Notation Systems[1]

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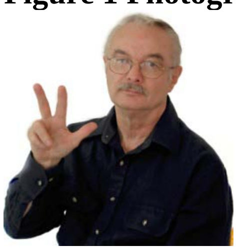
1 Introduction

Consider the following visual representations[2] for the concept *number 3*:

Figure 1 Photograph of ASL sign



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[2] In this chapter, where necessary to disambiguate, we will use the convention of double quote to refer to a spoken/signed word, <> to refer to a written form, and italics to indicate a concept or meaning. Thus, "three" refers to the speech event, while <three> refers to the written form. Capitals (e.g., THREE) refers to sign events.

Figure 2 Drawing of ASL sign

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Figure 3 English written word

Three

Figure 4 Common internationally recognized writing symbol

3

Figure 5 Sutton SignWriting symbol

Figure 6 IPA (International Phonetic Alphabet) notation of English spoken word

θɾi

Figure 7 HamNoSys symbols for ASL THREE

Figure 8 SignTyp Coding System entries for ASL THREE (cf. section 6)

Sign Id	**Stage**	**Field Name**	**Detail Level 1**	**Detail Level 2**	**Detail Level 3**
1	1	Location	Neutral Space	Lateral Dimension	Ipsilateral
1	1	Location	Neutral Space	Vertical Dimension	Chest Height
1	1	Handshape	Extended Finger Set	TIM	

Photographs (Figure 1), drawings (Figure 2), videotapes, and sound tapes are examples of *recordings* of linguistic data. Although they vary in their degree of data 'fidelity' due to the fact that any recording necessarily makes a selection from all the data points present in an actual utterance and its context, these recordings stay close to the actual utterance. They can be collected, but the collection cannot be sorted into subsets nor can subsets be counted meaningfully because a recording is a *non-analytic* representation of the perceptible side or form of a linguistic utterance. For example, without a notation system, one cannot select all recordings that show all fingers extended in a corpus of ASL signs.

Figure 3 through Figure 8 are *notations* of a linguistic utterance. Figure 3, Figure 4 and Figure 5 show *writing systems*, Figure 6 and Figure 7 *transcription systems*, and Figure 8 a *coding system* we are developing for signed languages. Notations, unlike recordings, intentionally abstract away from the original linguistic events in ways not dictated by limitations of the recording process or "artistic license", but by (more or less) systematic decisions to annotate or symbolize only some (discrete) elements of the original signal. In almost all cases, they are part of an analytic system of some kind, but they differ from each other in what they represent, how they do it, and their goals.

It seems relatively easy to distinguish between recordings and notations, but it can sometimes seem harder to distinguish between the purposes and characteristics of different notation systems, especially for sign languages. Are SignWriting and HamNoSys in competition with each other? Which should be used as coding systems for the analytic study of signs? We argue here that that SignWriting is (primarily) a writing system and HamNoSys is a transcription system, and are not in competition, but that neither should be used for a coding system. We will also show that some of the confusion may be due to two unusual characteristics of notation systems for sign: they are highly iconic and feature-based.

We may characterize a writing system, such as written English or SignWriting, as a system used by the general population of literate speakers or signers of a language for the purpose of communicating and remembering the meaning of some linguistic event – a conversation, a contract, an order, a shopping list, a poem, etc. In contrast, transcription and coding systems are tools for a much smaller population of scientific specialists to communicate, remember and further analyze the form of some utterance. A transcription system and a coding system can be distinguished on the basis of their goals. A transcription system seeks to accurately, unambiguously and rapidly notate language samples in a variety of media, ranging from paper and pencil, print to computer files so that they can be used as the basis for a more extensive analysis of the language and/or as illustrative examples. A coding system, as we define it, is specifically intended for use in the computerized analysis of language samples. For example, a coding system might be used to establish the frequency of coronal stops or handshapes with bent fingers in a language lexicon.

The boundaries between these types of notation systems are not always crisp, but we nonetheless discuss each type of system in turn, looking at its purpose, its requirements, and characteristics. Along the way we note some significant differences between these types of systems for speech and sign. The goal of this chapter is to present some of the basic terminology and notions important in understanding and using notation systems, and to try to pin down important characteristics shared or not shared by different notation systems[3] for different modalities.

1.1 Examples of Notation Systems

To clarify our discussion of notation system characteristics, we refer where possible to actual examples of these systems, so we provide here a small amount of background material for each. English writing and SignWriting are examples of writing systems, the IPA and HamNoSys of transcription systems and SignTyp of a coding system. With the exception of SignTyp, these are probably already familiar to many of our readers.

Writing systems. While written English needs no introduction, not everyone will be familiar with written sign. Perhaps the first to work out a comprehensive written sign system was Bébian (1825), discussed in some detail in Rée (1999), but no system had much public participation until Valerie Sutton proposed SignWriting in 1974 [4]. SignWriting has about 500 basic graphs, although any specific sign language would use fewer than that (Sutton, p.c 2007). According to its inventor, it is much easier to learn than a completely arbitrary writing system (Sutton, p.c. 2007). It has both computerized printing and shorthand hand printing forms. It is used in a number of schools for the deaf (Flood 2002), and by some deaf adults. From reports on

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[3] Missing from this chapter, for reasons of space and because discussions are available elsewhere, is a survey of a fourth type of notation, namely (linguistic) feature systems. Indeed feature models are also notational system in which the forms (the feature names), are either descriptive labels or taken as cognitive units that represent phonetic 'meanings'. For explicit discussions of analogues and difference between feature systems for spoken and signed languages, we refer to van der Hulst (1993, 2000). In a way, coding systems are feature systems, while differing in that they have been designed to capture phonetic details that go beyond what a (phonological) feature system would want to capture. In a sense, then, coding systems lie half-way between transcription systems and feature systems.

[4] Examples and explanations of the system can be seen online at http://www.omniglot.com/writing/signwriting.htm and http://www.signwriting.com/.

the SignWriting listserv (sw-l@majordomo.valenciacc.edu), there appear to be at least 14 schools around the world that are using it.

A second system, the ASL-phabet, that we discuss briefly was developed by Samuel Supalla and colleagues (Supalla, Cripps & McKee 2008, also described by Supalla and Blackburn at http://clerccenter.gallaudet.edu/KidsworldDeafnet/e-docs/Keys/learning.html). This is a much simpler writing system with far fewer graphic units, which appear to be similar to Stokoe's symbol set (Stokoe, Casterline & Croneberg 1965) or HamNoSys. The symbols are less iconic than SignWriting symbols. This system, much more that SignWriting, acknowledges the fact (rightly, we believe) that a written representation of a word does not need to be a recipe to produce it, but only to be sufficiently unique to act as a trigger to activate the relevant words in the reader's mind.

