial arrow shaft follows rules for movement arrows more than limb symbols.

Table 35. Examples of Wall Plane axial arrows



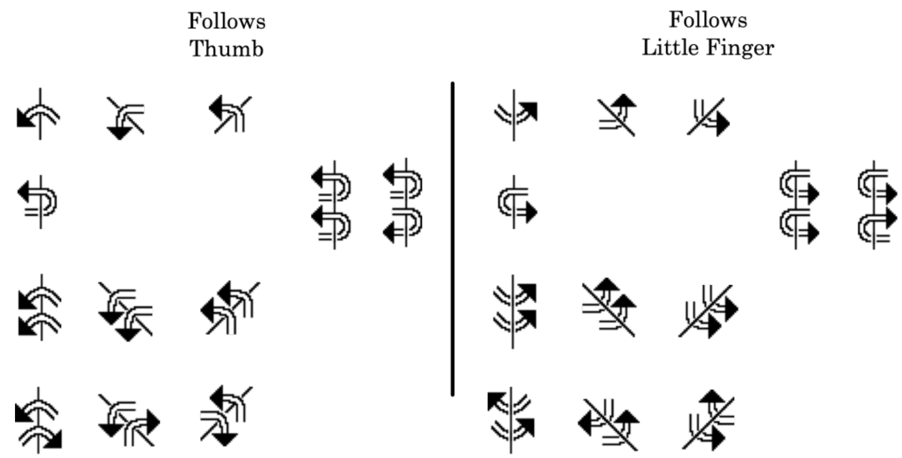
Floor Plane axial arrows

Examples of the Floor Plane axial arrows are shown in Table 36. The single-lined shaft also mimics the expected orientation of the forearm, which is on the Floor Plane. The forearm then rotates in the direction(s) indicated by the secondary arrow(s). There are two possible secondary arrows: an arc () that describes a 90˚ rotation or a semi-circle () that describes a 180˚ rotation.

Pedagogically, writers are taught that the choice to use  or  depends whether or not the thumb or the little finger leads the rotation or not. Admittedly, this is a subjective measure but it seems to help writers choose between the arrows. Certainly, both arrows describe the same rotation but from different perspectives (i.e., if one put paint on the thumb and little finger, you would find both arcs drawn when rotating the forearm.)[30] The shaft for the Floor Plane axial arrows can rotate 45˚ to either side from the vertical, representing the forearm at an angle.

[30] The fact that both arcs would be drawn if paint were on the thumb and little finger might be an argument that axial arrows (and possibly their straight arrow counterparts) could be simplified.

Table 36. Examples of Floor Plane axial arrows

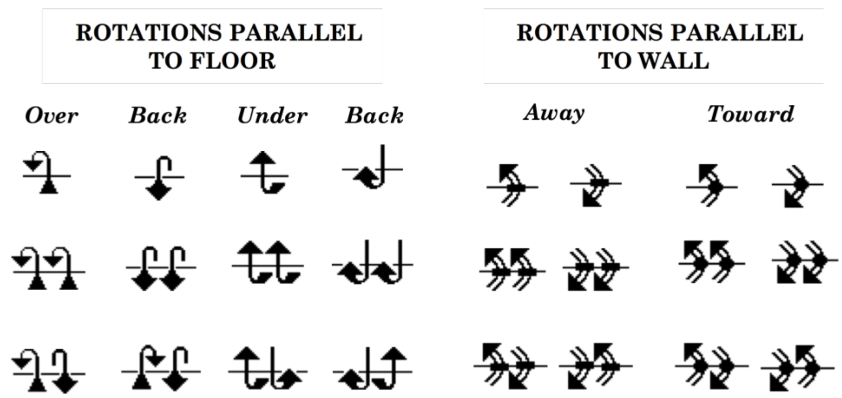


Side Plane axial arrows

The secondary arrows for the Side Plane axial arrows use the Side Plane curved arrows to show the same rotational distinctions as the Side Plane curved arrows (i.e., some rotations roughly move parallel to the Wall Plane while other rotations roughly move parallel to the Floor Plane). As illustrated in Figure 40, Side Plane curved arrows which run parallel to the Wall Plane typically accept ▬ and ● to show the movement on the Side Plane. Now with the Side Plane axial arrows, there is a visual clash between the ▬ and the shaft of the axial arrow. To compensate visually, the diacritic is thickened (▬) so it stands out. Unlike their counterparts that rotate parallel to the Floor Plane, the shaft for these Side Plane axial arrows does not rotate.

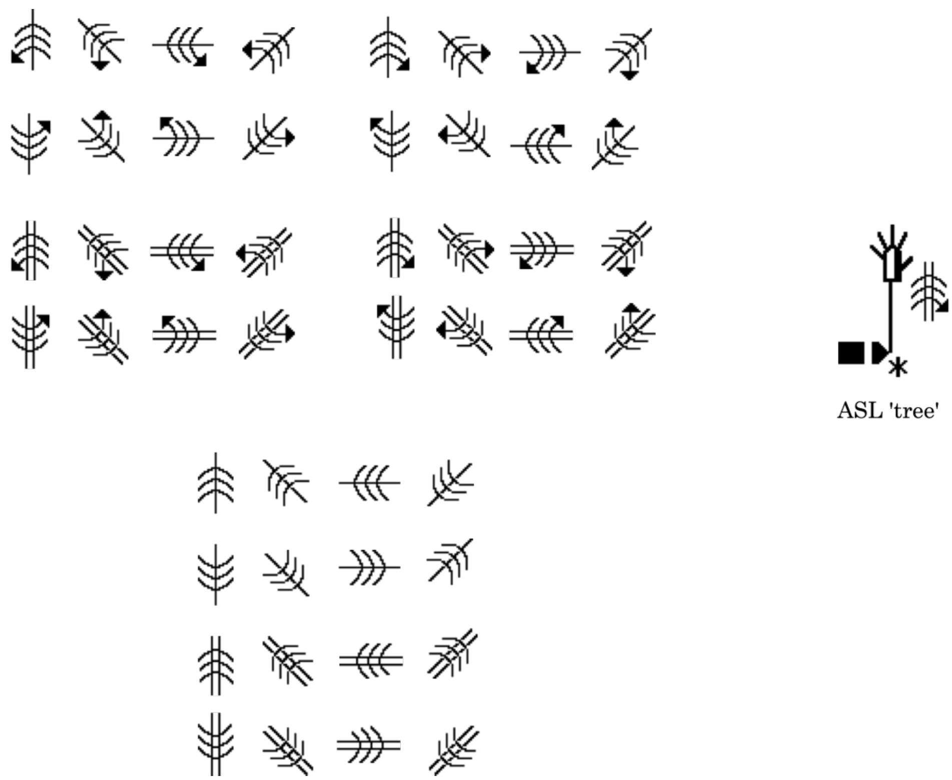
Rotations that run parallel to the floor follow the rotational pattern of those Side Plane curved arrows. Like the Floor Plane axial arrows, the shaft of the Side Plane axial arrow can rotate 45˚ to either side from the horizontal. Insofar as I have been able to determine, the angled versions of the Side Plane axial arrows appear to share the same meaning as their Floor Plane counterparts, making them synographs.

Table 37. Examples of Side Plane axial arrows



In addition, there is a special category of axial rotations used to describe a shaking movement or short, quick rotations of the forearm that I have termed **SHAKING AXIALS.** The shaking axial arrows do not exactly follow the other axial arrows, so they are treated separately as shown in Figure 42. These arrows use the same shafts as the Wall Plane and Floor Plane axial arrows. No distinction is made for the Side Plane. The tail of the primary shaft is the end on the concave side of the secondary arrows. If the actual direction of the shaking is important, the writer can use a version with the shaking lines that have the appropriate arrowhead. The arrowhead can only appear on the lowest arc closest to the tail of the primary shaft. If the actual direction of the shaking is irrelevant, the writer can use a version with the shaking lines that has no arrowhead. The angle of the shaking axial arrow shaft should agree with the actual angle of the forearm. These arrows would be placed close to the hand/arm moving such as shown in the ASL 'tree' below.

Figure 42. Examples of Shaking axials



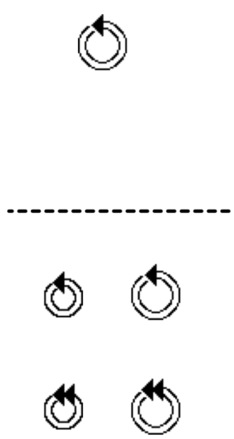
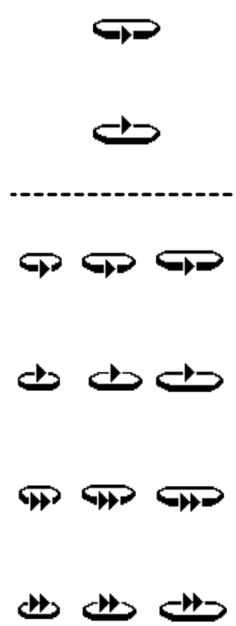
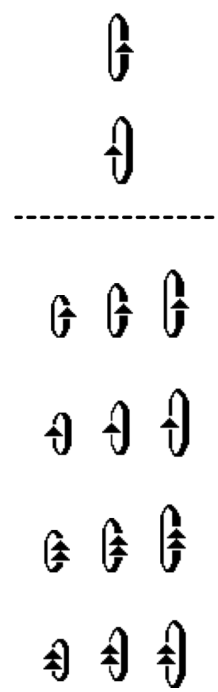
3.7 Movement circles

The system allows for three types of movement circles: **GENERAL MOVEMENT CIRCLES**, **WRIST CIRCLES**, and **FINGER CIRCLES**. General movement circles are used to describe circular movement made by any limb or hand that moves. Wrist circles and finger circles describe decreasingly smaller movements, which are reflected in the graphemes chosen to represent them. Each type of circle adopts a different, yet consistent appearance to help the reader identify which type of circular movement is being described. To depict an articulator completing two or more circles in a movement, all three types of movement circles allow for adding a second arrowhead.

3.7.1. *General movement circles*

The general movement circles have a shaft that indicates the completion of at least one full circle. In Table 38, the pattern for these circles is illustrated. To depict the full circle, an arrowhead is joined to the tail. This convention has two important implications: they are not used in composing more complex paths, and the start of the movement is where the arrowhead and tail are joined. The Wall Plane general movement circles follow the familiar motif of having a double-lined shaft. The Floor Plane and Side Plane general movement circles are members of the same grapheme set, differing only in rotation.

Table 38. General Movement circles

Wall	**Floor**	**Side**
length = (1, 2) 	length = (1, 2, 3, 4) 	length = (1, 2, 3, 4) 

The Wall general movement circles accept arrowheads at all eight points of the rotation as well as reflecting each of those rotations to show movement in the opposite direction.

The Floor and Side general movement circles actually share the same grapheme set. Figure 43 shows the rotations of one Floor/Side general movement circle. In the horizontal orientation, the reader sees a Floor Plane general movement circle with the thick portion of the shaft showing that portion of the path that is closer to the reader and the thin portion of the shaft showing that portion of the path that is further from the reader. In the vertical rotation, the reader sees a Side Plane general movement circle with the thick and thin portions having the same meanings. The arrowhead may only appear in the middle of the thick portion or in the middle of the thin portion as shown in (a) and (c). Reflections depict movement in the opposite direction.

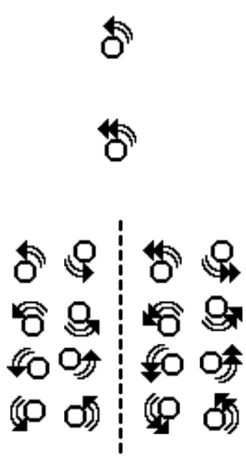
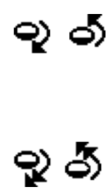
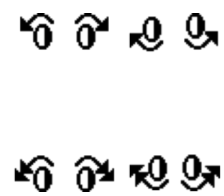
Rather than separating the Floor and Side arrows as separate symbols semantically within the ISWA, the system stores eight rotations (a) and eight reflections (b) as a set of 16 graphemes. The first symbols for (a) and (b) and the fifth symbols in (a) and (b) are synographs with the same meaning. The same is true for (c) and (d). Other Floor/Side general movement circles follow the same pattern. The angular rotations show circular motion on 45° planes between the Floor and Side Planes.

Figure 43. Rotations for the Floor/Side general movement circles

3.7.2. Wrist circles

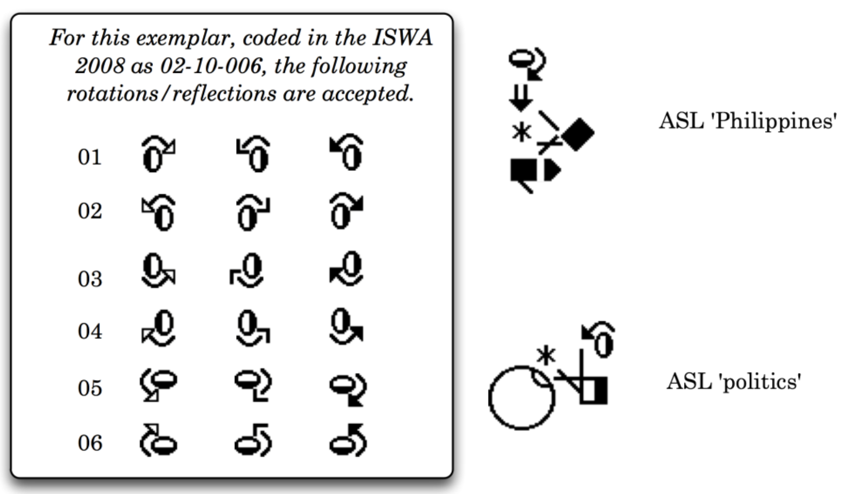
When the hand pivots at the wrist only (with no forearm movement), the system provides wrist circles. In Table 39, the pattern of the wrist circles is illustrated. The symbols are smaller and more complex, consisting of a circle or oval plus a separate arrow. There is only one size. The arrow traverses only about 90 degrees, but represents a full 360 degrees of movement. A double-shafted arrow with a small circle represents movement in the Wall Plane; a single-shafted arrow with an oval represents movement in the Floor or Side plane. The Floor or Side planes are distinguished by the rotation of the oval, and shading on the oval is used in the same way as shading on the shaft of general movement arrows. Wrist circles accept ▲, △, and ∧ arrowheads to identify which wrist is rotating. The wrist circle can accept one or two arrowheads (logically of the same kind) to indicate one or more than one circular wrist movement.

Table 39. Examples of Wrist circles

Wall	**Floor**	**Side**
length = 1 		

The rotations of the Wall Plane wrist circles follow the standard eight possible rotations and two reflections to depict where the motion began (as shown in Table 39). However, the Floor Plane and Side Plane wrist circles do not follow the standard rotations. Instead, they follow the unique pattern seen in Figure 44. The placement of the arrows shows where the circular motion originates. The first four rows show Side Plane circular motion originating at four locations: at the top moving forward, at the top moving backwards, at the bottom moving forward, and at the bottom moving backward, respectively. The last two show Floor Plane circular motion originating on the right or on the left and moving backward or forward. The rotations of the hands mirror each other.

Figure 44. Rotations for Floor and Side Plane wrist circles with example signs



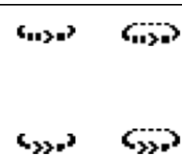
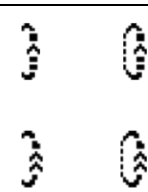
In the ASL example 'Philippines', the movement starts with a Floor Plane wrist circle before the right hand moves down to touch the back of the left palm. As mentioned in Section 9.3, the writer has a choice to write the handshape at the beginning or end of the arrow. In this example, the writer chose to write the ending handshape, but since no beginning handshape is given, it is assumed to be the same as the ending handshape. In the

ASL example ‘politics’, the wrist circle is associated with the hand symbol and that Side Plane Wrist circle becomes the initial movement before the middle finger of that hand touches the side of the head.

3.7.3. Finger circles

When one or more fingers are moving in a circle but the wrist and hand are both stationary, the system uses the finger circles. The shaft in this instance is a dotted line, and there is only one small size. In Table 40, the pattern of the finger circles is illustrated. These also contain a symbol for a half-circle, and the symbols are smaller than the other circles. The system continues the motif of having the Floor Plane and Side Plane finger circles also show a distinction based on horizontal versus vertical alignment. Unlike the general movement circles or the wrist circles, the finger circles only accept one or two ^ as the arrowhead. Since only the fingers are moving and the symbol is placed near the fingers that are moving, marking the actual hand is unnecessarily redundant. The use of this symbol appears to be rare and is not taught extensively.[31]

Table 40. Examples of Finger circles

Wall	**Floor**	**Side**
		

[31] Interestingly, I found only a few examples of the finger symbols in the ASL SignPuddle Dictionary and all of them appeared to be mistaking the finger circle for the wrist circle. The Parkhursts do not address the finger circles in any of their instructional materials.

3.8 Questions about movement arrows

In looking at the description of directional movement arrows, a few miscellaneous questions and issues came up. Rather than attempting to deal with them in the descriptions above, it seemed better to address them separately.

3.8.1. Are some movement arrows over-specified?

Certainly, the possibility exists for straight arrows with curved secondary arrows, axial arrows, wrist circles, and finger circles. In each of these instances, the use of the arrow or circle carries a redundant definition of the hand symbol's orientation. The question is whether that redundancy is helpful for visual clarity or whether it creates an unnecessary proliferation of symbols that can confuse writers and readers unnecessarily.

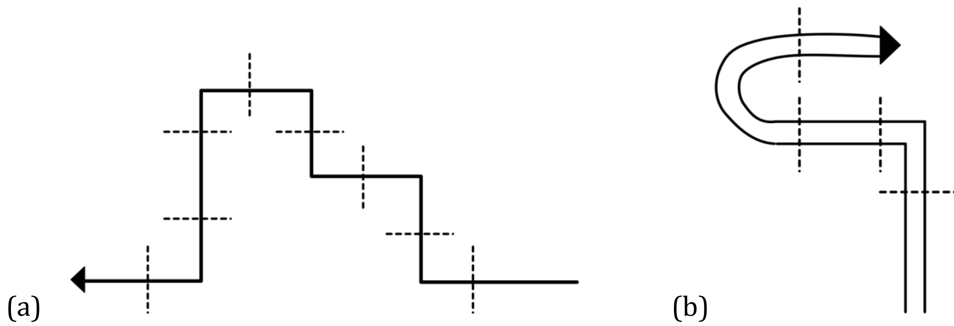
With the writing of sign languages in its infancy, we still lack the experience to know what distinctions are truly necessary. Perhaps, these distinctions may be useful for a more phonetic transcription. But, it is likely that everyday writers eventually will develop conventions for writing these symbols that might not use the full set of arrows.

3.8.2. How can complex combinations of arrows be written?

As noted previously, some arrows in the system are composites of simpler arrows. When using handwriting, the writing system actually allows for different shafts within the same class to append to one another. Notice the two example arrows in Figure 45. The dashed lines demarcate the several arrows that compose these more complex combinations. In (a), the arrow describes a path that might describe a car driving around the streets. In (b), the arrow describes a path that a helicopter or hoverjet might take. The arrows are attached to each other directly without any intervening arrowheads. This technique allows

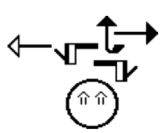
SignWriting to describe complex movements without actually having to modify the system itself. The outermost head and tail then act as the head and tail for this composite arrow.

Figure 45. Example of Two Complex Arrows



Some types of arrows such as general movement circles or the Side Plane curved arrows that are parallel to the Floor Plane do not participate in this kind of complex concatenation because the tail slot is already filled. Side Plane curved arrows have identifying patterns that fill the tail slot. General movement circles connect the head and the tail. This inability to attach to other movement arrows is evident in the ASL sign for 'heaven' in Figure 46.

Figure 46. Example of arrows that cannot concatenate



ASL 'heaven'

Currently, many complex forms can be handled, and the current software does permit some creation of complex arrows by affixing the shafts of some arrows to other existing arrows. However, the software currently does not restrict users in what symbols they may use to create more complex arrows. For instance, if a writer wanted a longer arrow than currently permitted, a writer could theoretically simulate a longer arrow shaft by using limb symbols instead of a headless arrow shaft, and then selecting the appropriate arrowhead to go with it. While this visually appears to be an acceptable representation, the underlying semantics for those symbols would be completely unrecognizable as a complex arrow, but rather as one or more limb symbols with an arrowhead attached, a configuration that is semantically unacceptable. Existing software currently has not yet implemented a way to flag such ill-formed constructions.

So far, in current implementations of the symbol set, only a few arrows have a headless version of their shafts that can be used to keep consistency in the coding behind the sign. In theory, a writer should be able to place an arrow and then append a headless shaft to the tail of a compatible arrow and it should "lock" into place and this "new" composite arrow should be understood to have one head and one tail for purposes of searching, etc. With this kind of flexibility, the software would also need to indicate which end was the arrowhead and which end was the tail. So, this is one example where the flexibility of the writing system has not been fully explored by computer software.

3.8.3. Are movement arrows used in other contexts?

Floor Plane and Wall Plane movement arrows are used in other contexts. It is a smaller arrow in length 0 or 1 with a neutral arrowhead (^). They are used to indicate head positioning when placed over the head (see Section 4.8) and used to indicate eye gaze when placed in the Upper section of the head circle (see Section 4.4.3). They are also used with the shoulder and hips to indicate movement by the torso (see Section 5.2.3).

3.9 Overview of symbols that do not describe a path

Movements that indicate a change in relationship or configuration typically do not describe a path of movement. Instead, they either describe changes to the relationship between various articulators or temporary changes in the handshape's configuration.

SignWriting uses contact symbols, surface symbols, knuckle symbols, and breathing symbols to represent this type of movement. **CONTACT SYMBOLS** describe the manner in which parts of the body interact when they contact. **SURFACE SYMBOLS** clarify the surfaces being contacted when usual rules of writing leave the sign ambiguous. **KNUCKLE SYMBOLS** describe the bent or straight configuration of the knuckles. **BREATHING SYMBOLS** describe the movement of air by the nose or mouth.

3.10 Contact symbols

Table 41 describes the contact symbols currently implemented in the system. Each symbol may be written twice to indicate repeated contact. The contact symbols describe the following interactions: touching, striking (i.e., a hard or sharp touch), grasping, rubbing, and brushing.

Table 41. List of contact symbols

Touch	∗ |∗|	Rub	@ |@|
Strike	# |#|	Brush	⊙ |⊙|
Grasp	+ |+|		

They may also appear between vertical lines to indicate contact that occurs "between" parts of the body. Examples of using "between" contact are given in Figure 47. In ASL 'start', the index finger touches between the index and middle fingers before it rotates in a forward arc. In ASL 'machine', the curved fingers grasp each other before they move as a unit up and down several times.

Figure 47. Examples of in-between contact

ASL 'to start'

ASL 'machine'

Previously, writers used the touch symbol (∗) even when it was clear from the placement of the hands that there was contact. Now, if the articulators (hands, face, etc.) clearly show touch occurring, then the touch symbol is considered unnecessary except to show repeated contact or subsequent locations where touching also occurs. The strike symbol (#) represents a stronger version of touch almost akin to hitting. The grasp symbol (+) shows something held between two surfaces (e.g., between two fingers, two hands, a hand and a part of the body, etc.)

The rub symbol (@) and the brush symbol (⊙) are often confused with each other. A unique characteristic of these two contact symbols is that they are used with directional movement arrows functioning more like diacritics that modify the movement arrow, but they can stand on their own. The rub symbol implies that the articulator never leaves the surface during the entire movement. By itself, the rub symbol describes a circular rubbing movement by the articulator. However, if writers wanted to convey a rubbing contact along a directional path of movement, they would simply include an arrow of the appropriate direction and write the rub symbol near the position of contact between the two articulators and near the arrowhead or tail of the arrow. The brush symbol, while similar, implies that the articulator leaves the surface during the movement, and in some cases may start the movement off the surface.

Perhaps an example like that in Figure 48 can clarify. In (a), the dominant hand index finger usually leaves the surface of the non-dominant hand index finger, so the brush symbol is used. On the other hand, in (b), the dominant hand index finger typically remains on the surface during the entire movement, so the rub symbol is used. Example (c) shows the rub symbol used without a movement arrow showing a rubbing circular movement. Example (d) shows the rub symbol between the parallel movement arrows.

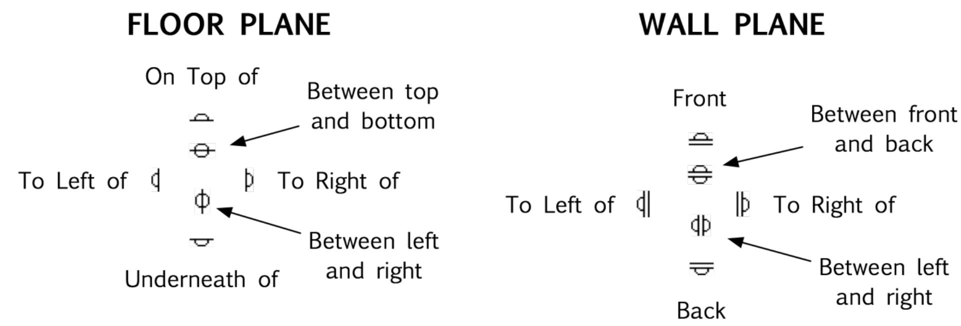
Figure 48. Examples of the brush and rub contact symbols

ASL 'monthly' (a) | ASL 'temperature' (b) | ASL 'island' (c) | ASL 'socks' (d)

3.11 Surface symbols

Often, if symbols are properly placed, the sign can be easily read without explicitly representing which surfaces of each articulator are involved. Occasionally, there are times when the relationship between articulators can be ambiguous, so surface symbols are available to disambiguate. Figure 49 lists the available surface symbols. The motif of single lines and double lines from the directional movement symbols is also employed by the surface symbols.

Figure 49. Diagram of surface symbols[32]



Surface symbols focus on the surface relationships between the articulators; the selection of surface symbols is based on which surfaces need clarification. When a writer chooses a surface symbol, it is usually associated with a specific surface on that articulator or on a contact symbol to show how the contact occurs. Figure 50 contains an example of the Wall Plane surface symbols. In this case, the focus is on clarifying the position of contact. The two hands without additional clarification would indicate the palms are touching. Instead, the ulnar side of the left hand is touching the radial side of the right hand.[33] So the two surface symbols associate with the touch contact symbol to clarify the contact.

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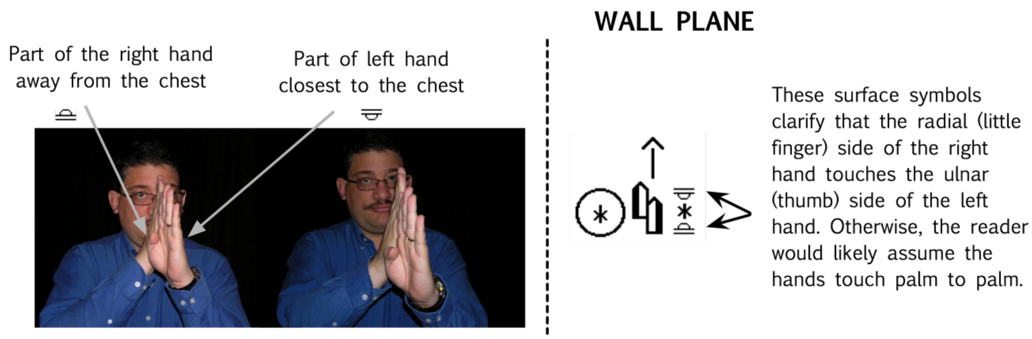
[32] Parkhurst and Parkhurst (2008) actually teach these symbols opposite of the way I explain here. Their approach is more consistent, however, with the motif of double lines for vertical alignment and single lines for horizontal alignment. In terms of the grammar of SignWriting, it makes no difference. For the examples in Figure 50 and Figure 51, I have chosen to stay with the explanation on the SignWriting website.

[33] The ulnar side of the hand is the side with the thumb and the radial side of the hand is the side with the little finger.

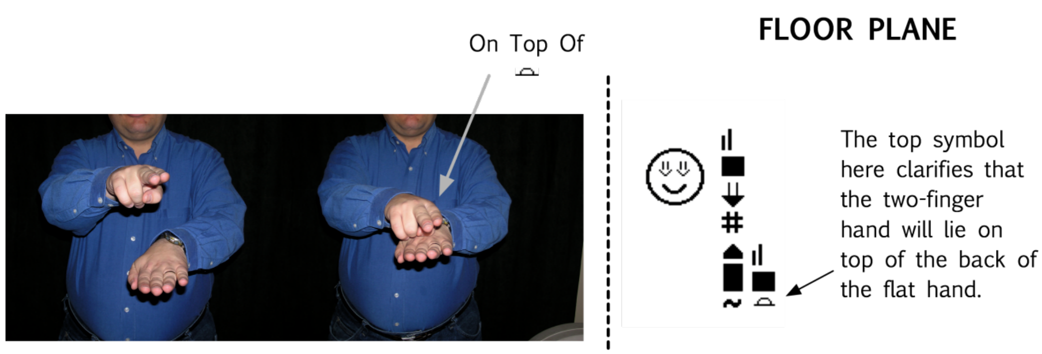
Figure 50. Example of Wall Plane surface symbols



The SignWriting examples are taken from http://www.signwriting.org/lessons/elessons/less028.html

Similarly, Figure 51 contains an example of the Floor Plane surface symbols. In this sign, the two-fingered hand is supposed to come down and rest hard on top of the back of the left hand. However, the writer cannot write that point of contact clearly. So the two-fingered hand is shifted to the side of the left hand and the top surface symbol is written under the two-fingered hand to indicate that it is actually on top of the left hand.

Figure 51. Example of Floor Plane surface symbols



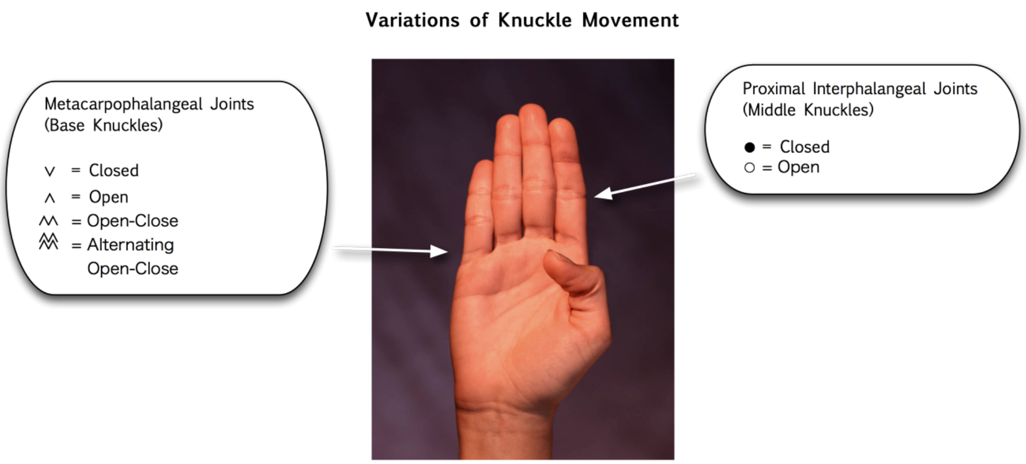
The SignWriting examples are taken from http://www.signwriting.org/lessons/elessons/less028.html

Like their counterparts in Directional Movement arrows, the surface symbols for the Wall and Floor Planes can both refer to the left and right surfaces. The distinction between them is subtle and one that depends on whether the surface is being viewed from the Wall Plane or the Floor Plane. In either case, the same surface remains in view. Whether this distinction is important to preserve or not will likely be something determined by usage.

3.12 Knuckle movements

As illustrated in Figure 52, there are two basic types of symbols that represent changes in the configuration of individual fingers, known in SignWriting as knuckle movement. Knuckle movements generally focus on the metacarpophalangeal joints and the proximal interphalangeal joints, referred to here as the **BASE** and **MIDDLE KNUCKLES**, respectively.

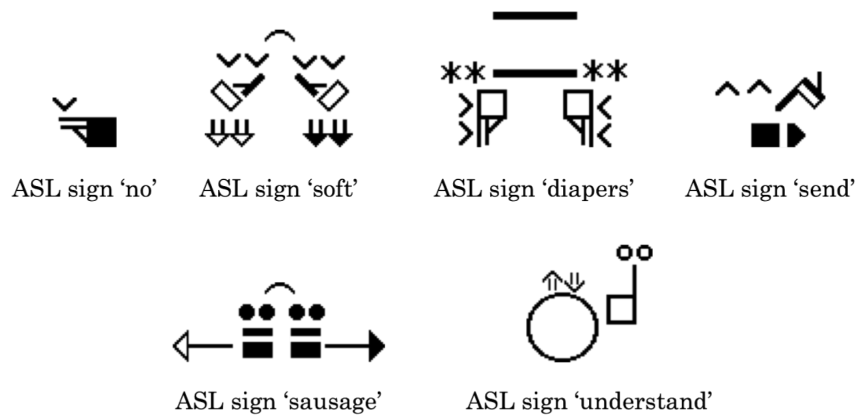
Figure 52. Basic knuckle movement symbols



Like contact symbols, they are placed near the finger(s) that change their state. All movement variations of the base knuckles are generally represented by ∧ and/or ∨. Individually, the ∧ (pointing away from the fingers) and ∨ (pointing toward the fingers) represent an opening (extension) or closing (flexing) movement at the base knuckles, respectively. When two or more ∧ join together (e.g., ∧∧), it means an opening movement followed by a closing movement. Likewise, when two or more ∨ join together (e.g., ∨∨), it means a closing movement followed by an opening movement. When two or more ∧ join together and are stacked (i.e., ∧∧), it represents alternating open and close movements such as a wiggling of the fingers. Knuckle symbols can rotate in all eight directions to fit the orientation of the hand symbol. The ∧/∨ symbol is also used elsewhere in the system to represent certain other parts of the body that might move up and down.[34]

All movement variations of the middle knuckles are represented by ∘ and •. The ∘ represents an opening middle knuckle, and can also be used to represent a flick of the finger off the thumb. The • represents a closing middle knuckle. An example of both types of knuckle movement is shown in Figure 53.

Figure 53. Examples of knuckle movements



Sometimes, there is a need to show the fingers moving from the knuckles in a sequential order. If it is the middle knuckles, the sequence can be written as / , / , / , or / , in which symbols are placed around the fingers of the hand symbol. If it is the base knuckles, the sequence can be written as / , / , / , or / . Each of these sequences can be rotated or flipped to fit the hand symbol to show the sequence. Despite the appearance of an arrow in these sequences, the arrow shows the sequence rather than indicating actual movement of the hand or fingers. If the hand(s) do move, a movement arrow needs to be added to show the movement.

[34] See Section 4.4.2 for an example where ∨ is used with eyelashes.

Using two variants of the ASL sign ‘pretty/beautiful’ shown in Figure 54, a distinction between the use of these two sequences of knuckle symbols can be drawn. The variant in (a) has the fingers closing from the little finger to the thumb ending in the final closed fist. The other variant in (b) has the fingers closing from the little finger to the thumb ending in all fingers being extended and touching the thumb. The difference between the two signs is the ending position. In the first variant, the ending position is a fist where the middle knuckles are bent requiring the use of the middle knuckle symbols. In the other variant, the ending position has the fingers and thumb protruding forward, thus only the base knuckles are bent requiring the use of the base knuckle symbols.

