II. Morphology

5. Word classes and word formation

Abstract

This chapter deals with three aspects of words in sign languages: (i) the special nature of the sub-lexical elements of signed words and the consequences for the relationship between words; (ii) the classification of words into word classes; and (iii) the morphological means for creating new words in the signed modality. It is shown that although almost all of the structures and phenomena discussed here occur in spoken languages as well, the visual-spatial modality has an impact on all three aspects in that sign languages may show different preferences than spoken languages. Three central morphological operations are discussed: compounding, affixation, and reduplication. Sign languages endow these operations with flavors that are available only to manual-spatial languages: the existence of two major articulators, and their ability to move in various spatial and temporal patterns. These possibilities are exploited by sign languages, resulting in strong preference for simultaneous morphological structures in both inflectional and derivational processes.

1. Introduction

Words have to perform several 'jobs' in a language: they provide the users of that language with means to refer to whatever concept the users want to express, be it an entity, an idea, an event, or a property. Words also have to combine with each other to allow users to convey information: to say something about something or someone. In order to fulfill the first task, there must be ways to create new words as the need arises to refer to new concepts. Regarding the second task, when combined to form larger units, words should be able to perform different roles, such as arguments, predicates, and modifiers. Different words may be specialized for particular roles, and languages may have means for creating words for specific roles.

Sign languages are natural languages produced in a physical modality different from that of spoken languages. Both types of language have to perform the same communicative functions with the same expressive capabilities, yet the physical means available to each type of language vary greatly. Sign languages are produced by hands, body,

and face; they are transmitted through space, and perceived by the eyes. Spoken languages are produced by the speech organs, transmitted as sound waves, and are perceived by the ears. Might these disparities make any difference to the nature of the elements that make up each system? To their organization? To the processes they undergo? Focusing on words, we ask whether words, the relationship between words, and the means for creating new words are affected by the particular modality of the language (see also chapter 25 on language and modality).

This chapter deals with three aspects of words in sign languages: the special nature of the sub-lexical elements of signed words and the consequences for the relationship between words; the classification of words into word classes; and the morphological means for creating new words in the signed modality. The modality issue runs across the entire chapter. In each section, I examine the ways in which modality affects the linguistic structures and processes described.

2. The signed word

Sign languages have words, that is, conventionalized units of form-meaning correspondence, like spoken languages. These units have psychological reality for their users (Zeshan 2002). They are composed of sub-lexical units and are therefore characterized by duality of patterning (Stokoe 1960). They are characterized by specific phonological structures and are subject to certain phonological constraints (Sandler 1999; see chapter 3, Phonology). Sign language words are usually referred to as *signs*, and we will adopt this terminology here as well.

Obviously, signs differ from words in their physical instantiation. The physical differences result in structural differences as well. Signs are much more simultaneously organized than words (Stokoe 1960), and tend to be monosyllabic (Sandler 1999). But signs differ from words in another important respect: they are much better at iconically depicting the concepts they denote (see Taub 2001 and references cited there). Sign languages make use of this capability. The lexicons of sign languages contain many more iconic and partly iconic signs than those of spoken languages, since spoken languages are limited to acoustic iconicity. Iconicity results from the nature of the sub-lexical elements building up a sign, which in turn has an effect on how signs are related to each other.

2.1. The nature of sub-lexical units

One of the design features of human language is duality of patterning (Hockett 1960), the existence of two levels of combinatorial structure, one combining meaningless elements (phonemes) into meaningful elements, the other combining meaningful elements (morphemes and words) into larger meaningful units. Sign languages are also characterized by duality of patterning. Signs are not holistic units, but are made up of specific formational units − hand configuration, movement, and location (Stokoe 1960). However, these formational units are in many cases not devoid of meaning. Take the verb EAT in Israeli Sign Language (Israeli SL) and other sign languages as

well, for example. The hand assumes a particular shape (✎), moving toward the mouth from a location in front of it, and executes this movement twice. 'Eat' means "to put (food) in the mouth, chew if necessary, and swallow" (*Webster's New Word Dictionary*, Third College Edition). The sign EAT is iconic, since there is a regular mapping between its formational elements and components of its meaning: the ✎ handshape corresponds to holding a solid object (food); the mouth corresponds to the mouth of the eater, the agent argument; the movement towards the mouth corresponds to putting the object into the mouth; and the double movement indicates a process. Many signs are only partially iconic: some formational elements correspond to meaning components, but not all. Other signs are arbitrary; none of their formational components can be said to correspond to a meaning component in any obvious way (though some researchers claim that no signs are completely arbitrary, and that the sign formational elements are always meaning-bearing, e.g., Tobin 2008). The lexicon of any sign language, then, consists of signs that are arbitrary and signs that are iconic to different degrees, yet all signs make use of the same formational elements.

Spoken language lexicons are not that different; they also have both arbitrary and non-arbitrary words. The difference between the two types of languages is in the relative proportions of the different kinds of words. In spoken languages, non-arbitrary words are quite marginal, making it possible (and convenient) to ignore them. In sign languages non-arbitrary signs constitute a substantial part of the lexicon. Boyes Braem (1986) estimates that at least a third of the lexical items of Swiss-German Sign Language are iconic. Zeshan (2000) estimates that the percentage might be even higher (at least half of the signs) for Indopakistani Sign Language (IPSL).

Iconic signs present a challenge for the traditional division between phonemes and morphemes, since the basic formational units, the phonemes of sign languages, may be meaning-bearing and not meaningless. Meaningfulness is usually regarded as the factor distinguishing phonemes from morphemes: phonemes are meaningless, while morphemes are meaningful units. Yet phonemes are also the basic building blocks of meaning bearing units in a language. But in sign languages, those basic building blocks are also meaning-bearing. Can they be regarded as morphemes, then? This would also seem problematic, since they are not composed of more basic formational elements, and the units they attach to are not words, stems, or roots, but rather other basic formational units. Johnston and Schembri (1999, 118) propose that these units function simultaneously as phonemes and morphemes, since they serve as the basic formational building blocks and at the same time as minimal meaning-bearing units. They propose the term 'phonomorphemes' to capture the nature of these basic elements. This dual nature of the basic formational units is even more evident in classifier constructions (see chapter 8 on classifiers).