Transcription systems. Many transcription systems for written speech have been proposed, including those by Thomas Wright Hill, Erasmus Darwin, Otto Jespersen, and Kenneth Pike (see Abercrombie 1967 for more details). Some used an existing alphabet such as the Roman alphabet; others used arbitrary holistic symbols for each separate speech sound, and still others tried to capture similarities between speech sounds *in* the notation, by using symbols that are 'directly iconic' in that the graphs are actual pictograms of the articulatory position and action of the vocal tract. Systems like this were devised by William Holdsworth and William Aldridge (1766), Isaac Pittman (1837), and perhaps most famously by Alexander Melville Bell (1867, 1881) who called his system *visible speech.* His system was later adopted and modified by Henry Sweet. It was extremely well designed, but linguists made very little, if any use of it. Instead, almost all linguists came to use the *International Phonetic Alphabet* (IPA).

The International Phonetic Association, founded in 1886, developed a phonetic alphabet that is rich enough to capture the speech sounds of all (known and studied) languages. Most IPA graphs represent 'complete' speech sounds, but some (called *diacritics*) represent specific properties of speech sounds. Graphs are taken from various varieties of the Roman alphabet, complemented by symbols from other alphabets (e.g. the Greek alphabet). Other graphs are mutated or inverted version of the above, while a few symbols are entirely 'made up'. The phonetic meaning of the IPA symbols, whose shape is arbitrary, has to be memorized. Hence serious training is required to transcribe speech into those symbols, or to read it back (especially for those whose own writing system is not some version of the Roman alphabet).

While a variety of transcription systems have been proposed for sign (see Miller 2001 for an overview) the system we will focus on here is HamNoSys, which is perhaps the most widely used of the current transcription systems. This system was developed at the University of Hamburg (Prillwitz, Leven, Zienert, Hanke, Henning 1989), and was originally based on Stokoe's 1965 notation system, but has evolved to a much more comprehensive set of approximately 200 symbols with the goal of allowing for a phonetic transcription of any potentially significant characteristic of any sign in any sign language. As in SignWriting, symbols in HamNoSys correspond to features or feature-groups. It uses a single symbol for handshapes (a feature group), but most of the other symbols would be considered to be single features.

Coding systems. Sign researchers have constructed coding systems and associated sign databases for a variety of purposes. The most extensive database focused on coding the form of signs is the *SignPhon* project with detailed codings for over 3000 signs from Sign Language of the Netherlands (Crasborn, van der Hulst and van der Kooij 2001). SignPhon, which uses a high number of condensed alphanumeric codes, has also been used for other sign languages. In this chapter we focus on *SignTyp*, a successor to SignPhon. SignTyp has an explicit cross-linguistic goal, and is discussed in some detail in Section 4.

2 Writing Systems

2.1 What is being represented?

We have already referred to the notions ‘form’ and ‘meaning’. Here we want to consider carefully the possible relationships between them because this provides an interesting categorization of notation systems. A *sign* (in the semiotic sense) has two sides: its *form* (the signifier) and its *meaning* (the signified), with a third ‘player’ being an actual or potential *referent*. For example, the ASL sign THREE and the spoken English word “three” are signifiers or forms for the meaning “the number that follows two”. In spoken/signed languages therefore the form and meaning of words are ‘associated’:

Figure 9 Relationship of form to meaning in speech or sign

Form ⟷ meaning

A notation system graph is also a sign with a form and meaning. In the IPA, for example, the form of each graph is associated with a specific speech sound, or aspect of a speech sound. (To avoid misunderstanding we could say that words, as signs, have a *semantic* meaning, while IPA symbols, as signs, have a *phonetic* meaning. From a semiotic point of view meaning is whatever the form of the sign is associated with.)

In the domain of writing systems there are three possibilities to consider: *pictographic*, *semagraphic* and *phonographic* systems. In pictographic systems, the graph has no relationship to any language, but represents extra-linguistic sensory-based representations, concept or referents rather than word meanings, usually in a highly iconic way. For example, the form < ○ > might refer directly to a meaning *bright object in sky*. Such systems are usually considered as potential precursors of semagraphic systems, the next possibility, rather than writing systems. (The distinction can be subtle, cf. Mallery 1893).

In a semagraphic system, graphs refer to elements of the meaning of spoken/signed words of a specific language[5]. For example, the symbol <$> refers to (the meaning of) the English word "dollar".

Finally, in a phonographic system, the graph refers to the form of a spoken/signed word. For example, the three graphs in <bat> refer in systematic ways to the forms (phonemes) of the spoken English word "bat"[6]. In this kind of system, the written system has no direct relationship to the semantic meaning of these words, but only a transitive one, i.e. via the form of these words. (However, it is certainly possible that <bat> has, or acquires a direct relation to the semantic meaning of the word "bat" in which case it effectively becomes part of a semagraphic system.) These relationships are illustrated in Figure 10.

[5] Often, the term logographic is used where we use semagraphic. However, we take the term logographic to refer to the size of the units that is referred to, *logo(s)* standing for a unit that has the size of a word. As we will see, semagraphic systems always appear to be logographic, while conceivable phonographic systems that use graphs for whole word (forms) do not seem to exist.

[6] Writing systems for speech usually mix phonographic and semagraphic units; English writing for example has many semagraphs (such as @, &, % etc.).

Figure 10 Possible relationships between form and meaning for writing systems and their parallel spoken/signed system (double lines represent internal spoken/signed language relationships)

Pictographic (no relationship to any spoken/signed language)

pictograph → concept/referent

Semagraphic (no relationship between graphic forms and spoken/signed forms)

semagraph → meaning

spoken/signed form ⇒ meaning

Phonographic (transitive relationship between graphs, spoken/signed forms and meaning)

phonograph → spoken/signed form ⇒ meaning

The oldest systems for writing spoken languages appear to be semagraphic (word or morpheme-based systems) with the graphs being iconic of (sensory-based representations of) the referent denoted by (the meaning of) words. Iconic writing systems of this sort can develop in two directions. In the first, the system remains basically semagraphic, although the graphs tend to lose their iconicity due to the fact that frequent use undermines the detail required to remain iconic. They can still remain *motivated* (with graphs for semantically related words sharing graphic properties) or they can become arbitrary. In the second, the system becomes more and more phonographic. Phonographic traits enter the system when graphs are taken to represent (aspects of) the (phonological) form rather than the word meaning. This is often due to what is called the *Rebus Principle*, where a semagraphic symbol for “sun” or “eye” comes to be used for other (near)homophonic word such as “son” or “I”. This tends to lead first to a syllabic system, and then, possibly (and at least once) to a system in which graphs represent speech sounds or phonemes (an alphabetic system), typically consonants at first, but with symbols for vowels in the alphabetic system that we are most familiar with. Phonographic elements may also enter a semagraphic system as *disambiguators*, i.e. symbols distinguishing two different pronunciations of an otherwise identical semagraph. For example, if < ○ > means both “sun” and “moon”, scribes might eventually start adding a small additional phonographic symbol for one or both meanings: s< ○ > versus m< ○ >[7].