Figure 54. Contrasting knuckle sequences using variants of ASL ‘pretty/beautiful’

(a) (b)

3.13 Breathing symbols

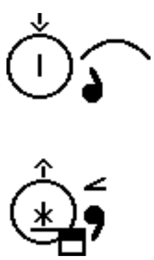
Two symbols are available to represent breathing that occurs: representing exhalation and representing inhalation. These can co-occur with the Air Out/In diacritics (described in section 4.7.4.)

When used with general movement arrows, they are placed at the position in the movement where exhalation or inhalation should occur. Sometimes, the inhalation or exhalation occurs periodically in a sign—such as the example in (14). The writer, then, places the symbol on each place in the path to show where the inhalation(s) or exhalation(s) occur. These diacritics are available in three sizes to depict the amount of inhalation or exhalation: , , and .

(14) 

ASL: ‘occasionally, from time to time’

The breathing symbols can also be placed beside the face such as in (15). In this case, dynamic symbols (see Section 6.2) are modifying the inhalation and exhalation symbols to show the speed of inhalation or exhalation. This action occurs in two stages. The inhalation occurs slowly as shown by the slow dynamic symbol. The exhalation occurs quickly as shown by the fast dynamic symbol. Notice the inhalation and exhalation symbols are close to the nose to show which articulator is inhaling or exhaling. The fact that dynamic symbols are modifying the breathing symbol indicates that the breathing symbols are movement symbols rather than face diacritics (explained in the next chapter.)

(15) 

ASL: mimed sneeze

CHAPTER 4

HEAD AND FACE SYMBOLS

4.1 Introduction

The head and face contain important articulators that play an active role in the grammar and discourse of sign languages. To date, one of the weaknesses of other writing systems for sign languages mentioned earlier such as Stokoe, HamNoSys, or SignFont is that their inventory of head and facial parameters is limited or non-existent compared to SignWriting. This is a significant problem. Phonological research in sign languages has clearly shown that the use of the face and head such as facial expressions, nose twitches, eye gaze, head motion forwards and backwards or side-to-side (to name a few) all play a role in the syntax and morphology of sign languages in addition, at times, providing subtle nuances to an utterance. Thus, a writing system for sign languages must take into consideration, among other things, the head and face.

Throughout the chapter, the difference between some diacritics may be a matter of selecting a particular articulator or emphasizing a particular movement by an articulator. This overlap may make it seem as if SignWriting has more diacritics than are necessary. Yet, the level of detail actually written will depend on the writer's intention and need.

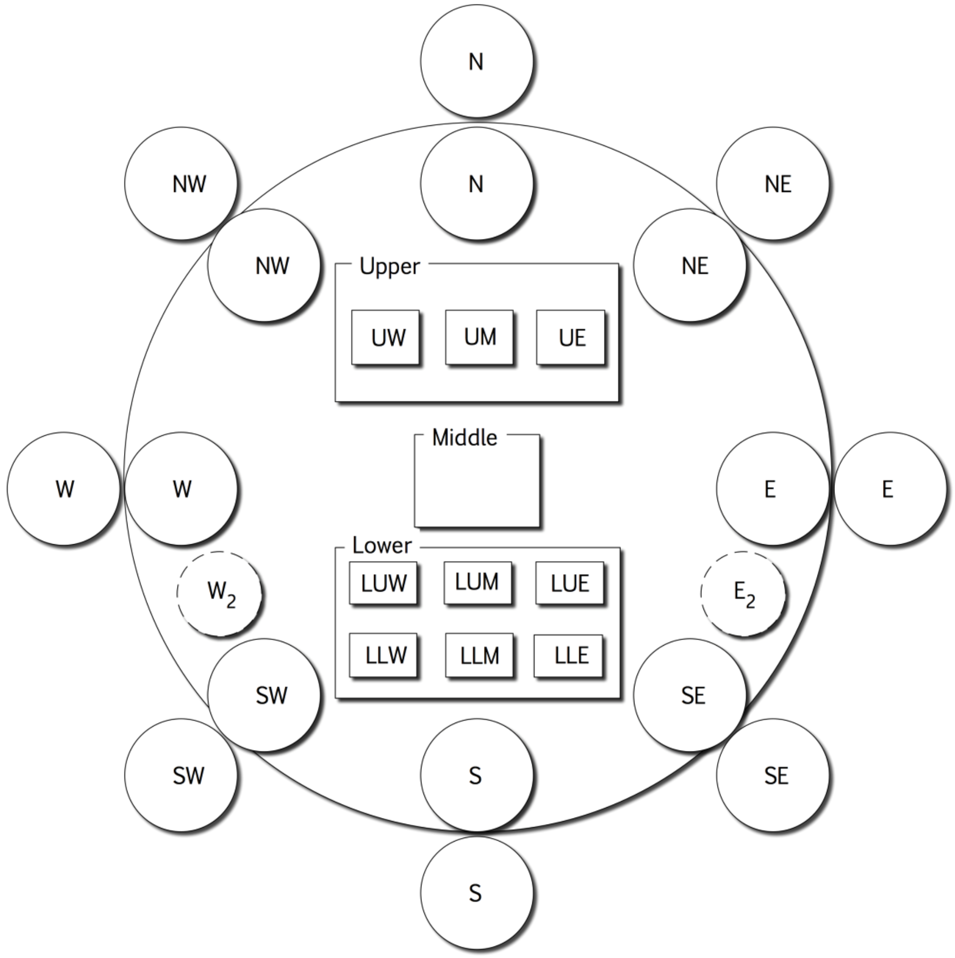
4.2 Head circle map

Conceptually, a simple circle represents the head and face. The **HEAD CIRCLE** has various diacritics added to it in order to represent the various articulators. To the extent that these diacritics do not occupy the same slots, multiple diacritics can be placed around and within the same head circle. Where necessary, additional head circles can be added sequentially (left to right within one sign) and additional diacritics can be added to those head circles. In this way, complicated facial expressions or mouth movements can be relatively easily written.

The previous paragraph describes conceptually how the system works, and when writing SignWriting by hand, this is the approach that the writer normally uses. However, with existing computer implementations, all head/face diacritics come already attached to a head circle. The head circles are then superimposed upon one another vertically (i.e., in z-order), appearing as one circle, but since each symbol is transparent, the lower diacritics show through.

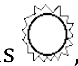
The head circle is the only truly independent symbol in this category; all the rest are diacritics that are positioned relative to the head circle. Figure 55 illustrates the slots where the diacritics are located with respect to the head circle. The following sections reference this illustration to discuss what symbols are available in each slot on the head circle. For instance, a comment that “some diacritics fit within the inner N slot or the outer N slot” is referring to the two circles with an N in the upper center of the head circle. A reference to the Upper, Middle and Lower slots are a reference to the rectangular slots with that label, which receive diacritics related to the eyes/forehead, nose, and mouth, respectively.

Figure 55. Locations for face and head diacritics



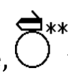
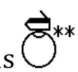
Due to the symmetry of the face, many facial diacritics are actually **PAIRED DIACRITICS** (i.e., eyes, eyebrows, ears, *etc*.) So, normally, both members of the pair are placed on the appropriate slot in the head circle. However, if the writer wants to draw attention to only one particular side of the face, then only the diacritic for that side of the face is placed in the appropriate slot.

The head circle is represented by . As we noted in Section 1.4.8, some symbols possess inherent opacity as they are superimposed on other symbols. The head circle and its associated diacritics frequently display this opacity. Throughout this chapter, we will note examples of opacity for the head circle.

One unusual use of the head circle is , composed of a paired diacritic that attaches on the outer E slot () and/or the outer W slot ().[35] Unlike other head circle diacritics, this one communicates excitement—an emotion—rather than the orientation of a particular articulator on the head.

Through the rest of this chapter, the diacritics are described in terms of the real world articulator being referenced. At the end of this chapter, the diacritics are summarized again in terms of the slots accepted and in terms of the type of diacritic (paired or single).

4.3 Diacritics related to specific position of contact

The rim diacritics indicate contact that occurs toward the sides of the head, but on the face rather than the very side. Rim diacritics attach to the inner N, S, E, W, NE, NW, SE, and SW points. For example,  would mean patting the top of the head, whereas  would mean tapping the forehead with the ulnar (thumb) side of the hand.

The rim diacritic for the chin () may co-occur with a pair of  or of  in the outer SE/SW slots to indicate movement of the jaw as shown in Figure 56. Wall Plane arrows, shown in (a), show the jaw moving up, down, or to the sides. Similarly, Floor Plane arrows, shown in (b), show the jaw jutting forward, moving backward, or moving the jaw itself back and forth from side to side. In this case, the Wall and Floor Plane arrows are synographs when indicating side-to-side movement.

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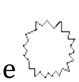
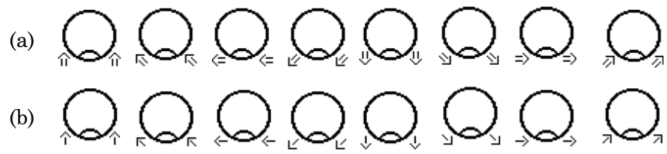
[35] A writer can use this pre-composed symbol or superimpose  on an existing head circle.

Figure 56. Diacritics showing the movement of the jaw



In addition to the rim diacritics, the system includes other diacritics that aid in noting more specific positions of contact. Sometimes, specific signs need to contact the back of the head. Placing parentheses around the head circle (e.g.,) signals that the contact is specific to the back of the head. The head circle can also accept a surface symbol () to describe more specifically where the contact occurs. When it appears with the head circle, it will attach to an outer slot. The flat part of the surface symbol always faces the head circle (, , etc.).

4.4 Diacritics related to the eyes and forehead

In all existing computer implementations, diacritics related to the eyes and forehead occupy the same location--the upper slot in Figure 55. So, if both eyes and forehead diacritics are needed when writing on a computer, they need to be placed on separate head circles. Obviously, with handwriting, the head circle can be adjusted for size so that all eye and forehead symbols can be included as needed.

4.4.1. Eyebrows and forehead diacritics

The eyebrow diacritics include two groups of paired diacritics: parallel lines and slightly curved parallel lines . The group of parallel lines paired diacritics are more phonemic focusing on (raised eyebrows), (neutral eyebrows), or (lowered eyebrows). The group of curved parallel lines are more phonetic, focusing on minor variations in which parts of the eyebrow are up or down such as , , , or .[36] In

[36] These may also be used more emotively such as for hopeful, for worried, etc.

theory, writers could employ different eyebrow diacritics simultaneously (such as depicting the famous Vulcan single raised eyebrow done by Spock). However, no explicit rules or examples of current usage state whether such a use is acceptable. Current usage (as of this writing) appears to be that writers use either both or one of a pair, but not a mix of eyebrow symbols.[37]

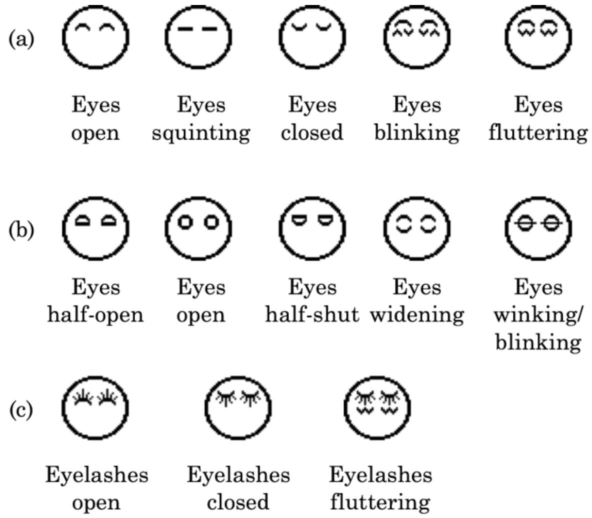
Forehead diacritics (which are not paired diacritics) attach to the very top of the Upper box. Forehead diacritics are limited to:  (neutral forehead),  (a touching contact with the forehead), and  (a wrinkled forehead). While there may be overlap in meaning between the eyebrow diacritics and the forehead diacritics, the distinction appears to be one of focus, whether the writer perceives the action coming from the eyebrows or the forehead.

4.4.2. Eyes and eyelash diacritics

The eyes and eyelash diacritics are paired diacritics, more frequently appearing as a pair. The diacritics for the eyes and eyelashes include those in Figure 57. Similar to the eyebrows, (a) shows diacritics that are more phonemic while (b) shows diacritics that are detailed about how the eyes are open. The diacritics in (c) focus on the eyelashes being either up or down with the final symbol showing a fluttering of the eyelashes (which is conveyed by adapting a smaller version of the knuckle symbol []). While there is significant overlap of these symbols, much of that overlap is a matter of how detailed a writer wants to be or which articulator the writer wants to emphasize.

[37] I am unaware of any examples of sign languages specifically using a mix of eyebrow positions. It seems to be a rare skill.

Figure 57. Eye and eyelash diacritics

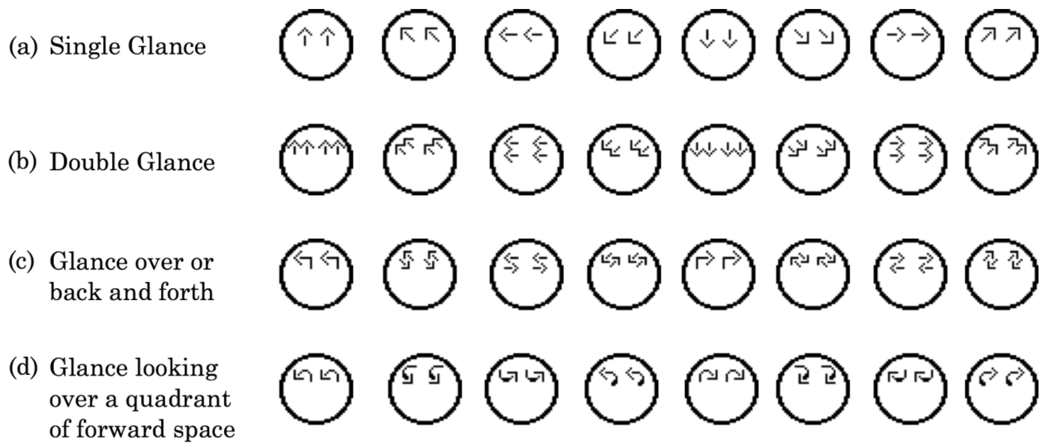


4.4.3. Eye gaze diacritics

The eye gaze diacritics use a metaphor in which eye gaze is treated like a form of movement in which the gaze "moves" from the eye toward the object being viewed. With that metaphor in place, small versions of directional movement arrows (described in Section 3.3) are used to represent the direction of the eye gaze. The arrows are placed where the eye diacritics would normally be placed. The neutral arrowhead (^) is used because the hands are not involved.

Glances that look forward, back, side to side, or looking at a quadrant of forward space are considered eye gazes on the Floor Plane. The diacritics representing these are illustrated in Figure 58 and use the familiar motif of a single-lined arrow shaft. This subset of the movement arrows only employs small versions of the straight, curved, and right angle arrows.

Figure 58. Floor Plane eye gaze diacritics



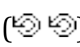
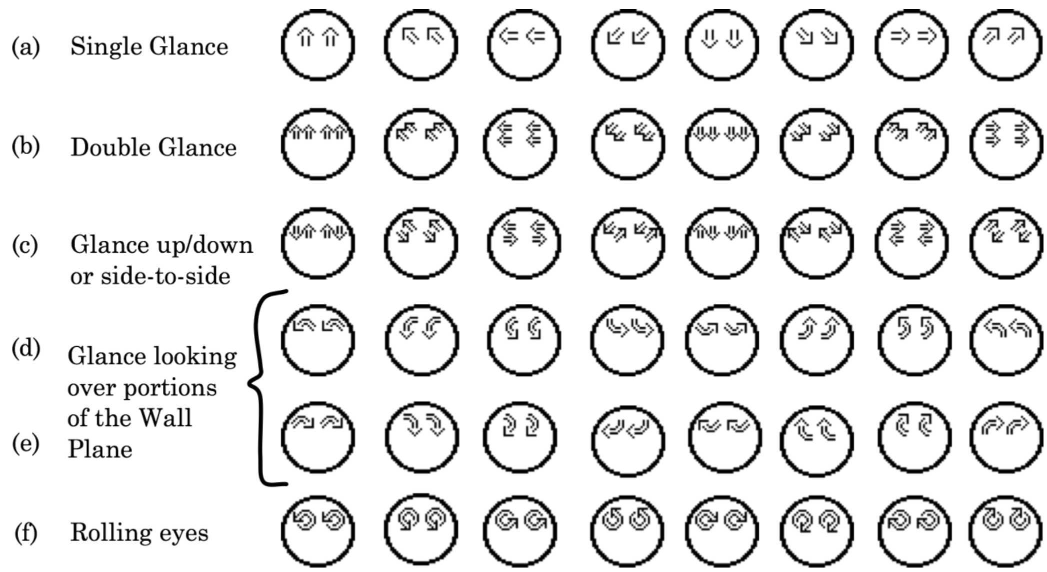
Similarly, glances that look up, down, side to side, around the wall plane in front of the reader, or a rolling of the eyes are considered eye gazes on the Wall Plane. Diacritics representing these are illustrated in Figure 59 and also use the familiar motif of a double-lined arrow shaft. This subset of the movement arrows only employs small versions of the straight, curved, and circle arrows. But the form of the circle arrows used for the eyes is somewhat different from the usual form for the general movement circles. The eye circles are slightly different with a little more gap by their tails () as compared to a comparable Wall Plane general movement circle ().

Figure 59. Wall Plane eye gaze diacritics



4.5 Diacritics related to the cheeks and ears

4.5.1. Cheek diacritics

Cheek diacritics are paired diacritics, having four forms: , , , and . means the cheeks are filled with air. means the cheeks have no air in them (essentially a neutral state). means the cheeks are sucked in. Again, like other paired diacritics, the diacritic may stand alone on one side of the face or the other. These diacritics only appear in the inner W/E slots.

borrows the dynamics symbol ~ (see Section 6.3), which typically represents a tense movement. In this case, the diacritic implies tenseness felt in the cheeks. The ~ usually appears in the inner W/E slots as a paired diacritic.

has 2 other variants which are very visually similar: and . When all three are used contrastively, (placed in the inner W/E slots) implies tenseness by the cheekbones, (placed in a little-used inner W_2 /E_2 slot) implies tenseness in the cheeks between the mouth and nose, and (placed in the inner SW/SE slots) implies tenseness in the cheek near the mouth. Such precision is only necessary for phonetic transcriptions.

4.5.2. Ear diacritics

Ear diacritics can appear in a pair or individually: , , or . They appear in the outer W/E slots. The ears are passive articulators, a location where hands contact in some manner.

4.6 Diacritics related to the nose

A thin vertical line in the middle slot of the head circle ( ) represents the nose. Alone, it indicates that the nose is somehow relevant to the sign, whether the hands approach it, touch it, or somehow position themselves relative to it. Additional nose diacritics that fit in the middle slot include , , and . Notice the reuse of other symbols in the system. ∗ superimposed on the nose symbol indicates a touch on the nose. The borrowing of the knuckle movement symbols ( ) indicates a nose twitching from side to side. Unique to the nose diacritics is the use of two parallel horizontal lines placed on the nose line to represent a nose wrinkling.

4.7 Diacritics related to the mouth and chin

Mouth diacritics are contained within the lower slot of the head circle with the exception of a few tongue diacritics and the air in/out diacritics. The lower slot is subdivided into upper and lower rows of W, M (middle), and E slots. Mouth diacritics usually have one primary diacritic, but some have secondary diacritics that appear with the primary one. Unless mentioned otherwise, the primary diacritic appears in the LLM slot.

4.7.1. Lip diacritics

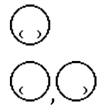
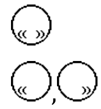
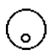
The lip diacritics specifically describe the contours of the mouth itself. In most cases, the lip diacritic stands alone in the LLM slot and sometimes can overlap the LLW and LLE slots. However, in some cases, there are secondary diacritics that modify the lip diacritic and provide additional information. The secondary diacritics can be placed on top of the lip diacritic (i.e., in the upper row of the lower slot) or, in the LLW and LLE slots if the lip diacritic has not overlapped those slots. Two of the secondary diacritics can stand alone without a lip diacritic.

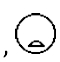
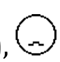
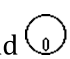
The secondary diacritics do not appear to be usable with all lip diacritics. Table 42 describes the meanings of each of the secondary diacritics. Table 43 captures current pre-composed combinations in the ISWA. Without a larger corpus of written facial expressions, it is difficult to determine if other combinations are possible or not.

Table 42. Meaning of lip secondary diacritics

^	Mouth wrinkles up
( )	Single wrinkles on either/both sides
(( ))	Double wrinkles on either/both sides
↑	Lips protrudes
↓	Lips sucks in
☼	Lips have wrinkles all around
✱	Contact on the lips

Table 43. Lip diacritics and their secondary diacritics

	^	( )	(( ))	↑	↓	✲	✱
 neutral							
 closed lips							
 closed smile							
 frown							
 open mouth							
 oval open mouth							
 kiss							
 tense lips							

In addition, the following lip diacritics do not appear to accept secondary diacritics:  (rectangular open mouth horizontally),  (rectangular open mouth vertically),  (lips sucked in and pressed together),  (open smile, half straight),  (open frown, half straight,  (upper lip over lower lip),  (lower lip over upper lip), and  (yawn – oval mouth open vertically).

4.7.2. Tongue diacritics

The purpose of the tongue diacritics is to indicate the positioning of the tongue when the use of the tongue is significant. The tongue diacritics can be grouped as shown in

Figure 60. Groups (a) – (d) convey different perspectives of the tip of the tongue while (e) simply depicts the tongue as being visible inside the mouth. The distinction between (b) and (c) is small; Figure 61 illustrates how both have the lips closed over the tongue, but (b) can extend beyond the lips but (c) does not. Groups (a) – (e) follow a fairly standard pattern starting with the tongue at due north and proceeding at 45˚ increments counterclockwise. Each of these diacritics attaches in the LLM slot.

Figure 60. Tongue diacritics focusing on tongue placement

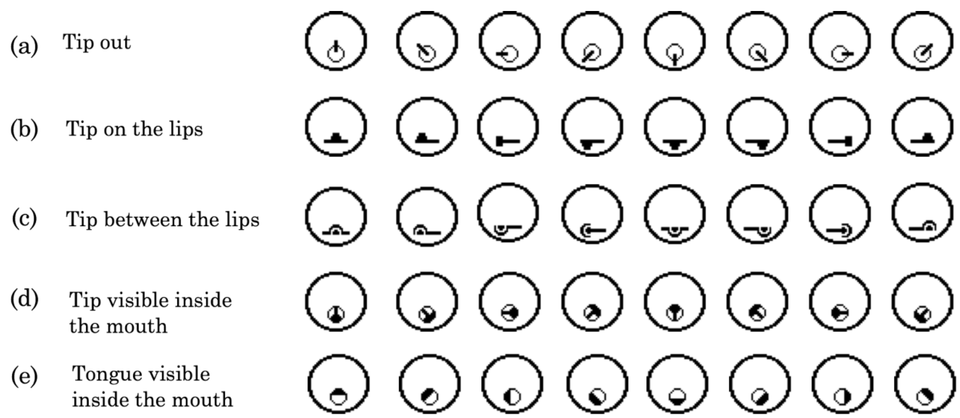


Figure 61. Distinction between (b) and (c) in Figure 60

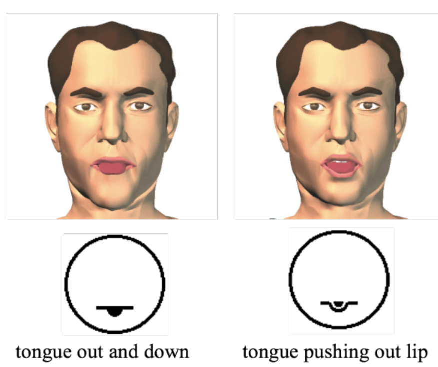
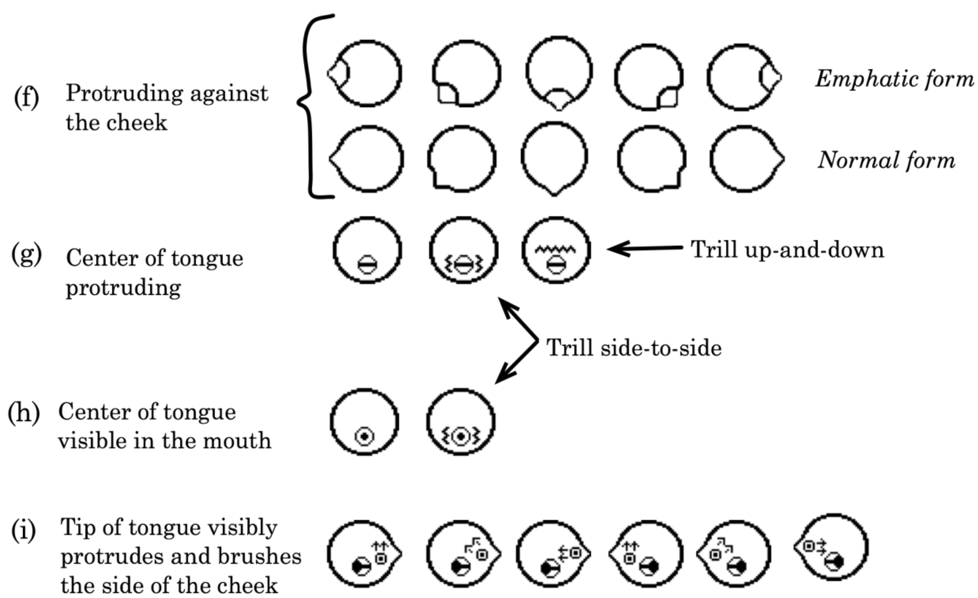


Illustration taken from
Parkhurst and Parkhurst (2008:135)

Figure 62 shows groups (f) – (h) which follow a different pattern than groups (a) – (e). Group (f) focuses on the tongue protruding against the cheek. The first row represents the protrusion when it is emphasized, usually as a point of contact or reference. This use of a protrusion in combination with a rim diacritic serves to draw attention to it. The second row represents the protrusion when it is simply being noted. The tongue diacritics in (f) attach to the inner W, SW, S, SE, and E slots. Groups (g) and (h) focuses on the center of the tongue itself either protruding (g) or being visible from within the mouth (h). Both groups (g) and (h) contain examples of the use of a trilling symbol attached to LLW and LLE, similar to that used with the nose, to show the tongue moving from side to side. Group (g) also contains a symbol that attaches to the LUM slot to show the tongue moving up and down in a trill. Finally, group (i) represents a specific use of the tongue to protrude and move against the cheek while the tongue is visible. Note the use of the brush contact symbol and the small arrow symbols (placed in the inner E/W slot), and the two specific visible tongue symbols described in (d) above (placed in the LLM slot as expected).

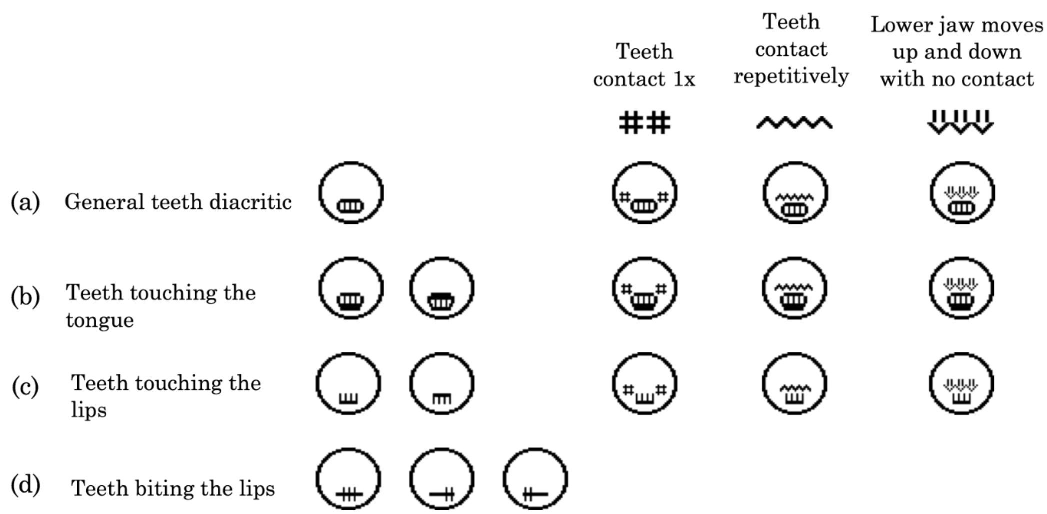
Figure 62. Tongue diacritics focusing on tongue protrusion



4.7.3. Teeth diacritics

The set of teeth diacritics is small and illustrated in Figure 63. The general diacritic for the teeth is reflected in Group (a). Group (b) – (d) represent the teeth interacting with the tongue and lips. Three of them have secondary diacritics that describe the movement of the lower jaw. Those secondary diacritics are smaller versions of other standard movement symbols: # appears both in the LUW and LUE slots; ^^^^ appears in the LUM slot (but spreads across to LUW and LUE); and ⇓⇓⇓ appears in the LUM slot.

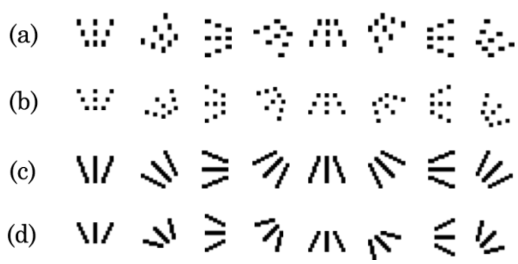
Figure 63. Teeth diacritics



4.7.4. Air in/air out diacritics

Two diacritics are used to represent breathing that necessarily happens as part of a sign. The air out/air in diacritics (and) are used to indicate air movement from the mouth. These diacritics (particularly the precomposed version) are usually placed inside the head circle in the inner SW/SE slot. If other mouth or cheek diacritics are present, the air out/in diacritics can move to the outer SW/SE slot. The air in/air out diacritics contain opaque areas that cover the rim of the head circle as they break outside. These breathing diacritics can also co-occur with the breathing symbols that are placed near movement arrows (as discussed in Section 3.13). Additional rotations of breathing diacritics are available such as in Figure 64 to show the direction of airflow. The directional air out breathings in (a) and (b) and air in breathings in (c) and (d) are available in two different sizes to represent shorter or longer bursts of air being blown out or sucked in. They may be doubled to represent repeated puffs of air. For instance, writing a person blowing out two puffs of air would be represented by  (Sutton, pc, 14 November 2010).

Figure 64. Rotations of breathing diacritics

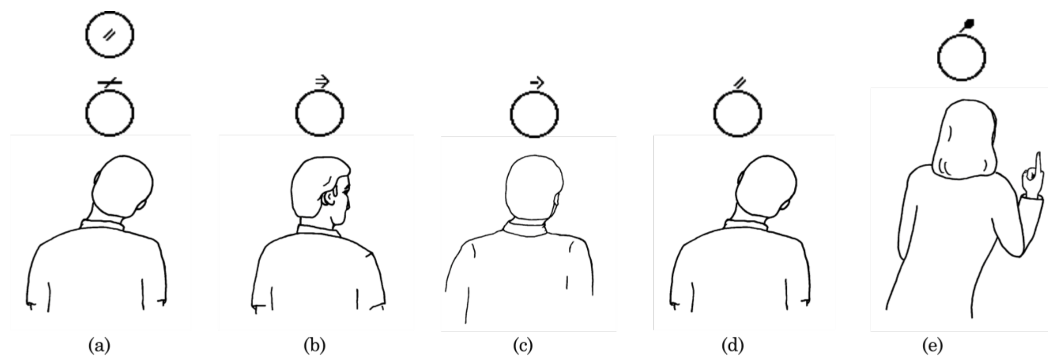


4.8 Diacritics related to the placement/movement of the head

Head placement and movement is another important distinction in the sign that the system must capture. One set of diacritics describes a “snapshot” of the head’s position at the moment of signing. The others provide different ways of describing the movement of the head during a sign.

Figure 65 illustrates the different ways of describing head placement and movement. In (a), there are two methods for capturing a snapshot of the head’s position at the time of signing. The upper one uses the nose’s angle to represent the head tilted left or right from the base of the skull. The lower one uses a vertical line intersecting a horizontal line to represent the head’s angle and position on the shoulders, a device that can depict the head’s position in more detail than the first. In (b), the nose moves within the Wall Plane, moving up or down (by tipping the head backward or forward from the base of the skull) or to the sides (by pivoting the head on its vertical axis). In (c), the nose moves in the Floor Plane, that is, the head moves forward, back and to the sides without tilting (by bending at the base of the neck as well as the base of skull). In (d), the head tilts. The difference between (a) and (d) is that (a) is a stationary “snapshot” without depicting movement, where (d) represents a movement to the angle depicted. In (e), the head moves due to bending from the hips rather than from the neck. In this section, we will look at these sets of diacritics.

Figure 65. Possible ways to describe the head's angle or movement[38]



4.8.1. Face position diacritics

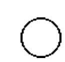
When simply recording the direction of the face in terms of its position as opposed to its movement, the writer has two choices. If writers are not concerned with a high level of detail, but want to note a tilt of the head, they can use  or , a diacritic placed in the middle slot that represents the angle of the nose. This simpler system is represented in the Simple Tilting row in Table 44.

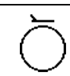
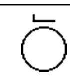
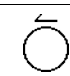
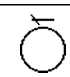
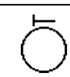
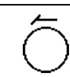
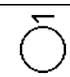
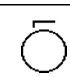
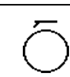
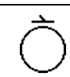
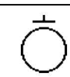
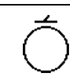
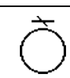
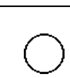
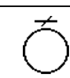
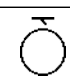
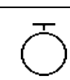
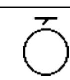
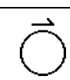
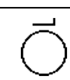
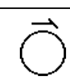
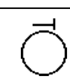
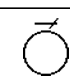
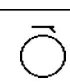
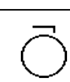
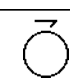
Ordinarily, if no head circles are necessary for that particular sign, the writer can simply use the torso symbol (a horizontal line) with a diacritic to represent the direction of the face. I discuss the torso symbol with the face position diacritic in more detail in

[38] Line drawings taken from Parkhurst and Parkhurst 2007.

Section 5.2.2. But if the writer needs to use a head circle, a small version of the torso symbol with a face position diacritic can be used as a diacritic itself for the head circle in the outer N slot. This gives a more detailed snapshot of the face's direction and angle, not just head tilt.