2.2. The structure of the lexicon: sign families

Leaving theoretical issues aside, the meaningfulness of the formational building blocks of signs has consequences for the organization of the sign language lexicon. Signs that share a formational element (or elements) often also share some meaning component. For example, many signs in Israeli SL that are articulated on the temple express some kind of mental activity (KNOW, REMEMBER, LEARN, WORRY, MISS, DREAM, DAY-DREAM); signs

articulated on the chest often denote feelings (LOVE, SUFFER, HAPPY, PROUD, PITY, HEART-ACHE). Many signs with a ✎ handshape denote activities performed by the legs (JUMP, GET-UP, FALL, WALK, RUN, STROLL). Fernald and Napoli (2000) enumerate groups of signs, or sign families, in American Sign Language (ASL) that share formational elements, be it location, movement, handshape, or any combination of these. They show that the phenomenon of word families is very robust in ASL, characterizing the entire lexicon. Works on other sign languages (e.g., Brennan (1990) on British Sign Language (BSL); Johnston and Schembri (1999) on Australian Sign Language (Auslan); Meir and Sandler (2008) on Israeli SL) show that this is characteristic of other languages in the signed modality. Signs in such a 'family' are related to each other not by inflectional or derivational means, yet they are related nonetheless.

Fernald and Napoli posit a new linguistic unit, the 'ion-morph', a combination of one or more phonological features that, within a certain set of signs, has a specific meaning. Take, for example, the signs MOTHER and FATHER in ASL: they have the same movement, orientation, and handshape. They differ with respect to the location: chin for MOTHER, forehead for FATHER. Within this restricted set of signs, the combination of specific movement, orientation, and handshape have the meaning of 'parent'. The chin and the forehead, in turn, are ion-morphs denoting female and male in signs expressing kinship terms, such as SISTER-BROTHER, NIECE-NEPHEW, GRANDMOTHER-GRANDFATHER.

Fernald and Napoli (2000, 41) argue that ion-morphs are relevant not only for sign languages, but for spoken languages as well. A case in point is phonosymbolism, the ability of certain sounds or combination of sounds to carry specific 'sound images' that go with particular semantic fields, such as *fl-* representing a liquid substance in motion, as in *flow*, *flush*, *flood*, or *fluid*. Yet one can find word families even in more grammatical domains. For example, most question words in English begin with *wh-*. The labial glide carries the interrogative meaning within a specific set of words, and it may contrast with the voiced interdental fricative in pairs like '*then/when*' and '*there/where*', the latter carrying the meaning of 'definiteness', as in *the/that/this/those*.

The examples from both sign and spoken languages clearly show that there are ways other than inflection and derivation to relate words to one another. Whether these relations are morphological in nature is a difficult theoretical question, which can be conveniently set aside when dealing with spoken languages, since word families are less central to the structure of their lexicons. In sign languages, in contrast, they are an important characteristic of the lexicon. They may also play a role in creating new words (as suggested by Fernald and Napoli 2000), since language users may rely on existing ion-morphs when new lexical items are coined. Such cases again raise the question of whether or not derivational morphology is at play here.

The special nature of the sub-lexical units in signs affects the lexicon in another respect as well. When phonemes are combined to create a sign, the meaning of the resulting unit is often componential and transparent. This means that signs in the lexicon of a sign language need be less conventionalized than words of a spoken language, since their meaning can often be computed. Johnston and Schembri (1999, 126) make a distinction between *signs* and *lexemes*, the latter having a meaning "which is (a) unpredictable and/or somewhat more specific than the sign's componential meaning potential even when cited out of context, and or (b) quite unrelated to its componential meaning components (i.e., lexemes may have arbitrary links between form and meaning)." Lexemes, then, can be completely arbitrary, but more importantly, they are com-

pletely conventionalized, and can therefore be thought of as stored in the lexicon of the language. Signs, in contrast, are more productive than lexemes. They can be invented 'on the spot', because of the transparency of their components, and are therefore less lexicalized and less conventionalized than lexemes. A signer, for example, can invent a sign meaning 'the three of them were walking together' by extending three fingers and moving the hand in space. Such a sign can be understood in the appropriate context even if there is no conventional sign with that meaning in the specific sign language used by the signer. Johnston and Schembri show that signs and lexemes have different phonological, morphological, and semantic characteristics, and suggest that only lexemes should be part of the lexicon. An interesting question that arises is whether signs (as opposed to lexemes) are words, and if they are, whether they form a separate word class. One specific phenomenon that has been referred to in this context is the issue of classifier constructions, whose word status is an unresolved problem in sign language literature (see chapter 8, Classifiers). Classifier constructions are often excluded from analyses of word classification because of their unclear status. We return to this issue in section 4.

The lesson to be learned from the nature of signs and their components is that the line between the lexicon and the morphological component may be less definite than is usually assumed. Having raised the problematic issues, we now turn to those that are more straightforward within the realm of morphology. We examine which morphological operations are available to sign languages, and how these operations are used to distinguish between different types of words and to create new words.

3. Sign language morphological processes

Morphology provides machinery for creating new words and for creating different forms of a word. The former is the realm of derivation, the latter of inflection. Derivational and inflectional processes differ in their productivity, regularity, and automaticity. Inflectional processes are regarded as regular and automatic, in that they apply to all members of a given category, while derivational processes are usually less regular and non-automatic (though, as with any linguistic categorization, this distinction is often blurred and not as dichotomous as it is presented). In spite of this functional difference, the morphological mechanisms used for both derivation and inflection are the same.

The main three morphological operations are compounding, affixation, and reduplication. Words formed by such operations are complex, in the sense that they contain additional morphological content when compared to the bases they operate on. However, morphological complexity need not coincide with added phonological complexity, since morphological operations can be sequential or simultaneous. A sequential operation adds phonological segments onto a base, suffixes (as in bak*er*) and prefixes (as in **un**happy). In a simultaneous operation, meaningful units are added not by adding segments but rather by changing them. The plurality of *feet*, for example, is encoded by changing the quality of the vowel of the singular form *foot*. Both types of operation are found in spoken and in sign languages, but there is a difference in preference. In spoken languages, the sequential type is very common while simultaneous operations
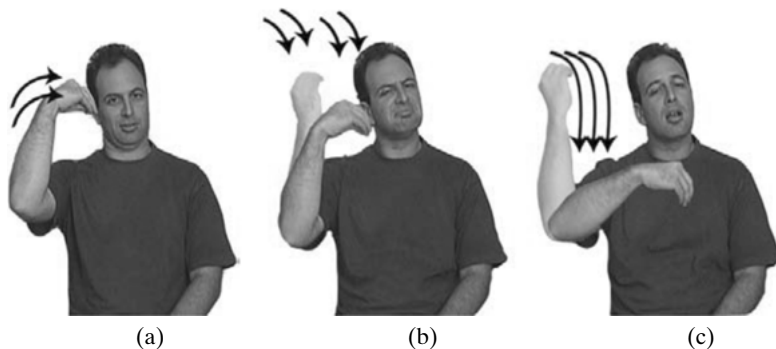
Fig. 5.1: Three forms of the sign LEARN (Israeli SL): (a) base form (b) iterative (c) durational. Copyright © 2011 by Sign Language Lab, University of Haifa. Reprinted with permission.