SignWriting might at first appear to be a (word- or morpheme-based) semagraphic system, but it is actually phonographic: the graphs depict aspects of the phonological form of signs. Wherever the phonological form is iconic of the semantic meaning, it *appears* that SignWriting is iconic of the semantic meaning because of the transitive nature of phonographs. The phonographic nature of its iconicity is demonstrated by the equal iconicity of the symbols for the completely arbitrary EUROPE and the highly iconic THREE (in ASL).

As for phonological or phonetic transcription systems (such as the IPA or HamNoSys), these of course are phonographic by design[8].

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[7] As a matter of necessity, semagraphs that started life as (referentially) iconic will, when used phonographically, be entirely arbitrary. It is noteworthy that people tend to make any type of sign system iconic at the time that they actually invent it, but, at the same time, they have no problem in learning or handling signs that are arbitrary, nor do alphabetic systems that are rooted in semagraphic origins show any signs of ‘re-iconizing’ with reference to (articulatory or acoustic) properties of phonemes.

[8] A semanticist might however, use a semagraphic ‘transcription system’ with symbols for (elements of) the meaning of words. In effect, notations used in logic (when linked to natural language expressions) are semagraphic transcription systems, whereas mathematical notation systems can be thought of as being pictographic, or, when non-iconic ‘ideographic’).

The discussion so far regards what notation units represent. We also need to look at how the form of notation units represents their meaning.

2.2 Iconicity and Motivation

Once the semiotic form/meaning distinction is made, we can ask what the nature is of the relationship between them. The following distinctions are usually made[9]:

1. Symbol: the relationship between form and meaning is arbitrary
2. Icon: the relationship between form and meaning is motivated

The prototypical "iconic" or motivated relationship claims some 'resemblance' between a form and its meaning (or, rather, a sensory-based representation of its referent), as in ASL THREE. But a second, more abstract motivation, which we will call *systematic motivation*, exists whenever forms correlate systematically to meanings, even without resemblance. An example is the placement of letters on the page where (in left-right/top-bottom systems) leftmost/topmost is earliest and rightmost/bottommost is latest in time, even though there is no obvious resemblance between the zigzag line down the page and temporal order[10].

Systematically motivated phonographic writing systems have graphs that are systematically related to their (phonological) meaning, i.e. their articulatory or acoustic properties. Suppose, for example, that all letters for labial consonantal phonemes contained a '^' shape, so that letters for /p/, /b/, /v/, /f/ etc. had this wedge shape in addition to other graphic elements which differentiate them. The wedge is not iconic per se, but its systematicity would

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[9] Another kind of relationship is that of an Index which is not further discussed here.

[10] Note that systematicity presupposes 'compositionality' of the sign forms and meanings because we speak of *properties* that different entities have in common.

make the writing system non-arbitrary vis-à-vis what it is that the graphs represent. Such a motivated system would in fact recognize the featural level without necessarily being featural all the way. (Think of the tilde for all nasal vowels.) It would be fully featural if *all* features were represented by a unique graphical element. A syllabary would be motivated in the same way if all graphs for syllables starting with a /p/ or with a voiced obstruent shared a graphical element. Such a system is syllabic while having alphabetic or featural traits.

Iconicity would exist if, for example, graphical elements resembled articulatory positions. Suppose that graphs for some or all labial sounds contain an < ()> like shape (resembling the two lips). Iconic systems are bound to introduce the featural level into either an alphabetic system or a syllabic system since it would be hard to select iconic graphs that uniquely resemble a single phoneme (unless, metonymically, if this phoneme had a unique feature , as in a trilled r). Thus, it would seem that motivation in phonographic systems involves introducing a lower level into a higher level system (i.e. featural graphs into an alphabetic system or alphabetic or featural graphs into a syllabic system).

Motivation typically plays an important role in another aspect of writing systems. Any writing system uses some ‘syntax’ to place its graphemes together, i.e. to create ‘graphic expressions’. Therefore, when considering motivation in writing systems we need to consider not only the units, but also their mode of combination. For example, in an alphabetic system, the letters are placed in some linear order (in the horizontal and vertical dimension). Such linear order can be said to be iconically motivated by the linear sequences of phonemes, no matter what the direction of writing.

If a writing system were featural *and* had iconic order, one could imagine representing the graphic feature units that jointly characterize a phoneme non-linearly in order to iconically capture their simultaneity. This is what happens in SignWriting, where both the forms and the syntax are motivated. As Martin (2000) points out, SignWriting has symbols for handshapes, actions, and orientations, but it does not have specific symbols for the location of the hands[11]. Instead, each written sign uses a two-dimensional space as a map of a human body. The symbols for the hands are placed within that space, so that the vertical and lateral dimensions of location are completely iconic[12].

SignWriting also has examples of systematic motivation. For example, various handshape symbols use the convention that the back of the hand is black, and the front is colorless.

2.3 Unit or level of representation

Phonographic writing systems are either feature-based (subsegmental) or alphabetic (the graphs have a (loose) relationship to phonemes or segments of the language). Written English, like many or even most writing systems for speech, is alphabetic. In contrast, SignWriting expressions are decomposable into a set of basic symbols that correspond to phonological features in all current phonological analyses. Not only SignWriting, but all writing and transcription systems created for signs (including that by Bébian) appear to be feature or feature-group systems[13].

[11] There is a special version of SignWriting for transcription which does have specific symbols for locations.

[12] Because SignWriting is two dimensional and is representing something that is three-dimensional, even location can't be completely iconic, because conventions are needed to establish the placement in the forward-back dimension.

[13] Some (including Stokoe 1960) refer to graphs that represent feature complexes (such the graph <A> for a certain handshape) as "alphabetic", taking handshapes as analogous to phonemes. But in all current analyses of signs, handshapes are subsegmental, and their graphs therefore are featural, not segmental.