Table 44. Face direction diacritics

	Tilted Left	Straight	Tilted Right
Simple Tilting			

Facing Left and Looking	Up			
	Straight			
	Down			
Facing Center and Looking	Up			
	Straight			
	Down			
Facing Right and Looking	Up			
	Straight			
	Down			

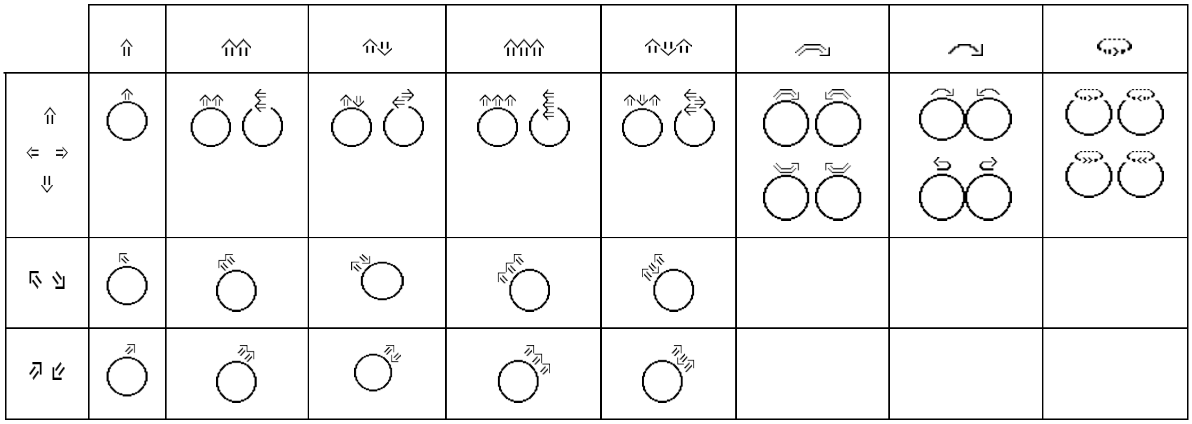
4.8.2. Head movement diacritics

The arrows for head movement are small versions of the general Wall and Floor Plane arrows. In this case, the articulator is the head and how the paths are interpreted is adjusted to reflect how the head articulates. Because of the flexibility of the neck, there are many possibilities. With Wall Plane arrows, the head pivots left or right or tilts up or down from the base of the skull. This covers movements like nodding or shaking the head from side to side. With Floor Plane arrows, the entire head is shifting in the horizontal direction indicated, by motion from the base of the neck with compensating adjustments at the base of the skull, without the nose moving in any direction of the ways indicated by the Wall Plane arrows.[39]

All arrows follow the same general placement rules. See Table 45 below for examples using Wall Plane arrows and circular movement arrows. The same paradigm applies to the Floor Plane arrows. All single arrows always attach to the outer N slot. Double and triple horizontal or vertical arrows always attach to the outer N slot. When the double and triple horizontal arrows and the circular movement arrows attach to the outer N slot, they spread into the inner N slot and their opacity results in the appearance of a gap over the N slot. Double and triple arrows that are oriented NW/SE attach to the outer NW slot. Double and triple arrows that are oriented SW/NE attach to the outer NE slot.

[39] In this instance, the left/right Wall Plane arrows and the left/right Floor Plane arrows are not synographs since they represent movements by different joints: the Wall Plane reflects movement by the base of the skull and the Floor Plane reflects movement by the base of the neck.

Table 45. Head movement arrow placement



4.8.3. Head tilt diacritics

The movement arrows do not provide any way to represent the head tilting side-to-side from the base of the skull, so this is done using the same two diacritics used to show static "nose" tilt, except with the diacritic in the outer N slot rather than at the nose. Tilting movement incorporates a simple paradigm. If the head tilts once, the diacritic is two diagonal parallel lines placed at the angle of the closing position of the nose (i.e., or). If the head tilts multiple times, the diacritic can appear in sets of two ( ) or threes ( ). If the tilting alternates from side to side, the two angles can be written with one or two small Floor Plane side-to-side arrows to indicate which tilt happens first (i.e., or).

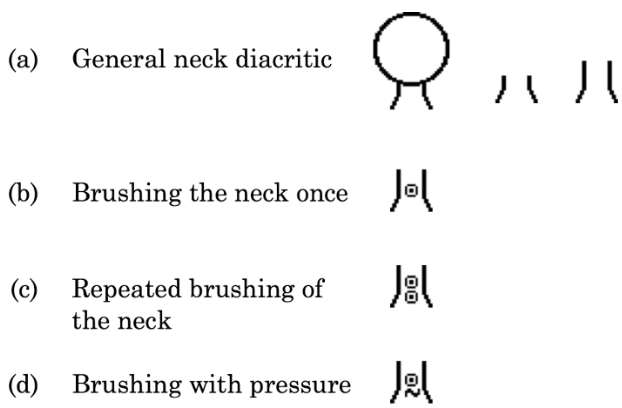
4.8.4. Body tilt diacritics

The symbol (described more fully in Section 5.2.3) also refers to a tilting movement. Section 5.2.3 focuses on its use with the shoulder symbol. In that case, it refers to the tilting of the shoulders. However, in the context of the head circle, it refers to a tilting of the whole body from the hip joint—the neck and torso do not bend during this movement. When used with the head circle, these symbols follow the same placement rules as the Floor Plane and Wall Plane arrows described in Section 4.8.2.

4.9 Diacritics related to the neck and hair

 or  is used when the neck is a passive articulator in a sign. SignWriting includes both plain and precomposed neck diacritics that attach at the outer S slot. The precomposed neck diacritics such as those in Figure 66 simply include common contact symbols placed on the neck diacritic to show contact with the neck. When an articulator contacts the neck, one or more contact symbols may be placed on the center of the neck diacritic. (b) – (d) represent the precomposed neck diacritics with contact symbols already placed. Though no precomposed neck diacritics include other contact symbols, nothing in the system precludes the use of other contact symbols attached to the center of the neck diacritic.

Figure 66. Neck diacritics

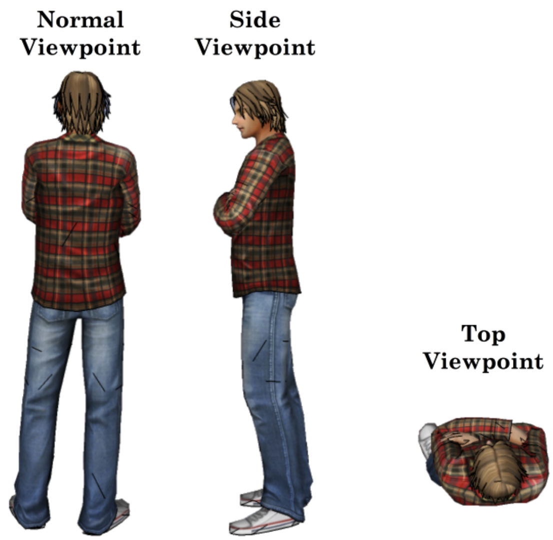


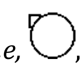
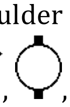
 is used when the hair is a passive articulator in a sign. The paired symmetrical diacritic  () attaches at the outer W/E slot.

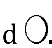
4.10 Viewpoint diacritics

As touched on briefly in Section 1.4, SignWriting is generally written in the expressive mode using the normal viewpoint. As shown in Figure 16 (reproduced below), SignWriting also includes the top and side viewpoints. This section looks at diacritics that attach to the head symbol to signal a change in viewpoint.[40] While the viewpoint may change, the Planes remain fixed and do not move.

Figure 16. SignWriting viewpoints



By default, the  symbol establishes the normal viewpoint. To change the viewpoint to the side or top viewpoint, the head circle accepts specific diacritics. For a side viewpoint, the addition of a "nose" to the outer NW, W, NE, or E slots of the head circle (*i.e,* , , , or ) signals that the signer is facing the Side plane and the angle of the nose communicates the tilting of the face.[41] Likewise, the addition of shoulder bars to the outer E/W, SE/NW, N/S, or SW/NE slots of the head circle (i.e*.,* , , , or ) signals a

[40] Two other little-used symbols for lesser 45˚ perspectives exists, namely  and . While they are present in the system, I have not noticed them regularly used. Unlike the other viewpoint symbols, the shading appears on the inner W and E slots instead of the outer W and E slots.

[41] Interestingly, this symbol has no precomposed versions with the nose at the SW and the SE slots.

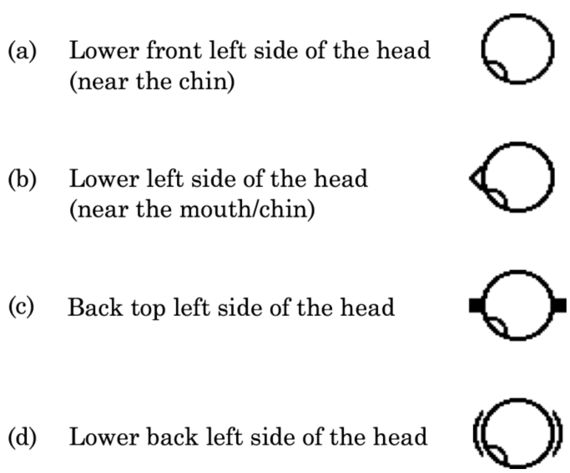
top-down viewpoint.[42] Limb symbols (Section 5.3) can be added to the shoulder bars to convey the relative extension of the arms as illustrated in Figure 67.

Figure 67. Limb symbols with shoulder bars

ASL mime ‘tap in front of me’

The rim diacritics can also be used in conjunction with viewpoint diacritics, and the interpretation of the rim diacritics changes because the “front” surface changes depending on the viewpoint diacritic used. Figure 68 illustrates the different interpretations of the rim diacritics for a lower left front surface.

Figure 68. Interaction of rim and viewpoint diacritics

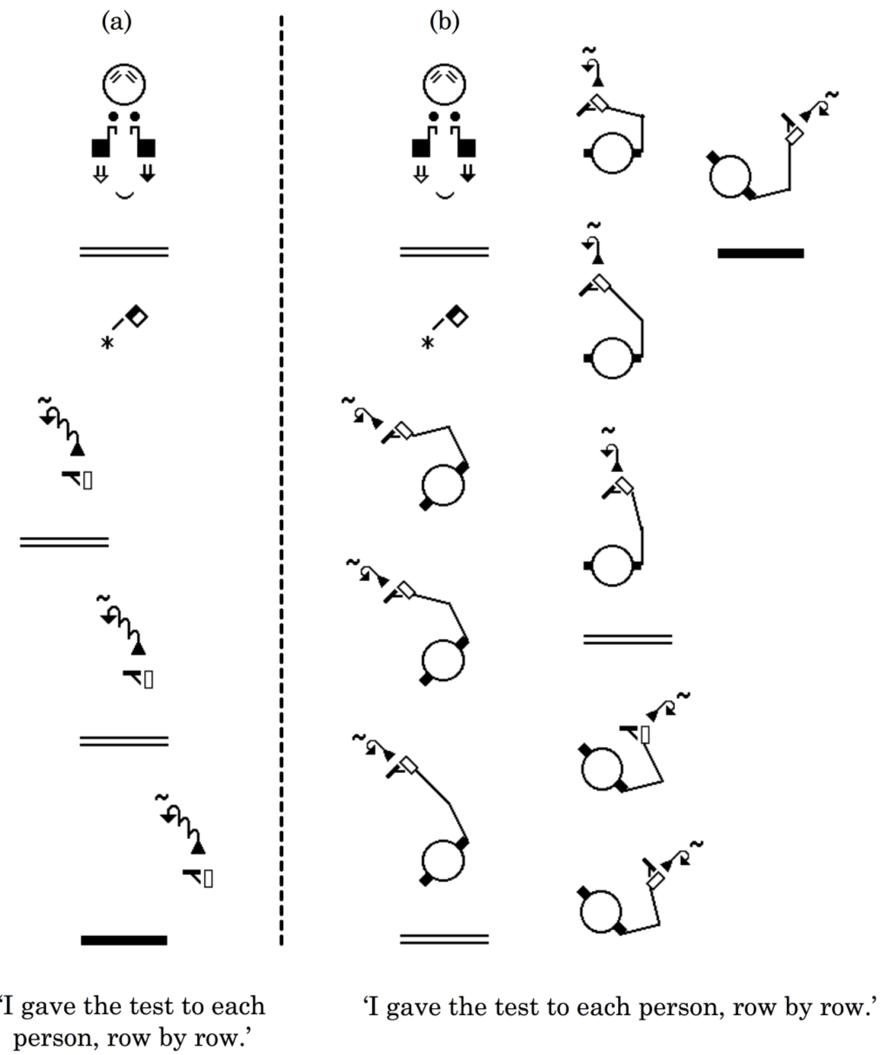


To visualize the difference between the normal and top viewpoints, take, for instance, the example sentences in Figure 69. (a) shows the sentence from the normal viewpoint.

[42] While my analysis of the top down diacritic is a paired diacritic representing each shoulder, an acceptable alternative analysis could be the placement of a torso symbol (described in Section 5.2) underneath an opaque head symbol attaching in a similar way.

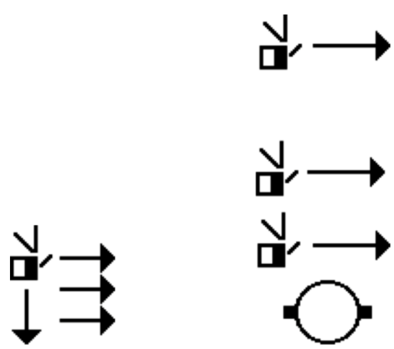
(b) shows the same sentence utilizing the top viewpoint to express more explicitly the depth of each sign. Both sentences describe the same basic movements; however, (b) includes more physical details about how close or far away the arms were extended when giving the tests to the students. A computer would not necessarily be able to extrapolate (b) from data in (a). It certainly wouldn't be a simple replacement of symbols.

Figure 69. Example sentences showing normal and top viewpoints



While understandably more difficult at the sentence level, would it be possible just for individual signs? In theory, a computer might be able to take any sign and apply a specific algorithm and produce the same sign in different viewpoints; however, the purpose in differentiating between the normal and top viewpoints is to capture signs where depth is significant to the writer. That is, translation between the normal and top viewpoints simply may not have the relevant depth information to make an automated transformation possible. Look at the example in Figure 70. The first sign in (a) represents the normal viewpoint. As you can see, there is no depth information included. All we know is that there are three rows of vehicles. The sign in (b) is more explicit about the depth of the sign and here we can see that there is a gap between the first row of vehicles and the second and third rows of vehicles.

Figure 70. Comparison of normal and top down viewpoints



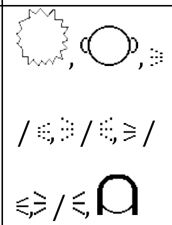
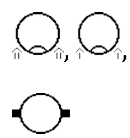
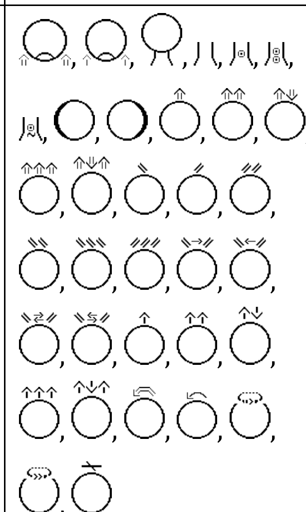
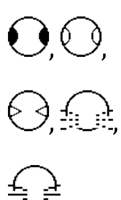
(a) (b)

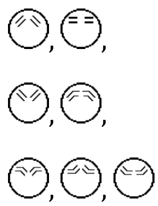
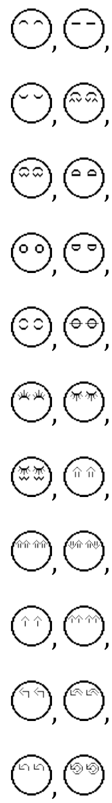
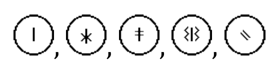
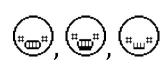
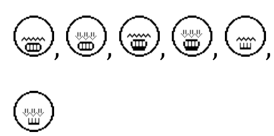
ASL 'three rows of vehicles'

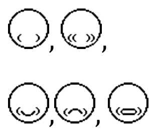
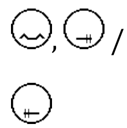
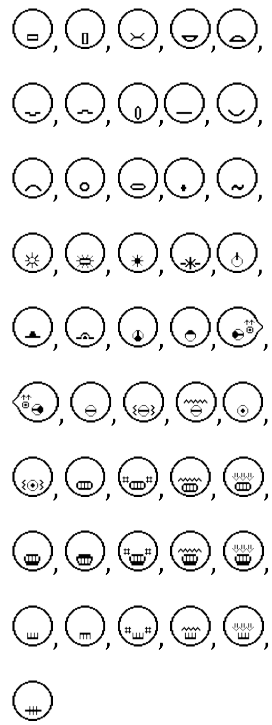
4.11 Summary of head circle diacritics

The summary of head circle diacritics found in Table 46 and Table 47 looks at the diacritics using two different classifications. In Table 46, the diacritics are summarized depending on whether the diacritic is a symmetrical pair, an identical pair, or a single diacritic, together with an approximate indication of what slot they attach in. While most pairs of diacritics can be used singly or together, some pairs must be used together even though they follow the same visual pattern as the paired diacritics that can appear singly. In the table below, paired diacritics are distinguished on the basis of whether they can appear alone and together or only together.

Table 46. Head circle diacritics by diacritic type

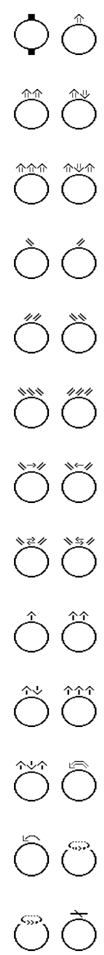
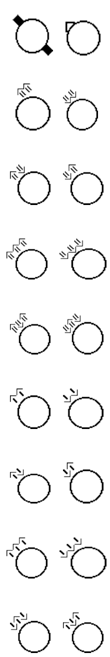
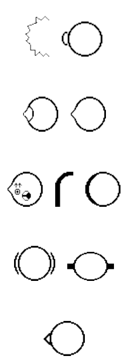
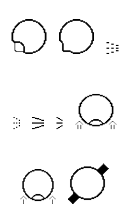
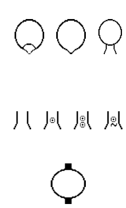
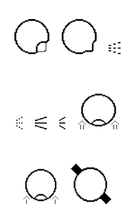
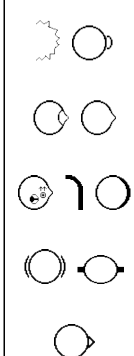
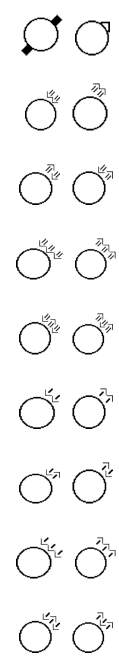
	Symmetrical Pairs		Identical Pairs		Single
	Alone/ Together	**Only Together**	**Alone/ Together**	**Only Together**	
Outer					
Inner					

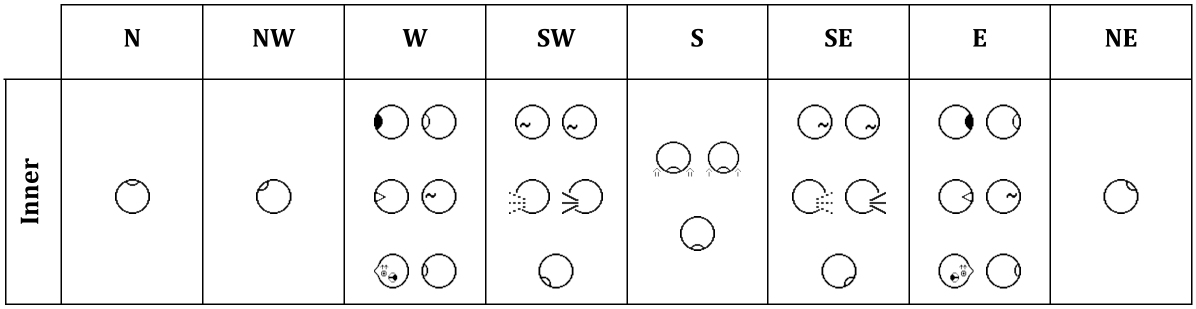
	Symmetrical Pairs		Identical Pairs		Single
	Alone/ Together	Only Together	Alone/ Together	Only Together	
Upper					
Middle					
Lower Upper					

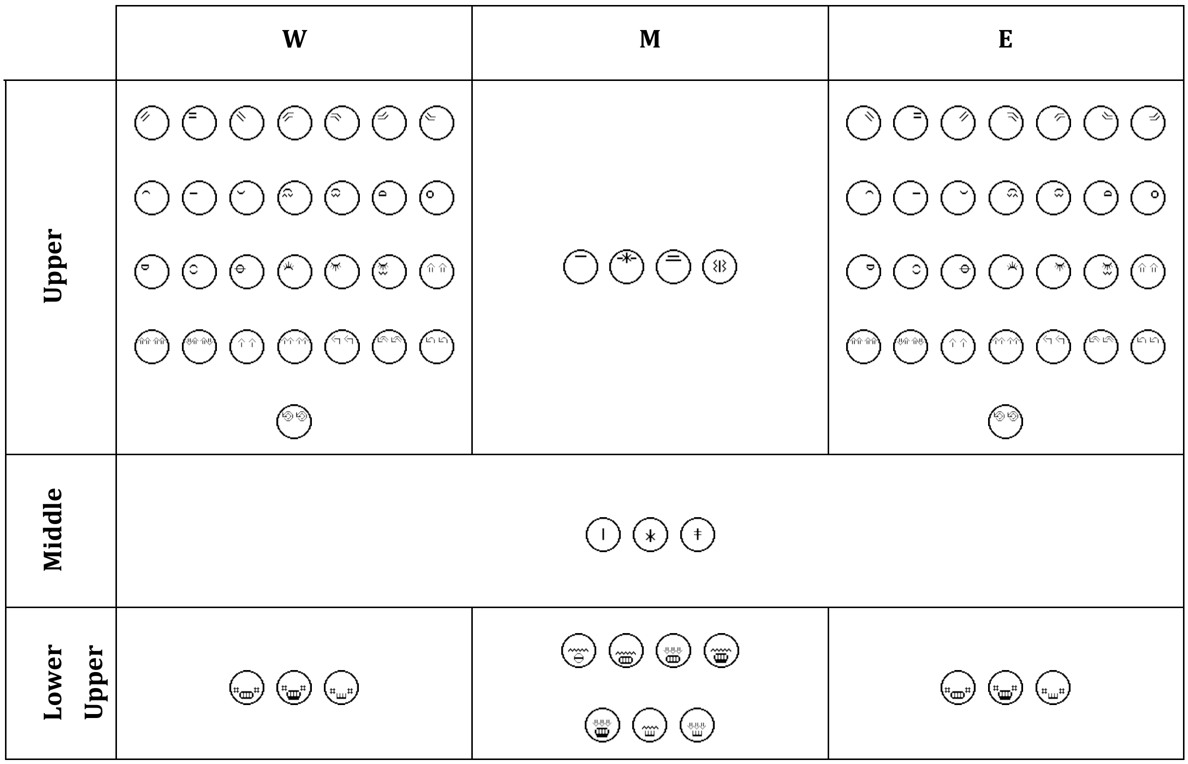
	Symmetrical Pairs		Identical Pairs		Single
	Alone/ Together	Only Together	Alone/ Together	Only Together	
Lower Lower					

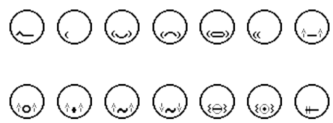
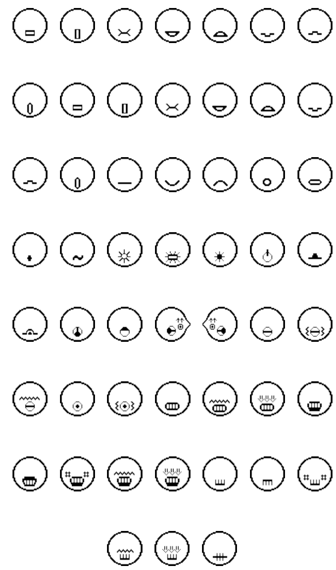
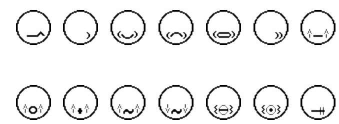
In Table 47, the diacritics are summarized based on what specific slots can accept them. In cases where the symbol rotates within the same slot (e.g., the eye gaze diacritics), only a representative diacritic is listed rather than clutter the tables with unnecessary repetition. In a few instances, some precomposed head circles have two or three diacritics present in one head circle symbol. In those instances, head circles appear in the table in each of the slots where a diacritic appears.

Table 47. Head circle diacritics by slot accepted

	N	NW	W	SW	S	SE	E	NE
Outer								


N
NW
W
SW
S
SE
E
NE
Inner


W
M
E
Upper
Middle
Lower
Upper

Lower **Lower**			

CHAPTER 5

TORSO AND LIMB SYMBOLS

5.1 Introduction

Signs can reference a location on the torso or on one of the limbs using the corresponding torso or limb symbols. When needed, these symbols provide context and location when a sign is made near or on a specific location on the torso or limbs instead of occurring in neutral space or on/by the head. In some cases, they are also used to represent movement by the torso or limbs.

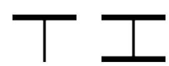
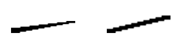
5.2 Torso

5.2.1. Shoulders and hips

The torso bar ( ) is the base for symbols related to the torso. A torso symbol consisting of a single torso bar refers to the shoulders. A torso symbol composed of two torso bars placed on top of each other with some distance between them ( ) represents both the shoulders and the hips. Various diacritics can be added to these two torso symbols to describe the movement or positioning of the shoulders and/or hips. Unless otherwise specified, diacritics usually focus on the shoulders, not the hips.

A torso bar can also angle to the left ( ) or to the right ( ) to represent shifting of the torso to one side or the other; this is a common non-manual marker used in sign languages to indicate a change in speakers. Different variants of the torso bar are possible. Table 48 lists the possible variants. The first column describes a single torso bar representing the shoulder and its two possible angles. The second column describes one or two torso bars attached by a single line stretched down from the center and representing the center of the body with or without the hip; this variant does not have any angled equivalents. The third column describes two torso bars representing both the shoulder and the hip as well as showing angled variants of both.

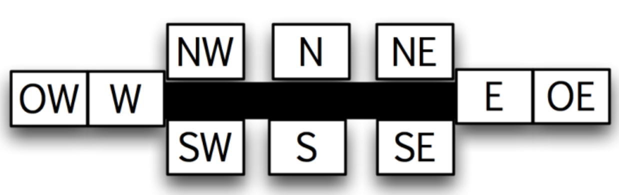
Table 48. Variant torso symbols with one or two torso bars

Shoulder	Center	Shoulder and Hip
		
		
		

5.2.2. Positional diacritics

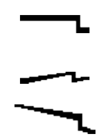
Like other symbols in the system, the torso bar can accept diacritics to alter its meaning. The possible slots for diacritics on the torso bar are indicated in Figure 71. Diacritics attach directly to the torso bar except for the outer west (OW) and outer east (OE) slots.

Figure 71. Slots for attaching torso diacritics



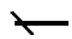
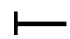
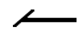
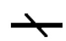
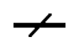
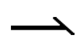
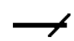
One set of diacritics indicates the position of the shoulders. These are ligating diacritics that visually adjust in appearance depending on which torso bar variant is selected. The diacritics can be used with the straight torso bar or its angled variants. The diacritics and indicate raised shoulders. The diacritics and indicate lowered shoulders. All four diacritics attach to the W and E slots. If the torso bar angles to show the shoulders facing left or right, the diacritics adjust to fit the angle of the torso symbol. The table below summarizes the various positions described by these diacritics.

Table 49. Shoulder positional diacritics

		Right Shoulder (E)		
		Plain	Up	Down
Left Shoulder (W)	Plain			
	Up			
	Down			

In Section 4.8.1, the head circle could accept a miniaturized torso symbol with a face position diacritic as a diacritic to represent face position. If the positioning of the face is important but the head circle is otherwise not needed, the standard straight torso symbol with the face position diacritic is available. The face position diacritic is a vertical bar that can be straight or slanted to the right or left to show head tilt. The placement of this diacritic on the torso symbol represents whether the face is turned up, down, left or right, as shown in Table 50.

Table 50. Face position torso symbols

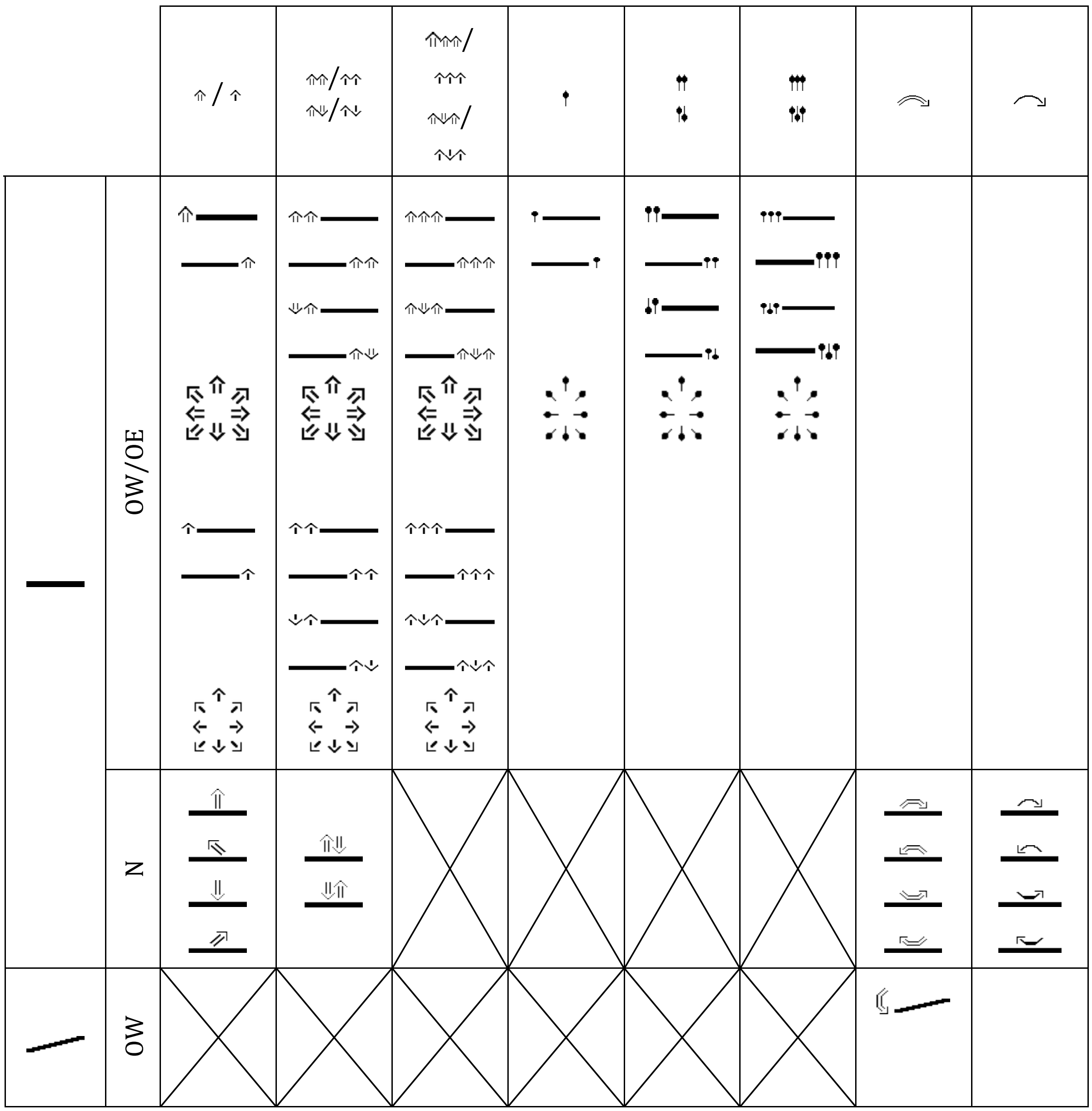
		Tilted Left	Straight	Tilted Right
Facing Left and Looking	Up			
	Straight			
	Down			
Facing Center and Looking	Up			
	Straight			
	Down			
Facing Right and Looking	Up			
	Straight			
	Down			

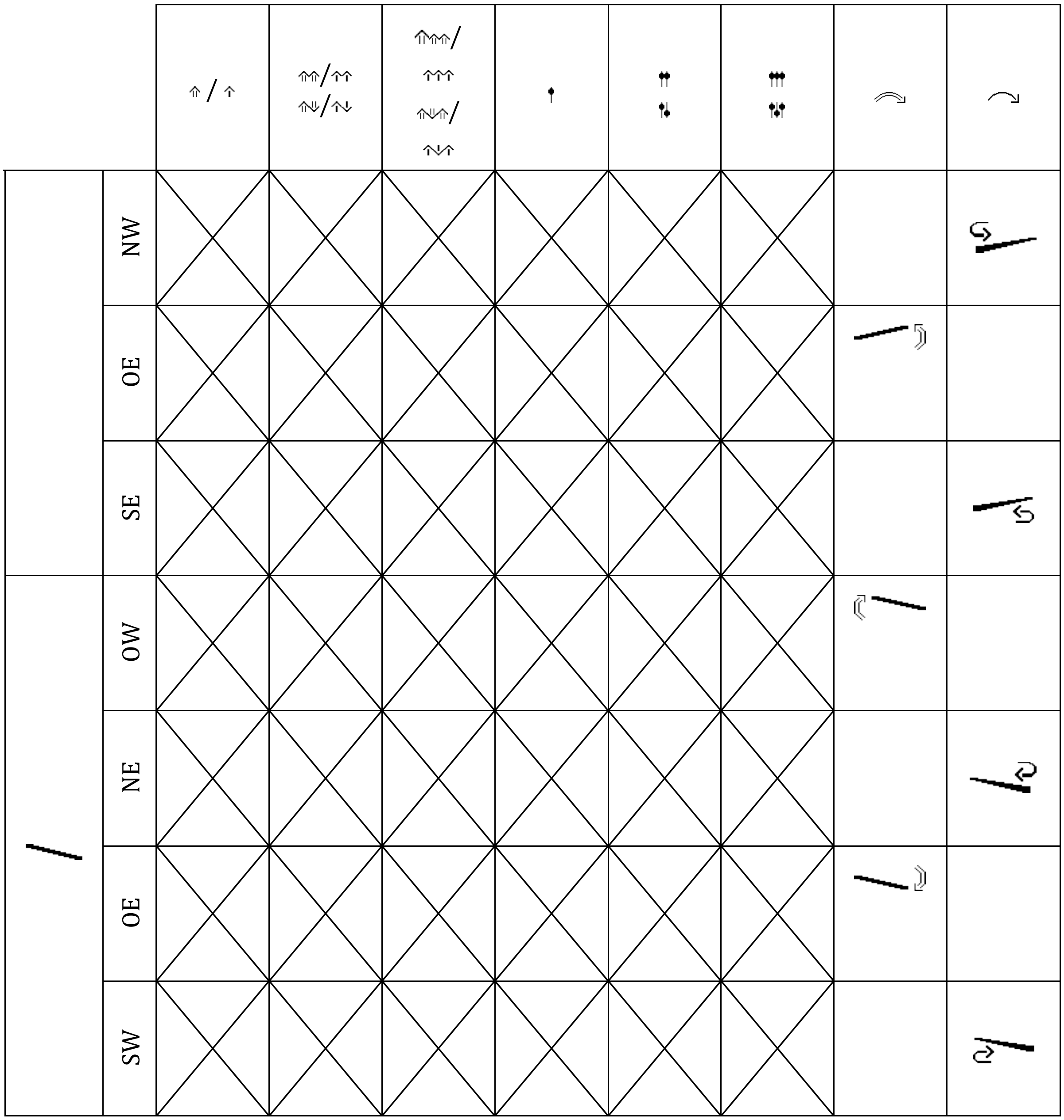
5.2.3. Movement diacritics for the shoulders

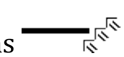
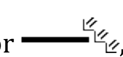
Another set of diacritics on the torso symbol indicates movement by the shoulders. The diacritics are selective in which positions or which torso symbol they work with. The  symbol indicates the shoulders move up or down on the Wall Plane. The  symbol indicates the shoulders move forwards or backwards on the Floor Plane. The  symbol (while placed by the torso bar representing the shoulders) indicates a tilting of the body at the hips on the Floor Plane while the neck and torso usually remain straight. The movement diacritics can be duplicated (similar to that observed by regular movement arrows) to show repeated torso movement.