are rarer. Sign languages, in contrast, show a marked preference towards simultaneous morphological operations. Sequential affixal morphology is very infrequent, and (apart from compounding) has been reported in only a few sign languages. This tendency towards simultaneous structuring characterizes all linguistic levels of sign languages, and has been attributed to the visuo-spatial modality (Emmorey 2002 and references cited there; Meier et al. 2002).

Sequential morphology in the signed modality is quite similar to its spoken language counterpart: elements in a sequence (words and affixes) form a complex word by virtue of being linearly concatenated to one another. The Israeli SL compound VOLUNTEER is formed by combining the two signs HEART and OFFER into a complex lexical unit. In the process, several changes, some of which are modality-driven, may take place, and these are described in section 5.1.1. But by and large, sequential operations in both modalities are quite similar.

However, when turning to simultaneous morphology, the analogy is less clear. What would simultaneous morphology look like in a sign language? Which phonological features are changed to encode morphological processes? It turns out that it is the movement component of the sign that is the onemost exploited for morphological purposes. Take for example the sign LEARN in Israeli SL (Figure 5.1). The base form has a double movement of the hand towards the temple. Several repetitions of the sign with its double movement yield an iterative meaning 'to study again and again'. If the sign is articulated with a slower and larger single movement, repeated three times, then the verb is inflected for a continuative aspect, meaning 'to study for a long time'.

A change in the movement pattern of a sign distinguishes nouns from formationally similar verbs in several sign languages (see section 4.4.1). Repetition of a noun sign in several locations in space denotes plurality (see chapter 6, Plurality). A change in the direction of a specific class of verbs (agreement verbs) indicates a change in the syntactic arguments of the verb in many sign languages (see chapter 7, Verb Agreement). In addition to change in movement, change in handshape with classifying verbs can also be analyzed as simultaneous inflection (and as a certain kind of verb-argument-agreement, see chapter 8, Classifiers).

Thus simultaneous morphology in sign languages is implemented by changing features of the movement of the sign, and to a lesser degree by handshape change. It is

simultaneous in the sense that it does not involve adding phonological segments. The signs ASK and QUESTION are related to each other more like the English noun-verb pair *cóntrast-contrást* than the pair *govern**ment**-govern*. Both signs consist of one syllable. They differ in the prosodic features imposed on the syllabic structure. This type of simultaneous morphology is often described as comparable to the templatic morphology characteristic of Semitic languages, where morphological distinctions are encoded by associating phonological material to different prosodic templates (Sandler 1989; Sandler/Lillo-Martin 2006).

The two types of sign language morphology are characterized by different properties (Aronoff/Meir/Sandler 2005). Sequential operations are sparse; they are arbitrary in form; the affixes are related to free forms in the language and therefore can be regarded as being made grammatical from free words; they are derivational and less regular. Simultaneous operations are numerous; many of them are productive; they are related to spatial and temporal cognition, and most of them are non-arbitrary to various degrees. They can be inflectional or derivational. It follows, then, that there is partial correlation between simultaneity vs. sequentiality and the inflection vs. derivation dichotomy: sequential processes in sign languages are derivational. Simultaneous processes can be both inflectional and derivational. Thus inflection in sign languages is confined to being simultaneously instantiated. Derivational processes not only make use of simultaneous morphology, but also take the form of sequential morphology. These differences are summarized in Table 5.1. Both morphologies play a role in distinguishing word classes in sign languages and in deriving new lexical items.

Tab. 5.1: Two types of sign-language morphology

SIMULTANEOUS	SEQUENTIAL
− Adds morphological material by changing features of formational elements (mainly the movement component)	− Adds morphological material by adding phonological segments to a base
− Preferred in the sign modality	− Less preferred in the sign modality
− Both inflectional and derivational	− Only derivational
− Numerous in different sign languages	− Relatively sparse in different sign languages
− Motivated to various degrees, related to spatial cognition	− Tend to be more arbitrary
− Not grammaticized from free words	− Grammaticized from free words

4. Word classes

4.1. Introduction

Word classes are often referred to as 'parts of speech', from Latin *pars orationis*, literally 'piece of what is spoken' or 'segment of the speech chain'. Although the two terms

are used interchangeably in current linguistic practice (a practice which I follow in this chapter as well) it should be pointed out that, for the Greeks and Romans, the primary task was to divide the flow of speech into recognizable and repeatable pieces (hence parse). Categorizing was secondary to identification (Aronoff, p.c.). In this chapter, however, we will concern ourselves with categorization and classification.

There are various ways to classify the words of a given language. However, the term 'word classes' usually refers to classification of words according to their syntactic and morphological behavior, e.g., the ability to appear in a certain syntactic environment, to assume a specific syntactic role (argument, predicate, modifier), and to co-occur with a particular set of inflectional affixes. Many of the words belonging to the same class also share some aspect of meaning. For example, words which typically occur in argument position and take number and case inflections often denote entities, whereas words occurring in predicate position and taking tense inflection often denote events. Yet there is no full overlap between a semantically based classification and a morpho-syntactic one, making the classification of any given language challenging, and a cross-linguistic comparison even more so.

The first major division of words in the lexicon is into content words and function words. Content word classes are generally open (i.e. they have large numbers and accept new members easily and regularly) and they tend to have specific meaning, usually extra-linguistic (they are used to refer to the world or to a possible world). They tend to be fairly long, and their text frequency is rather low (Haspelmath 2001). Function words usually belong to small and closed classes. They are usually defined by their function as they do not have concrete meaning, they tend to be quite short, and their text frequency is high. A few function word classes in sign languages are explored in other chapters of this volume: pronouns (chapter 11) and auxiliary verbs (chapter 10). Other function word classes mentioned in the sign language literature are numerals (see e.g., Fuentes/Tolchinsky 2004), question words and negative words (Zeshan 2004a,b; see also chapters 14 and 15). In this chapter the focus is on content class words. Function words will be mentioned only when they are relevant for diagnosing specific content class words.