Table 1 shows that writing systems in general differ with respect to the level or size of the linguistic unit that is represented by the graphic units (using the invented terms *podic* and *motic* to refer to feet and word based systems):

Table 1 Types and examples of writing systems

System type	Linguistic form level	System examples	
		Phonographic	Semagraphic
Featural	Features	SignWriting, Korean (Hangul)	
Alphabetic	Phonemes	English	
Syllabic	Syllables	Cherokee, Cree, Hiragana	
Podic	Feet		
Motic	Word/morpheme		Chinese

The table shows interesting gaps. No system targets any semagraphic elements below the word or morpheme level (such as semantic 'features' or conceivable intermediate semantic structures). No phonological system targets feet or words. Furthermore, there may be a modality difference as well, since it appears that written sign exclusively targets the feature level, which is uncommon for written speech. Only Hangul has been claimed to be based on features, but, as such, it is far from transparent or exceptionless in the way that SignWriting is. We do see, however, that writing systems frequently use feature-based diacritics (such as the tilde, umlauts) or letter doubling to indicate length.

Why do the only attested cases of semagraphic systems choose to represent whole word (or morpheme) meanings (which is why the term logographic is commonly used)? If there are semantic units below the level of morpheme meaning, i.e. a set of basic semantic features, it would be conceivable to design a writing system that targets these units. Such a system does not seem obvious as a practical writing system, probably because such smaller semantic units are not salient enough either in themselves or in comparison to competing units, such as phonemes[14].

Also, why are there no phonographic podic or motic systems? The number of symbols required would be very large, but this objection would apply equally to semagraphic motic systems which do occur. Again the answer may lie in what is cognitively salient. When someone creates a written system, the natural focus is the word, which must be more cognitively salient than lower phonological levels, and much more likely to be committed to memory than sentences. In turn, the meaning of words is more salient than the form which is merely the vehicle. It is well known that it is much easier for people to invent iconic signs than to come up with something arbitrary, so the most natural starting point for a writing system would seem to be a set of iconic graphs that represent word meanings as a whole, leading to a motic semagraphic system. However, semagraphic systems raise a learnability problem because of the large number of graphs required to symbolize all the language's morphemes. In addition, the iconicity of the original invention will soon run into problems because of the variability of the referents (as well as different perceptions of them) that are the source of the iconicity. These factors may be causes (along with other factors such as the introduction of disambiguators or the use of the Rebus Principle) for the emergence of phonographic systems, both syllabic and alphabetic. Such systems, of course, pose learnability problems of their own since their use requires an awareness of the phonological structure of words or 'phonemic awareness', i.e. of meaningless chunks of form like syllables and phonemes. While phonemic awareness generally

[14] As mentioned earlier, logical and mathematical notations (think especially of Frege's Begriffsschrift; Frege 1879) might be regarded as aiming at the representation of (submorphemic) basic concepts. Also, semantic theories that decompose meanings into basic concepts employ submorphemic semagraphic notation systems, which usually use invented symbols for logical operators and connectives, while using 'words' in bold or capital for the larger set of semantic primitives. We think of such systems as semantic transcription systems.

requires teaching, children are clearly capable of learning these distinctions. Less clear is their ability to become feature-aware for spoken languages, which may be one reason why featural systems are uncommon for spoken languages. A second factor is that a feature based system for speech will generally result in a set of complex or bundled symbols which are grouped and understood at the segmental level (as appears to be the case in Hangul). This type of bundled symbol readily decays into a non-decomposed unitary alphabetic symbol.

Thirdly, why are there no podic systems, either phonographic or semagraphic? We suggest that their absence is rather easily explained if we assume that feet are 'phonetic' rather than cognitive-phonological units (cf. van der Hulst, to appear). It is, indeed, rare if not non-existent for writing systems to encode phonetic, such as allophonic properties of speech.

Lastly, why are all sign writing systems based on features or feature groups? Within the phonographic category we could imagine systems that target a higher phonological level, such as a segmental/phonemic or syllabic level. That these candidate systems do not exist bears on a well known problem of sign language phonology: there is little consensus on either the existence or definition of the various phonological levels in sign language beyond the feature or feature class (such as handshape).

Most representational systems for signs have at least one phonological unit or level smaller than the word. Candidates for this unit are the segment (phoneme) or syllable. Sandler (1989), Perlmutter (1989, 1990) and Liddell & Johnson (1989) propose **multisegmental** approaches, with most signs having 2 or 3 segments. Although these systems allow a syllabic level (explicitly or implicitly), multi-syllabic signs are usually cases where the second and succeeding syllables are copies of the first syllable. Thus, such systems, while allowing for two phonological levels, do not actually need the full power of a syllabic level (repeating syllables might equally well be handled with a repeat feature (see Channon 2002b). The multisegmental perspective claims that there are segmental and syllabic levels that should be available for an alphabetic or syllabic system exactly like spoken languages. The fact that such systems are not attested argues that either they are (strangely) less cognitively salient than the featural level or that such levels do not exist in signs[15].

Brentari (1998) proposes a **syllabic** model, which eliminates the segmental level in favor of the syllabic, with timing units dependent on the syllabic level. Van der Hulst (1993, 2000) and Channon (Crain 1996, Channon 2002a) propose **monosegmental** models, which establish a formal parallel between the representation of a sign and a phoneme, each consisting of a set of 'class nodes' defined in terms of a set of features, and without a syllabic level of organization. The syllabic and monosegmental views converge on the notion that in addition to the phonological level of features there is only *one* further significant phonological level which comprises the whole phonological form of monomorphemic signs. A writing system that would target this level would therefore be alphabetic, syllabic and motic all at the same time. The choices for a writing system are therefore featural (attested) or motic (not attested).

If, as suggested above, in the case of spoken languages, (iconic) motic semagraphic systems tend to come first, why then, do we not get analogous systems for sign languages? Why is it, that in sign, the form takes precedence over the semantic meaning in 'capturing the

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[15] This being said, we should perhaps pay more attention to the fact that all sign phonologists, starting with Stokoe, recognize feature groups for handshape, location, movement and orientation as intermediate levels, which Stokoe designated as analogous to phonemes in spoken languages, whereas van der Hulst and Channon compare them to 'class nodes' (the units for place, manner and laryngeal properties of speech sounds). Clearly, the salience of class nodes in signs is much higher than class nodes in speech phonemes which explains why sign writing systems sometimes have holistic graphs for, in particular, handshapes, which are perhaps, the most essential aspect of signs, or at least have some kind of special status (van der Hulst 1993).

attention' of writing units? We suggest that contrary to what we find for spoken languages, it seems that signers have a high degree of awareness for sign features and feature bundles (class nodes), due to the visibility of sign articulation, which makes it easy to develop graph sets that are iconic of the phonological shape. In spoken languages, articulation is largely invisible. Moreover, the immediate vehicle of meaning is the acoustic effect of the articulation, not the articulation itself. Apparently, acoustic events (being auditory) do not capture the attention of a visually based writing system because a clear basis for iconicity is lacking. Finally, as mentioned above, because the form of signs tends itself to be iconic, an iconic phonographic system for signs is often also iconic of their meaning, so that, if iconicity is desirable (all other things being equal), an iconic phonographic system may be the best of all possible choices for writing systems for sign languages.