Table 51 below shows which diacritics attach at what points and to which torso symbol (e.g., straight or angled). The chart also indicates which rotations are applicable to each movement diacritic. In general, if all 8 rotations are available, I include a diagram like this after the diacritics in question: . In other cases, a diacritic may only have a limited number of rotations, in which case I have listed each rotation individually.

Table 51. Shoulder movement diacritics





The diagonal triple arrows, such as  or , while occurring in the OW/OE slots, can spread to nearby slots. If in the OW slot, it can spread to the NW/SW slots. If in the OE slot, it can spread to the NE/SE slots.

5.3 Limbs

LIMB SYMBOLS are available when a sign involves one or more of the limbs (arms or legs).[43] The same symbols are used for both arms and legs; the relative positioning of the symbols (e.g., attached to a shoulder, hip, or hand symbol) will generally clarify whether an arm or leg is being specified. In general, the use of the limb symbol to represent an arm is more frequent, since sign languages rarely use the legs as articulators.

5.3.1. Individual Limb Symbols

The individual limb symbols have been divided into 5 sets, each having a thin and thick variant. The thin/thick variation is frequently used in SignWriting to indicate the relative distance of the limbs. This is important when the writer wants to note which limb specifically comes in front of another limb. A thin line represents a limb that is further away from the reader, and a thick line represents a limb that is closer to the reader. The following table lists the available options for limb symbols, each of which has four visually distinct rotations.[44] The small variants in the first column will likely be used more for fingers than for limbs. The others can be combined to show different parts of the arm or leg.

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[43] In existing implementations of SignWriting, the writer has a choice of composing his own limbs or using a set of pre-composed limb combinations.

[44] The ISWA does include sixteen rotations, but only four are visually unique. Maintaining sixteen rotations will only be helpful if the writer (via the software) is aware of which end can attach to a torso symbol and which can attach to another limb symbol or a hand symbol. However, such distinctions are not readily visible to the writer.

Table 52. Possible limb lengths

	1	2	3	4	5
Thin					
Thick					

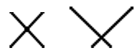
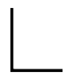
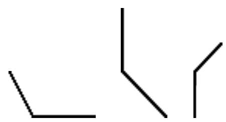
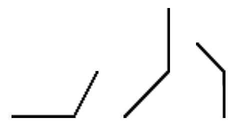
5.3.2. Limb symbols in association with other symbols

If an arm is used in neutral space and the specific handshape is irrelevant, limb symbol(s) may appear alone. However, a limb symbol may also attach to another limb symbol, a hand symbol, and/or attach to a torso symbol to provide a clearer context. If two limb symbols are attached to each other, this usually depicts the elbow or knee joint. If a limb symbol is attached to a hand symbol, it attaches to the part of the hand symbol that represents the wrist. If a limb symbol attaches to a torso symbol, then it attaches at the W/E slots.[45]

More often than not, a simple line does not convey the information needed about a limb. For example, the elbow might be part of the sign or the crossing of the limbs is significant. For this reason, the ISWA and earlier inventories of SignWriting symbols (described further in Appendix A) have provided common combinations depicting the arms or legs in certain configurations. Table 53 describes a set of combinations that, while not exhaustive, covers many commonly used combinations.

[45] In the set of signs I could search, there is no information concerning how limb symbols and shoulder diacritics interact. Based on my understanding of the system, the order of precedence in placing symbols in the W/E slots would be shoulder positional diacritics or face position diacritic > limb symbols > shoulder movement diacritics.

Table 53. Limb combinations

	Left	Right
Cross		
Acute angle		
Right angle		
Obtuse angle		

CHAPTER 6

DYNAMIC SYMBOLS

6.1 Introduction

Like any grammar, initial attention is paid to the nouns and verbs that form the nucleus of a sentence. Other descriptive words tend to appear later in the grammar. Similarly, the dynamic symbols and punctuation in SignWriting are the last to be covered in this thesis. The symbols discussed thus far function like nouns and verbs, identifying which articulators are selected and how they are to move. Within the grammar of SignWriting, dynamic symbols function much like modifiers, modifying the articulators and movement symbols to provide additional information on the manner in which those articulators are to be moved.

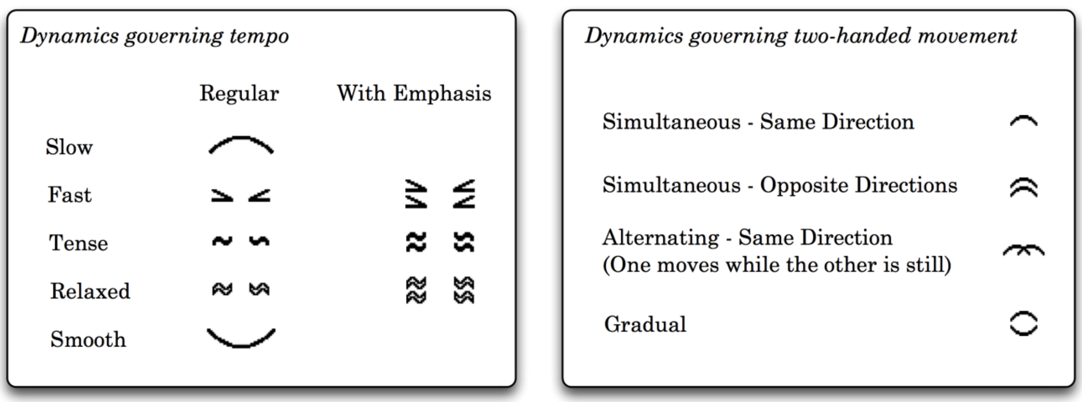
The textbook *Lessons in SignWriting* (Sutton 2002) identifies five different uses of the dynamic symbols. These symbols can modify movements, hand symbols, and faces. While two other uses include modification of punctuation and prosodic brackets, it seems better to treat these under punctuation symbols, so they are covered in the next chapter.

6.2 Movement dynamics

Movement dynamic symbols function much like adverbs to describe how the movement is taking place. For instance, is the movement fast or slow, tense or relaxed, simultaneous or alternating? These modulations of movement are generally contrastive features in the phonology of sign languages, and so SignWriting provides a way to represent them.

Table 54 shows the movement dynamic symbols. The second markers for Fast, Tense, and Relaxed are mirrored forms that can be used for left and right hands.[46] The second markers have the same meaning as their mirrored counterparts, but are available because symbols are designed to relate to the center of the body. (Sutton, pc, 6 April 2010). If it is a two-handed sign with no dynamics symbol that governs two-handed movement, then it is assumed that ⌒ is present. The doubled tempo dynamic symbols are used to show movement that is more tense, more fast, or more relaxed than normal.

Table 54. Movement Dynamic Symbols



Of the tempo dynamic symbols, only the symbol for "slow" can go through all eight rotations. All but the bottom rotation retain the meaning of "slow"; the bottom rotation is interpreted as "smooth". If both "slow" and "smooth" surround the movement, it is understood to be a slower smooth movement. All of the two-handed movement dynamic symbols rotate.

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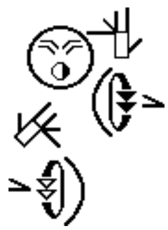
[46] I personally had not noticed them until researching the ISWA 2008. Sutton (pc, 6 April 2010) commented that the IMWA 2004 and earlier inventories did not really emphasize this, but the new ISWA 2008 and 2010 were emphasizing this more. Semantically, there is no difference. The distinction is more aesthetic than semantic.

Sometimes, these symbols work together to modify a particular movement. One such example is the fast/slow distinction that occurs when describing circular movements that alternate between fast and slow. For example, the sign in (16) sandwiches the circular movements between a fast and slow movement dynamic symbol. This indicates which part of the circular movement should be fast and which should be slow.

(16) 

ASL 'to be sick over a long period of time'

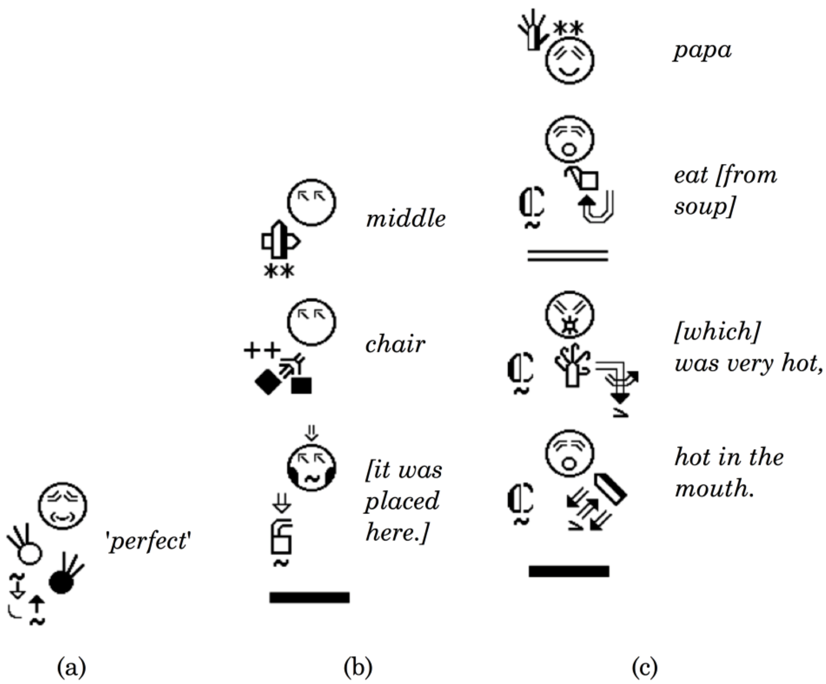
6.3 Other uses of the tension symbol

The tension symbol (~) can play several different roles so it is important to distinguish between them. Figure 72 shows the tension symbol in selections taken from a retelling of "Goldilocks and the Three Bears" in ASL (Gunsauls, 1999: 4,10). In (a), the tension symbol functions as a movement dynamic symbol to describe tension in the movement. In (b), the tension symbol serves to mark the use of a classifier whose function is to describe the placement and general appearance of an object being mentioned. In (c), the non-dominant hand is a classifier that persists through three signs, representing a bowl of soup, a construction that is one form of a buoy.[47] The tension symbol serves to indicate this

[47] Liddell (2003:223) notes: "Signers frequently produce signs with the weak hand that are held in a stationary configuration as the strong hand continues producing signs. Semantically they help guide the discourse by serving as conceptual landmarks as the discourse continues. Since they maintain a physical presence that helps guide the discourse as it proceeds I am calling them *buoys*." The remainder of that chapter proceeds to describe various kinds of buoys.

persistence. Both (b) and (c) are examples of other uses of the tension symbol. Their purpose is not to show tenseness in movement like (a), but to identify a particular hand symbol as having a particular grammatical function in the signing. When used in this manner, the tension symbol typically appears at the wrist position of the handshape in question.

Figure 72. Three uses of the tension symbol



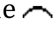
As noted in Section 4.5.1, the ~ symbol also appears in the cheeks and the lips. This symbol communicates tense facial muscles, representing cheeks that are tense and lips that are pressed together. The tension symbol appears in more contexts than the other dynamics symbols, but it usually carries the "tension" theme in each context.

6.4 Distinctions between dynamic symbols and diacritics

Some might wonder how dynamic symbols differ from diacritics. Admittedly, there can be questions as to whether they could be construed as diacritics. My analysis treats them as being generally distinct with limited exceptions (which I discuss later). Semantically, dynamic symbols (unlike diacritics) do not change the movement or configuration of the symbols they modify. Rather they simply clarify the manner in which those symbols move. This can be contrasted with the head circle diacritics or the shoulder position diacritics, both of which actually change the head circle or torso symbol's interpretation to something other than what it was before the diacritic was applied.

Grammatically, the relationships between the dynamic symbols and other symbols are more in line with a separate symbol analysis. For instance, two-handed dynamic symbols show a relationship between more than one symbol. They can associate with two movement arrows or two hand symbols to show the sequencing of the movements for both hands. The slow and smooth symbols can encompass the whole sign. The tension symbol is more flexible than the other tempo dynamic symbols in its placement (unlike diacritics). In fact, when applying both contact symbols and dynamic symbols, the rules for the contact symbol are applied first, then the rules for the dynamic symbol.

Semantically and grammatically, these characteristics lend credence toward making them separate symbols, not diacritics. That said, when the tension symbol is being used to mark a classifier or buoy, those uses are more characteristic of a diacritic than a separate symbol. Still, it seemed more consistent to simply call it a special use of the tension symbol.

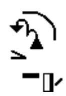
Perhaps a few examples can illustrate the claims above. Figure 73 shows a few signs using dynamic symbols. Example (a) shows a two-handed dynamic symbol  present. The symbol simply clarifies that both hands move at the same time. In this case, the  symbol associates with both hands. Similarly, the longer  in (b) clarifies that, during the curved segment of the movement, the hand should be moved more slowly than normal.

In (c), the tension symbol (~) adds the idea of a certain tenseness in the motion already described by the hand symbols and arrows. Finally, the fast symbol (≻) in (d) indicates that the downward motion already described should be done more quickly than normal. So, the dynamics symbols function somewhat differently than diacritics.

Figure 73. Examples of dynamic symbols in use

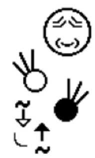
ASL
'facial expression'

(a)



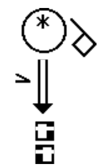
ASL 'a series of
next events'

(b)



ASL 'perfect'

(c)



ASL 'faith, trust'

(d)

CHAPTER 7

PUNCTUATION

7.1 Introduction

SignWriting provides two types of punctuation symbols. The first type corresponds to the usual categories of punctuation symbols in oral languages, marking pauses, questions, statements and exclamations. These generally mark the boundaries of clauses and phrases. The other type, whose use is still in flux, identifies phrases and clauses that share one or more non-manuals. There is no agreement on the name for this later type. Sutton (2002:173) refers to them as unit connecting lines. Parkhurst and Parkhurst (2007:116) simply call them brackets. In this chapter, I will use the term "prosodic brackets" since that seems to capture their purpose more clearly.

7.2 Traditional punctuation

SignWriting has several punctuation marks that have the same name and function as various punctuation marks in oral languages, but their form is quite different. Two thin parallel lines written alone (══════) is a short pause—similar to a comma.[48] A thick single line written alone (▬▬▬▬▬▬) is a full stop—similar to a period. The system also

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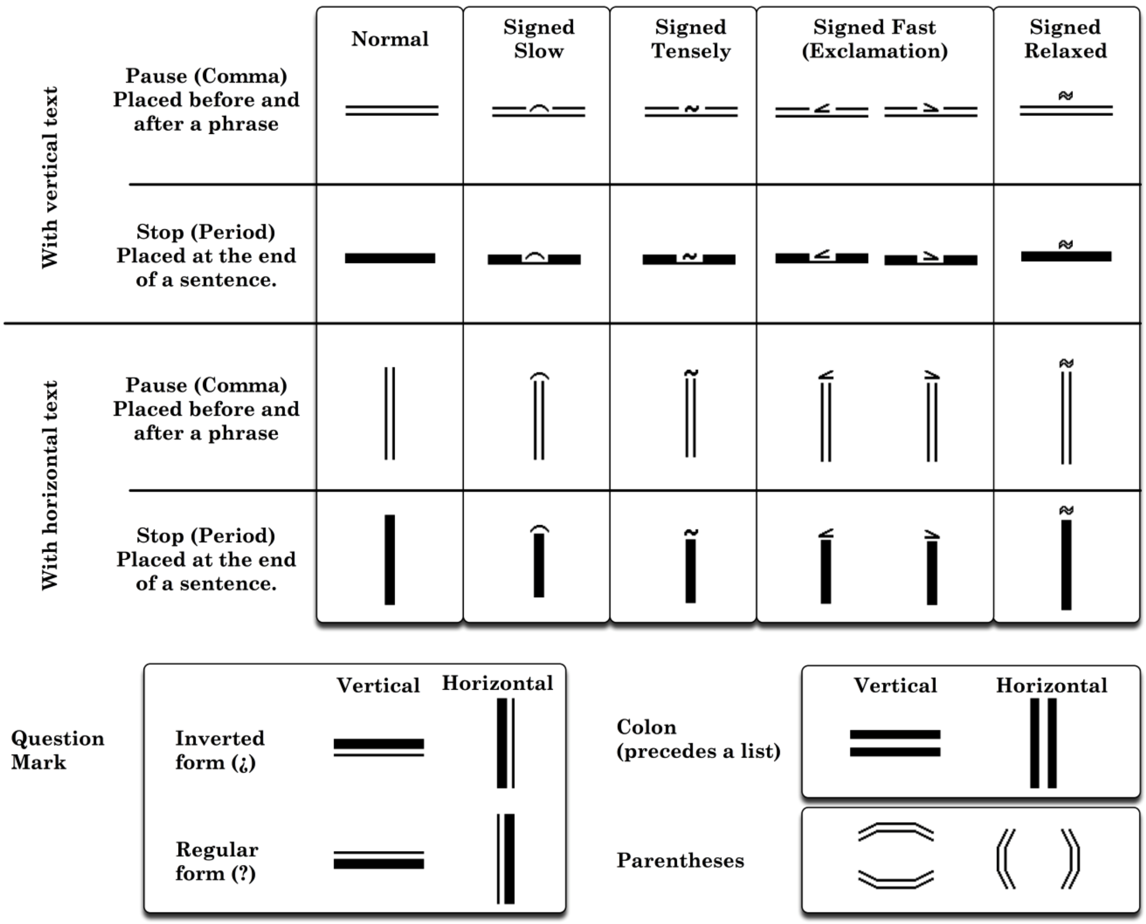
[48] The rules of SignWriting technically allow for a variation of space between the lines to signal the length of the pause. However, there is no example in printed SignWriting since software implementations like SignPuddle do not provide any means of altering the space between the lines (unless of course writers use visually similar symbols such as limb symbols to do so manually).

includes a question mark (), a colon (), and opening and closing parentheses, respectively ().

Punctuation marks appear alone in the text stream. They are never included in a sign box, but rather they are handled separately in their own box. This provides another way to visually distinguish the full stop symbol from the shoulder torso symbol. Table 55 summarizes the punctuation marks available. Horizontal versions of the symbols are typically used in vertical text; vertical versions of the symbols are used for horizontal text.[49] The movement dynamic symbols to show tempo may be used with the pause and full stop punctuation symbols to indicate whether that phrase, clause, or sentence was signed fast, slow, tensely, or relaxed. The full stop punctuation symbol with the fast dynamic symbol is used as an equivalent to an exclamation mark.

[49] While a full set of rotations for the punctuation symbols is present in the IMWA and ISWA, I have only seen vertical or horizontal symbols in actual use.

Table 55. SignWriting punctuation symbols[50]



7.3 Prosodic brackets

When writing longer sections of text, there are often situations where a non-manual marker (a facial expression, a tilt of the shoulders, etc.) spreads over several signs. There is some debate how to write this. Some feel the non-manual marker should be written for every sign, while others advocate the use of prosodic brackets. The brackets surround a section of text over which one or more non-manual markers spreads. The opening bracket

[50] The latter two variants of the question mark do not usually appear in ASL documents but may be used by signers in Spanish speaking countries who are used to bracketing their questions with ¿ … ? Documents written by the Parkhursts in LSE show this approach.

contains a slot for non-manual markers, usually a head circle or a torso symbol.[51] The closing bracket has no slot available as it is assumed that the signer returns to a neutral stance.

The prosodic brackets were originally introduced when SignWriting was written horizontally. The LSE example in Figure 74 shows an example of using prosodic brackets with horizontal text. Now with vertical writing as the standard, there is a debate about whether the prosodic brackets are still needed. Vertically, prosodic brackets look more like Figure 75.

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[51] Usually, the "label" for the opening prosodic bracket is a head circle or torso symbol. Some writers have experimented with the use of other symbol combinations in that position such as  to represent quotations. However, this has not become a mainstream convention.

Figure 74. Prosodic brackets in horizontal writing (LSE - Parkhurst and Parkhurst, 2007)

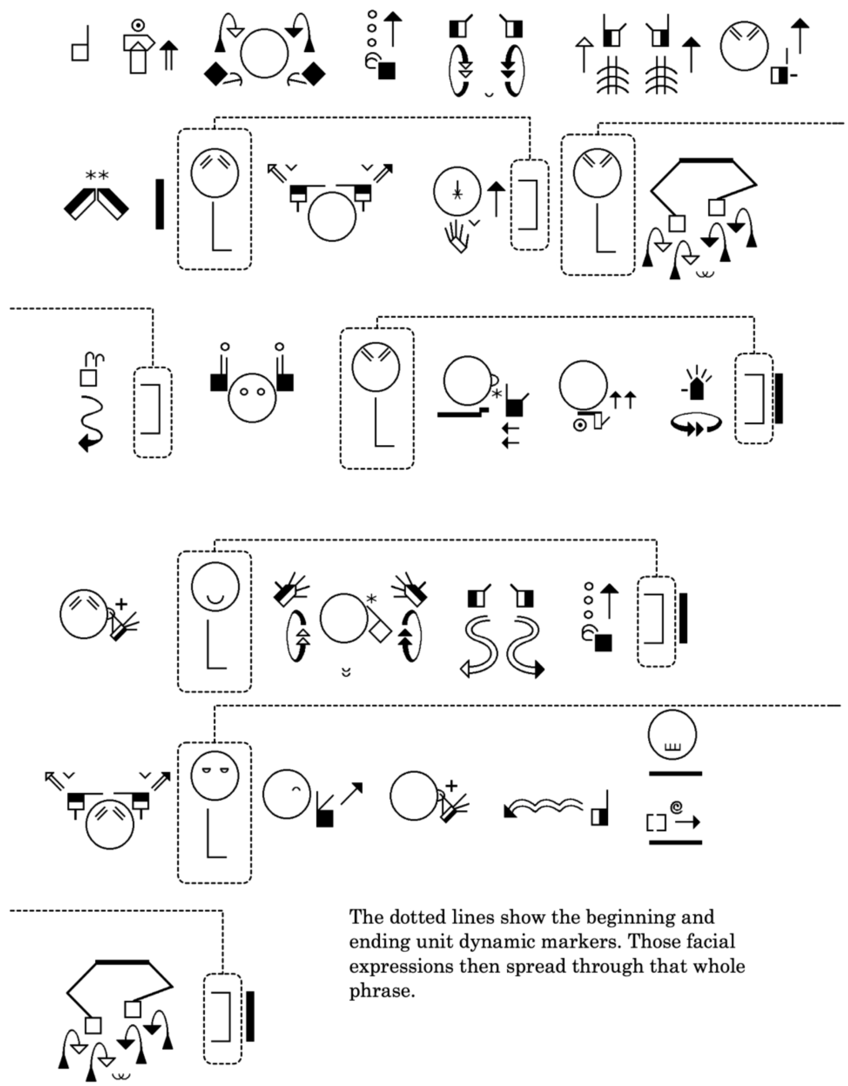
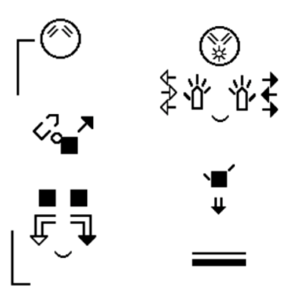


Figure 75. Prosodic brackets in vertical writing (ASL example)



CHAPTER 8

SIGNSPELLING NOTATION

8.1 Introduction

Given the two-dimensional structure of SignWriting, there is no obvious method by which users might order a list of signs in "alphabetical order" like most spoken language writing systems. Linear scripts for spoken languages usually have an explicit order in which symbols are written that can be used for collating. While there is a certain amount of ordering inherent in a sign, based on its internal temporal organization as it is articulated, when written, the order often becomes implicit. SignSpellings are Sutton's solution for ordering a list of signs, such as in a dictionary, in which she makes explicit a linear sequence of the symbols in a sign. These SignSpellings can then be used as a basis for ordering a list of signs. In addition to the symbols normally included in the sign, SignSpellings sometimes include additional symbols that function as "control characters" that describe the spatial relations and the sequential ordering implicit within the sign. These extra symbols are analogous in some ways to the special characters dictionaries use to describe pronunciation. These symbols are described below for the sake of a complete description of the symbols in the SignWriting system even though they are not actually used (or intended to be used) in everyday writing.[52]

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[52] Some people have suggested that they could be used for detailed research writing. But I am unaware of anyone using the SignSpelling notation in this way.

8.2 SignSpellings

Sutton defines a **SIGNSPELLING** as follows:

> A SignSpelling consists of a series of SignWriting Syllables. Syllables are written sequentially in time. Syllable 1 always comes before Syllable 2. But inside each Syllable, time stands still. The symbols inside one Syllable are "happening at the same time". So SignSpellings are BOTH simultaneous and sequential. (2004b:6)

It should be noted that Sutton's usage of the term *syllable* differs from current usage in sign language phonology. From a linguistic perspective, syllables are identified by a path movement, an internal movement, or a location. What Sutton calls a "syllable" is actually more like what linguists call a segment, and so this chapter substitutes the term **SEGMENT** throughout.

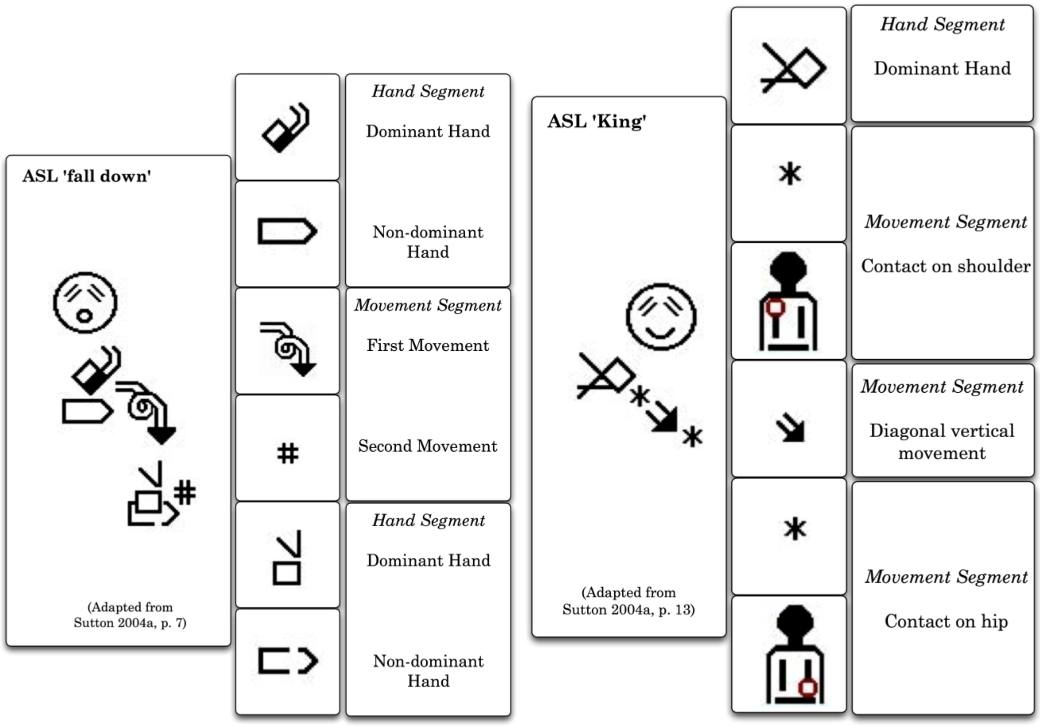
SignSpellings focus on two primary segment types: Hand and Movement. Table 56 lists the various segments SignWriting has identified. With Simple Spellings, she divides Hand segments into Dominant Hand and Non-Dominant Hand, and Movement segments into Movement of Dominant Hand and Movement of Non-Dominant Hand. With more detailed SignSpellings, the SignSpelling will be more precise and detailed. Simple Spellings only record what is necessary to distinguish the sign from another sign, limiting the number of additional symbols needed.

Table 56. Detailed SignSpelling Segments

Hand Segments	**Movement Segments**
Dominant Hand	1st Movement Dominant
Non-Dominant Hand	1st Movement Non-Dominant
Location Dominant	2nd Movement Dominant
Location Non-Dominant	2nd Movement Non-Dominant
Arm Position	Segment Depth Location
Shoulder Position	
Head Position	
Facial Expression	
Segment Depth Location	

Figure 76 gives two examples of simple SignSpellings. The first example does not require any additional symbols but simply rearranges the normal symbols into a linear sequence. In the second example, there are additional location symbols, which are the last symbols written in each segment.

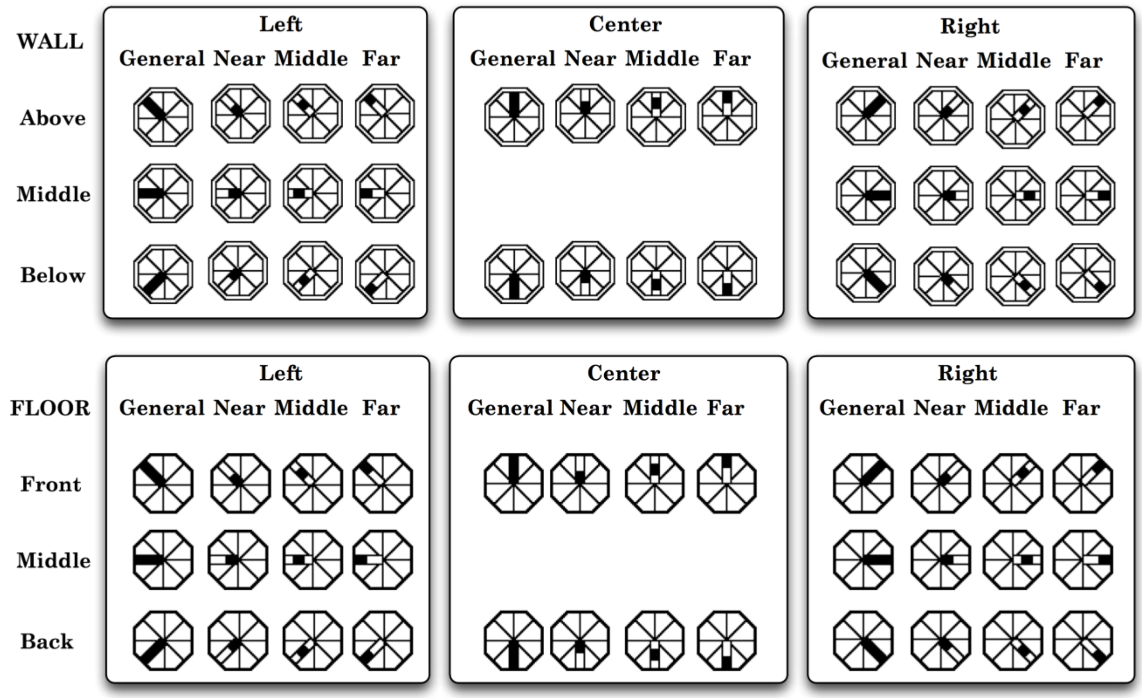
Figure 76. Examples of SignSpellings



8.3 Planar Location

The first set of additional location symbols described in Table 57 describes locations in neutral space using the concept of the wall and floor planes and the location's proximity to the body. If the proximity to the body is not significant, then a speller can use one of the general symbols. Otherwise, when proximity is important, a speller can choose between symbols showing locations that are close, midway, and far from the body. Extending conventions used elsewhere in the system, the boxes with a double exterior line represent the wall plane and the boxes with a single exterior line represent the floor plane. No symbols exist for the Center Middle positions for the Wall and Floor Planes. Those positions appear to be the default location if no symbol is present.

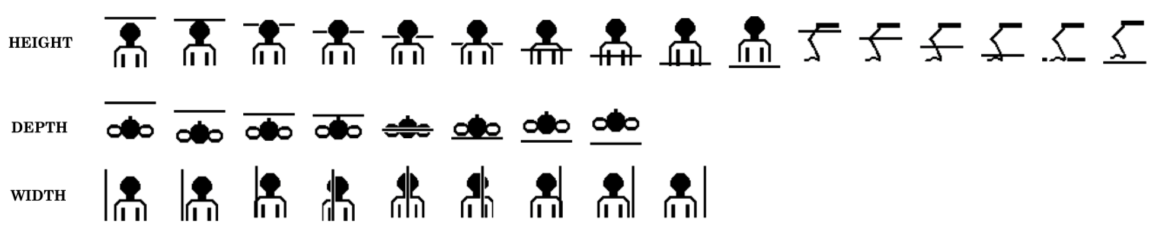
Table 57. Location Symbols - Wall and Floor Planes



8.4 Location by Height, Depth, and Width

Alternatively, locations in neutral space can be specified using a combination of three iconic body location symbols showing the three-dimensional location in relation to the body. Table 58 shows the location symbols that describe height, depth, and width.

Table 58. Location Symbols that Depict Height, Depth, and Width

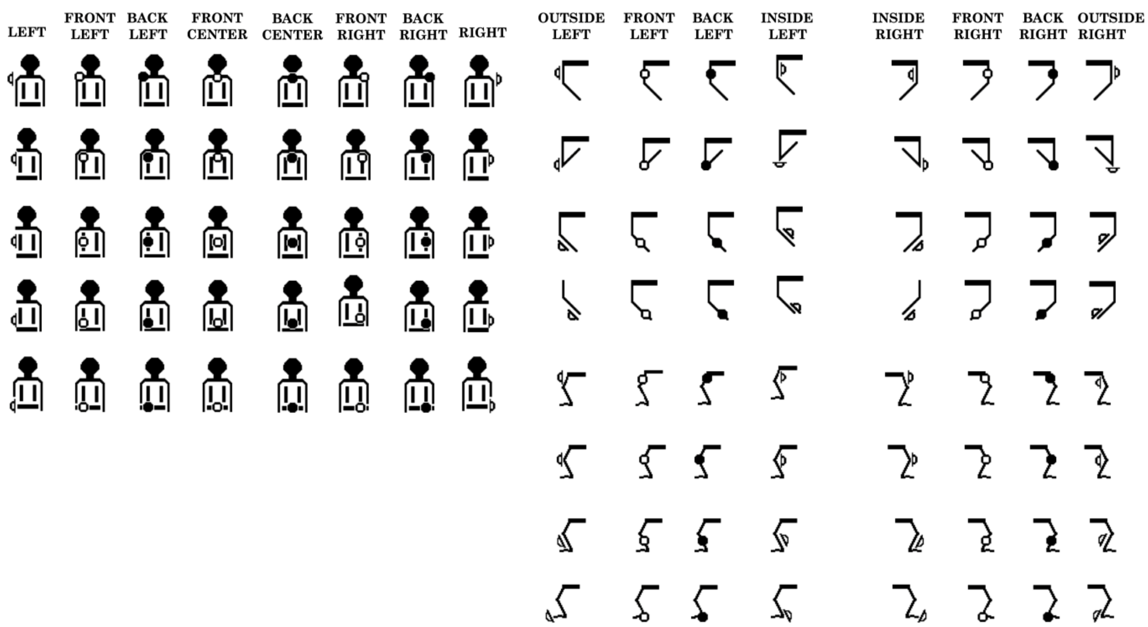


8.5 Location Symbols for the Body

Sometimes it is important to be explicit about the specific location on the torso or limbs. For those kinds of detailed spelling, Sutton developed the location symbols listed in

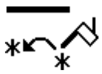
Table 59. Three symbols represent key parts of the body: the torso ( ), the arms ( ), and the legs ( ). Employing surface symbols and filled/unfilled circles, one can mark the torso, arms, and legs to describe specific locations with ● representing the back surface, ○ representing the front surface, and the surface symbols with their usual meanings.