The major content word classes are nouns, verbs, adjectives, and adverbs. It is an empirical question whether this classification is universal, and whether the same set of criteria can be applied cross-linguistically to identify and define the different classes in every language. Clearly, languages vary greatly in their syntactic and morphological structures. Therefore syntactic and morphological criteria can be applied only on a language-particular basis. For a cross-linguistic study, a semantically-based classification would be much more feasible, since all languages presumably have words to refer to different concept classes such as entities, events, and properties. But, as pointed out above, semantic criteria often do not fully overlap with morpho-syntactic criteria for any particular language. The challenge, then, is to develop a set of criteria that would be descriptively adequate for particular languages, and at the same time would enable cross-linguistic comparison. As Haspelmath (2001) points out, the solution that is usually adopted (often implicitly) is to define word classes on a language-particular basis using morpho-syntactic criteria, and then use semantic criteria for labeling these classes: the word class that includes most words for things and persons is called 'noun'; the one that includes most words for actions and processes is called 'verb'; etc. It is also usually the case that the correspondences 'thing-noun' and 'action-verb' are the

unmarked extension of the respective word class. Marked extensions are often indicated by derivational affixes. This methodology implicitly assumes some kind of semantic basis for word classification, and that this basis is universal. Such assumptions should be tested by studying languages that are typologically diverse as much as possible. Sign languages, as languages produced in a different modality, constitute a very good test case.

4.2. Word classes in the signed modality

Sign languages, like spoken languages, have lexicons consisting of lexemes of different types that refer to different notions (entities, actions, states, properties, etc.) and combine with each other to form larger units, phrases, and sentences. However, as a group, sign languages differ from spoken languages in three major respects relevant for the present discussion. Firstly, and most obviously, they are articulated and transmitted in a different modality from spoken languages. Secondly, sign languages as a group are much younger than spoken languages. And finally, the field of sign language linguistics is young, having emerged only a few decades ago.

The modality difference raises several questions:

(i)   Would languages in a different modality display different kinds of word classes? For example, would the spatial nature of sign languages give rise to a word class that denotes spatial relations?
(ii) Would iconicity play a role in differentiating between word classes?
(iii) Do languages in a different modality have different set of properties to distinguish between word classes?
(iv) Do we need to develop a totally different set of tools to categorize signs?

Sign languages as a group are also much younger than spoken languages. Spoken languages are either several millennia or several hundred years old, or they are derived from old languages. In contrast, the oldest sign languages known to us today are about 300 years old or so (for BSL, see Kyle and Woll 1985; for French Sign Language (LSF), see Fischer 2002) and some are much younger: Israeli SL is about 75 years old (Meir/ Sandler 2008), and Nicaraguan Sign Language (ISN) is about 35 years old (Senghas 1995). It may very well be that sign languages existed in older times, but they left no records and therefore cannot be studied. All we know about sign languages comes from studying the sign languages available to us today, and these are young. Young spoken languages, creoles, are characterized by dearth of inflectional morphology (McWhorter 1998). Furthermore, the lexicons of both creoles and pidgins are described as consisting of many multifunctional words, that is, words used both as nouns and verbs, or nouns and adjectives. For example, *askim* in Tok Pisin can function both as a noun and as a verb (Romaine 1989, 223). As we shall see, multifunctionality is characteristic of sign languages as well. Therefore, word classification in young languages cannot rely on morphology.

These two factors, modality and young age, contribute to the fact that sign languages as a group form a distinct typological morphological type (Aronoff/Meir/Sandler 2005). As new languages they hardly have any sequential morphology. They lack nominal

inflections such as case and gender inflections. They also do not have tense inflections on verbs. These inflectional categories are key features in determining word classes in many spoken languages (though, of course, many spoken languages lack such inflectional categories, and therefore similar difficulties for word classification arise). On the other hand, as visuo-spatial languages, they are characterized by the rich spatial (simultaneous) morphology described in section 3. Can spatial modulations play a role in determining word classes as morphological inflections of spoken languages? Would they identify the same word classes found in spoken languages?

In addition to the youth of the languages, the field of sign language linguistics is also new, dating back to the early 1960s. In analyzing the linguistic structure of sign languages, sign linguists often rely on theories and methodologies developed on the basis of spoken languages. Since linguistics as a field is much older than sign linguistics, it makes sense to rely on what is known about how to study spoken languages. It also has the advantage of making it possible to compare findings in the two types of languages. However, it runs the risk of analyzing sign languages through the lens of spoken languages, and missing important phenomena if they are unique to sign languages (see, e.g., Slobin 2008 on this issue).

These three factors − modality, youth of language, and youth of field − make the study of word classes in sign languages challenging and non-trivial. Indeed systematic studies of word classification in sign languages are very few. Though terms such as *noun, verb, adjective, pronoun,* etc. are abundant in the sign language literature, there have been very few attempts at principled word classification of any studied sign language, and very few researchers explicitly state on what grounds the terms 'noun', 'verb', etc. are used. However, as the sign language linguistics field expands, more linguistic operations and structures are discovered which can be helpful in determining word classes in sign languages. We turn to look at some classifications that have been suggested, and to examine the means by which sign languages differentiate between word classes.

4.3. Word classifications suggested for sign languages

The earliest attempt to provide criteria for identifying word classes of a sign language lexicon is found in Padden (1988). She suggests the following criteria for identifying the three major content word classes in ASL: Nouns can be modified by quantifiers, adjectives can inflect for intensive aspect, and verbs cannot be pre-modifiers of other signs. Under this classification, nouns and verbs are defined on distributional syntactic grounds, and adjectives on morphological grounds. Notice that verbs are only defined negatively, probably because there is no inflection common to all and only verbs in the language. Also, it is not clear that this set of criteria applies to all and only the members of a certain class.