2.4 Bi-uniqueness

Bi-uniqueness is another aspect of the relationship between form and meaning to be considered. Is the relationship between form and meaning one-to-one (a unique form for each meaning), or can several forms refer to the same meaning, or several meanings be referred to by one form?

The "ideal" of a one grapheme ~ one phoneme system is rare, although nearly attained in some writing systems such as Finnish writing, but certainly not in English, which is notorious for the extent to which it deviates from this ideal. Deviation arises when the phonological system of a language changes over time, while the writing system remains the same (in accordance with what is sometimes called the etymological principle). Due to its faithfulness to history, writing may preserve semantic distinctions between words that have become homophonic (thus, in a sense, introducing a semagraphic dimension to a phonographic system: <to>, <two> and <too> represent different meanings). But they may also find their root in other design principles. For example, the decision to write <hond> for the Dutch word for dog which is pronounced [hɔnt], with a <d> rather than a <t> is that in the plural <honden>, pronounced [hɔndə], a [d] surfaces. The relevant design principle is often called the morphemic principle. Thus a phonographic writing system may deviate from the bi-unique goal due to historical faithfulness or faithfulness to allomorphic alternation. One might even argue that phonographic writing systems for spoken languages due to both the etymological and morphological principle display a semagraphic tendency, though not a requirement, for a bi-unique relationship between graphs and (semantic) meanings.

SignWriting, unlike most or all spoken language writing systems, appears to maintain a rigid requirement for bi-uniqueness of graphic form to phonological form. For example, in ASL the signs APPLE and ONION are distinct forms, and they are equally distinct in SignWriting, but the signs GOOD and THANKYOU are not (manually) phonologically distinct, and they will not be distinct in SignWriting. The kind of mismatch seen in English "read" (present tense) and "read" (past tense) which are distinct spoken forms but the same graphic forms could not occur in SignWriting, because it is always faithful to the phonological form.

Bi-uniqueness in semagraphic systems is difficult to maintain because it is hard to come up with (and learn) different forms for all the different morphemes. Hence, we see that in such systems the same units are used for different semantically related morphemes. To point the reader to the different morphemes phonographic disambiguators may then be added.

2.5 Economy and redundancy

Reductionism (the strategy to break down entities into increasingly smaller primes) reduces the number of basic units, but this simplicity is counterbalanced by an increase in the complexity of the combinatorial system (i.e. the syntax). Featural writing has fewer primes than alphabetic writing, which has fewer primes that syllabic writing. Writing systems that have a separate graph for each morpheme/word have the simplest ‘syntax’ for writing down words, but the largest number of basic unit (namely as many as there are morphemes/words). It might be that systems in general tend to increase reductionism, although, at the same time, single forms for complex meanings may be favored if, by offering shortcuts, they reduces frequent uses of complex syntax. An example of this (which we call ‘bundling’) is the use of handshape forms (like ‘A’) in sign notation systems.

The notion of *economy* refers to the idea that any representational system, given its primes and syntax, favors simple over complex forms to represent a given set of meanings. Economy reduces the amount of ‘effort’ that its takes to produces form and thus favors that different form are minimally distinct. However, to be resilient, sign systems typically do not go for minimal differences and the reason is that minimal differences can easily be missed, i.e. overwritten by ‘noise’ or by the detrimental effect of overzealous production efficiency or ‘laziness’. To counterbalance noise and signal deterioration, signifiers tend to display *redundancy* in their form. It has long been understood (cf. Shannon and Weaver 1949) that if differences are minimal the slightest ‘noise’ may cause confusion, wiping out the crucial difference between two forms. If there are multiple cues, in other words *redundancy*, forms will be more resistant to noise. Redundant coding can take various forms, including repetition or doubling, extra properties (enhancement) or amplification (magnification). In general, redundancy increases *dispersion*, i.e. it maximizes differences between different form.

Any sign system that has evolved in/for humans or has been designed to be used by them will establish a balance between economy and redundancy. Depending on the goal of the system, one or the other may be given more weight. It seems obvious that writing systems for both speech and sign (as well as speech and sign in their own right) make ample use of redundancy because, after all, perceptual clarity is of paramount importance.

2.6 Summary – writing systems

To summarize, we have discussed several important characteristics of writing systems. First, writing systems for spoken languages can be phonographic (dependent on the form of another linguistic system) or semagraphic (dependent on the meanings of another linguistic system), although both types typically have ingredients of the other kind. The writing systems that we know of for sign all appear to be purely phonographic. Second, phonographic written speech, in addition to using semagraphic units (i.e. '&' in English writing), often display a tendency for holistically matching a unique written symbol sequence to one spoken form (due to the etymological and morphological principle). Sign writing, as mentioned, seems to adhere more strictly to its phonographic basis. Third, phonographic written speech is almost always phonemic (alphabetic), but it appears more natural for written sign to be featural. Fourth, written speech generally uses symbols which even if they are originally iconic, over time become entirely arbitrary. The order of the symbols on the page is iconic. Written sign systems seem to use primarily iconic symbols. SignWriting (but not all written sign systems), also uses iconic order.[16] Fifth, written systems in both modalities show some evidence of tendencies toward more economical syntax by using bundled symbols.

Will SignWriting succeed? It is an elegant solution to the problem of writing signs, and has a natural and understandable quality about it that is appealing. Children can learn it without any difficulty greater than that involved in hearing children learning to write speech, perhaps less in fact. But just as external realities have established English as the *de facto* language of science

[16] Supalla's ASL-phabet does not have iconic order.

instead of other languages, SignWriting may succeed or fail because of extrinsic demographic, political and technological realities. The Deaf community is small and may be shrinking (Johnston 2004). Most deaf children have hearing parents, who naturally emphasize the writing system for their native, spoken language. These children usually acquire sufficient skills in English (or another spoken language) to manage to communicate with hearing people and with other deaf people, while many hearing people do not really learn to sign, let alone use SignWriting. Additionally, most technological devices deaf people use for communication such as email, instant messaging, and ttys are not currently available in a form that would allow SignWriting to be used.

Regardless of whether SignWriting is ultimately successful, we suggest that the use of SignWriting by children as well as the learning process should be interesting topics for research, especially because SignWriting may be the only true example of a rigidly bi-unique, feature level writing system, as well as the clearest example of an iconic phonographic writing system.