Table 59. Location Symbols for the Torso and Limbs



An example of the use of these symbols to distinguish between similar signs is in Table 60. The spellings distinguish between the ASL signs ‘member’ and ‘breast(s)’. The distinguishing element for these nearly identical signs is that contact for ‘member’ occurs just below the shoulders but contact for ‘breast(s)’ occurs slightly above or on the breasts. A SignSpelling is unable to account for the difference in location without the location symbols.

Table 60. Example of location symbols used to distinguish signs

ASL Sign	SignSpelling without Location Symbols	SignSpelling with Location Symbols
 ASL 'member'		
 ASL 'breast'(s)		

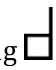
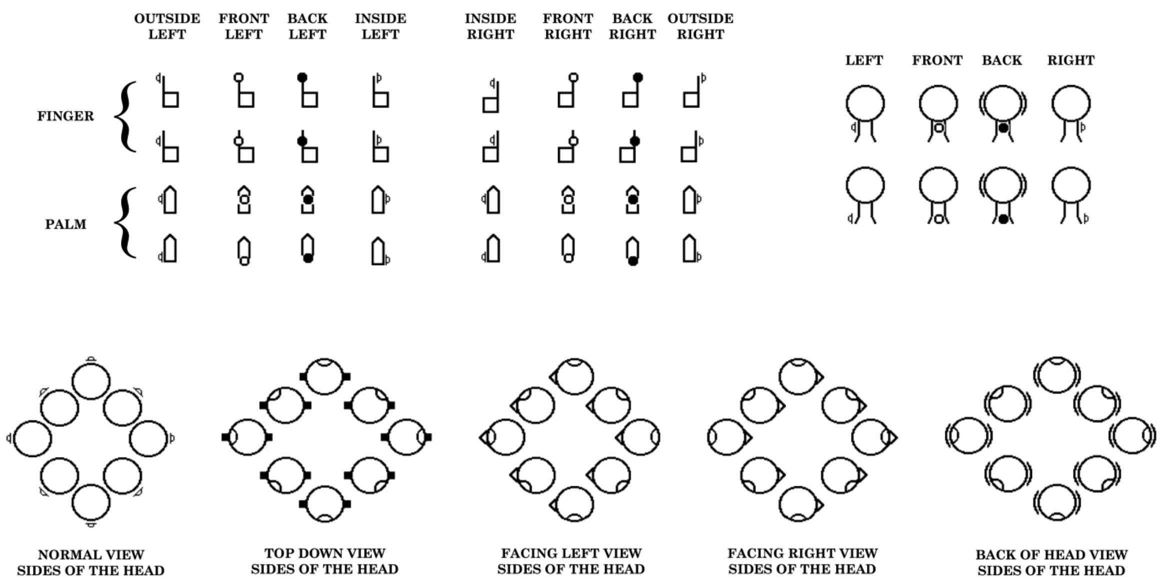
In addition to the torso and limbs, the writer may need to be more precise in describing contact or movement related to the head or to the hands as illustrated in Table 61. Using  to represent the finger and  to represent the hand itself, one set of symbols describes locations on the finger and on the hand itself. Another set of symbols uses the neck symbol () to describe locations around the neck. Both use the same diacritics (•, ∘, and surface symbols) to describe specific locations. A third set of symbols uses various combinations of viewpoint and special contact diacritics with the rim diacritics to focus on positions on and around the head. Interestingly, none of these involve any new symbols, but rather the reuse of existing symbols with a new context of SignSpellings.

Table 61. Location Symbols for the Head and Hands[53]



8.6 Relationship to Linear Encoding for Unicode

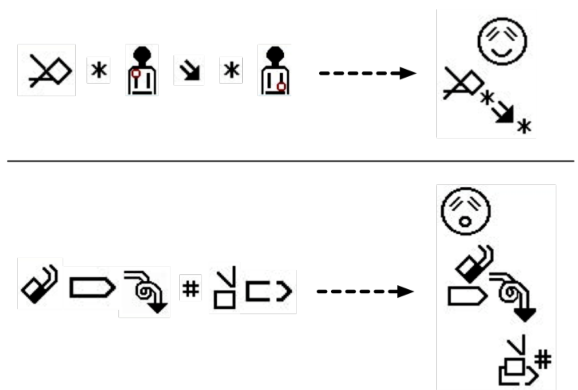
Some readers may wonder at this point if these SignSpellings would be adequate as a linear representation of SignWriting for an encoding such as Unicode. Unfortunately, while the symbols do add explicit details that are implicitly present in the two-dimensional representation and thereby useful for the purpose of ordering and distinguishing between signs, those details are (by themselves) insufficient to recompose the sign normatively.

Figure 62 shows the SignSpellings presented earlier in Figure 76. If using the SignSpellings to recreate the two-dimensional written sign, several key pieces of information are clearly missing. First, the facial expression is not included in either SignSpelling since the facial expression in both signs are not part of the citation form of the sign. Second, in the first example, the logical positions for the two points of contact (the shoulder and the hip) are clearly shown, so the contact symbols and the arrow could likely

[53]The center of the back of the head is specified by using the normal symbol for the back of the head ( ).

be placed clearly if the rendering engine understood the location symbols to say that the first contact symbol is to be placed by the tail of the arrow and the second contact symbol is to be placed by the arrowhead. However, the string does not contain information on the placement of the hand symbol in relation to the contact symbol. In the second example, there is no information on the relative placement of the dominant and non-dominant hand symbols for both the opening and closing positions. In addition, there is no information where to place the contact symbol in relation to the closing position of the hands.

Figure 62. SignSpelling as linear to 2D representations?



Thus, a significant drawback is that the extra notational conventions that represent location vary in how well they could be translated back into specific details about symbol arrangements on a screen or on paper. In other words, SignSpellings make explicit some details that are implicit in ordinary SignWriting and which are helpful for collation and research yet they lack the necessary detail needed for recomposing the sign and they may omit elements of the sign that are not germane to their purpose. Their primary value is that they provide a means of storing additional metadata about a sign that can help with analysis or ordering. While SignSpellings could be adapted for the purpose of an encoding, the current purpose and design of SignSpellings is insufficient as an encoding.

CHAPTER 9

RULES FOR COMPOSING SIGNS

9.1 Introduction

With a review of the extensive symbol set available to SignWriting complete, a discussion of the rules that govern the composition of signs is in order. Just as it is difficult to compose grammatically correct sentences with mere knowledge of vocabulary, writers cannot write with only knowledge of a list of symbols. They need to understand the rules behind composing a sign. Fortunately, the iconicity prevalent in SignWriting provides some guidance. In addition, writing conventions and the natural tendency of writing systems to capture only what is needed for the reader to understand tends to adjust the way signs are written (particularly when the iconicity fails due to the limitations of a two-dimensional representation). The following sections, while not exhaustive, give a basic understanding of composing signs and placing them within documents. A more exhaustive analysis of placement is needed before an encoding is finalized to allow for unusual cases, local idiosyncrasies, and other exceptions.

In this chapter, I will discuss writing at two levels: the page level and the word/sign level. At the page level, writing is concerned with the layout of sentences into lines, paragraphs, and larger sections of text. For instance, English documents expect words to be placed in horizontal lines from left to right with spaces in between each word and the lines to be arranged from top to bottom. SignWriting has rules for how lines of text within the document itself should be laid out. At the word level, writing is concerned with describing how the various symbols may be combined into words. While English (for instance) tends to place symbols in the order the sounds occur, not all writing systems do that. In Thai (as illustrated in Figure 77), symbols for the vowels may be placed before, above, and/or after the symbol for the consonant. Similarly, SignWriting has rules for how each symbol can be placed in relation to each other, and that positioning is much more flexible than most spoken language writing systems.

Figure 77. Symbols for Thai vowels when preceded by the letter o ang *(Ager 2011)*

อะ	อา	อิ	อี	อึ	อื
a	a	i	i	ue	ue
[aʔ]	[aː]	[i]	[iː]	[ɯ]	[ɯː]
อุ	อู	เอะ	เอ	แอะ	แอ
u	u	e	e	ae	ae
[u]	[uː]	[eʔ]	[eː]	[ɛʔ]	[ɛː]
โอะ	โอ	เอาะ	ออ	อัวะ	อัว
o	o	o	o	ua	ua
[oʔ]	[oː]	[ɔʔ]	[ɔː]	[uaʔ]	[ua]
เอียะ	เอีย	เอือะ	เอือ	เออะ	เออ
ia	ia	uea	uea	oe	oe
[iaʔ]	[iːa]	[ɯaʔ]	[ɯːa]	[ɤʔ]	[ɤː]
อำ	ใอ	ไอ	เอา	อ์	
am	ai	ai	ao	silences	
[ɑm]	[aj]	[aj]	[aw]	vowel	

In this chapter, I begin in Section 9.2 by describing the rules for placing signs on a page. Subsequent sections will look at the sign level. After I lay out the general rules for placing symbols in Section 9.3, I look at specific rules describing interactions between different types of symbols in Sections 9.4–9.9. Finally, in Section 9.10, I look at punctuation symbols.

9.2 Placement of signs on a page

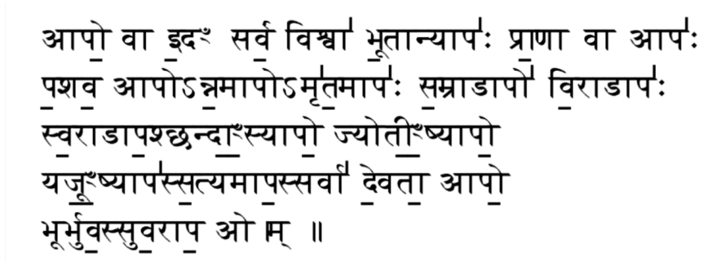
The earliest SignWriting documents were written horizontally. Even into the 1990's, those using the older software continued to produce documents with this layout. Today, the most recent software for SignWriting no longer follows horizontal writing. Instead, it uses vertical columns. Feedback from Deaf users indicated that it felt more natural to write vertically. This section will describe the rules for placing signs vertically.

9.2.1. Reviewing general concepts of word placement

When composing a line of text, writing systems generally impose a baseline that organizes the line of text. Writers using Western writing systems are used to a baseline that is placed underneath the characters. Strokes within the characters may rise above or fall below the baseline, but all characters are aligned on the baseline. But not all writing systems choose a baseline underneath the characters. Figure 78 shows some examples from Devanagari and Monogolian scripts. In (a), this Sanskrit sample using the Devanagari script shows the baseline running along the top of the characters, giving the appearance of the characters "hanging" from the baseline. Mongolian, in (b), shows a baseline (or midline) that runs through the center of the vertically written script. The characters then emerge from either side of the midline.

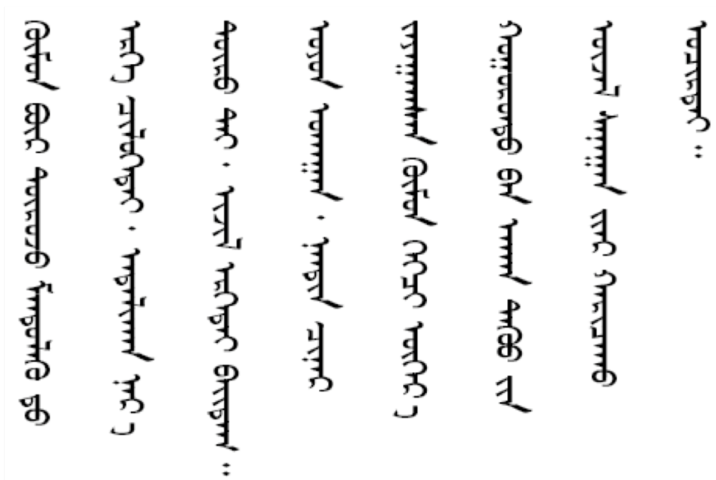
Figure 78. Examples of Devanagari and Mongolian scripts

(a)



Taken from the first page of the Udakashaanti Mantra (http://sanskritdocuments.org/doc_veda/udakashaanti.ps)

(b)



Article 1 of the Universal Declaration of Human Rights translated into Mongolian (http://www.omniglot.com/writing/mongolian.htm)

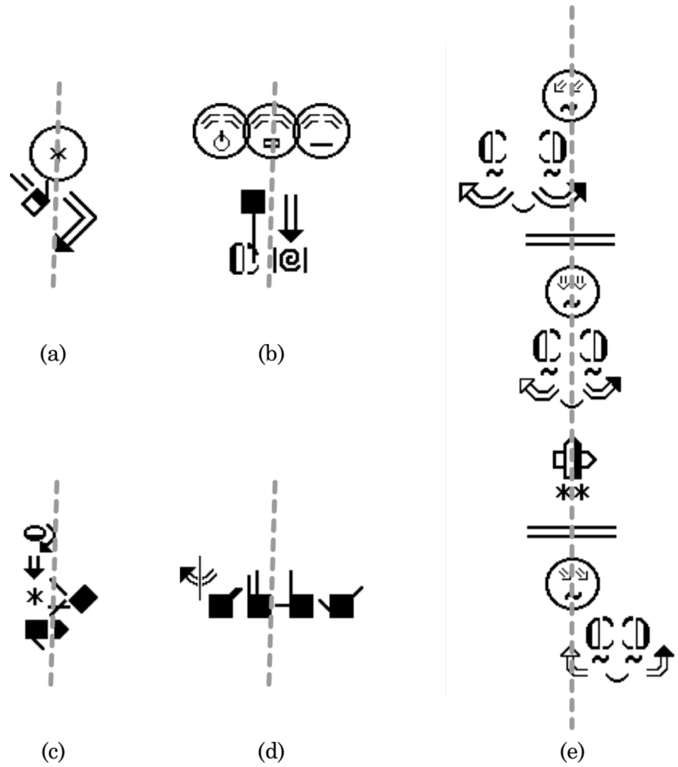
9.2.2. Placing signs on the default midline

The current convention for SignWriting is to write signs in vertical columns, top to bottom, with the columns proceeding left to right across the page, sharing some similarities with the Mongolian script. A sentence in SignWriting, then, consists of a series of sign boxes and punctuation boxes that ends with a punctuation box. A sign box contains an arrangement of symbols described in chapters 2–6. A punctuation box will be limited to symbols described in chapter 7. These boxes are placed vertically along the midline.

Writing vertically provides several benefits. First, using the body's natural vertical line of symmetry as the baseline (midline) for placing signs makes the writing seem more natural since it mimics the way the eyes perceive signing in real life. Second, it creates the possibility of recording body shifting more simply. (Body shifting is a device in signed languages that involves moving the shoulders or whole body from side to side to represent different characters in a discourse.)

Figure 79 illustrates the conventions for determining the placement of the sign on the midline. Typically, if a sign has at least one head or torso symbol, the sign is placed with that head or torso symbol centered on the midline (a). If more than one head is present, the sign is placed with the center head or the center of the cluster of heads on the midline (even if that places the center between two heads). (b). If no head or torso symbols are present, then one must look for contact that occurs in the sign. If contact occurs within the sign, the sign is placed with the place of contact on the midline (c). In the event that there is no contact or there are multiple contacts within the sign, the sign is placed with the visual (or computed) center of the cluster of symbols on the midline (d). Occasionally, the sign is not made in the center of neutral space, but off to one side or the other (e). This technique is often used for structures like comparison/contrast or placing things in space side by side. In (e), the excerpt is from the story of Goldilocks and the Three Bears where the mother is setting out three bowls: one big, one medium, and one small. The three bowls are set in specific locations so they can be referred to spatially. When signs are purposely shunted to the side, they are not placed on the midline, but to the side of the midline. Sometimes a head is written to help show the midline and clarify that the sign is made to the side.

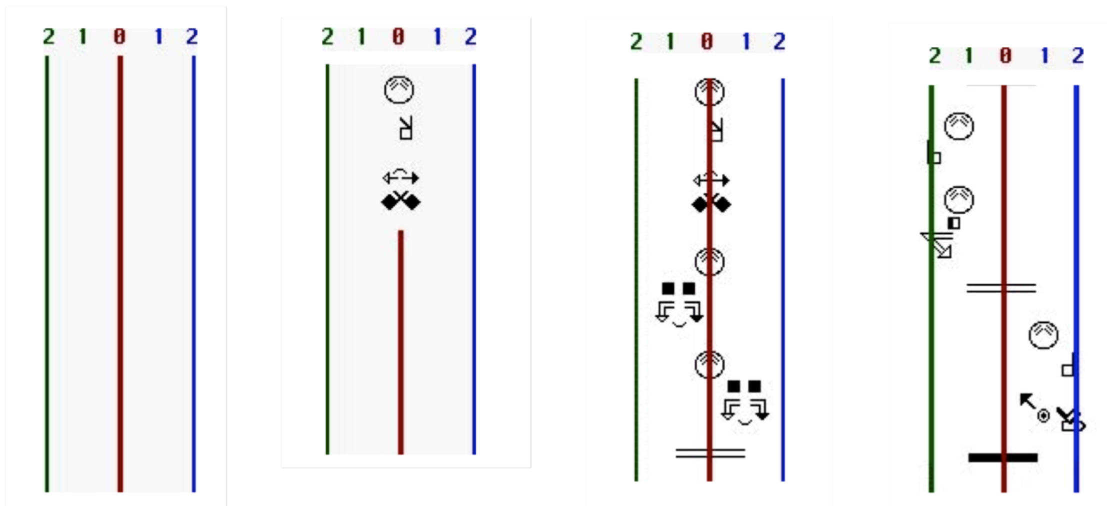
Figure 79. Finding the midline



9.2.3. Using multiple midlines

In addition, SignWriting allows for two additional midlines to each side of the central default midline. The SignWriting materials speak of lanes shown in Figure 80, numbering them from the center out on both sides as 0 through 2. The default midline is lane 0. When signs are shunted off to one side or the other, the signs are placed in lane 1 (i.e., to the side of the midline) with the head (if present) in the default midline. When the shoulders actually shift to one side or the other, the sign is placed in lane 1, which is the midline for situations where the shoulders shift to one side or the other. If the shoulders shift to one side or the other while the signs are also shunted to the side, then the head is placed in lane 1 while signs are placed in lanes 0 or 2. Punctuation, which is placed independently of signs, always appears on the default midline.

Figure 80. SignWriting lanes



(1) Lane Diagram (2) Neutral Text (3) Signs shifted (4) Body and signs shifted

Taken from Sutton 1998b:3-5

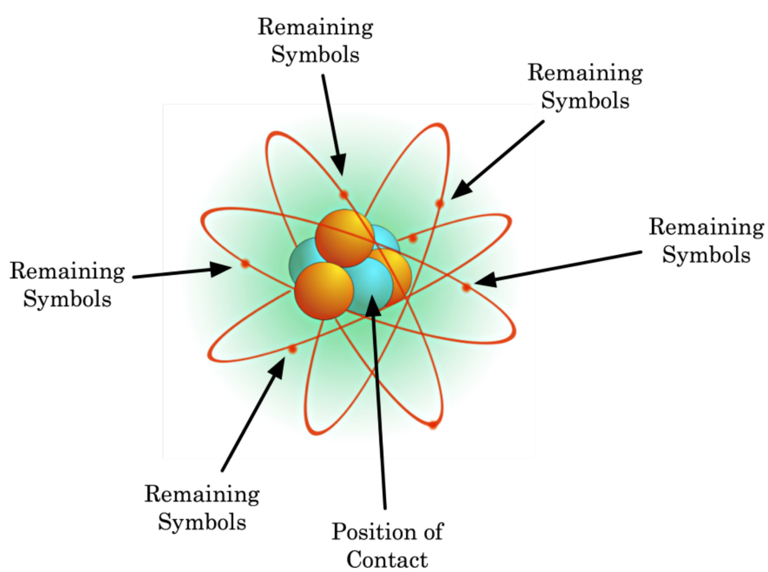
By adopting alternative midlines left and right of the default midline, it avoids the need for additional symbols to indicate this shifting—usually shoulder positional diacritics (Section 5.2.2) or shoulder movement diacritics (Section 5.2.3). Reducing the need for additional symbols allows writers and readers to adopt a simplified convention for knowing when the shifting occurs.

9.3 General placement of symbols in a sign

Having discussed placement at the page level, the next question is how to place symbols within a sign box. In the SignWriting pedagogical materials (both in print and online), Sutton frequently emphasizes the position of contact as the place to start when composing a sign. More often than not, signs include at least one contact between two active articulators or between an active and passive articulator. Where more than one contact occurs, a movement arrow likely depicts the relationship between each contact unless it is a sequential change in configuration by the hand symbols. For signs where one hand acts in concert with another, one of the contacts represents the initial contact from which subsequent movement and/or contact occurs. For signs where the hands move parallel with each other, there may not be any contact, but the hands may use the change of location as a contact instead.

When transcribing a sign, it is useful to think in terms of each contact between articulators being a nucleus. Then, by analogy, like electrons move around the nucleus of an atom pictured in Figure 81, the remaining symbols in a written sign are placed in relationship either to the nuclei in a sign or to other symbols already in relationship with a nucleus. The nucleus is written first, and the other symbols added where they fit best.

Figure 81. Analogy of the position of contact similar to the atomic nucleus



With this analogy in mind, this and subsequent sections discuss general and specific conventions for symbol placement within a sign. Determining the ideal placement of symbols largely rests on this idea of one or more nuclei around which the remaining symbols are placed. I will refer to each contact by articulators as a **nucleus** of a sign. The best practice for writing the nuclei of a sign is given in (17).

(17) The writer determines which articulators are contacting each other in a given sign. Typically, it will be a hand symbol with another hand symbol or a hand symbol with a head, torso, or limb symbol, or possibly the placement of an articulator in space. The symbols for the articulators contacting each other should be written directly with the symbols touching each other just as they are signed. Where writing direct contact will make the symbols for the articulator(s) difficult to read or where it is impossible to accurately place symbols for the articulators in a way that makes sense, a contact symbol can be placed where direct contact occurs with symbols for the articulator(s) placed as close to the contact as possible. If there is no contact, just movement, within a sign, the starting and ending positions of the hands function as the nuclei of the sign.

The following examples provide a selection of signs with the nuclei isolated and the additional symbols placed in relationship to them. In (18), for the ASL sign 'each', (a) shows us that the brushing of the two thumbs forms the nucleus of the sign. By definition, a brushing contact symbol must also attach to a movement symbol. In this case, it is two movements downward shown in (b). Finally, (c) show us that the motion to the right comes from both hands, but, being movement to the right, attaches to the right hand symbol.

(18) 

(a) (b) (c)

ASL 'each'

In (19), for the ASL sign 'staff', the sign has two nuclei where contact occurs. In (a), the initial contact is made on the right side of the shoulder using the fist handshape (). In (b), a curved arrow attaches from the first nucleus toward the second nucleus to show the subsequent curved movement away from the body and back. At the arrowhead in (c), the second contact is noted which includes a changed handshape (to an ASL 'f' handshape ) and a touch symbol.

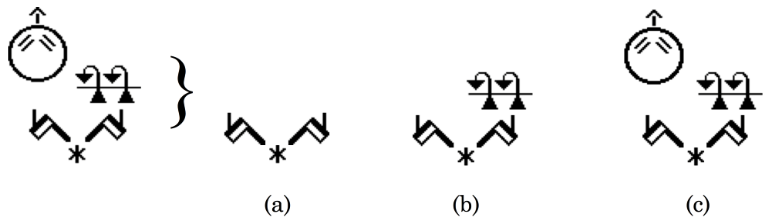
(19) 

(a) (b) (c)

ASL 'staff'

In (20), the ASL sign 'how?', the nucleus in (a) is the two hands bent toward each other and touching on the fingertips. Since the right hand is the only hand that moves, the tail of the double axial secondary arrows attaches to the top of the hand in (b). By placing the hand by the tail of the secondary arrows, it shows the flow of the movement more easily. Placing the axial arrow to the side, for example, could cause the reader to be less certain as to whether the writer is describing a beginning handshape (i.e., the configuration before the axial movement) or an ending handshape. In this case, it is a beginning handshape. In this example, the sign is a rhetorical use of 'how?', so the obligatory facial non-manuals—upraised eyebrows and a tilting of the head forward—are placed above the hands where head and torso symbols belong as shown in (c). Ordinarily, the nucleus would be centered below the head symbol on the default midline (since the head symbol marks the center of the sign). In this case, the writer is conveying that the nucleus is shunted somewhat to the side, so the nucleus is centered in lane 1 to the right of the midline.

(20)



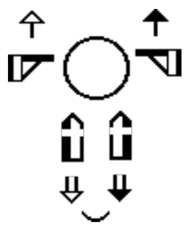
ASL 'how?'

Finally, in (21), the ASL sign 'number', again, we have two nuclei where contact occurs. The initial nucleus is generally written first as shown in (a). Since there is no movement arrow, only a change in configuration where the hands touch again, the second nucleus is written underneath the first as shown in (b). This is an example of a sequential action that involves no movement other than changes in the configuration of the handshapes.

(21)

ASL 'number'

Sequential actions can either appear beside one another or below one another. Fingerspellings (sequences of handshapes that convey the written form of a spoken language, discussed in depth below in Section 9.4.3) are typically horizontal. Signs containing sequential action that does not include a movement arrow, or signs that are a compound as shown in (22) are typically written vertically.

(22) 

ASL 'teacher' [TEACH + PERSON]

However, if an arrow is present and the direction of the arrow is horizontal, then the sequence may also be horizontal (or nearly horizontal) such as (23).

(23) 

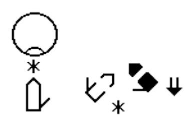
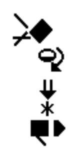
ASL 'amount'

Sutton (2005a:¶2-3) explains the importance of writing the position of contact:

> Contacted positions are more important because they hold the meaning in signs. The eye focuses on the contacted position, when reading. This was tested with a group of Deaf adults who were skilled in SignWriting (the DAC), and we found that when the position of contact was not written, readers had to piece the sign together slowly, but when the two hands were written together in the contacted position, like a unit, the sign was read faster.
>
> Writing the Position of Contact also creates smaller signs in width and height, which makes writing in vertical columns more centered and compact, making the columns themselves less wide.

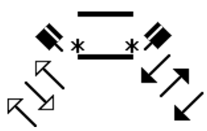
To help people work through this concept to write clearer signs, Sutton (2005c) listed ten Flemish Sign Language (VGT) signs and illustrated the difference. She created a similar set of illustrations with ASL signs (Sutton 2005a). Some of these illustrations are listed in Table 63. I note other examples at appropriate places in this chapter. In (a), the original shows nothing at the tail or arrowhead to show the order of movements. Also, the contact between the two flat palm hand symbols is unclear. In the rewrite of (a), the writer correctly observed that there were two nuclei tied by the downward arrow. By writing those nuclei and connecting them with the downward arrow, the writing was clearer. In (b) and (c), the hand symbol does not change during the movement, so by placing the hand symbol at the ending position and writing it first as the nucleus, the reader can follow the order of movements more easily.

Table 63. Contrasts between not writing the nucleus and writing the nucleus

	Original	**Rewrite**
(a) VGT 'gelukkig' ('happy, fortunate')		
(b) ASL 'Philippines'		
(c) ASL 'Ireland'		

Sometimes, a sign contains complex movements requiring the use of clusters of movement symbols to convey the appropriate movements. In these cases, the rule is to transcribe the movements from the nucleus out to the sides and then from top to bottom. Thus, the first cluster of movements is written in the center with each new set of movements on either side of it or below it. Table 64 provides examples of this rule.

Table 64. Examples of multiple movements

Example	Interpretation of movement
 ASL 'anyway'	Since the movements are placed horizontally, they are interpreted from the center out. The nucleus is the pair of hands brushing each other. The right hand first moves back while the left hand moves forward, then the right hand moves forward while the left hand moves back.
 ASL 'boast'	Since the movements are placed vertically, it is read from the top down. We have two nuclei moving oppositely, but independently. The right hand alternates down, up, then down while the left hand alternates up, down, then up.
 ASL 'a set of differences'	Since the movements are placed both vertical and horizontal, it is read from the center out. The middle longer arrow conveys the primary movement. Thus, the shorter, secondary arrows are read in harmony with the direction of the longer, middle arrow. This sign only has one nucleus. Both hands move downward as the index fingers brush each other as they move outward three times.

The remaining sections focus on describing the interactions between various types of symbols. Each type of symbol described in this thesis has a specific pattern of interaction with each of the other symbol types. I will discuss the following combinations of symbols as outlined in Table 65.

Table 65. Discussion of Symbol Interactions

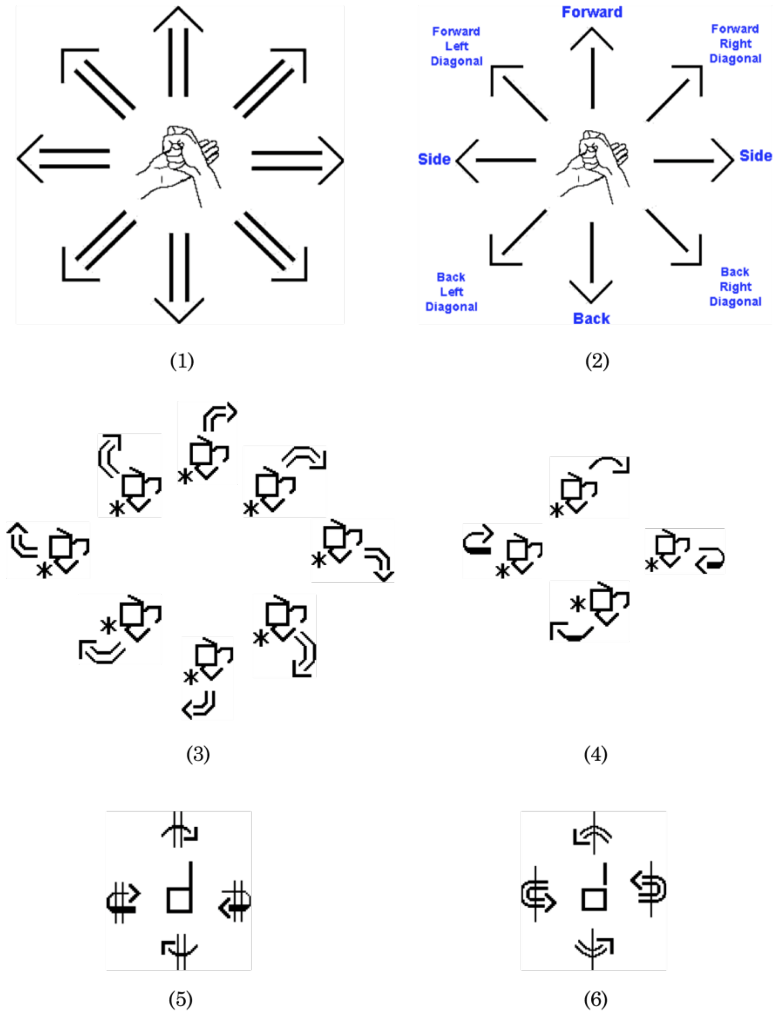
9.4 Hand symbols	9.4.1 With movement symbols 9.4.2 With other hand symbols 9.4.3 Fingerspelling and numbers 9.4.4 With head symbols 9.4.5 With dynamic symbols
9.5 Movement symbols	9.5.1 With movement arrows 9.5.2 With head symbols 9.5.3 With dynamics symbols
9.6 Contact, knuckle, and surface symbols	9.6.1 With hand symbols 9.6.2 With movement symbols 9.6.3 With head circles 9.6.4 With torso symbols 9.6.5 With dynamics symbols
9.7 Head symbols	9.7.1 With torso symbols
9.8 Torso symbols	9.8.1 With hand symbols
9.9 Dynamic symbols	9.9.1 With hands or movement arrows
9.10 Punctuation symbols	9.10.1 Punctuation symbols 9.10.2 Prosodic Brackets

9.4 Hand symbols

9.4.1. With movement symbols

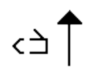
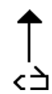
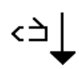
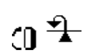
Hands are generally placed near the arrowhead or the tail of the arrow. The writer may opt to show the opening, closing, or both positions for hands that move. When placing movement arrows, it is helpful to imagine the hand symbol(s) at the center of all possible arrows with the hand symbol being pulled in the direction of the selected arrow. Another way of expressing this rule is that the hand symbol(s) at the beginning of a movement are generally placed as close to the tail of the arrow as possible. Similarly, the hand symbol(s) at the end of a movement are generally placed as close to the arrowhead as possible. Sutton (2005b) used the helpful diagrams shown in Figure 82 to illustrate these points. As illustrated in (1) – (4), the contacting hands are placed as close to the center of the tail as possible. (5) and (6) describe a related placement rule for arm rotations, where the curved arrow describing the rotation is placed so that its concave side is toward the hand symbol.

Figure 82. Movement arrow placement (Sutton, 2005b)



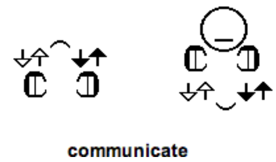
Sutton used some of the examples presented in Table 66 to illustrate how to position arrows. Granted, none of the hand symbols in Table 66 are contacting any other articulators. But where no contact exists, a hand symbol placed in a specified location constitutes a nucleus. In (a) – (d), the original has the hand symbol to the side of the arrow. The rules above state that hand symbols are placed at the tail or the head of the arrow to show the order of the movements and to clarify the position and orientation of the hand symbol at the beginning or end of a movement. Thus, in (a) – (c), the signs show more clearly that the handshape is at the beginning of the movement. In (d), the sign appears much more compact and the head is more properly centered in the sign when the hand symbol is placed at the tail of the arrow rather than to the side. This compactness, in turn, aids the reader in understanding the text.

Table 66. Placing arrows with the nuclei

	Original	**Rewrite**
(a) *VGT 'geven'* *('give')*		
(b) *VGT 'gevenmij'* *('give-to-me')*		
(c) *VGT 'cl-bekervallen'* *('CL-glass-fall-over')*		
(d) *VGT 'verwittigen'* *('alarm'?)*		

Sometimes, the placement of the arrows shifts when other symbols interfere. For instance, in (24), the placement of the arrows in the sign 'communicate' changes when the head circle is added because of the interference from the head circle. In this case, the head circle is shared between the two nuclei because it is showing the hands in a specified location with the head as a passive articulator. Alternating arrows can be placed above or below the hands because each set of arrows has both a head and a tail pointing toward the hand symbols.