Zeshan (2000) suggests a word classification of IPSL according to the spatial characteristics of signs. One class consists of signs that cannot move in space at all, a second class consists of signs that are produced in neutral space and can be articulated in various locations in space, and the third class consists of directional signs, that is signs that move between locations in space associated with referents. The criterion of spatial behavior is clearly modality specific, since words in spoken languages do not have

spatial properties. Therefore, such an analysis, even if it provides a descriptively ad-equate analysis of a particular language, does not allow for cross-modality comparisons and generalizations. In addition, it is not clear whether such a classification has any syntactic and semantic corollaries within the language. For example, the class of signs that cannot move in space includes signs meaning 'understand', 'woman' and 'I' (Ze-shan 2000, 58). These signs do not seem to have any semantic commonality, and it is doubtful whether they have anything in common syntactically. Therefore, the useful-ness of this classification does not extend beyond a purely formational classification.

Recently, a comprehensive and methodological attempt to establish a set of criteria for defining word classes in sign languages has been posited by Schwager and Zeshan (2008). Their goal is to develop a cross-linguistically applicable methodology that would give adequate descriptive results for individual languages. They explicitly take the semantics as a starting point, since the semantic classification is cognitively-based and hence language independent. They compile a set of binary semantic features that define three basic concept classes: entity, event, and property. After assigning signs to different classes based on their semantics, Schwager and Zeshan proceed to examine how signs in each concept class map to syntactic roles and morphological operations. Four basic syntactic roles are listed: argument, predicate, argument modifier, and predi-cate modifier. As for morphological criteria, a list of 17 morphological processes that have been described in the sign linguistics literature is compiled. These processes are classified according to the concept classes they co-occur with.

In order to test the validity of their approach, they apply it to corpora compiled from three unrelated sign languages: German Sign Language (DGS), Russian Sign Language (RSL), and Sign Language of Desa Kolok (KK), a sign language that devel-oped in a small village community in Bali with high incidence of hereditary deafness. Words with comparable meanings were identified and extracted from the corpora, and were analyzed according to the procedure described above. This comparison pinpoints both similarities and differences between the languages. Even at the semantic level, signs referring to similar concepts may not belong to the same concept class in the two languages. For example, the sign DEAF in DGS may refer to a person or a property, while in KK it refers only to a person. Therefore, in DGS this sign will be listed both as an entity and as a property, while in KK it is classified only as an entity. In consider-ing the combination of concept classes with syntactic roles, some more interesting dif-ferences emerge. DGS, but not KK, has event signs that can be used in argument position. The sign WORK, for example, can be used in predicate position, but also in argument position, as in (1) (Schwager/Zeshan 2008, 534, example 26). Also, in DGS signs denoting properties can assume a modifier or a predicate position, whereas in KK they are restricted to predicate position.

(1)   WORK FIND DIFFICULT#INTS(intensive)   [DGS]
        'It is very difficult to find a job.'

The list of morphological modulations serves as a useful tool for identifying the mor-phological nature of different sign languages. KK has far fewer morphological proc-esses than DGS and RSL, especially in the event class. Of the 13 processes listed for events, KK has only 3, while DGS and RSL have 11 each. Therefore KK is much more isolating than the two other languages, and morphological operations are much less helpful in establishing word classes in this language.

These results show that, as in spoken languages, different sign languages vary in terms of their word classes. However, it might be that the variation in the signed modality is less extreme than that found among languages in the spoken modality. Further comparative studies of sign languages, and of sign vs. spoken languages, is needed to assess this intuitive observation.

One type of evidence that is not used in their analysis is distributional evidence, such as the co-occurrence of signs with certain function word classes. Distributional properties are language-specific, and hinge on identifying the relevant function words and syntactic environments for each language. Yet some cross-linguistic generalizations can be made. For examples, nouns are more likely to co-occur with pointing signs (often termed INDEX or IX), and can serve as antecedents for pronouns. Verbs are more likely to co-occur with auxiliary verbs. As I point out below, some such observations have already been made for different languages, and it is hoped that they will be incorporated in future investigations of sign language word classes.

In spite of the lack of distributional evidence, Schwager and Zeshan's analysis shows that it is possible to arrive at a systematic, theoretically sound approach to word classification in sign languages. Such an analysis provides descriptions of word classes of specific languages, but also allows for cross-linguistic and cross-modality comparisons.

4.4. Means for differentiating between specific word classes

Though very few works try to establish general criteria for determining word classes of the entire lexicon of a sign language, many works target more restricted domains of the lexicon, and describe certain structures and processes that apply to specific classes or sub-parts of classes. These involve both morphological and distributional criteria.

4.4.1. Noun-verb pairs

Descriptions of various sign languages often comment that many signs are multifunctional, and can serve both as a nominal and as a verb (denote an entity or an event). This is not surprising given the young age of sign languages, but it has also been argued to be modality driven. The following paragraph is from an introduction to the first dictionary of Israeli SL (Cohen/Namir/Schlesinger 1977, 24):

> Two concepts which in spoken language are referred to by words belonging to different parts of speech will often have the same sign in sign language. The sign for sew is also that for tailor, namely an imitation of the action of sewing ... eat and food are the same sign ... and to fish is like fisherman ... In English, as in many other languages, words of the same root belonging to different parts of speech (like 'bake' and 'baker') are often distinguished inflectionally. They are denoted by the same sign in sign language since it has neither prefixes nor suffixes. These, being non-iconic, would seem to be out of tune with a language in which many signs have some degree of transparency of meaning, and are therefore unlikely to arise spontaneously in a sign language.
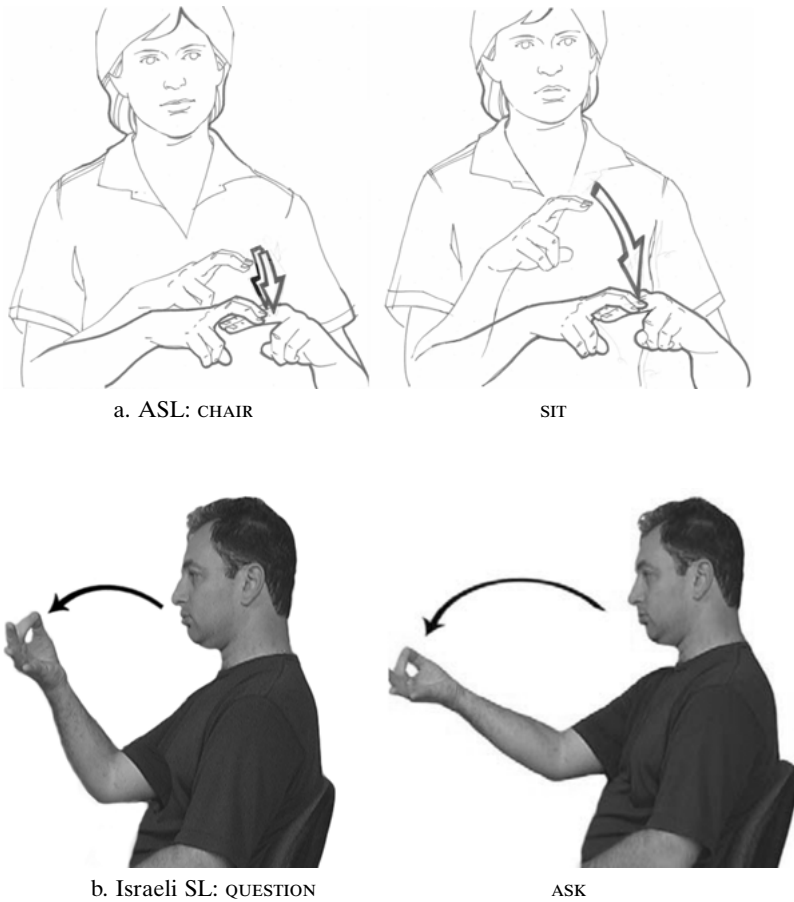
a. ASL: CHAIR   SIT