3 Transcription and tagging systems

3.1 How is a transcription system distinguished from a writing system?

A transcription system is usually meant to notate the form side of linguistic expressions[17]. In many cases, transcription is needed to capture phonetic details whether allophonic, free, stylistic, geographic (dialectal), pathological, or characteristic of second language learners[18].

[17] Notating meanings is certainly possible as well, as in the Berkeley Transcription System (Hoiting and Slobin 2001), which we would call a semantic transcription system.

[18] Even though transcriptions are meant to be accurate renderings of the perceptible form of linguistic expressions, transcription, like any analytic process, always involves abstraction. The gestures of language are largely continuous, both at the phonemic and word level, apart from pauses when people breathe or rest, but transcriptions normally slice this stream as though there were discrete phonemes and words.

The basic requirements for a transcription system are:

a) Bi-uniqueness: no graphic unit can be ambiguous, while using two units with the same meaning should be avoided.
b) Completeness: There must be a graphic unit for all phonetic properties that might be ‘relevant’ for intended further analysis

Desirable characteristics would be:

c) transcribable on a computer
d) Appropriate documentation available
e) Stable group responsible for maintaining/changing the system
f) easy to learn, write and read back

Phonographic writing systems (and of course semagraphic systems as well) for speech are clearly inadequate, because 1) they do not rigidly adhere to biuniqueness, 2) the graph inventory of any given written language is not adequate to represent the sound inventory of all languages

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Paralinguistic properties of the sign (properties that depend on factors such as gender, size, age, mental state or mood, physical abnormalities, amount of alcohol and so on) are usually excluded.

Furthermore, as is well known, transcriptions differ in terms of the amount of phonetic detail that is acknowledged, depending on the goal of the transcription. If the goal is to arrive at a phonological analysis of normal speech, the transcription will anticipate the phonemic analysis by mostly notating phonetic distinctions that are, at least, potentially contrastive (i.e. have been shown to be contrastive in at least one language). For example, a broad transcription system would register aspiration in English consonants because this property is contrastive in languages such as Hindi or Thai, but the difference between released and unreleased final obstruents would not. For signs, a phonologist might decide that the difference between the 1A and 6S handshape is not contrastive and therefore notate both handshapes with the same symbol.

(lack of completeness), and 3) they are typically alphabetic or phonemic and cannot easily represent featural distinctions.

Written sign systems, however, are somewhat different. SignWriting is phonographic, but it is featural, and maintains rigid bi-uniqueness between the written and signed forms. As such, SignWriting expressions can include more or less phonetic detail as desired. Furthermore, partly by design and partly because of the phonological similarity of sign languages, the symbol set is sufficient to cover all sign languages, as amply demonstrated on the SignWriting web site. This makes SignWriting (and Supalla's ASL-phabet) a potential transcription system in addition to being a writing system.

The IPA, HamNoSys and SignWriting all fulfill the two most important criteria of rigid bi-uniqueness and completeness (granted that new empirical work may uncover new entities that need to be notated with new forms).We can next ask the question as to whether they equally fulfill the desirable characteristics[19].

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[19] Even though an excellent iconic system, Bell's Visual Speech, was proposed and worked out in great detail, linguists have chosen to use the non-iconic IPA. Why did the IPA succeed when many systems with newly invented symbols, whether iconic or systematic, did not gain general acceptance? There are probably several reasons. Firstly, many people described languages (either as a hobby or more professionally) before such specialized notation systems had been designed, or they were unaware of the existence of such systems. As many of those used the Roman alphabet, a tradition of transcription based on this alphabet simply emerged. (There are similar examples of phonetic uses of other scripts in India, China or Arabic countries.) Secondly, newly invented symbols must be learned and memorized, which is a stumbling block for everyone. Connected to this is that those who do take the trouble of learning the new system will see their work ignored by the majority of potential readers who do not take the trouble to learn it. Thirdly, newly invented systems pose problems to typewriters, printers and proof readers. That the Roman alphabet and not some other alphabet became the basis for IPA is, of course, the result of eurocentrism. Fourthly, and probably most importantly, the idea that iconicity or systematicity is a *crucial* (or even desirable) feature of a notation system is probably an illusion. As mentioned, iconicity may be a natural drive in the design of a notation system. However, once such a system is mastered, each symbol will eventually start functioning as an arbitrary sign for a specific speech sound. This will lead to iconicity, if present initially, 'wearing off', even though when people design new notation systems they find it irresistible to come up with iconic symbols.

If we compare HamNoSys and SignWriting as transcription systems, there is one major difference. HamNoSys is a linear 1-dimensional system similar in that respect to written alphabetic systems. HamNoSys uses an arbitrary linear ordering of symbols (handshape, location, movement). A HamNoSys expression has no significant internal structure which can be freely altered. Thus, while the HamNoSys symbol set is iconic, its order is not. The linear ordering is purely an artifact of the system and has no iconic resemblance to the actual temporal order. For practical purposes, a specific linear order can be (and has been) adopted as a matter of convention. (Supalla's ASL-phabet has a similar arbitrary linear order.)

In contrast, a SignWriting symbol does have internal structure. For example, one SignWriting symbol is a round circle representing the signer's head. Sub-symbols are placed within it for eye shapes (squinting, widened), eyebrows (frowning, raised), and mouth (smiling, frowning, mouthing, exhaling, etc.). This means that SignWriting is a non-linear, two-dimensional, iconically arranged symbol set which appears to circumvent at least one of the problems that Miller (2001) notes with linear systems such as HamNoSys. In sign, as has often been said, many things happen at the same time.

A system that allows non-linear or multilinear notation[20] therefore seems desirable, but there is a related drawback. While it is certainly possible to use SignWriting on the computer, it requires specialized software to manipulate the symbols to the appropriate place. While SignWriting does have decomposable symbols which can be translated or converted to a coding system, there may be potential difficulties in a conversion, especially with regard to the non-

[20] The lack of iconic order does make the HamNoSys representation harder to read, but this may not be a serious drawback, since anyone trained in the system will be able to read it with adequate speed.

linear locations (cf. above). (Their web site discusses a form of SignWriting which is intended for research purposes, and does have specific location symbols.) In contrast, HamNoSys (and Supalla's ASL-phabet) can adapt easily to a computer. It is quite easy to download the fonts for HamNoSys and use them for transcription. HamNoSys may therefore have an edge as a more easily digitized system, although they seem equally good choices for manual transcription.