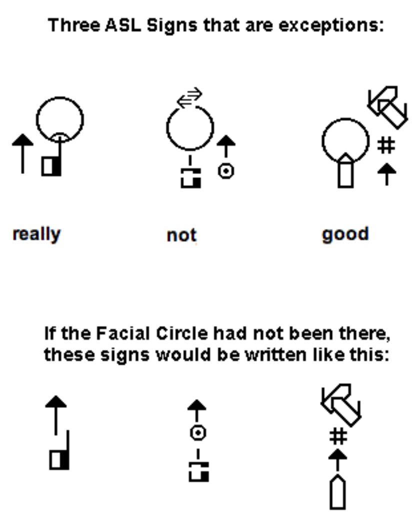
(24)



(Sutton, 2005b)

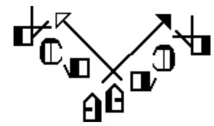
Sometimes the arrow is shifted to the side (whether it switches to the left or right seems to be a matter of aesthetics at this point). Sutton (2005b) used the diagram in Figure 83 to illustrate the sideways shifting. Again, the head circles in the example below are all part of the nuclei, so the arrow has to be placed outside the nucleus. With the head symbol in the place where the arrow would usually attach, the arrow's next best placement is to the side because all of these arrows show forward motion.

Figure 83. Movement arrow shifting

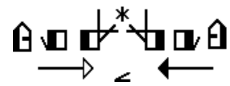


While the usual rule for placing arrows with hands does not permit hand symbols along the sides of arrows, fingerspelling while moving is a unique case where it does occur. In (25), the fingerspelling 'back' serves as a verb describing a motion where the subject returns back to outward locations. In (26), the fingerspelling serves as a verb describing motion by two subjects returning back to each other. In this way, the fingerspellings have attributes of both a fingerspelling and a sign.

(25) *back to an outward location (ASL)*



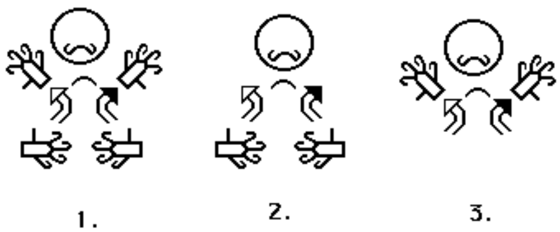
(26) *back together (ASL)*



9.4.2. With other hand symbols

When the hands are contacting each other or contacting another location of the body, then the nucleus is written to depict that contact as directly as possible. When the hands remain the same during the sign (or the beginning or ending position is predictable by the reader), writers have a choice to write the hand symbol at either the beginning or ending position. This choice depends on which representation is clearer or which results in the contact. If there is a handshape or orientation change that is not predictable, then writers typically include the beginning and ending hand symbols in a sign. For instance, Figure 84 shows three valid spellings Sutton (2000) wrote for the ASL sign for ‘angry’, which has four nuclei (i.e., the opening and closing positions for each hand). The first spelling shows the hand symbol at the beginning and ending positions, the second spelling shows them at the beginning position only, and the last spelling shows them at the ending position only. Sutton noted that she had observed more people using the second spelling in this instance, but all are valid spellings.

Figure 84. Three valid spellings for ASL 'angry'



9.4.3. Fingerspelling and numbers

Fingerspellings are borrowings from spoken languages that are typically spelled out using a manual alphabet that fits the spoken language being represented. Manual alphabets are usually sequences of handshapes oriented in a specified fashion, each of which depicts one letter in the standard writing system for the spoken language. Sign languages vary in whether they use one or two hands for their manual alphabet. Numbers usually follow a similar pattern as fingerspellings, but may include signs for *hundred*, *thousand*, *million*, and higher as part of the overall expression.

The usual convention thus far in SignWriting is to write this sequence horizontally from left to right, mirroring an actual left to right movement that sometimes occurs during fingerspelling (with the right hand) although some people are experimenting with vertical fingerspellings.[54] By convention, most SignWriting documents are composed as if writers are right-handed.[55] In actual production, when left-handed signers move their hand while

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[54] I examined SignWriting dictionaries available online for sign languages in locations where the national or regional spoken language wrote right-to-left. That did not yield any specific examples of how they typically wrote fingerspellings. A possible reason for a lack of information may be that fingerspelling has a broader use in ASL compared to many sign languages where it may be limited to names. Further investigation may change this preliminary analysis of written fingerspelling.

[55] Little has been done to look at how left-handed signers write fingerspelling (or how a right-handed person deliberately fingerspelling with the left-hand might write that part of his/her signing). This may impact how the rules are constructed for fingerspelling.

fingerspelling, they move from right to left. When they write, do they follow how they signed it or how the printed form is written? My suspicion is the latter.

Fingerspellings generally follow the rules for signs (with limited exceptions) when movement or contact symbols are needed. In (27), there is an example of normal fingerspelling for 'Kansas'. This is simply a sequence of handshapes to represent the English letters. Fingerspelling, in general, follows a pattern essentially the same as (27). Some fingerspelled letters have additional movements included such as the 'j' in July in (28). In some sign languages, fingerspelling or numbers can include contact with the other hand such as the Kenyan number 'ten' shown in (29). Those additional movement, location, and/or contact symbols follow the same rules as if they were in a sign.

(27) *Kansas (ASL)* 

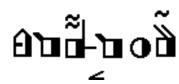
(28) *July (ASL)* 

(29) *Number 10 (KSL)* 

In some cases, the fingerspelling undergoes lexicalization in which case the fingerspelling actually becomes a sign and no longer merely forms a sequence of letters borrowed from a spoken language. Visually, it may look like a fingerspelling, but it often contains changes in the production that are not typical of fingerspellings. A potential sign of lexicalization in the written form is the addition of more movements or dynamic symbols.

Lexicalizations result in interesting placement questions. In (30), there is a lexicalized fingerspelling for Kansas. The movement and tension dynamic at the end of the fingerspelling is not normally associated with the spelling of 'n' and so that additional movement attached to 'n' in addition to the elision of 'sas' indicates lexicalization. In (31), 'billion' is represented by a fingerspelling that has two tense movements on the 'l' and followed by a more rapid spelling of 'ion' followed by tension on the last 'n'. (32) illustrates a lexicalized fingerspelling that is not strictly linear. This causes the fingerspelling to appear more like a sign.

(30) *Kansas (ASL)* 

(31) *billion (ASL spelling #1)* 

(32) *fun (ASL)* 

Because lexicalizations allow for hand and movement patterns that are unique, they form a set of special cases that must be taken into consideration in devising placement rules. Unlike signs, they may follow a different pattern. Therefore, those differences will need to be factored into a final list of placement rules.

9.4.4. With head symbols

The hands sometimes appear beside, above, or in contact with the head circle symbols. My review of the data shows that most hand symbols attach to the head circle at the specific locations already marked on the head circle map. Examples are given in Figure 85. If the hands touch the outer surface of the head circle, the fingers or the position on the hand symbol where the contact occurs attaches at the appropriate slots on the head circle, as shown in (a). If the contact occurs to the front of the face, sometimes the hand symbol is superimposed over the head circle symbol with fingers or the position on the hand symbol contacting where the contact actually occurs, as shown in (b). If other symbols are needed on the head circle such as eye gaze, mouthings, contact with the nose, etc. or if it is simply more readable off the head circle symbol, then the contact symbols are placed on the face at the appropriate locations and the hand is placed to the side (the left hand on the left side and the right hand on the right side) as shown in (c).

Figure 85. Examples of hand symbols with head circles

ASL 'think'

(a)

ASL 'appears'

(b)

ASL 'rat'

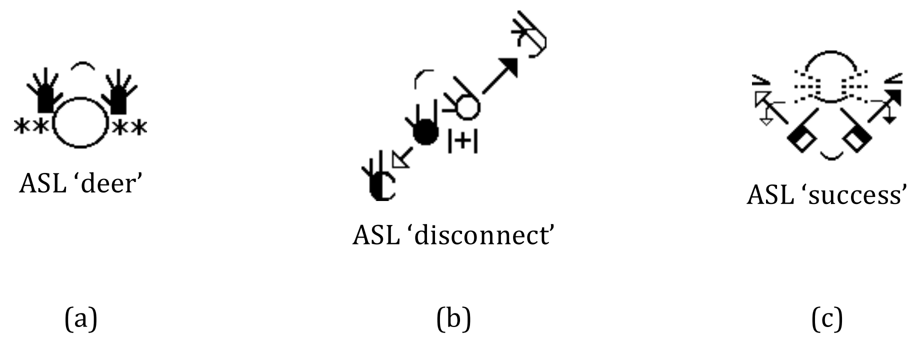
(c)

9.4.5. With dynamic symbols

As noted in Section 6.3, the tension symbol can attach underneath the hand symbol to mark classifiers or non-dominant hands that are acting as a buoy. However, in fingerspellings where the tension symbol is being used to show tension, examples (30), (31), and (32) earlier show that the tension symbol may also appear on top of the hand symbol. With signs, it can appear above or below the handshape, and less frequently to the side.

With the exception of fingerspelling, the other tempo dynamic symbols (e.g., fast, slow, etc.) typically appear with arrows, not handshapes (see Section 9.5.3). Two-handed dynamic symbols can appear over or under and between the hands as shown in Figure 86.

Figure 86. Examples of hand symbols with two-handed dynamic symbols



9.5 Movement symbols

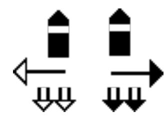
Symbols for articulators that can move (such as fingers, hands, limbs, or head) typically attach to slots near the arrowhead or the tail of the arrow. Some symbols may attach along the shaft of the arrow, but that is a more restricted possibility. One example already discussed includes lexicalized fingerspellings. Other possibilities are dynamic symbols and other movement arrows (when describing movement in two directions simultaneously), a scenario which is described in this section.

9.5.1. With movement arrows

Movement arrows can appear with other movement arrows when describing simultaneous movement in two directions. For instance, the ASL sign 'set of differences' illustrated in Table 64 and reproduced in the first example in Figure 87 shows a primary movement downward while simultaneously moving outward. In this case, the primary movement is the downward movement and the other arrows associate with the shaft of the main arrow to show that they are secondary movements. The two hands are attached to the movement as a unit, but more specifically, the brush symbol and its associated arrow. Similarly, the single outward motion by each hand in ASL 'children' represents the primary movement arrow to which the secondary downward arrows are associated. Like the first example, the hands are attached to their respective set of arrows. However, the hands are more specifically attached to the downward arrows than the outward arrow. This may be a byproduct of the choice to write vertically, so the vertical arrows present a more natural association.

Figure 87. Movement arrows in two directions simultaneously

ASL 'set of differences'



ASL 'children'

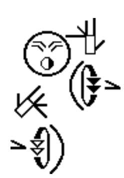
9.5.2. With head symbols

As we described earlier in Section 4.8, the head symbol uses an adaptation of the movement arrows to show head movement. Those specific diacritics are fixed in their position and do not exhibit the same flexibility as regular movement arrows.

9.5.3. With dynamics symbols

In some cases, dynamic symbols may occur next to the shaft of the arrow, showing the manner in which the movement occurs. A good example is (16) reproduced below. The fast and slow dynamics symbols modify the circular motion to show the movement as alternating between fast and slow movements.

(16)



ASL 'to be sick over a long period of time'

9.6 Contact, knuckle, and surface symbols

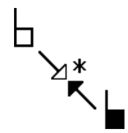
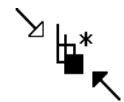
Contact symbols, knuckle symbols, and surface symbols may co-occur within the same sign, but they never relate to each other. Instead, they are positioned relative to symbols related to the hands, head, torso, and/or movement symbols.

9.6.1. With hand symbols

The contact symbol is usually placed as close to the nucleus as possible. Contact symbols generally attach to the articulators contacting one another. The contact symbols can be placed under, over, or to the side of the articulators contacting. That said, there are still writers today who give priority to placing the contact symbols rather than the articulators when writing the contact. Today, this is usually discouraged unless writing the contact between the articulators would be too difficult to read clearly.

Contrasting examples of writing with the contact symbol at the position of contact versus the hand symbols at the position of contact are shown in Table 67. Perusing the column with the contact symbol in the position of contact shows potential for ambiguity. On the other hand, writing the hand symbols in the position of contact yields a clearer spelling.

Table 67. Hand symbols vs. contact symbols at the position of contact

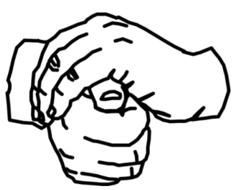
	Contact Symbols at the Position of Contact	**Hand Symbols at the Position of Contact**
(a) *VGT 'bestaan'* (*'exist'*)		
(b) *ASL 'two-people-meet'*		

In (a), writing the hand symbols (as shown in column 2) in the position of contact keeps the position of contact as the nucleus with the contact symbols staying in a secondary role to provide supplemental information clarifying the contact. Similarly, in (b), when the hands are written in the position of contact (as shown in column 2), there is a clear nucleus with movement symbols and contact symbols providing the additional information. When the writer uses the contact symbols in the position of contact (as shown in column 1), the reader is left to guess the final configuration of the hand symbols and there is no clear nucleus to which the movement arrows or contact symbols can connect. In most cases, if the hand symbols are written directly in the way that they contact when hands move from one location to another, it is easier for the reader to fill in the opening or closing configuration of the hand symbols.

The symbols ∗, +, and # only associate with two symbols: usually a hand and another hand or another location on the body. Often if the contact between the hands or between the hand and another location is written by means of the symbols actually touching each other, and the type of contact is the simple touch (∗), then the contact symbol is usually not written because it is assumed in writing the symbols are contacting one another. Double touches are still written as **.

There are instances where iconicity cannot be preserved in the written form of the handshape and the written form does not conform to its real life position. In those instances, the contact symbols should still follow the rule of being placed where the actual contact occurs. For instance, the ASL sign 'turtle'—illustrated in Figure 88—is written . In the written form, the right hand visually appears to have the right thumb on the side. An over-reliance on iconicity rather than reading the actual fills might lead a reader to think the curved portion of the left hand () is touching the knuckles of the top of the right ASL 'a' hand (), instead of contacting the left hand on the thumb.

Figure 88. The actual configuration of the hands in ASL 'turtle'



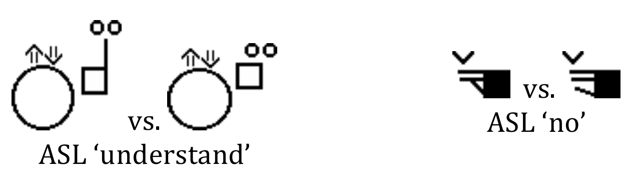
The placement of the grasp symbol near the base of the thumb of the right hand where the two hands contact provides the necessary clue for a correct reading. If the writer had not placed the grasp symbol (+) by the right thumb, the reader might assume the position of contact is the top of the fist, an initial fair assumption. But the grasp symbol changes the interpretation.

Surface symbols are rarely used except when a writer feels a sign cannot be distinguished or understood without them.  (ASL 'rough') is an example of a sign written with the surface symbol . The surface symbol is written close to the hand that is being clarified. In this case, the cupped hand might be perceived as brushing the side of the flat hand, but the surface symbol indicates that the cupped hand is actually on top of the flat palm. In the limited examples I have been able to observe (particularly with two-handed signs), the surface symbol appears to attach to the hand symbol representing the dominant hand showing its relationship to the non-dominant hand. In this case, the dominant hand is on top of the non-dominant hand. SignWriting instructional materials encourage writers to explore alternative spellings to avoid surface symbols where possible.

Knuckle symbols (●,○,^,v) in their various forms (as well as the Finger Arrows) associate only with finger symbols or the locations on the hand symbols that represent the fingers. We discussed the placement of the knuckle symbols in Section 3.12, and noted that the position of knuckle symbols are fixed with respect to the hand symbols and rotate in conjunction with the hand symbol.

When selecting the hand symbol for a sign that uses a knuckle movement, it is best to use the ending position for the hand symbol rather than the beginning position, since it is usually easier to extrapolate a beginning position than an ending one, like ASL 'understand' in (a) or ASL 'no' in (b) in Figure 89. In (a), the finger flick in the ASL sign 'understand' ending in an extended index finger is more easily understood in the first spelling than the second. Similarly, in (b), the hinge closing ending in a contact of the fingers and thumb in the ASL sign 'no' is more easily understood in the first spelling.

Figure 89. Examples of knuckle symbol placement



(a) (b)

9.6.2. *With movement symbols*

The movement symbols ⊙ and @ associate with three symbols at once: usually the dominant hand, the non-dominant hand or a location on the body, and one or more arrows.[56] For @, if a circular rub is intended, the arrows are not written, the motion being implicit in the form of the contact symbol. Without an arrow, it follows the pattern of the other contact symbols discussed earlier. However, when these two contact symbols appear with a movement arrow, they typically appear at the tail of the arrow. If a set of two arrows or a set of three arrows (in the same direction) is used, @ and ⊙ are centered across the tails of the set. If a set of three arrows is used where two move in one direction with the center arrow moving in the opposite direction, @ and ⊙ associate with the arrowhead of the center arrow. It can also appear between two sets of movement arrows in a two-handed sign. A few other alternative placements were observed, but could be considered misspellings. Figure 48, which also illustrates the placement of these two symbols, is reproduced below.

Figure 48. Examples of the brush and rub contact symbols

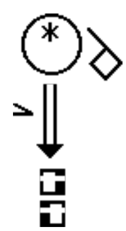
ASL ‘monthly’	ASL ‘temperature’	ASL ‘island’	ASL ‘socks’
(a)	(b)	(c)	(d)

[56] Section 4.7.2 provides a good example of the brush symbol’s association with the neck and a movement arrow.

9.6.3. *With head circles*

The available slots for contact with the head circles roughly correspond to the same slots available for diacritics. The touch symbol on the nose has already been described. In Figure 90, other examples of contact symbols on or around the face are shown. In (a), the contact is in the general location of the eyes (i.e., on the eyelids or near the eyes), so the contact symbols are placed there. In (b), the contact is the ASL "5" hand () contacting the sides of the head so the nucleus is written first with the hands touching the head where the contact occurs. The touch symbols are added underneath later. In (c), the index finger touches the forehead. Ordinarily, the index finger should have been written at the position of contact with the head, and the touch symbol placed slightly above the position of contact. When a writer feels writing the actual contact between articulators is too confusing, the next choice is to place a contact symbol at the position of contact and then put the hand symbol to the side as done here. Last, in (d), the contact is on the cheekbone under the eye.

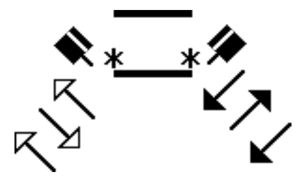
Figure 90. Examples of contact symbols with the head circle

			
ASL 'contact lenses'	ASL 'deer'	ASL 'faith'	ASL 'looks-like'
(a)	(b)	(c)	(d)

9.6.4. *With torso symbols*

The available slots for placing contact symbols with the torso symbol correspond with the possible slots available for diacritics. Table 68 provides several examples of this. In (a), the touch contact symbols indicate contact with the two sides of the shoulder. In (b), the touch contact symbols indicate contact with the edge of the shoulder. Last, in (c), the touch contact symbols indicate contact with the hips.

Table 68. Examples of contact symbols with torso symbols

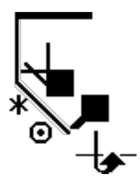
 ASL 'staff'	 ASL 'boss'	 ASL 'boast'
(a)	(b)	(c)

Limb symbols typically have more possible available slots than torso symbols as shown in Table 69. In (a), the contact is a circular rubbing movement by an ASL 'y' handshape on the elbow. The hand symbol is written as part of the nucleus with the limb symbol. The contact symbol is written below the hand symbol. In (b), the full movement is a series of contacts along the limb symbol. The nucleus is the flat palm contacting the limb symbol at the first contact. The touch symbols are placed on the limb symbol at each place where the hand touches the limb.[57] In (c), the nucleus is the contact between the two hands while touch contact symbols again are placed on the hand and arm where the right hand touches the left hand and elbow. In (d), an example of a name sign using the fingerspelling of 'k' () and 'j' () is presented. Notice the fingerspelling 'k' uses a touch symbol where it connects and the axial movement of the ASL fingerspelling 'j' becomes a brush on the forearm instead of a touch. For name signs, placing the contact can be challenging especially

[57] While not wrong, the first touch symbol is not necessary since the flat palm on the limb symbol conveys that first touch. These signs follow the older spelling rules that always included the touch symbol.

when the contact is in the same exact spot. Often it is spelt with the second letter slightly lower with the assumption the reader will know the second letter contacts in the same place. Last, in (e), the sign has two nuclei. The first nucleus is the flat palm symbol in contact with the head symbol. The second is the hand symbol contacting the crook of the arm symbol. For the head symbol, slightly above the hand symbol is the closest location to write the contact symbol. For the limb, under the limb symbol is the closest place to write that contact symbol.

Table 69. Examples of contact symbols with limb symbols

				
ASL ‘country’	ASL ‘improve’	ASL ‘parlimentary’	ASL namesign ‘KJ’	ASL ‘son’
(a)	(b)	(c)	(d)	(e)

9.6.5. *With dynamics symbols*

In cases when both a contact symbol and a dynamic symbol must be placed together, the rules for placing a contact symbol are applied first, and then the rules for the dynamic symbol.[58] Table 70 provides example signs that illustrate the two combinations found thus far including a tension symbol placed under a grasp symbol as in (a) and a digraph (a combination of ~ with ∗) introduced by Sutton (n.d.) to express the concept of “pressing” as shown in (b) – (d). (a) shows the tension symbol underneath the grasp symbol, functioning

[58] This observation is one reason for considering contact symbols and dynamic symbols to be separate classes.

not as a digraph, but as a normal use of the tension symbol to indicate tense grasping. The tension symbol is attached to the grasp symbol, in this case, not the hands. So, it appears the default position would be for the tension symbol to be underneath.

Table 70. Examples of contact and tension symbol combinations

 ASL 'connect'	 'hand pressing against the stomach'	 'two hands pressing together'	 ASL 'pressure, stress'
(a)	(b)	(c)	(d)

In the digraph, the tension symbol represents the articulator(s) providing the pressure. So, it may appear above the contact symbol, below the contact symbol, or in both positions. Example (b) shows the hand applying pressure toward the hips (near the stomach), (c) shows the two palms pressing against each other by having two tension symbols contacting each other, and (d) shows the spread palm hand symbol pressing down on the fist. Apparently to avoid confusion as to whether the non-dominant fist is providing the pressure, the tension symbol moved above the touch symbol.

Other dynamic symbols appear to modify directional movement symbols or hand symbols, but do not associate with any contact symbols.

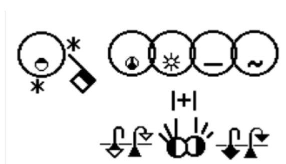
9.7 Head symbols

Sequences of facial expressions or mouth movements are handled by a horizontal set of head circles representing that sequence, written from left to right within the sign box. Some writers overlap the head circles while others position the head circles flush against each other. As mentioned earlier in the chapter, the center-most head circle (or the center of the sequence if there is an even number of head circles) is placed on the midline.

This is particularly useful for the representation of mouth movements. Sign languages vary in their use of mouth movements, which can be divided into mouth gestures or mouthings. Mouth gestures are mouth movements that are unrelated to the local, regional, or national spoken language and a natural part of the sign language, such as example (1) in Table 71 (ASL 'success', which includes the mouth gesture 'pah'). Mouth gestures can either be separate morphemes that contribute to the meaning of the sign, or simply part of the lexical definition of the sign. Mouthings, on the other hand, are full or partial representations of a corresponding word in a spoken language, such as the mouthing in the second example in Table 71 (DGS 'Deaflympics' with the mouthing sequence 'lymp'). Sometimes mouthings are the only distinction between two signs produced similarly.[59]

Table 71. Examples of mouth gestures and mouthings

(1)



(2)

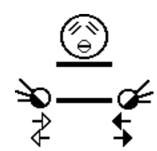
9.7.1. With torso symbols

As mentioned in Section 5.2, the torso symbol represents a specific location on the shoulders, chest, or hips. The addition of the head circle is only necessary if the sign will include specific facial non-manuals. Head circles are placed centered above a torso symbol if

[59] For instance, mouthings distinguish between the ASL signs 'but' and 'different', or the LSM signs 'donde' and 'quien'. How much this is used will vary from sign language to sign language and certainly from signer to signer depending on their exposure to the national spoken language.

a torso symbol is present. Table 72 shows examples of the head circle with the torso symbols. With the exception of (a), the non-manuals presented on the head circle represent important additional information for the sign. Example (b) shows the hand symbol in contact with the upper left breastbone. The contact symbols are written below to show it occurs twice. Example (c) is an example of mime written out. The additional attention to the details of the body posture is more typical of mime sequences than of signs. Example (d) shows contact with the tops of the shoulders. The brushing symbols go underneath the hand symbols to show the contact with the shoulders, but the arrows go above the hand symbols because that allows the hand symbols to be closest to the tails of the secondary arrows. Finally, in (e), there is no contact, but the hand symbols are located near the hips representing the location of the hands near the hips. The hand symbols at this location represent the two nuclei of the sign. The side-to-side movement is written underneath.

Table 72. Examples of head circles with torso symbols

				
ASL ‘angel, fairy’	ASL ‘lazy’	ASL mime ‘sad’	ASL ‘not my job’	ASL ‘very nothing’
(a)	(b)	(c)	(d)	(e)

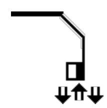
9.8 Torso symbols

A sign with only a torso symbol is usually centered with the torso symbol on the midline. Only one torso symbol can be present in a sign (whether representing just the shoulder or representing the shoulder and hip).

9.8.1. *With hand symbols*

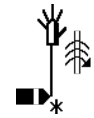
Limb symbols often attach to other symbols at one end or the other: a torso or hip symbol at the upper end, or a hand symbol at the other end like the examples in Table 73. In (a) and (b), one end of the limb symbol is attached to the torso symbol and the other end is attached to a hand symbol. In (c), only one end attaches to a shoulder bar on a head circle. Since the shoulder bar represent the torso in a top-down viewpoint, the limb attaches to the shoulder bar just as it would for a torso symbol.

Table 73. Examples of limb symbols attached to the torso and to a hand

		
ASL mime 'look sad'	ASL 'bag'	ASL mime 'tap in front of me'
(a)	(b)	(c)

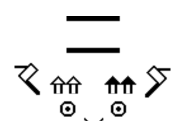
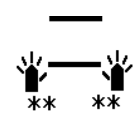
If the actual configuration of the hand is irrelevant, and the limb is simply depicted for the location of the sign, the limb symbol may stand completely alone without a torso symbol like the examples in Table 74. In (a) and (b), the non-dominant hand is irrelevant, so it is purposefully not written. The dominant hand then uses the elbow and forearm, respectively, as the nucleus for these signs. In (c) and (d), the non-dominant hand is relevant to the sign, so it is written. Since the shoulders are irrelevant to these signs in Table 74, the torso symbol is not written and the limb symbols stand alone.

Table 74. Examples of limb symbols that stand alone

			
ASL 'country'	ASL 'improve'	ASL 'parliamentary'	ASL 'tree'
(a)	(b)	(c)	(d)

When representing specific contact on legs, the torso symbol representing both the shoulders and the hip usually appear with the relevant leg depicted. Table 75 gives some examples of signs involving the hips and/or legs. Sutton (n.d.) gave examples (a) – (c) for showing the legs. Note that the foot has no symbol in SignWriting since it is not typically an articulator. In some cases, the passive articulator is a generic "below the waist" location (often assumed to be the legs) and so the sign may not even specify an articulator as in (d). If the hips themselves are the position of contact then, symbols relate to the hips like they might relate to the shoulders as in (e).

Table 75. Examples of signs with the hip symbol

				
ASL mime 'rubbing the knee'	ASL mime 'putting on a boot'	ASL mime 'slapping the foot'	ASL ' pants'	ASL 'Russia'
(a)	(b)	(c)	(d)	(e)

9.9 Dynamic symbols

9.9.1. With hands or movement arrows

Movement dynamic symbols can associate with either hands or movement symbols. In two-handed signs, the movement is either parallel or symmetrical. The two-handed dynamic symbols (, , and ) help identify these parallel or symmetrical clusters of hands and arrows. In these parallel or symmetrical clusters of symbols, there is a pair of hands and a pair of movement arrows. Usually, a dynamic symbol will attach to the hands or the arrows. This is determined by which pair of symbols is closer together. Where both pairs are equally close together, the dynamic symbol attaches more to arrows than to hands.

Table 76 shows examples of these symbols associating with the arrows. For parallel movements as shown in (a) and (b), the usual form is for the dynamic symbol to attach slightly above or below and between the right- and left-handed arrows. In example (c), the dynamic symbol attaches at the closest point where the arrows are parallel. The concave side of the two-handed dynamic symbols is the side that faces the symbols being grouped (whether it is the pair of hands or pair of directional movement arrows), so these symbols will rotate accordingly.

Table 76. Movement dynamics symbols associated with the arrows

ASL
'facial expression'

(a)

ASL 'stream, river'

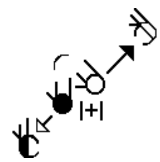
(b)

ASL 'peace'

(c)

When the movement is not parallel but symmetrical, they attach slightly above or below and between the pair of hands because the hands are the pair closest together. Table 77 provides examples. With the arrows further apart, the best choice is the pair of hands.

Table 77. Movement dynamics symbols associated with the hands

 ASL 'sausage'	 ASL 'wall'	 ASL 'let go, disconnect'
(a)	(b)	(c)

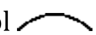
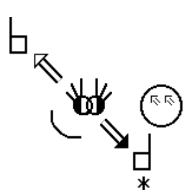
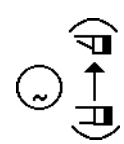
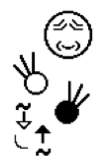
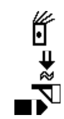
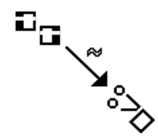
The dynamic symbol  —in all but one of its rotations—describes slow movement. When it appears as , it describes a smooth movement. Table 78 provides some examples. It typically attaches under the center of the sign as shown in (a). However, a common idiom appears in (b) and (c) where the slow symbol and the fast symbol can appear on the shaft of an arrow opposite of each other to show varying speeds of movement on opposite sides of a circle. Sometimes it appears above and below an entire sign or the hands themselves as in (d), usually defined as a gradual or very slow movement.

Table 78. Examples of the slow dynamics symbol

 ASL 'disconnect'	 ASL 'a series of next events'	 ASL 'to be sick over long period of time'	 ASL 'disappear into the horizon'
(a)	(b)	(c)	(d)

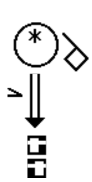
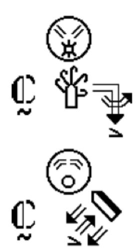
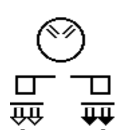
The tension symbol () or relaxation symbol (), when used as a movement dynamic symbol, appears at a point on the arrow (arrowhead, shaft, or tail) where the movement tenses or relaxes. Table 79 shows some examples. In (a), the tension symbol attaches to the tail of the arrow whereas in (b) and (c) the symbol attaches to the arrowhead. Example (d) shows the symbol attaching to the shaft of the arrow.

Table 79. Examples of the tension and relaxation dynamics symbol

 ASL 'perfect'	 ASL 'resist'	 ASL 'light from sunset'	 ASL 'shoot an arrow'
(a)	(b)	(c)	(d)

Finally, the fast symbol () can appear in several different locations. One example is the idiom shown in Table 78. Table 80 illustrates other possible uses. In (a), the fast symbol attaches to the shaft of the arrow to show the movement is fast. In (b), (c), and (d), the fast symbol attaches to the arrowhead to show the ending movement is done quickly. In (e), the fast symbol attaches to the knuckle symbols to show a fast opening and closing movement.

Table 80. Examples of the fast dynamics symbol

 ASL 'faith, trust'	 ASL 'very hot'	 ASL 'argue'	 ASL 'write easily'	 ASL 'amazed'
(a)	(b)	(c)	(d)	(e)

9.10 Punctuation symbols

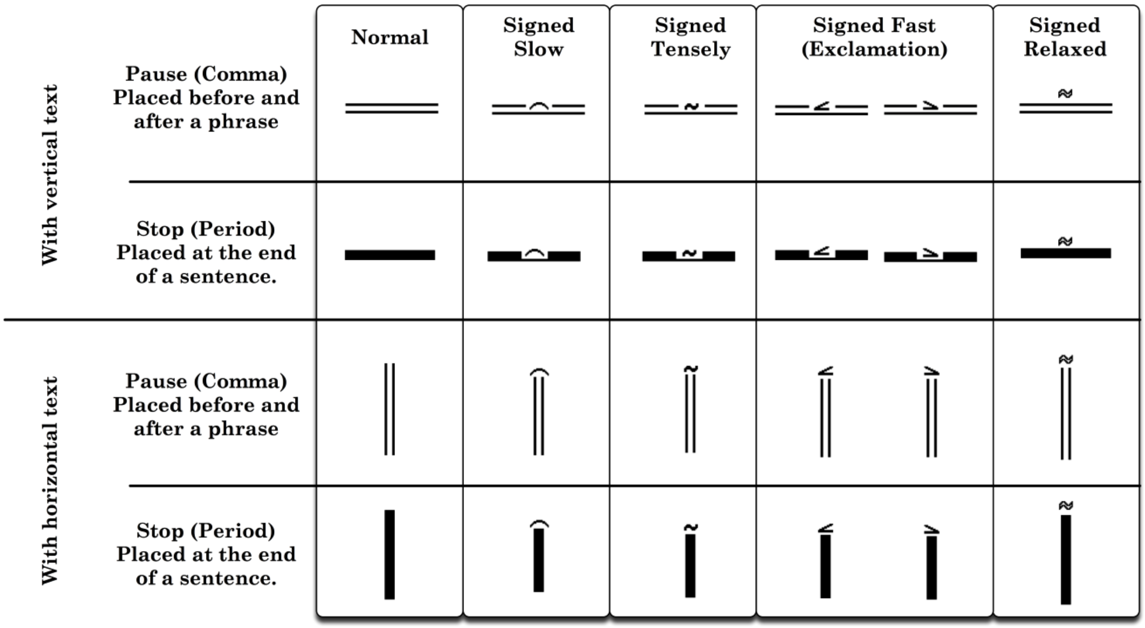
Written English enforces a number of rules about punctuation such as ending punctuation must be attached to the word it follows, or punctuation like the opening quotation mark or parenthesis must be attached to the word it precedes. Rules regarding punctuation in SignWriting are still in flux, but this section will describe standard usage.

9.10.1. Punctuation symbols

The only clear rule regarding punctuation is that punctuation symbols are never included in the same “box” as a sign, but rather occur in their own sign box. When writing in columns, they are always centered on the default midline. Presently, current computer implementations do not enforce any rules regarding which symbols may be placed in a sign box versus a punctuation box, nor do they enforce placement of punctuation boxes on the default midline.

Punctuation symbols can accept tempo dynamic symbols. The tempo dynamic symbols may attach either at the top of the punctuation symbol if positioned vertically or centered above the punctuation symbol if positioned horizontally. Examples are shown in Figure 91. These help the writer to signal a bit more of the “feel” of the phrase or clause.

Figure 91. Dynamic symbols placed with punctuation symbols



There is some limited variation in how punctuation is used. Often, it is similar to how that community's spoken language is written. For instance, some writers who live in Spanish-speaking countries practice the bracketing of exclamations and questions much like Spanish does with its punctuation (such as using ‖ … ‖ or ═ ⋮ ═ for ¿ … ?). Others employ one punctuation mark at the end of the clause similar to English.