b. Israeli SL: QUESTION   ASK

Fig. 5.2: a. ASL noun-verb pair: CHAIR-SIT; b. Israeli SL noun-verb pair: QUESTION-ASK. Figure a reprinted wth permissions from Padden (1988). Figure b Copyright © 2011 by Sign Language Lab, University of Haifa. Reprinted with permission.

Given the propensity of sign languages towards iconicity, and the non-iconicity of sequential derivational affixes, those affixes comparable to, e.g., *-tion*, *-ize*, and *-al* in English are not expected to be found in sign languages. Yet several studies of noun-verb pairs show that it is not impossible to distinguish formationally between word classes in a sign language. However, one has to know what to look for. It turns out that subtle differences in the quality of the movement component of certain signs may indicate the word class of specific signs.

The first work to show that nouns and verbs may exhibit systematic formational differences is Supalla and Newport (1978). They describe a set of 100 related noun-verb pairs, where the nouns denote an instrument, and the verb an action performed with or on that instrument, e.g., SCISSORS and CUT-WITH-SCISSORS, CHAIR and TO-SIT (see Figure 5.2a) or IRON and TO-IRON. These pairs differ systematically in the properties of

the movement component: in nouns it is reduplicated, restricted, and constrained; the movement of the related verbs is not.

Following their seminal work, similar phenomena have been attested in various sign languages. Sutton-Spence and Woll (1999, 109) report that in BSL noun-verb pairs, e.g., SERMON-PREACH, nouns have a restrained, abrupt end and verbs do not. This specific example shows that signs exhibiting this alternation are not necessarily restricted to instrument-action pairs. Similarly, in Israeli SL formationally related nouns and verbs, the verbs typically have a longer movement, as in QUESTION vs. ASK (Meir/Sandler 2008, see Figure 5.2b). In Russian Sign Language as well, qualities of the movement component were the most reliable properties distinguishing nouns from verbs (Kimmelman 2009): nouns but not verbs (in noun-verb pairs) tend to have repeated movements, and verbs tend to have wider movement amplitude than the corresponding nouns. Johnston (2001) provides an explanation for the repeated movement of nouns but not their paired verbs in Auslan. In this language, the best exemplars of the alternation are signs referring to actions which are inherently reversible, such as OPEN-SHUT (e.g., turning a knob, opening and shutting a drawer, turning a key). The signs representing these actions and entities are iconic, their direction of movement depicting the direction of the action. It is this iconicity that is the basis for the noun-verb distinction: a single movement in one of the two possible directions is interpreted as a process (one of the two possible processes), while a repeated bi-directional movement is interpreted as naming a salient participant in the action, the participant on which the action in both directions is performed (the knob, the drawer, or the key in the actions mentioned above).

The formational difference between nouns and verbs may be rooted in iconicity, as suggested by Johnston, but in some sign languages this formational difference has expanded to non-iconic cases as well, suggesting that the form is taking a life of its own. Hunger (2006) measured the duration (in terms of numbers of frames) of 15 noun-verb pairs in Austrian Sign Language (ÖGS) both in isolation and in connected speech. Her results show that verbs do indeed take twice as long to produce as nouns. Interestingly, the longer duration of verbs characterizes even verbs which are not inherently durational (e.g., BOOK-OPEN, PHOTOGRAPH, LOCK). Therefore, Hunger concludes that the longer duration of verbal signs cannot be attributed to iconicity effects. Rather, this formational difference "can be interpreted as a distinctive marker for verbal or nominal status" (p. 82).

The lesson to be learned from these studies is that word classes can be distinguished formationally in the signed modality, by recruiting the movement component of signs for the task. Although this device may be rooted in iconicity, in some languages it seems to have already extended beyond the iconically-based set of signs, and is on its way to becoming a formal morphological entity.

4.4.2. Inflectional modulations

One of the most commonly used criteria for determining word classes in spoken languages is morphological inflections. Inflectional affixes are very selective with respect to the lexical base they attach to (Zwicky/Pullum 1983). A group of words that take a particular inflectional affix can therefore be regarded as belonging to one class. Notice,

however, that the term 'affix', which is commonly used for a concrete sequential morpheme, can be also used to refer to a process or a change in features that is expressed simultaneously on the inflected word.

In sign languages, inflections take the form of modulations to the movement component of the sign. Numerous inflections have been described in the literature, the main ones being:

Verbs:	(a) Encoding arguments: verb agreement; reciprocal; multiple; exhaustive.
	(b) Aspect: habitual; durational; continuative; iterative; protractive; delayed completive; gradual.
Nouns:	plurality.
Predicative adjectives:	pre-dispositional; susceptative; continuative; intensive; approximative; iterative; protractive.

What all these inflections have in common is that they make use of the movement component of the sign in order to encode specific grammatical categories. For example, the intensive inflection of adjectives in Israeli SL imposes lengthening of the movement on the base sign (Sandler 1999). In ASL this inflection takes the form of increased length of time in which the hand is held static for the first and last location (Sandler 1993, 103−129). Many aspectual modulations, such as the durational and iterative, impose reduplicated circular movement on the base sign.

Most of the inflections occur on verbs and adjectives, suggesting that inflectional modulations are restricted to predicate position. Since several inflections occur on both verbs and adjectives (e.g., continuative, iterative, protractive), it may be that these inflections are diagnostic of a syntactic position more than a specific word class. This, however, should be determined on a language-specific basis.