SignWriting appears to be well documented on its web site, with manuals for teaching the system, plus children's books and other material to practice with. In contrast, the documentation for HamNoSys is somewhat difficult to obtain and seems to be still in progress.

One other issue is that while the IPA is controlled by an organization with broad support in the linguistic community, but SignWriting and HamNoSys, although in competent hands, do not have this type of large organizational support.[21]

3.2 Tagging systems

While a transcription system by itself is often adequate, many researchers want and need to refer back to the original data as well. A difficulty with videotapes or other multimedia sources is that it is not always easy to find and return to a specific point in the tape and to tag it for comparison with another point in the same or a different tape. Both SignStream and ELAN focus on the important task of aligning linguistic information with original source data.

These software tools allow researchers to tag video material (frame by frame, if necessary) with information arranged on multiple lines, each line being defined (by the program or by the user of the program) in terms of some relevant linguistic property (handshape, location, etc.). There are few if any restrictions on the types of properties that can be annotated. SignStream was developed by researchers at Boston University

[21] For a comprehensive overview of sign notation systems we refer to Miller (2001).

(http://www.bu.edu/asllrp/SignStream/) and ELAN (EUDICO Linguistic Annotator) by researchers at the Max Planck Institute (http://www.mpi.nl/tools/). SignStream is primarily aimed at syntactic analysis of signs but it allows some phonetic detail to be entered. It is available for Mac systems only. ELAN has a more phonetic focus, although it allows almost any kind of detail to be transcribed. It is available for Mac, Windows and Linux systems. Both could be considered to be counterparts in the visual realm for PRAAT, software developed by Paul Boersma and David Weenink to annotate audio material (http://www.fon.hum.uva.nl/praat/).

One concern with these kinds of programs is that because sign language linguistics is a relatively small, relatively low budget research area, it may not be possible to maintain complex, specialized software. It should also be noted that these annotators are intended to work with multimedia material only (not still photographs, drawings, or dictionary descriptions). With these minor caveats, these tagging systems appear to be valuable tools for the examination and transcription of phonetic data on videotapes.

3.2.1 Summary

The crucial characteristics for a transcription system are that it observes bi-uniqueness and completeness. Both HamNoSys and SignWriting have these characteristics. HamNoSys is probably a better transcription system however, because it appears to be more easily computerized.

Perhaps the most interesting characteristic of transcription systems for sign languages is that while it is unlikely that any written speech system could function effectively as a transcription system, it seems that SignWriting, HamNoSys and the various Stokoe-based systems are actually all potentially both writing and transcriptions systems[22]. This appears to be a joint result of their featural as opposed to alphabetic nature and their iconicity, which seems to lead naturally to rigid bi-uniqueness.

In addition, we briefly discussed two tagging systems which allow detailed notation of videotaped signs.

4 Coding systems

4.1 Requirements

A coding system is a research tool to allow linguists to research questions about various aspects of language. It requires high explicitness and simplicity for its users, and ease of data storage and retrieval.

In comparing coding and transcription systems, we can note first that both must be bi-unique and complete. The crucial distinction is that a coding system must allow computerized sorting, counting and comparing of any significant characteristic, while a transcription system need not (it may not even be computerized).

[22] There are many written speech systems that do not have a clear one-to-one relationship between the written form and the spoken form. But all sign writing systems do, although they vary to one degree or another in what is omitted. It is possible that this is a result of the relative youthfulness of all written sign systems, and that over time, historical 'garbage' may accumulate. Intuitively, this seems unlikely, especially with SignWriting, and it also seems that the reasons for this are connected not with its age, but with its iconic and featural nature. While writing systems for speech can lag behind phonological change, we find it difficult to imagine a situation where, for example, a SignWriting symbol which represented the hand at the forehead was accepted as a good symbol for a sign made on the cheek (although there should be no difficulty in accepting that something is written in citation form without regard to a specific performance). This question must be left for future investigation, but we mention it as a possible significant difference between written speech and sign.

Because transcription systems emphasize writing speed, they use many *bundled* symbols that contain information about many different characteristics, such as HamNoSys and representing a hand with either one or two fingers extended. But bundled symbols do not allow sorting, counting or comparing the subunits of the coded entity. For example, it would be difficult to sort the above two HamNoSys symbols simultaneously for thumb posture and number of extended fingers. The two symbols cannot be compared to determine if the number of extended fingers or the thumb postures are the same. They cannot be counted to find how many times a hand has a single extended finger. This poses a barrier to the user (although specialized software could be used to get around this). A coding system must therefore avoid bundled symbols.

A transcription system emphasizes ease and speed of use from the writer's/creator's perspective, while a coding system emphasizes ease and speed from the reader's/user's perspective. Thus, it is important that the symbols for a coding system should be not only unbundled, but they must be as transparent as possible to reduce the reader's learning curve. Even iconic symbols such as are not completely transparent (what is the thumb doing? Does the symbol represent the extended index or the extended pinky?) Character codes and abbreviations are even more difficult for a user. We therefore propose that the symbols be selected from a closed vocabulary of ordinary English[23] words. This has the additional advantage that special fonts are not needed, and greatly reduces (though it doesn't eliminate) the need for system documentation. A further advantage is ease of correction: single character codes, or

[23] We propose a closed vocabulary of *English* words simply because at the present time, English is the de facto language of science, and therefore a database using English will have the largest number of scientists who will not require translation before use. Because it is a closed set of words, translation into various other languages should be relatively straightforward.

combinatorial codes (such as <cd> for contralateral and downward) are almost impossible to correct if errors are made, while if a data entry error is made in a word like *contralateral*, it is a simple matter to see that *contraladeral* should be corrected to *contralateral*. A related principle is to use the more common word over the more technical wherever possible: words like *pinkyside* and *thumbside* are easier to understand than *radial* or *ulnar*, and make the database language accessible to a wider audience.

4.2 A proposed database structure: SignTyp

While the above principles for choosing a symbol set are probably applicable to almost any coding system, we now turn to something more specialized: the structure of SignTyp, which apparently represents an entirely new approach to sign language databases. SignTyp is both a physical database (currently including about 12000 signs from 9 different sources) and a coding system. It is not a software system, and can be used with any database software. Output from the tagging systems discussed above or data transcribed using a transcription system can become input to SignTyp.

The data structure for SignTyp is the same structure used in phonological feature trees (directed graphs)[24]. However, instead of being a graphic representation, it is tabular, because graphical representations are not suitable for analytic work. (Of course, SignTyp includes a much broader range of data than a phonological tree, but this does not affect the structure.)