9.10.2. Prosodic Brackets

As part of the overall category of punctuation symbols, prosodic brackets do not appear in the same "box" as signs they precede or follow. Prosodic brackets have only one slot on the opening bracket where it can accept symbols for one or more non-manual markers, usually head circles or torso symbols. The closing bracket has no slots available as it is assumed the signer returns to a neutral stance if no additional head or torso symbols are present on subsequent signs after the marked phrase(s) or clause(s).

CHAPTER 10

FUTURE DIRECTIONS FOR RESEARCH

10.1 Introduction

Current schemes for representing SignWriting in proprietary software use Cartesian coordinates within a 250 x 250 pixel grid to identify the location of each symbol in an individual sign; this approach appears impossible for a Unicode encoding. A Unicode encoding expects an encoding that could potentially be implemented in different ways but end up with the same visual results. One of my hopes for this thesis was that I would be able to uncover some rules that would help provide a more restricted method of conveying spatial relations. While this thesis is not able to answer that question in full, my hope is that it brings us a step closer to potentially finding that solution.

My analysis of this question has led to two promising avenues of research to find a more restricted means of encoding the spatial relationships. First, more work on identifying the underlying structure of a written sign is needed. Second, with the structure more clearly identified, we should combine this with deeper understanding of symbol relationships and explore the constraints that arise from that understanding.

In the sections below, I discuss four tasks that I believe are necessary to explore in further detail as part of finding a satisfactory encoding. The first task is to define the underlying structure of a written sign, which includes determining relevant attachment points for each symbol. The second task is to find a way to express and define distances between symbols in a way that can be constrained, but adequately express the distance between symbols. The third task (closely related to the second) is to determine the closest attachment points between symbols. The relationships between symbols can be expressed as the angle and distance between selected attachment points on the two symbols. The fourth task is developing a linear stream that can be reinterpreted into the two-dimensional representation that SignWriting expects. While this thesis only provides a basic exploration of these tasks, at a minimum, further research could help us determine if we can develop an implementation-neutral encoding.

10.2 Task #1: Defining underlying structure and attachment points

Given that SignWriting is capturing the movements of the human body using what is essentially a template of the human body, there is definite interplay between the layout of the human body and the layout of signs written using SignWriting. This suggests the possibility of a tree relationship between the various symbols within a sign. On the surface, the obvious nodes for the tree include the head, each hand, and the torso (the last of which could be represented by either neutral space or one of the torso symbols).[60] A definitive identification of some kind of tree structure may help determine some rules that can limit the symbols a rendering engine must analyze when decomposing or recomposing a sign.

Table 81 presents a basic diagram showing the logical relationships within the underlying structure of a written sign itself. Working down the diagram, the first element is

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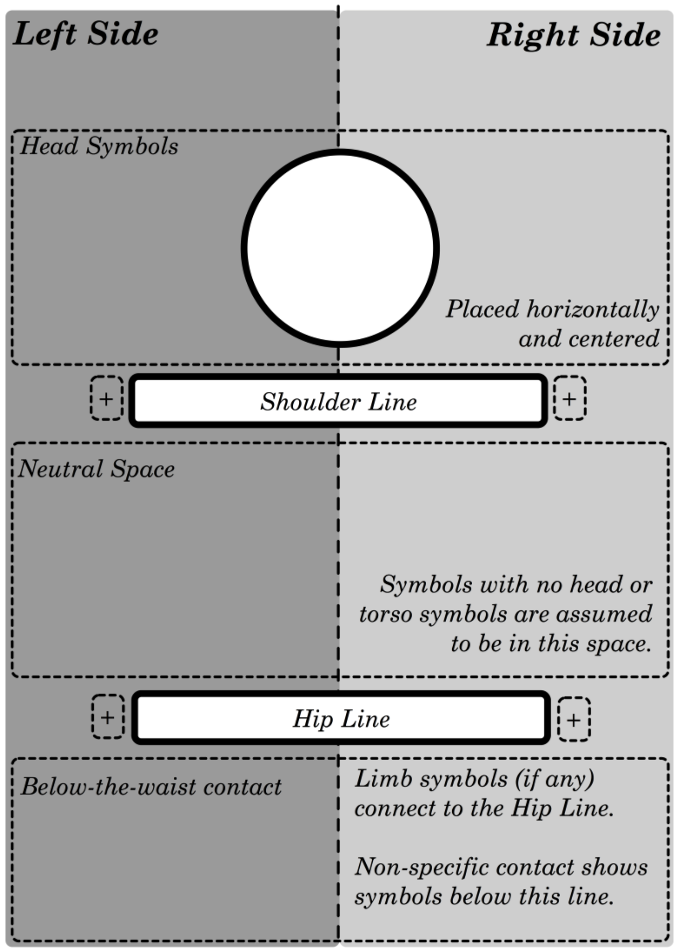
[60] While the legs might constitute possible nodes, the use of the legs during normal conversation is minimal. Such instances are usually depicted in SignWriting using limb symbols attached to the torso/hip symbol or using empty space below the hip to signify contact "below the hip". As such, the legs would then be considered children of the torso/hip symbol.

a specific region in which head circles may appear. Usually, if a head circle is present, it is centered within that region, but if multiple heads are involved, then the heads center together within that region.

Table 81. Basic underlying structure of a sign box



The next visible elements in the tree are the shoulder and hip lines. Both represent slots where torso bars fit. On each end of both the shoulder and hip lines, the '+' slot represents the attachment of children (usually limb symbols and any associated hand symbols). Torso symbols in the shoulder and hip slots are optional if there is no need to reference them. However, the slots are reserved as part of the underlying structure. They form the boundaries that demarcate the "neutral space" forming the space in between them. If both head and torso symbols are not present, the symbols are assumed to be in the "neutral space".

The sign box is also divided into left and right sides representing the two hands. Each side acts as an element of the tree, containing one or more hand symbols with its associated movement symbols and contact symbols. The sides are a logical construct, not necessarily a visual representation of the sign. For instance, if a hand symbol appears on the opposite side (e.g., a left hand symbol on the right side or a right hand symbol on the left side), the hand symbol will be represented as a child of its logical side. This forms a unit that can be analyzed and placed independently of other branches as expected in a tree structure. Hand symbols can appear anywhere within the diagram.

A more formal analysis or description of these relationships—possibly in the form of an attribute value matrix (AVM)—may yield more constraints that could help us use this structure in the development of an encoding that notes the spatial relationships of symbols.

Along with the definition of the structure of a sign, each exemplar needs a set of possible attachment points defined. Attachment points are positions on each symbol where other symbols may attach or associate. This is similar to the analysis I did for the hand symbols to see where the fingers attached to the base form of each hand symbol. By limiting the places where symbols may attach, we can look past minute differences between spellings that writers would generally characterize as being the same, but which are not precisely the same, pixel-wise. By identifying where symbols can "snap" into place, this improves the ability of both computers and users to identify, sort, or otherwise organize signs. Such research requires a more detailed analysis of how specific symbols connect with other symbols. This, too, may yield some patterns that may help predict certain ways that symbols connect with each other.

10.3 Task #2: Defining and expressing distances between symbols

Once we understand the structure and relationship between symbols, we are still left with one quandary. How should we handle the distances between symbols? Unlike other writing systems, the spacing between symbols is relevant. Historically, SignWriting has tracked symbols independently on a 250x250 pixel grid, storing the Cartesian coordinates (x,y) for the placement of the symbols on that grid. If symbol placement is to be included in a specification for SignWriting in Unicode, using Cartesian coordinates is unlikely to pass muster. Cartesian coordinates would be too specific. Differences of even a pixel could potentially cause otherwise identical signs to be regarded as different. The ideal encoding should show the logical relationship of symbols to each other in the structure of the sign along with the relevant distance such that the sign can be appropriately composed.

An alternative approach could be to use polar coordinates, which associates points in space to one another using angle and distance. Under this approach, one symbol could be placed initially, and then all symbols could be stored with the angle and distance relative to the position of that initial symbol. Admittedly, this shares some of the same challenges as Cartesian coordinates. However, with the logical structure of the sign in place and with each symbol having a set of possible attachment points, the sign could be decomposed into a tree with nodes where each symbol is stored along with the angle and distance relative to an attachment point on its parent node. This could lead to shorter distances to store, potentially resulting in a more acceptable encoding.

10.4 Task #3: Determining the closest attachment points between symbols

While I hoped this thesis would have more answers, my preliminary research into this question has suggested that the signs might indeed be able to become a tree that can be "walked". Once the structure of sign boxes has been confirmed, attachment points of all symbols are defined, and we have used polar coordinates to determine mathematical relationships between symbols, our next step is to define a method to determine closest attachment points. Eventually, this method will also need to take into consideration overlapping and superimposed symbols in determining closest attachment points, but, for simplicity's sake, I chose to ignore overlapping and superimposed symbols in my preliminary investigation.

In exploring this possibility, I took a sample of 383 ASL signs out of 7,279 signs taken from the SignPuddle Public Dictionary located at http://www.signbank.org/signpuddle. I wrote a Python application that analyzed the SBML data for all 7,279 signs and then helped me isolate the 383 sample signs. Using this application, I did various experiments using both on-screen reporting and the production of HTML-based reports. Part of the analysis included a prototype attachment point analysis where the application traced the outline of each symbol and identified and stored the positions of the outermost pixels for each symbol. The purpose of storing the outermost pixels was to approximate the attachment point analysis. If we had a genuine analysis of attachment points, we would not need this step.

The next step in the analysis was to analyze the relationships between symbols and find which symbols are closest to each other and by how much. Keep in mind that the two pixels used as proto-attachment points in my analysis are simply the two mathematically closest outermost pixels between two given symbols. My assumption was that the closest pixels between the two symbols would be approximately close enough for the purposes of this preliminary analysis. Time did not permit me to adjust my analysis for overlapping or superimposed symbols. This likely distorted the analysis for some symbols.

Next, I wrote a proximity analysis report that asked for a threshold pixel distance (i.e., a minimum distance between symbols), using that distance to find the closest symbols for each symbol in each sign. After giving it a threshold of fifteen pixels, it then presented the data (in a 216-page report). Sample output for the sign 'turtle' is shown in Table 82 (other examples will be examined later in Table 84 and Table 85). Looking at Table 82, the first column tells me the filename for the graphical image of this sign. The second column presents the sign and its English gloss (according to SignPuddle). The next column presents each symbol found in the sign and its ISWA long-form number followed by the glyph that number represents. The order of the symbols is how the user entered the symbols. The last column presents, for each symbol, a list of symbols that are within a fifteen-pixel threshold between their respective closest pixels as well as the angle between those closest pixels (presented as *pixels* θ *angle*). For example, the first line shows , and notes that its closest symbol is . The distance between their closest pixels is four pixels and the angle between those closest pixels is 90°. As you can see from this example, this preliminary analysis roughly corresponds with the logical structure diagram I presented earlier.  is in the left side branch.  is in the right side branch. The contact and knuckle symbol closely relate to , i.e., they are closer to it than to other symbols.

Table 82. Proximity analysis sample - Turtle

File	Sign	Symbols	Related?
2088.png	turtle 	**000** 01-05-036-01-02-09 -	- 4 θ 90
		001 01-10-003-01-05-01 -	- 4 θ 270 - 3 θ 0 - 3 θ 71
		002 02-02-005-01-01-01 -	- 3 θ 180 - 9 θ 135
		003 02-01-004-01-01-01 -	- 3 θ 251 - 9 θ 315

10.5 Task #4: Developing a linear stream that can represent the 2D sign

The next step in my analysis is more of a thought experiment than an actual implementation. Taken what I have done so far, let us imagine we now have a sign entered into an input method editor (IME).[61] I assume that the IME will internally store information much like existing implementations do, using symbols placed with Cartesian coordinates in a defined grid (e.g., 250 pixels x 250 pixels). I also assume that not all writers will necessarily place the individual symbols in the same order.

How could this data be repackaged into a structure that could be represented in a linear sequence? One possibility is a tuple containing every symbol in the sign, each with its own tuple of neighboring symbols, distances, and angles.[62] The IME could run a proximity

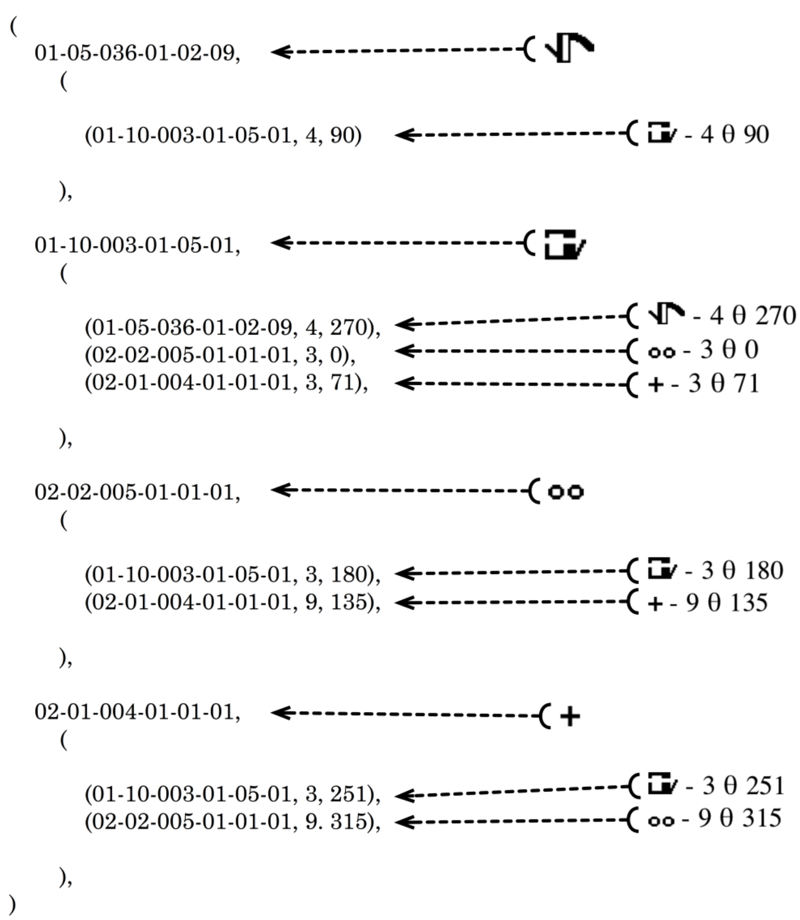
[61] Some non-Roman scripts employ an intermediate program or method of keyboarding called an input method editor (IME) when entering text into an application. Most commonly, IME's are used for Chinese, Japanese, and Korean text entry. Applications delegate the input of text to the IME and expect the IME to return with a Unicode-approved string that the application can then manipulate or store.

[62] A tuple is a computer term for a fixed, ordered list of elements. In this case, we are talking about a list of symbols in a sign and each symbol has its own list of closest symbols that includes distance and angle between them. Essentially, a condensed version of what I

analysis such as I have done and use this analysis to linearize it. Admittedly, this approach doesn't fully take into consideration the logical structure of a sign, but that is something that could be incorporated to add more refinement to the analysis.

To help us visualize the input from a document or from an IME's proximity analysis, let us assume the sign is the ASL sign for 'turtle' as shown in Table 82. The resulting tuple would be similar to Figure 92, except it would have the appropriate Unicode glyph for the symbol and control characters to represent the distances and angle. On the right, you see the comparable information from Table 82.

Figure 92. Illustration of a sign tuple



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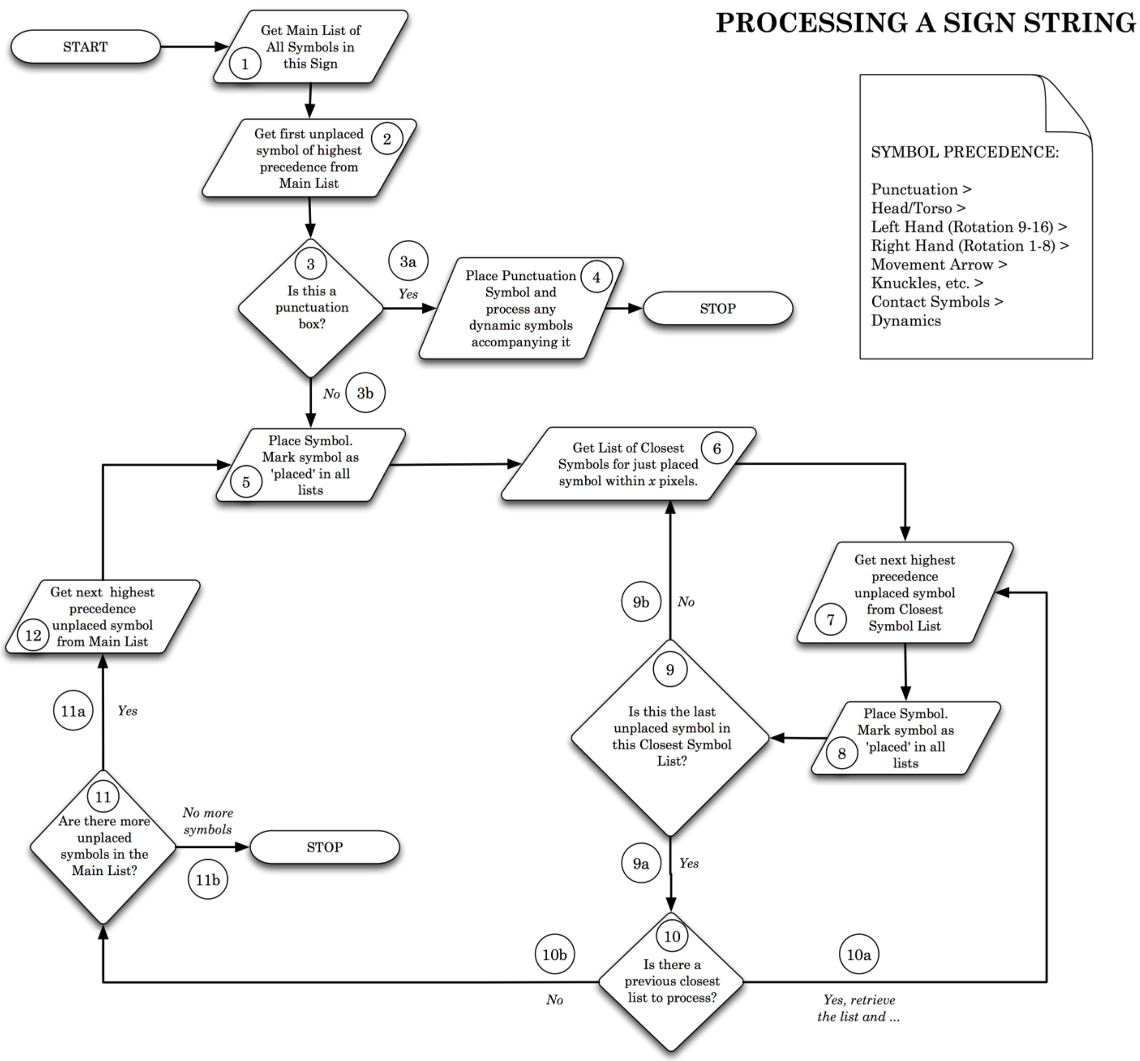
present in Table 82.

Taking this stream of data, I worked out the flowchart illustrated in Table 83 and found it to be generally productive. Essentially, the flowchart describes how to process a sign represented as a tuple for placement given the data shown. The process assumes the use of polar coordinates and the existence of a single midline for now. Adding metadata later for the use of the alternative midlines should be relatively trivial.

Using the flowchart, I was able to mentally recompose the majority of the signs. Some challenges did exist where the computer's prediction of closest pixels were not accurate or where overlapping or superimposed symbols were not handled properly. But there seemed reasonable promise that more research investment might yield better results.

Table 83. Flowchart for Symbol Placement within a Sign



Flowchart description

In a nutshell, here is a textual description of the flowchart:

(1) When processing a document, the renderer identifies a SignWriting sign (in the tuple format shown in Figure 92.)[63] It begins reconstructing the sign in this

[63] Ultimately, there will need to be a decision where the processing should occur. What should be given to the IME and what should be given to the renderer? In this preliminary analysis, I am giving processing to the renderer, but it may be better done by the IME beforehand.

fashion. It extracts the list of symbols to be placed. This is the main list of symbols. This list is saved for processing as it must be updated after each symbol placement to know which of these symbols has not yet been processed.

(2) The process then selects the highest precedence symbol from the main list.[64]

(3) The first decision is to determine if it is a sign box or a punctuation box. If the symbol of highest precedence is a punctuation symbol, it is a punctuation box. Signs and punctuation cannot occupy the same sign box.

(3a) If it is a punctuation box, continue to step 4.

(3b) If it is not a punctuation symbol, continue to step 5.

(4) The punctuation symbol should be placed and any other dynamic symbols with it. Processing now stops because the punctuation box has been processed.[65]

(5) Place the symbol and then mark it as 'placed' on all symbol lists. For the first symbol, it can be placed neutrally. For remaining symbols, it will depend on the distance and angle to the symbol whose closest symbol list is being processed.

(6) Get the closest symbol list for the symbol just placed.[66] If the process is currently working through a closest symbol list, then it should be saved to the stack so that it can process this one.

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[64] In the current rules of precedence, I have followed the norm for a right-handed person, placing landmark before trajector. However, this flowchart does not address whether this precedence adequately accounts for left-handed signing. That is another question to consider.

[65] Ideally, when processing punctuation, the IME should prevent any other symbols from being accepted other than what is acceptable for a punctuation box.

[66] In my report, I used a threshold of 15 pixels, but it may be possible that future research finds a better number.

(7) Get the highest precedence symbol from the closest symbol list.

(8) Place the symbol and then mark it as 'placed' on all symbol lists.

(9) Determine if this is the last symbol in this closest symbol list.

(9a) If it is the last symbol, continue to step 10.

(9b) If it is not, continue to step 6.

(10) Determine if we have another closest symbol list on the stack.

(10a) If there is another list on the stack, retrieve it and continue to step 7.

(10b) If there is not, continue to step 11.

(11) Determine if we have any more unplaced symbols in the main list.

(11a) If we have more unplaced symbols, continue to step 12.

(11b) Processing stops because there are no more symbols.

(12) Get the next highest precedence symbol from the main list.

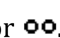
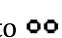
The flowchart applied to examples

We will now process two examples to give a feel for the process. You have already seen the example of the ASL sign 'turtle'. I have re-organized the data in Table 84.

Table 84. Analysis of the sign 'turtle'

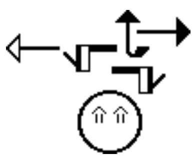

ASL 'turtle'

Main List	Closest Lists
	 - 4 θ 90
	 - 4 θ 270  - 3 θ 0  - 3 θ 71
	 - 3 θ 180  - 9 θ 135
	 - 3 θ 251 - 9 θ 315

In this case, the highest precedence symbol is . We first check it to make sure it is not a punctuation mark. Next, we place the symbol neutrally (i.e., there is no specific coordinates for the first symbol) and then mark it as placed. Next, we check out its closest symbol list and find it has only one symbol: . So we place it in relationship to  (4 pixels away at 90°) and mark it as placed. Next, we look at the closest symbol list for  and we find , , and  in the list. So, we have already placed , so the next highest precedence symbol is . We place it in relationship to  (3 pixels away at 0˚) and mark it as 'placed'. Next, we get a Closest Symbol List for . It shows  and . The next available unplaced symbol is . So we place it in relationship to  (9 pixels away at 135˚) and mark it 'placed'. This being the last unplaced symbol in the closest symbol list for , we turn back to the closest symbol list for . The next highest precedence symbol is , which is already placed. So, with no additional symbols to process, and no remaining symbols in the Main List, processing for this sign is complete.

For another, more complex example, look at Table 85 to see the symbol list for the ASL sign 'heaven'.

Table 85. Analysis of the sign 'heaven'



ASL 'heaven'

Main List	Closest Lists	Main List	Closest Lists
	- 9 θ 270 - 5 θ 135 - 6 θ 270		- 5 θ 315 - 13 θ 247
	- 9 θ 90 - 3 θ 213 - 13 θ 67 - 13 θ 329 - 6 θ 0		- 13 θ 149 - 5 θ 180
	- 3 θ 33		- 6 θ 90 - 6 θ 180 - 5 θ 90

In this case, the highest precedence symbol is . We check to make sure it is not a punctuation symbol, and then place it, marking it 'placed' on all lists. We retrieve the closest symbol list for , and we find and . Of these, has higher precedence. So we place it in relationship to (13 pixels away at 247°) and mark it as 'placed'. Next, we check the closest symbol list for . It has , , , , and . The next highest unplaced symbol is . So, we place it in relationship to (9 pixels away at 90°) and mark it as placed. Checking the closest symbol list for , we only see , , and . Of these, only is unplaced. So we place it in relationship to (6 pixels away at 270°) and mark it as 'placed'. Now, we check the closest symbol list for . It has , , and . Of these, only has not yet been placed. So, we place it in relationship to (5 pixels away at 90°) and mark it as 'placed'. Then, we look at the closest symbol list for . It only has and . Both have been placed, so we return to the closest symbol list for and . All of their closest symbols are placed. We return to the closest symbol list for . Only one has not yet been placed, . So we place it in relationship to (3 pixels away at 135°). With all closest symbol lists processed and the main list processed, we are done.

10.6 Concluding thoughts

Naturally, this preliminary analysis has some weaknesses. First, the attachment points used by my program are not necessarily meaningful from a writer's viewpoint or the most useful for the algorithm that draws the sign based on input data; they simply represent the closest point to the other symbol. Valid attachment points that would make sense to a writer might yield more dependable threshold data and help us know the maximum distance we need to keep track of in order to recompose signs. The goal of this analysis is to find out how we could limit the need for control characters to express the distance between characters. In this preliminary analysis, we found that we could limit distance to a possible fifteen pixels.

Second, it is insufficient to simply record distance. We must also consider the angle from the attachment point. Initial results from my sample set, which included 4,020 symbols in all, showed about 55.57% of the symbols use the set of four 90° angles (i.e., 0°, 90°, 180°, and 270°). If the set of 45° angles are included, for a total of eight possible angles, coverage is increased to 65.67%. Changing to a set of 22-23° angles (23.5° being the angle between 45° angles), coverage is increased by slightly less than 3% to 68.21%. So, any attempt to encode the angles also needs to determine how to handle the 32-34% of angles that do not fit 90°, 45°, or 22.5° increments.

It may be possible that adjusting the angles to a "standard" angle might not affect the sign much. It may also be that its relationship to some other symbol might be with a standard angle. For example, in Table 85,  is 13 pixels away at 247° from , but 9 pixels away at 270° from . So changing the reference point might be another way around it. Or it may be that if each symbol had predefined attachment points, using them to calculate distance and angle might result in a different distance/angle that is more standard. Yet another solution might be to explore how to integrate the logical structure more, which might also make relationships easier to establish. Time did not permit me to explore these other avenues of adjusting the angle.

Additional research in the area of structure, attachment points, and how to handle the unusual angles may uncover more useful elements that can help us develop a better encoding and the rules to support that encoding. SignWriting is paradoxically complex and simple, yet that very flexibility is what makes it a useful tool for recording signs in written form. Hopefully, continued research in this direction will permit SignWriting to join the many writing systems already in use as part of the Unicode standard and become one of the writing systems supported by mainstream software.

APPENDICES

APPENDIX A

CURRENT IMPLEMENTATIONS OF SIGNWRITING

A.1. Numbering Schemes

Over the years, there have been various systems developed to classify, sequence, and otherwise organize the different symbols used in SignWriting and other MovementWriting systems. These have taken the form of systems of assigning unique numerical codes to each symbol. Throughout the discussion below of the various numbering systems for cataloging SignWriting symbols, I use the symbol , representing the right fist with one index finger pointing up and the palm facing the writer, to illustrate the different numbering schemes.

Steve Slevinski and Valerie Sutton continue to work on making SignWriting more easily used on computers. The purpose of both appendices is to provide some historical documentation of the work that has been done over the years to make SignWriting accessible on computers. For up-to-date information on their efforts in this regard, check their work at http://www.signbank.org/swis.

A.1.1. 1995-1999 Sign-Symbol-Sequence (SSS 1995 and SSS 1999)

The first numbering systems for SignWriting were called the SSS (Sign-Symbol-Sequence) numbering. The SSS supported the first computer programs for the Apple IIe and MS-DOS called *SignWriter*. An increase in memory for computers led to an expansion of the number of symbols the computer programs supported. These numbering systems were only for the SignWriter program. They were not an exhaustive listing of all the possible symbols.

The SSS numbering systems took the form of a series of numbers separated by hyphens. For example, in the SSS-1995,  was 000-0-0. In the SSS-1999,  was 001-1-1-1. The four parts of this code are explained in Table 86. The ranges in each row represent the valid range for that element in the numbering system. These numbers for the SSS were usually only seen inside of a computer program.

Table 86. SSS Numbering System

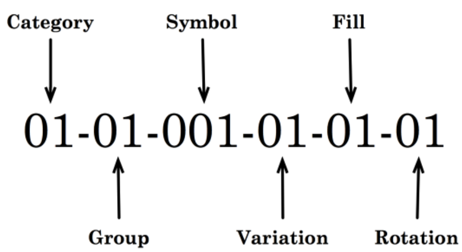
Symbol	**1995:** 001-247 **1999:** 001-262	Due to the limits of early computers such as the Apple IIe and the IBM PC, the early symbol sets were quite small.
Variation (SSS-1999 only)	1-6	This was added for SSS 1999 to identify symbols that were very similar to an existing symbol rather than giving that symbol a totally separate symbol number.
Fill	1-6	The fills were mostly used for hands and arrows. If a symbol did not have a fill, this was left blank.
Rotation	01-16	Many symbols had rotations and reflections. Both were included in this slot. If a symbol did not have a rotation, this slot was left blank.

A.1.2. 2002-2004 International MovementWriting Alphabet (IMWA)

With the advent of Unicode, the removal of the 256 character limits of ASCII, and the increasing memory available to computers, the SignWriting community and developers began to look at including all the MovementWriting symbols. Initial work to extend the SSS numbering eventually coalesced into the International MovementWriting Alphabet (IMWA). The IMWA became the first attempt to have a detailed and organized listing of all the symbols in the MovementWriting system. The IMWA numbering system uses the format described in Figure 93.

Using this numbering,  has a symbol ID of 01-01-001-01-01-01 using the basic template as shown in Figure 93. The various parts help to organize and classify each of the glyphs in the system using Category, Group, Symbol, Variation, Fill, and Rotation as the identifying elements. In Table 87 through Table 92 below, the meaning of each element is described. The ranges listed under each element represent the maximum ranges for that element in the numbering system.

Figure 93. IMWA Numbering Template



Category

The first number represents the Category or type of symbol being considered. The IMWA categories are listed in Table 87. The first two (Hand and Movement) are obvious. The distinction between categories three and four is that Face focuses on the eyebrows, eyes, nose, mouth, etc. while Head focuses on the movement or positions of the head itself. Upper Body symbols focus on the shoulders and torso. Full Body symbols focus on limbs and more elaborate symbols needed for expressing more detailed body configurations like that needed for DanceWriting. Space deals with the special notation used for SignSpellings (described in Chapter 8). The “Punctuation” category includes both dynamics symbols and true punctuation.

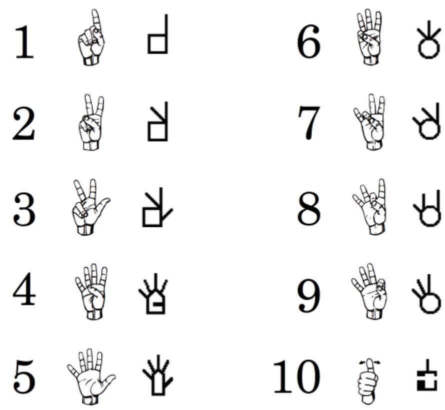
Table 87. IMWA Categories

Category	01-08	01 – Hand 02 – Movement 03 – Face 04 – Head 05 – Upper Body 06 – Full Body 07 – Space 08 – Punctuation

Group

The next portion of the symbol's IMWA number is called the "Group". Groups help to organize the many symbols that occur in the larger categories. For Hands (Category 01), the ASL numbers 1 to 10 are the basis for dividing the hands into ten groups (see Table 88 for a visual of this). Movements (Category 02) are grouped by different types of movement. Face symbols (Category 03) are grouped based on the different articulators available on the face. The groups make it easier to extend the system and keep it organized when a need for additional symbols is discovered. With an estimated 400 sign languages around the world (most of which have yet to be researched), this flexibility is important since the SignWriting community has a strong commitment to continually extending the system as needed to write any sign language.

Table 88. IMWA Groups

Group	01-10	This subdivides each of the categories into different groups. For example, under Hands, the system groups the hands based on the ASL numbers one through ten. 

Symbol

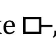
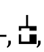
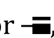
The third part of the IMWA symbol ID is the "symbol" number as shown in Table 89. Later numbering schemes refer to this as the BaseSymbol. Despite variations in visual appearance due to fill, rotation or other minor adjustments, underneath all those variations, it is considered the same BaseSymbol. For example, the hand symbol used for ASL number ten (a fist with the thumb extended ) can be written like , , , , , or , depending on its orientation but all of these different graphemes are classified as having the same BaseSymbol (01-10-001). While not all symbols have such extreme glyph variation, having a numerical code for the BaseSymbol allows the system to establish a sense of "symbol" that is more abstract than each of the 35,000 elements of the IMWA, encompassing different rotations, fills, etc.

Table 89. IMWA BaseSymbols

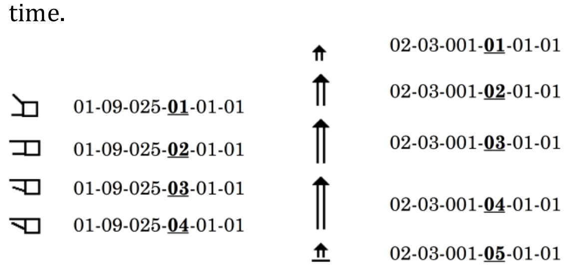
Symbol (BaseSymbol)	001-050	At this level is where symbols are considered to be the "same" in the abstract sense of a BaseSymbol, i.e., disregarding differences of variation, fill, or rotation.

Variation

Some BaseSymbols have one or more minor variations (in addition to rotation and fill), and this is represented by the fourth element in the IMWA symbol ID. Not every BaseSymbol has a variation. Usually, variations occur when two or more similar, yet visually distinct sets of symbols appear so closely related that they were classified under the same BaseSymbol as variants of the same BaseSymbol. Examples of variations are given in Table 90. The arrows often use variation to show different sizes or other adjustments to the arrows. For the hands, one example is for the BaseSymbol 01-09-025. The basic configuration of the fingers is the same for variations 01-04; the difference is in the spacing between the index finger and the thumb.

From the perspective of this thesis, an exemplar is equivalent to a Variation for the hands and the general movement arrows (to a degree), but equivalent to a Symbol (or BaseSymbol) for other categories of symbols.