The use of these inflections for determining word classes is somewhat problematic. Firstly, morphological classes often do not coincide with concept classes. No single morphological operation applies across the board to all members of a particular concept class. For example, Klima and Bellugi (1979) describe several adjectival inflections, but these co-occur only with adjectives denoting a transitory state. Verb agreement, which in many spoken languages serves as a clear marker of verbs, characterizes only one sub-class of verbs in sign languages, agreement verbs. Secondly, many of these operations are limited in their productivity, and it is difficult to determine whether they are derivational or inflectional (see Engberg-Pedersen 1993, 61−64, for Danish Sign Language (DSL); Johnston/Schembri 1999, 144, for Auslan). Thirdly, since all these inflections involve modulation of the movement component, sometimes their application is blocked for phonological reasons. Body anchored verbs, for instance, cannot inflect for verb agreement. Inflectional operations, then, cannot serve by themselves as diagnostics for word classes. But, as in spoken languages, they can help in establishing word classes for particular languages, with corroborative evidence from semantic, syntactic, and distributional facts.

4.4.3. Word-class-determining affixes

Although a language may lack formational features characterizing the part of speech of base words, it may still have certain derivational affixes that mark the resulting word

as belonging to a certain part of speech. The forms of English *chair*, *sit*, and *pretty* do not indicate that they are a noun, a verb, and an adjective respectively. But *nation*, *nationalize* and *national* are marked as such by the derivational suffixes *-tion*, *-ize*, and *-al* in their form.

Can we find similar cases in sign languages? In general, sequential affixation is quite rare in sign languages, as discussed above. Of the descriptions of affixes found in the literature, very few refer to the part of speech of the resulting words. Two relevant affixes are described in Israeli SL, and two in Al-Sayyid Bedouin Sign Language (ABSL), a language that emerged in a Bedouin village in Israel in the past 70 years.

Aronoff, Meir and Sandler (2005) describe a class of prefixes in Israeli SL that derive verbs. This class includes signs made by pointing either to a sense organ − the eye, nose, or ear − or to the mouth or head. Many of the complex words formed with them can be glossed 'to X by seeing (eye)/hearing (ear)/thinking (head)/intuiting (nose)/saying (mouth)', e.g., EYE+CHECK 'to check something by looking at it'; NOSE+SHARP 'discern by smelling'; MOUTH+RUMORS 'to spread rumors'. But many have idiosyncratic meanings, such as NOSE+REGULAR 'get used to' and EYE+CATCH 'to catch red handed' (see Figure 5.3). Although the part of speech of the base word may vary, the resulting word is almost always used as a verb. For example, the word EYE/NOSE+SHARP means 'to discern by seeing/smelling', though SHARP by itself denotes a property. In addition to their meaning, distributional properties of these complex words also support the claim that they are verbs: they co-occur with the negative sign glossed as ZERO, which negates verbs in the language. Aronoff, Meir and Sandler conclude that the prefixes behave as verb-forming morphemes.
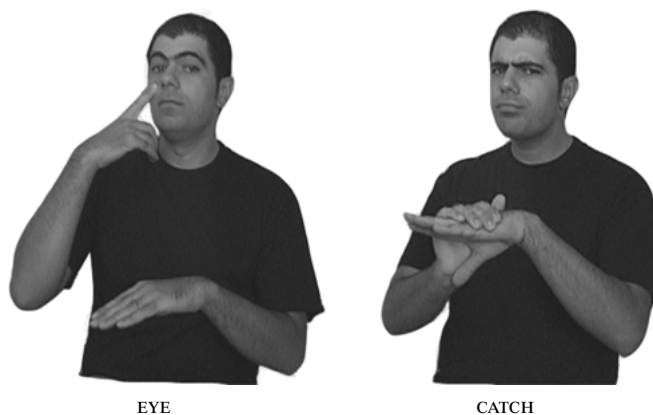

EYE   CATCH

Fig. 5.3: Israeli SL sign with a verb-forming prefix: EYE+CATCH 'to catch red handed'. Copyright © 2011 by Sign Language Lab, University of Haifa. Reprinted with permission.

Another Israeli SL affix is a suffix glossed as -NOT-EXIST, and its meaning is more or less equivalent to English *-less* (Meir 2004; Meir/Sandler 2008, 142−143). This suffix attaches to both nouns and adjectives, but the resulting word is invariably an adjective: IMPORTANT+NOT-EXIST means 'of no import', and SUCCESS+NOT-EXIST 'without success, unsuccessful'. The main criterion for determining word class in this case is semantic: the complex word denotes a property ('lacking something').
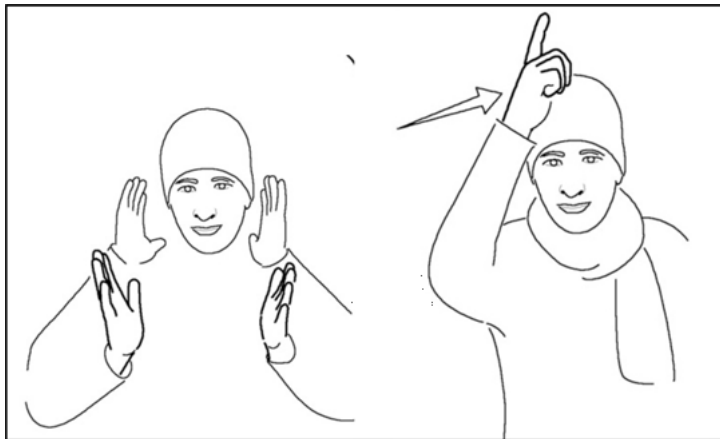
a. PRAY THERE
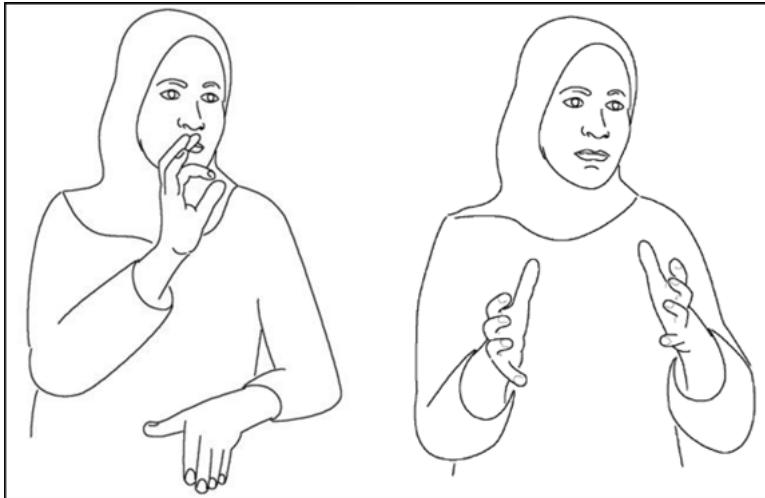
b. DRINK TEA+ROUND-OBJECT

Fig. 5.4: Two ABSL complex words with suffixes determining word class: a. Locations: PRAY+THERE 'Jerusalem'; b. Objects: DRINK-TEA+ROUND-OBJECT 'kettle'. Copyright © 2011 by Sign Languge Lab, University of Haifa. Reprinted with permission.