To understand this, consider the directed graph representations of location for the ASL signs BEAUTIFUL and FLOWER, shown in Figure 11 and a corresponding tabular representation in Table 2. (In BEAUTIFUL, the fingers moves in a circular gesture over the face as a whole, while in FLOWER, the hand contacts the ipsilateral and contralateral nostrils). For

[24] SignTyp can also be seen as an attribute-value structure in which a value can itself be an attribute (Scobbie 1997).

our purposes here, we are not concerned with any particular phonological theory, but have simply selected a reasonable possible structure for location features. These are ordinary (somewhat simplified) phonological trees, rotated so that the root is oriented to the left instead of to the top of the page. It should be easy to see the relationship between the graphic tree in Figure 11 and the tabular tree in Table 2.

The graphic tree uses lines to show the relationship between the text boxes (nodes): *Face* is a dependent of *Location*. In SignTyp, the root node is the leftmost column and the terminal node is the rightmost column. Columns to the right are dependents of columns to the left. The left to right organization of the columns and the repetition of all non-terminal nodes on each row substitute for the lines in the graphic tree form.

A graphic tree has one additional convention: sister nodes to the left are temporally ordered before those to the right. In the tabular tree, the stage value makes explicit the temporal order of the data. Both graphic and tabular methods therefore provide the same information for dependency and linear order.

Figure 11 Partial feature trees for BEAUTIFUL and FLOWER (rotated)

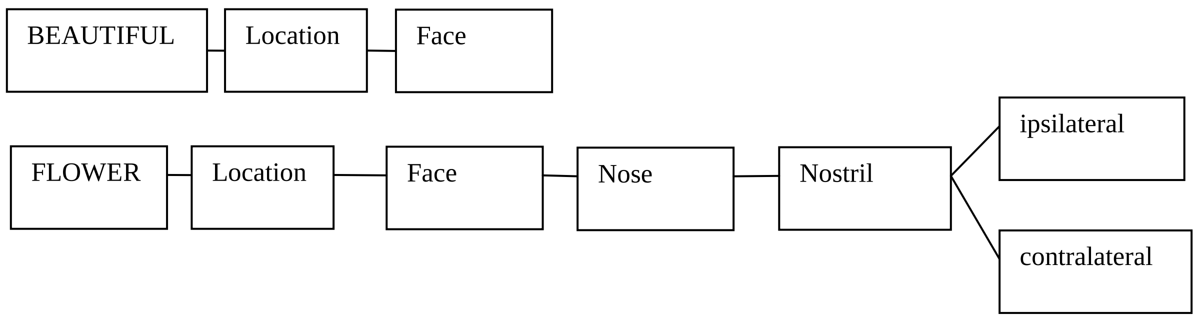

Table 2 SignTyp records for BEAUTIFUL (SignID 1) and FLOWER (SignID 2)

SignID	**Stage**	**Field Name**	**Field Values Detail**			
			Level 1	**Level 2**	**Level 3**	**Level 4**
1	1	Location	Face			
2	1	Location	Face	Nose	Nostril	Ipsilateral
2	2	Location	Face	Nose	Nostril	Contralateral

The SignTyp structure has numerous advantages:

The structure directly mirrors the hierarchical nature of the data, and shows relationships between fields. Related fields are automatically and naturally sorted together, and pivot tables or similar data summaries will always result in like material being kept together. For example, location information will sort separately from orientation.

Similar material will be aligned. BEAUTIFUL's terminal node is *face*, while FLOWER's terminal nodes are the contralateral and ipsilateral *nostrils*. Both FLOWER and BEAUTIFUL share a *face* node, which shows up in the same column for both signs. In a traditional row-column structure, *face* for BEAUTIFUL and *nostril* for FLOWER would probably be put in the same column, which would miss a generalization. Data with more detail will have more nodes, but all the data can be compared on any shared higher nodes. This also means that data from different databases that code different depth of detail can be united in SignTyp (after normalization of labels). For example, data source A might treat all locations on the chest as a single location while data source B might distinguish upper chest, mid chest, lower chest and so on. Both databases can be compared at Detail Level 1 where they would both have a value of chest, even though DataSource A has no further information available for any sign, while DataSource B has much more information available.

With an ordinary relational database, once the database administrator has set up the database structure, and the data structure, the analyst can add more rows at any time without needing to ask the administrator to change anything. But if the analyst wanted to add a new field, *iconic location,* the database administrator (and probably the website designer/administrator) would need to review, approve and make this change. This can be a problem in a research database, which is much more likely to add or change fields than a business database, because the analytic process frequently means that new fields will be added.

SignTyp handles the problem of changing data structure much more neatly. In the example above, *iconic location* is not a new column, but just a new possible value for a record. No database changes would be required. New kinds of data are simply new rows of data with different node names. This structure goes a long way to freeing the researcher from dependence on the database and website administrators.

SignTyp can also be used with videotapes, photographs, drawings or other source material. It is meant to be cross-linguistic and can record different historical stages of languages as well as different languages, thus allowing study of historical change and cross-linguistic typological or genetic relationships. It can also function as an archive for material from different projects.

4.3 Summary – coding systems

In this section, we have provided an overview of a new coding system for signs that uses a closed English vocabulary to describe signs in as much detail as the analyst wants, and allows for simple searches and sorts on atomic data. The unusual database structure, while remaining relational, allows researchers more freedom in making changes to the data structure without involving the database or website administrator.

5 Summary

In this chapter we have examined three types of notation systems: writing, transcription and coding, with special attention for their use in sign languages. We discussed their properties, compared them to similar systems for spoken languages, and speculated on the reasons why some conceivable systems do not exist or are unpopular.

If a writing system is phonographic, it focuses on the phonemic or syllabic level for speech, and on the feature level for sign. The success of alphabetic systems for written speech suggests that the phoneme is a central cognitive unit for speech (cf. Taylor 2006), even though phonemic *awareness* is a stage that needs considerable training. In signs on the other hand, the featural level system appears to be more successful and usable, suggesting that in this modality the feature or feature group is the central cognitive unit for sign. This difference in which level of analysis is salient reflects a fundamental difference between speech and sign. Both written speech and sign have iconic timelines (order of symbols), but only written sign uses iconicity systematically and, apparently, persistently. Children's use of SignWriting should be an interesting research topic, because SignWriting is an unusual combination of a feature level writing system, as well as the clearest example of an iconic, phonographic, and rigidly bi-unique writing system.

Most of these differences also occur for transcription systems which, in this sense, are much like writing systems, differing mainly in terms of the bi-uniqueness and completeness requirements. Our discussion of coding systems was limited to sign language. We have proposed that a coding system for signs should use a symbol set of English words to allow for understandability and ease of sorting, and have a data structure that is a tabular version of a phonological tree.

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