Table 90. IMWA Variation

Variation	01-05	Not every symbol has a variation, but some do. No symbol has more than 5 variations at this time.  01-09-025-**01**-01-01 01-09-025-**02**-01-01 01-09-025-**03**-01-01 01-09-025-**04**-01-01 02-03-001-**01**-01-01 02-03-001-**02**-01-01 02-03-001-**03**-01-01 02-03-001-**04**-01-01 02-03-001-**05**-01-01

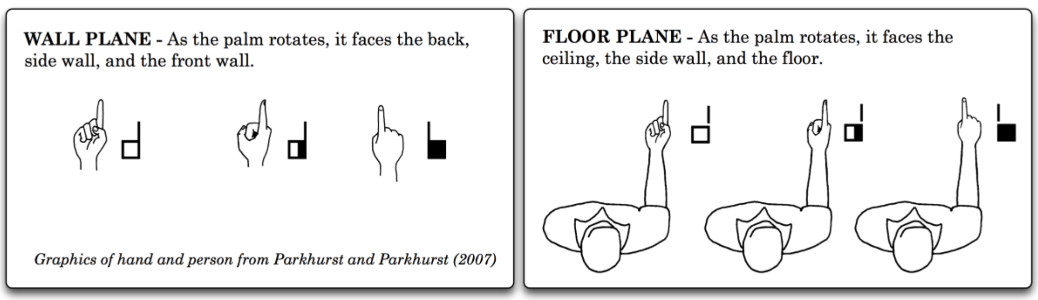
Fills

The fifth portion of the IMWA symbol ID, shown in Table 91, represents the fill, primarily used for arrows and hands. Section 1.4 above introduced the concept. Sections 2.3.4 and 3.2 apply the concept of fills specifically to hands and arrows. Fills 01-06 for the hands correspond to the six fills that we describe in Figure 19 reproduced below.

Table 91. IMWA Fills

Fill	01-06	Fills are mostly used for hands and arrowheads.

Figure 19. Fills for right hands



Rotation

The final portion of the IMWA Symbol ID, shown in Table 92, represents rotations and reflections, which apply to BaseSymbols that inherently include directionality.

Table 92. IMWA Rotation

Rotation/Reflection	01-16	BaseSymbols with an inherent definition of directionality have some form of rotation, varying between 4, 8, or 16 rotations. Where necessary, rotations also include a reflected form.

A.1.3. 2008-2010 International Sign Writing Alphabet (ISWA)

The ISWA is an updated numbering system that was released in August 2008. As a convenient way of describing the overall groupings of the symbols, ISWA can describe the system as containing seven categories of symbols, or thirty SymbolGroups, or 639 BaseSymbols. Those serve as general descriptors of the system. However, for a more detailed specification of individual symbols, the ISWA adopted the same numbering structure as the IMWA, but changed the definition of the categories to seven instead of the eight in the IMWA.

The revised category descriptions are listed in Table 93. IMWA category 'Face' and 'Head' merged into ISWA category 'Face and Head'. IMWA categories 'Upper Body' and 'Full Body' merged into ISWA category 'Body'. IMWA category 'Space' (used for SignSpellings) was renamed to 'Advanced Sorting' and placed at the end of the symbol list. The actual symbol code itself looks the same whether it is an IMWA code or an ISWA code. Presently, the only way to distinguish whether a document refers to symbols using the IMWA or the ISWA without the relevant metadata (other than the date when the document was created) is to see if the file contains any symbol in Category 8 because the ISWA only has seven categories.

Table 93. ISWA Categories vs. IMWA Categories

IMWA	ISWA
01 – Hand 02 – Movement 03 – Face 04 – Head 05 – Upper Body 06 – Full Body 07 – Space 08 – Punctuation	01 – Hand 02 – Movement 03 – Face and Head 04 – Body 05 – Dynamics and Timing 06 – Punctuation 07 – Advanced Sorting

The ISWA also added the concept of a character code. Since the ISWA contains 639 BaseSymbols, each of which can have a maximum of 96 variations (6 fills and 16 rotations), this allows all SignWriting symbols to be encoded as a long integer value between 256 and 61599. Since not all BaseSymbols have 6 fills or 16 rotations, there are a number of character codes in this range that do not refer to any character and are marked *invalid*. Character codes can be expressed in decimal or hexadecimal. This character code is intended to be used in programming situations to represent a specific symbol in less bytes. In the ISWA,  has three possible representations: a symbol ID of 01-01-001-01-01-01, a decimal character code of 256, and a hexidecimal character code of 0x100.

In early 2010, The Center for Sutton Movement Writing released the ISWA 2010. Time did not permit me to include any changes from the ISWA 2010 in this thesis. Nevertheless, changes to the 2010 ISWA are not expected to have a material effect on the information presented in this thesis.

A.2. Current Software Implementations

Since the mid to late eighties, SignWriting has had several software applications available to users of the system. Each was a custom application that used its own unique file format. The first section describes the most popular early software applications. Then the discussion will focus on two current software applications: SignPuddle and SignBank.

A.2.1. Early Software Applications

SignWriter DOS

The most widely used software product was SignWriter DOS written in Pascal and assembly language for use under DOS 3.3.[67] The final version of the software is still

[67] As an amusing side note, in the past, some individuals were more familiar with the software program than the name of the system and so they used the name “SignWriter” for the system rather than the more proper “SignWriting”.

available for download. Full versions were available for eight different countries: Brazil, Colombia, Finland, Germany, Nicaragua, Spain, Swiss-German, and the United States. Instructional material in PDF format is also available. SignWriter DOS primarily printed in horizontal formats. Basic vertical formatting was possible through a utility called "ColumnMaker" but the bugs were never fully worked out. Two features unique to SignWriter DOS that is not available in more recent software was its use of the keyboard to enter data and the ability of the user to include signs from their personal dictionary. Sutton designed a keyboard for signing and a keyboard for each country's fingerspelling. All of the more recent software depends exclusively on the mouse for input and expect users to enter the sign in full rather than relying on the dictionary.

The DOS application can no longer be run natively under Windows NT/2000/XP or later versions because of assembly code that tries to write directly to the hardware, something that is no longer allowed. Emulators such as DOSBox allow users running Linux, Windows, and OS X (on Intel) to still run SignWriter DOS. Printing can be an issue, but SignWriter DOS allows for exporting documents to Postscript or BMP files so using external programs to print is still possible. Despite its age and lack of support for the full ISWA, some still use this program.

SignWriter Java 5.0

This was the last iteration of the SignWriter series of software. Various programmers worked with Sutton to port SignWriter DOS to Java so it could run on any computer. While its catalog of SignWriting symbols were substantially better than the DOS version, it suffered from stability issues and an incomplete printing system. Later, another programmer attempted a full re-write called SignWriter Tiger. Some limited funding was available for this project, but ultimately it stalled and was never released as a stable application.

SW Edit

Developed by Rafael Piccin Torchelsen & Professor Antônio Carlos da Rocha Costa, this application was the first SignWriting application to be entirely mouse-driven where symbols were dragged and dropped from a palette onto a grid. The community was divided about which input method was "faster". Some preferred the keyboard method that Sutton developed where others found a mouse-driven input method to be more effective.[68] When the program was first run, the menus were in Portuguese, but it could be changed to English. This application was not complete in that the dictionary did not work properly. Because of its grid approach, SW Edit was able to handle vertical or horizontal text. Unfortunately, programming stalled on this project as well and it was never developed further.

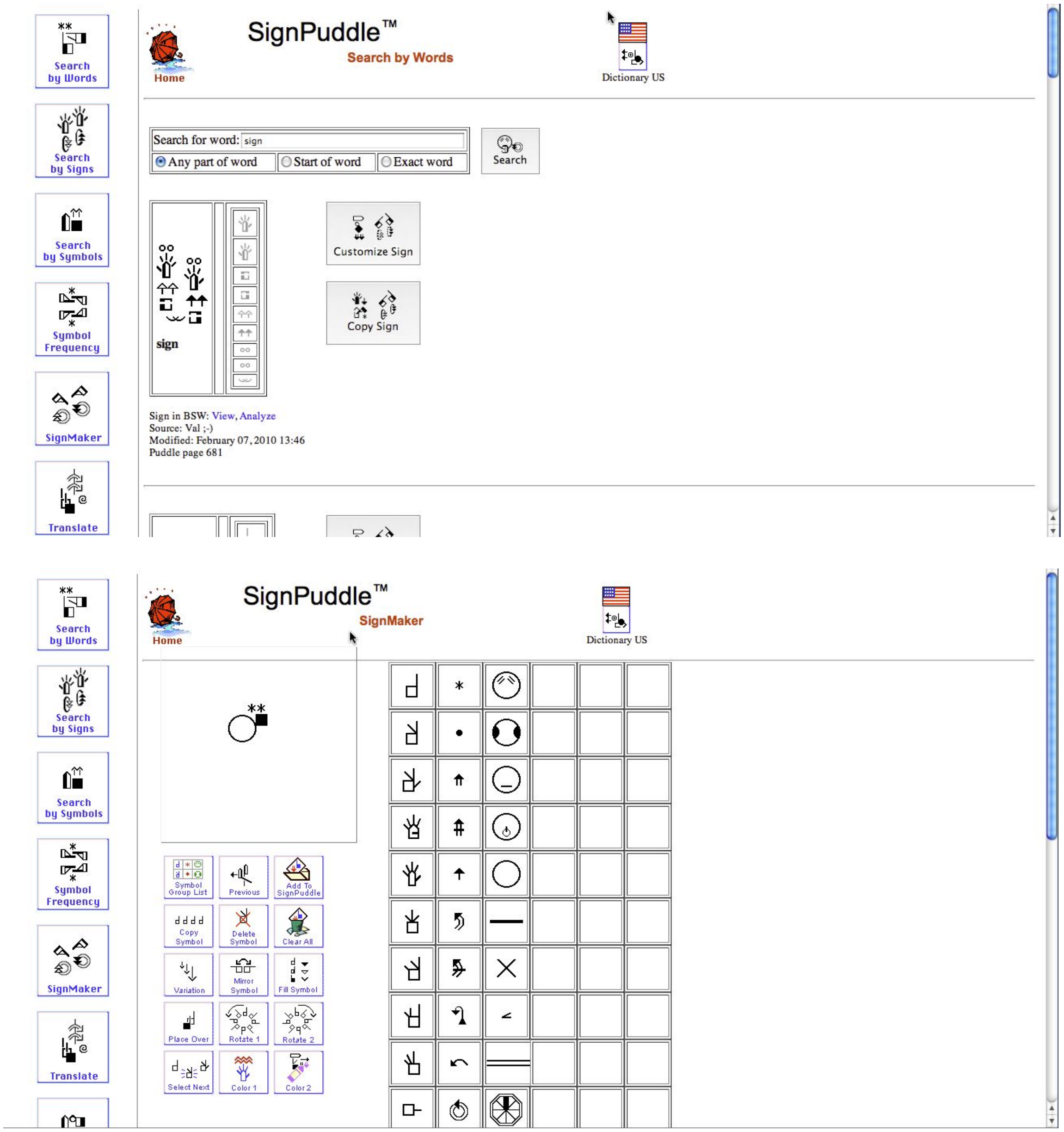
A.2.2. SignPuddle

Another developer, Steve Slevinski, decided to try a different approach by developing a Web-based application using PHP. He called his software SignPuddle and it initially was a dictionary, but later added an editor and had the ability to draft documents. Table 94 shows examples of the search screen and the input screen for writing a sign (called "SignMaker").

[68] This debate between mouse-driven versus keyboard-driven input methods is still alive today. With SignPuddle being mostly mouse-driven, that is what most users since the early 2000's have used. Those who had experience with the earlier software still look for the option of a keyboard in the future.

SignPuddle 1.5 currently contains dictionaries for 50 sign languages with source information that can be entered in both spoken and sign languages. At present, anyone can add a sign to the public dictionaries. While editors are assigned to the various public dictionaries, there is no formal process to ensure that the signs in the dictionary follow the rules of SignWriting and that the written forms are the preferred way for that sign to be written. Still, they do serve as representations of how SignWriting is presently being used. As of the time of this writing, the public dictionaries range from a few hundred entries to over 8,300 entries in the American Sign Language dictionary. These dictionaries provide fields that allow users to specify SignSpellings for their entries to make them sortable.

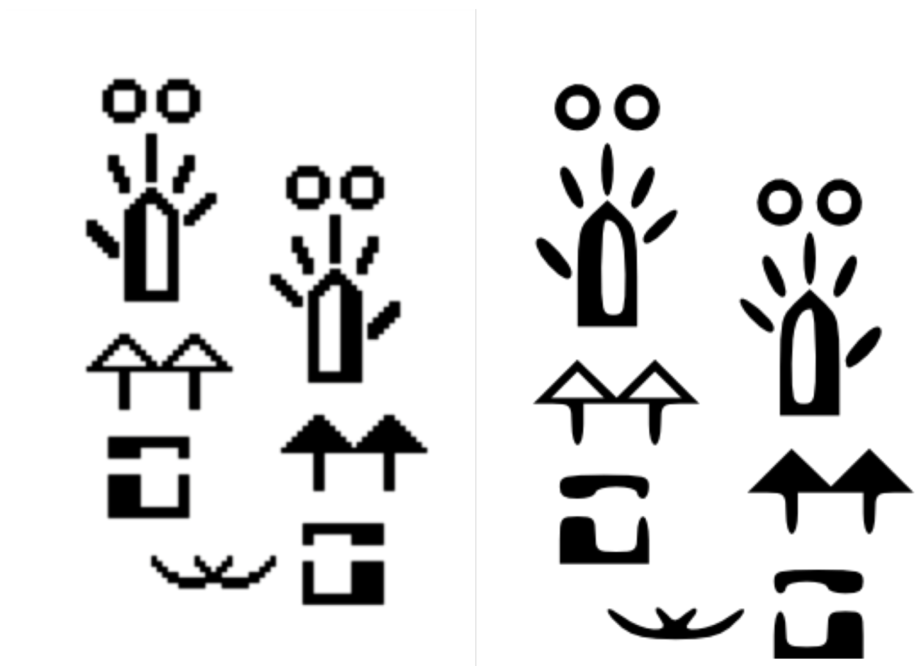
Table 94. SignPuddle Screen (Search Screen and SignMaker Screen)



In addition to the dictionary itself and various tools for searching it, SignPuddle offers three additional tools: Translate, SignText, and SignMail. Translate is a gloss-based translation tool. SignText allows the user to create entire documents in SignWriting. SignMail allows the user to send documents from Translate or SignText to another user over email. All documents can be produced in a vertical format.

The png images created by SignPuddle are created at a higher resolution than the symbols used by the older software, but they are still bitmap graphics. Bitmap graphics are computer graphics that are drawn by placing a set of dots on a grid to produce a picture. When enlarged, the viewer typically sees jagged edges on the bitmap graphics because the dots that make up the image become visible. Vector graphics, by comparison, uses lines to draw an image and can usually be enlarged and retain a sharper image without seeing jagged edges. See the example comparison in Table 95.

Table 95. Bitmap Graphics versus Vector Graphics



Bitmap **Vector**

A public version of SignPuddle is available on the Internet at http://www.signbank.org/signpuddle. The public version has private "puddles" for those who wish to pay a fee to have a private space. It is also available as a "Pocket Puddle" to be used as a standalone application. For those who wish to use it within their own organization, a version of SignPuddle as a server application is also available. Since SignPuddle uses the latest version of the ISWA, it has largely replaced the use of any other previous SignWriting software.

A.2.3. SignBank

Developed using the commercial database Filemaker[69], SignBank is another dictionary application designed by Sutton. SignBank is available with a runtime version of FileMaker for those who do not have a copy of FileMaker themselves. Those who do have a copy of Filemaker can simply download the databases and run them from within FileMaker. Unlike SignPuddle, SignBank does not contain any editing features for creating the signs themselves. SignBank expects the user to create the composite image of the sign in another application and then insert a single bitmap image of that sign into SignBank. SignBank was the first application that provided a way to mark the sorting order of a sign using SignSpellings. The program also can include images and video of different signs or the object itself. SignBank also includes a SymbolBank, which allows the user to view all the symbols in the IMWA. As of SignBank 8.5, there is now the ability to exchange data between SignPuddle and SignBank. Additional information on this program is available from http://www.signbank.org/signbank.html.

A.3. Current Document File Formats

Over the years, there have been various document file formats. During the period where the DOS application SignWriter was in vogue, SignWriting documents were shared via a format called the .SGN format. With the emergence of the Web and the SignPuddle

[69] Filemaker is available for both Apple and Microsoft computers. A server version is available for Linux.

application, XML has become the preferred means of sharing SignWriting documents. The next two sections will briefly discuss the XML SignWriting standard as well as some recent changes in how SignWriting can be stored in a more compressed format. Obviously, since there is no existing font for SignWriting, any software application that plans to render these documents must have a collection of all of the bitmap graphics for the ISWA in separate files.

A.3.1. SignWriting Markup Language (XML)

Originally developed by Antônio Carlos da Rocha Costa and his team, SignWriting Markup Language (SWML) was intended to be a way to use XML to represent SignWriting without having to include graphic symbols in the text that is sent or received. As SWML has been used in specific projects, various programmers have adapted the original version of SWML to fit their particular program. All have made a commitment to make sure that it is possible to easily translate between the various dialects of SWML. For those who are versed in XML, a copy of the various specifications for SWML is listed in Appendix B. Table 96 shows an example of the sign 'California' in XML format. In the build node, the data stream contains sequences of the ISWA Symbol ID followed by the (x,y) coordinates needed to place the symbol within a 250x250 pixel grid. In the sequence node, the data stream includes an ordered list of ISWA Symbol IDs organized by the SignSpelling Sequence rules.

Table 96. ASL 'California' in XML

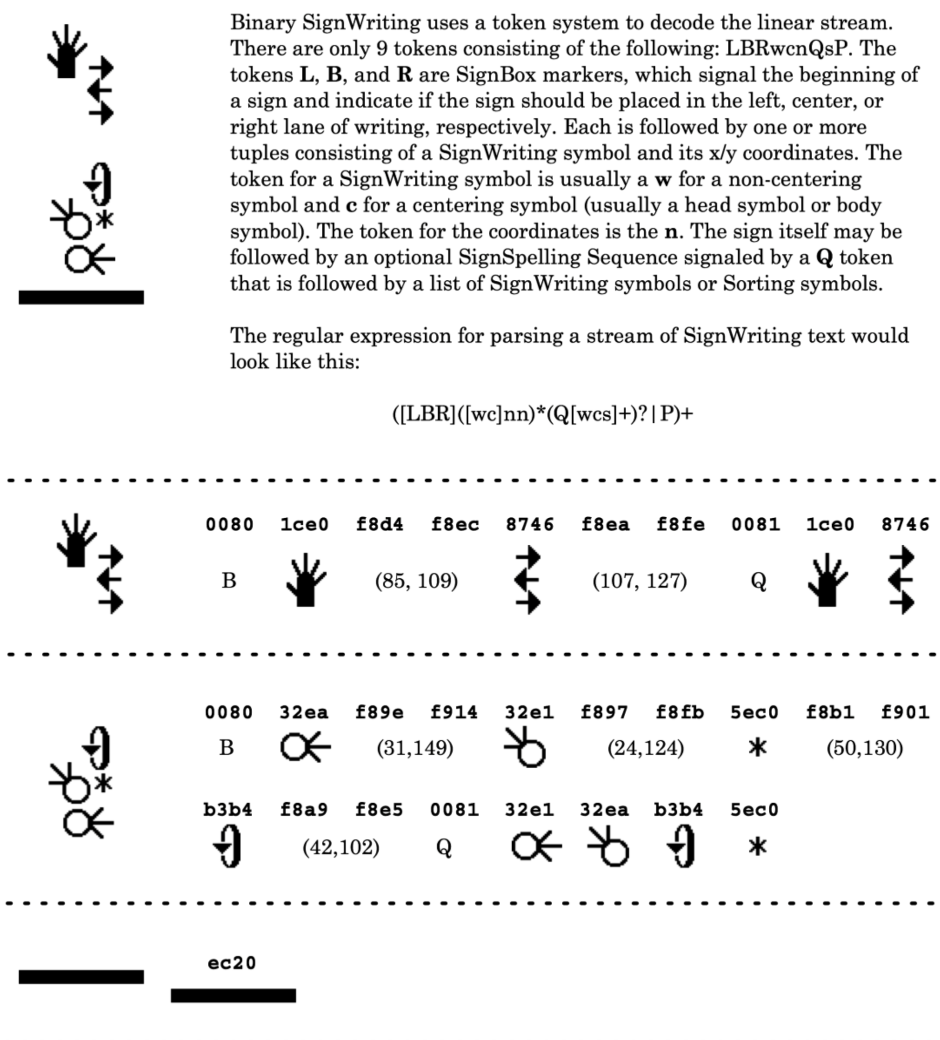
```
<sign>
    <id>sgn4_4481</id>
    <build>03-05-002-01-01-07,57,80,01-06-015-
01-02-02,86,99,02-03-015-01-01-05,93,132,02-01-
001-01-01-01,96,87,01-06-013-01-02-
01,92,167</build>
    <sequence>01-06-015-01-02-02,02-01-001-01-
01-01,02-03-015-01-01-05,01-06-013-01-02-01,03-
05-002-01-01-07</sequence>
    <detail>California</detail>
</sign>
```

One weak point of various versions of the SWML is that the DTDs have had insufficient metadata concerning which numbering system (SSS 1995, SSS 1999, IMWA 2002, IMWA 2004, ISWA 2008, etc.) is being used to represent the symbols in the XML document. Further, there is only limited resources on how to translate symbols between the various numbering systems. Older programs utilized the Sign Symbol Sequence numbering system while more recent programs have used the IMWA and now the ISWA. With the advent of the IMWA and the ISWA, the symbol set has become more stable. However, limited time and effort has been spent to make it easy to translate older documents (particularly those made with the DOS version of the SignWriting program) so they can be expressed in SWML in a current version of the ISWA. Currently, documents written in the older software have simply been rewritten using more current software.

A.3.2. Binary SignWriting (BSW)

Binary SignWriting is a new method of encoding SignWriting text using the ISWA character code mentioned under discussion about the ISWA. This method of encoding the the text is still under development and is subject to change. As mentioned briefly in Section A.1.3, the glyphs themselves can be encoded between decimal 256 and 61599. In order to encode text, he added new character definitions. Characters 128 through 255 are used as control characters. Characters 61696 through 65533 are used to specify unique numbers between -1919 through 1918 for the purpose of encoding the x/y coordinates of the upper left corner of SignWriting symbols. Table 97 uses an example from the Binary SignWriting Reference Guide to show how the text stream is constructed.

Table 97. Binary SignWriting in Use


Binary SignWriting uses a token system to decode the linear stream. There are only 9 tokens consisting of the following: LBRwcnQsP. The tokens **L**, **B**, and **R** are SignBox markers, which signal the beginning of a sign and indicate if the sign should be placed in the left, center, or right lane of writing, respectively. Each is followed by one or more tuples consisting of a SignWriting symbol and its x/y coordinates. The token for a SignWriting symbol is usually a **w** for a non-centering symbol and **c** for a centering symbol (usually a head symbol or body symbol). The token for the coordinates is the **n**. The sign itself may be followed by an optional SignSpelling Sequence signaled by a **Q** token that is followed by a list of SignWriting symbols or Sorting symbols.

The regular expression for parsing a stream of SignWriting text would look like this:

([LBR]([wc]nn)*(Q[wcs]+)?|P)+

With the advent of Binary SignWriting, the previous XML representations of SignWriting (SWML) may become obsolete. In its place, Steve Slevinski, the developer responsible for most of the current web-based applications for SignWriting, has proposed a new DTD that uses Binary SignWriting. In an email dated 1 March 2010 to the SignWriting List, Steve explained the new DTD for recording Binary SignWriting in XML (named BSWML). The DTD is available online at http://www.signpuddle.net/bswml.dtd and in Appendix B. The DTD merely defines the structure, but it does not validate the data to ensure that the symbol IDs chosen actually exist.

His email gave the following example of BSWML as shown in Table 98. BSWML contains two main tags: `<sign>` and `<punc>`. The `sign` tag includes a `lane` attribute (accepting an integer value between -1 to 1 with a default of 0) and contains a series of `sym` tags and `seq` tags. The `sym` tag describes a symbol using `x` and `y` attributes to encode the Cartesian coordinates of the symbol. The `seq` tag is for help with the collation of the sign. It accepts values in the range of 0100 to EBBF or EDA0 to F09F. The `punc` tag stands alone with simply the symbol ID for that punctuation symbol, a hexadecimal number in the range of EBC0 to ED9F. It does share one weakness with its predecessors in that it does not contain metadata about what symbol set is in use to make it easier to convert a BSWML document if the ISWA continues to be refined.

Table 98. DTD for Binary SignWriting in XML

```
<!DOCTYPE bswml SYSTEM "http://www.signpuddle.net/bswml.dtd">
<bswml>
 <sign lane="0">
  <sym x="85" y="109">1ce0</sym>
  <sym x="107" y="127">8746</sym>
  <seq>1ce0</seq>
  <seq>8746</seq>
 </sign>
 <sign lane="0">
  <sym x="31" y="149">32ea</sym>
  <sym x="24" y="124">32e1</sym>
  <sym x="50" y="130">5ec0</sym>
  <sym x="42" y="102">b3b4</sym>
  <seq>32e1</seq>
  <seq>32ea</seq>
  <seq>b3b4</seq>
  <seq>5ec0</seq>
 </sign>
```

<punc>ec20</punc>
</bswml>

APPENDIX B

SIGNWRITING MARKUP LANGUAGE DIALECTS

These are specifications for SWML that I downloaded off the internet. The first three were archived on the SWML Site (http://sign-net.ucpel.tche.br/swml), but (as of August 2008) they were no longer present on that site. I record them here for historical reasons.

The original DTD and schema for SWML did have some metadata about which symbol set was in use. Only the dictionary schema (SWML-D) contained which language was in use.

The SWML-S (the original DTD for SignPuddle), developed later, did not carry an attribute for which character set was in use. It did have metadata for which sign language and which gloss language was in use. Later DTD's for SignBank and for BSWML do not contain metadata for the symbol set or for the sign language in use.

B.1. SWML DTD (Original Specification – Version 1.0 Draft 2)

```
<!ELEMENT swml  (generator? ,  (sw_table | sw_text ) )>
<!ATTLIST swml  version   CDATA  #REQUIRED
                symbolset CDATA  #FIXED 'SSS-1995' >
<!ELEMENT generator  (name , version )>

<!ELEMENT name  (#PCDATA )>

<!ELEMENT version  (#PCDATA )>

<!ELEMENT sw_table  (sw_table_defaults? , table_length , table_entry* )>

<!ELEMENT sw_text  (sw_text_defaults? ,  (sign_box | text_box | new_line )* )>

<!ELEMENT sw_table_defaults  (sign_boxes? , glosses? )>

<!ELEMENT sw_text_defaults  (sign_boxes? , text_boxes? )>

<!ELEMENT sign_boxes  (unit , height? , width? )>

<!ELEMENT text_boxes  (boxtype , unit , height? , width? )>
```

```
<!ELEMENT boxtype  (#PCDATA )>

<!ELEMENT unit  (#PCDATA )>

<!ELEMENT height  (#PCDATA )>

<!ELEMENT width  (#PCDATA )>

<!ELEMENT table_length  (#PCDATA )>

<!ELEMENT table_entry  (sign_box , gloss )>

<!ELEMENT new_line EMPTY>

<!ELEMENT gloss  (#PCDATA )>
<!ATTLIST gloss  separator   CDATA  #IMPLIED
                 field_names CDATA  #IMPLIED >
<!ELEMENT text_box  (chr* )>

<!ELEMENT sign_box  (symbol* )>

<!ELEMENT chr  (#PCDATA )>
<!ATTLIST chr  x CDATA  #REQUIRED
               y CDATA  #REQUIRED >
<!ELEMENT symbol  (shape , transformation )>
<!ATTLIST symbol  x CDATA  #REQUIRED
                  y CDATA  #REQUIRED >
<!ELEMENT shape EMPTY>
<!ATTLIST shape  number    CDATA  #REQUIRED
                 variation CDATA  #REQUIRED
                 fill      CDATA  #IMPLIED >
<!ELEMENT transformation EMPTY>
<!ATTLIST transformation  rotation CDATA  #REQUIRED
                          flip     CDATA  #REQUIRED >
<!ELEMENT glosses  (separator , field_name* )>

<!ELEMENT separator  (#PCDATA )>

<!ELEMENT field_name  (#PCDATA )>
```

B.2. SWML-D Schema

```
<?xml version="1.0" encoding="ISO-8859-1" ?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
   <xs:annotation>
      <xs:documentation>
         <![CDATA[
            <swml symbolset="1995">
               <dictionary>
                  ....
               </dictionary>
               <dictionary>
                  ....
               </dictionary>
            </swml>
            ]]>
      </xs:documentation>
   </xs:annotation>
   <xs:element name="swml">
      <xs:complexType>
         <xs:choice maxOccurs="unbounded" minOccurs="0">
            <xs:element name="dictionary" type="dictionaryType"/>
         </xs:choice>
```

```
        <xs:attribute name="symbolset">
           <xs:simpleType>
              <xs:restriction base="xs:positiveInteger">
                 <xs:enumeration value="1995"/>
                 <xs:enumeration value="1999"/>
                 <xs:enumeration value="2002"/>
                 <xs:enumeration value="2004"/>
              </xs:restriction>
           </xs:simpleType>
        </xs:attribute>
     </xs:complexType>
  </xs:element>

<!-- Sign -->
  <xs:annotation>
     <xs:documentation>
        <![CDATA[
        <!-- In the 199. symbolset -->
           <sign>
              <symbol x="47" y="20" number="208"/>
           </sign>

        <!-- The 200. symbolset -->
           <sign>
              <symbol x="67" y="20" category="2" group="4" variation="1"
fill="1" number="3">
                 <rotate degrees="45"/>
                 <mirror axis="vertical"/>
              </symbol>
              <!-- This one is different from the symbol above.  This is to make
the difference between symbolsets who first rotate and then mirror (1999) or
symbolsets who first mirror and then rotate (1995)!-->
              <symbol x="67" y="20" category="2" group="4" variation="1"
fill="1" number="3">
                 <mirror axis="vertical"/>
                 <rotate degrees="45"/>
              </symbol>
              <!-- If no variation or fill is set, those values are believed to
be 1.  So the above symbol is the same as this one -->
              <symbol x="67" y="20" category="2" group="4" number="3">
                 <mirror axis="vertical"/>
                 <rotate degrees="45"/>
              </symbol>
           </sign>
        ]]>
     </xs:documentation>
  </xs:annotation>

  <xs:complexType name="signType">
        <xs:sequence>
           <xs:element name="symbol" type="symbolType" maxOccurs="unbounded"/>
        </xs:sequence>
  </xs:complexType>

  <xs:complexType name="symbolType">
     <xs:all>
        <xs:element minOccurs="0" name="mirror" type="mirrorType"/>
        <xs:element minOccurs="0" name="rotate" type="rotateType"/>
     </xs:all>
     <xs:attribute name="x" type="xs:integer" use="required"/>
     <xs:attribute name="y" type="xs:integer" use="required"/>
     <xs:attribute name="category" type="xs:positiveInteger" />
     <xs:attribute name="group" type="xs:positiveInteger"/>
```

```
      <xs:attribute name="number" type="xs:nonNegativeInteger" use="required"/>
      <xs:attribute name="variation" type="xs:positiveInteger" default="1"/>
      <xs:attribute name="fill" type="xs:nonNegativeInteger" default="1"/>
   </xs:complexType>

   <xs:complexType name="rotateType">
      <xs:attribute name="degrees">
         <xs:simpleType>
            <xs:restriction base="xs:nonNegativeInteger">
               <xs:maxExclusive value="360"/>
            </xs:restriction>
         </xs:simpleType>
      </xs:attribute>
   </xs:complexType>

   <xs:complexType name="mirrorType">
      <xs:attribute name="axis" default="horizontal">
         <xs:simpleType>
            <xs:restriction base="xs:string">
               <xs:enumeration value="horizontal"/>
               <xs:enumeration value="vertical"/>
            </xs:restriction>
         </xs:simpleType>
      </xs:attribute>
   </xs:complexType>

<!-- Dictionary -->
   <xs:annotation>
      <xs:documentation>
         <![CDATA[
         <!-- the international abbreviation for the language region -->
         <dictionary lang="nl-BE">
            <entry word="circus">
               <!-- The 199. symbolset -->
               <translation>
                  <sign>
                     <symbol x="47" y="20" number="208"/>
                     <symbol x="77" y="20" number="310"/>
                  </sign>
            <!-- As you see, in the meaning you can use signwriter symbols and
also text.  This allows things as example sentences in the meaning -->
                  <meaning>symbol used as in: signwriter <sign>
                        <symbol x="47" y="20" number="208"/>
                        <symbol x="67" y="20" category="1" group="3" variation="2"
fill="2" number="3">
                           <rotate degrees="45"/>
                           <mirror axis="vertical"/>
                        </symbol>
                     </sign>
                  </meaning>
               </translation>
            </entry>
         </dictionary>
         <dictionary lang="nl-BE">
            <entry word="word">
               <!-- The 200. symbolset -->
               <translation>
                  <sign>
                     <symbol x="67" y="20" category="hand" group="fivefingers"
number="5">
                        <rotate degrees="45"/>
                        <mirror axis="vertical"/>
                     </symbol>
```

```
                  <symbol x="77" y="20" category="head" group="eyebrows"
number="3">
                     <rotate degrees="90"/>
                  </symbol>
               </sign>
               <meaning>What is this?</meaning>
            </translation>
         </entry>
      </dictionary>
      ]]>
    </xs:documentation>
  </xs:annotation>

  <xs:complexType name="dictionaryType">
    <xs:sequence>
      <xs:element maxOccurs="unbounded" minOccurs="0" name="entry"
type="entryType"/> <!-- Allow the empty dicionary -->
    </xs:sequence>
    <xs:attribute name="lang" type="xs:language"/>
  </xs:complexType>

  <xs:complexType name="entryType">
    <xs:sequence>
      <xs:element name="translation" maxOccurs="unbounded">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="sign" type="signType"/>
            <xs:element name="meaning" minOccurs="0">
              <xs:complexType mixed="true">
                <xs:sequence>
                    <xs:element maxOccurs="unbounded" minOccurs="0"
name="sign" type="signType"/>
                </xs:sequence>
              </xs:complexType>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
    <xs:attribute name="word"  type="xs:string" use="required"/>
  </xs:complexType>
</xs:schema>
```

B.3. SWML-S DTD (Original SignPuddle Specification)

```
<!ELEMENT swml (sign+)>
<!ATTLIST swml
  dialect CDATA #FIXED "S"
  version CDATA #FIXED "1.1"
  lang CDATA #REQUIRED
  glosslang CDATA #IMPLIED
>
<!ELEMENT sign (gloss | symbol)+>
<!ATTLIST sign
  lane (-1 | 0 | 1) "0"
>
<!ELEMENT gloss (#PCDATA)>
<!ELEMENT symbol (#PCDATA)>
<!ATTLIST symbol
  x CDATA #REQUIRED
  y CDATA #REQUIRED
>
```

B.4. SignBank Markup Language (SBML)

```
<!ELEMENT sbml (sign+)>
<!ELEMENT sign (id,build,sequence,detail)>
<!ELEMENT id (#PCDATA)>
<!ELEMENT build (#PCDATA)>
<!ELEMENT sequence (#PCDATA)>
<!ELEMENT detail (#PCDATA)>
```

B.5. Binary SignWriting Markup Language (BSWML)

```
<!ELEMENT bswml (sign|punc)*>
<!ELEMENT sign (sym*,seq*)>
<!ATTLIST sign  lane (-1|0|1) "0">
<!ELEMENT sym (#PCDATA)>
<!ATTLIST sym  x CDATA #REQUIRED>
<!ATTLIST sym  y CDATA #REQUIRED>
<!ELEMENT seq (#PCDATA)>
<!ELEMENT punc (#PCDATA)>
```

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