An interesting class of complex words has been described in ABSL, whose second member is a pointing sign, indicating a location (Aronoff et al. 2008; Meir et al. 2010). The complex words denote names of locations − cities and countries, as in LONG-BEARD+THERE 'Lebanon', HEAD-SCARF+THERE 'Palestinian Authority', PRAY-THERE 'Jerusalem' (see Figure 5.4a). If locations are regarded as a specific word class, then these words contain a formal suffix indicating their classification (parallel to English -*land* or -*ville*).

Finally, another set of complex words in ABSL refers to objects, and contains a component indicating the relative length and width of an object by pointing to various parts of the hand and arm, functionally similar to size and shape specifiers in other sign languages (Sandler et al. 2010; Meir et al. 2010). The complex signs refer to objects, and are therefore considered as nouns, though the base word may be a verb as well: CUT+LONG-THIN-OBJECT is a knife, DRINK-TEA+ROUND-OBJECT is a kettle (Figure 5.4b).

4.4.4. Co-occurrence with function words

Function words are also selective about their hosts. Therefore, restrictions on their distribution may serve as an indication of the word class of their neighbors. Padden (1988) defines the class of nouns on distributional grounds, as the class of signs that can be modified by quantifiers. Hunger (2006), after establishing a formational difference between nouns and verbs in ÖGS, notices that there are some distributional corollaries: modal verbs tend to occur much more often next to verbs than next to nouns. On the other hand, indices, adjectives, and size and shape classifiers (SASS) are more often adjacent to nouns than to verbs.

Another type of function words that can be useful in defining word classes is the class of negation words. Israeli SL has a large variety of negators, including, inter alia, two negative existential signs (glossed as NEG-EXIST-1, NEG-EXIST-2) and two signs that are referred to by signers as 'zero' (glossed as ZERO-1, ZERO-2). It turns out that these two pairs of signs have different co-occurrence restrictions (Meir 2004): the former co-occurs with nouns (signs denoting entities, as in sentence (2), below), the latter with verbs (signs denoting actions, as in sentence 3). In addition, signs denoting properties are negated by NOT, the general negator in the language, and cannot co-occur with the other negators (sentence 4).

(2)   IX$_1$COMPUTER NEG-EXIST-1/*ZERO-1/2/*NOT   [Israeli SL]
        'I don't have a computer.'

(3)   IX$_3$ SLEEP ZERO1/2/*NEG-EXIST-1/2
        'He didn't sleep at all/He hasn't slept yet.'

(4)   CHAIR IX$_A$ COMFORTABLE NOT/*ZERO-1/2/*NEG-EXIST-1/2
        'The chair is/was not comfortable.'

Finally, in Israeli SL a special pronominal sign evolved from the homophonous sign PERSON, and is in the process of becoming an object clitic, though it has not been fully grammaticalized yet (Meir 2003, 109−140). This sign co-occurs with verbs denoting specific types of actions, but crucially it attaches only to verbs. This conclusion is supported by the fact that all the signs that co-occur with this pronominal sign are also negated by the ZERO signs described above.

4.4.5. Co-occurrence with non-manual features

Non-manual features such as facial expressions, head nod, and mouthing play various grammatical roles in different sign languages (Sandler 1999). In this, they are quite

similar to function words, and their distribution may be determined by the word class of the sign they co-occur with. In various sign languages, some facial expressions have been described as performing adverbial functions, modifying actions or properties (e.g., ASL: Baker/Cokely 1980; Liddell 1980; Anderson/Reilly 1998; Wilbur 2000; Israeli SL: Meir/Sandler 2008; BSL: Sutton-Spence/Woll 1999). These facial expressions can be used as diagnostic for word classes, since their meaning is clearly compatible with specific concept classes. Israeli SL has facial expressions denoting manner such as 'quickly', 'meticulously', 'with effort', 'effortlessly', which modify actions, and can be used as diagnostics for verbs.

In some sign languages (i.e., many European sign languages) signers often accompany manual signs with mouthing of a spoken language word. Mouthing turns out to be selective as well. In the studies of noun-verb pairs in ÖGS and Auslan, it was noticed that mouthing is much more likely to occur with nouns rather than with verbs. In ÖGS, 92 % percent of the nouns in Hunger's (2006) study were accompanied by mouthing, whereas only 52 % of the verbs were. In Auslan, about 70 % of the nouns were accompanied by mouthing, whereas only 13 % of the verbs were (Johnston 2002).

4.4.6. Conclusion

At the beginning of this section we questioned whether sign languages are characterized by a different set of word classes because of their modality. We showed that it is possible to arrive at a theoretically based classification that can be applied to both types of languages, using similar types of diagnostics: meaning, syntactic roles, distribution, morphological inflections, and derivational affixes. The main diagnostics discussed in this section are summarized in Table 5.2 below. The main content classes, nouns, verbs, and adjectives, are relevant for languages in the signed modality as well. On the other hand, there are at least two types of signs that are clearly spatial in nature: one is classifier construction (see chapter 8), whose word class status has not been determined yet, and might turn out to require different classification altogether. The other type consists of two sub-classes of verbs, agreement verbs and spatial verbs, the classes of verbs that 'move' in space to encode agreement with arguments or locations. These classes are also sign language specific, though they belong to the larger word class of verbs.

Are there any properties related to word classes that characterize sign languages as a type? Firstly, more often than not, the form of the sign is not indicative of its part of speech. For numerous sign languages, it has been observed that many signs can be used both as arguments and as predicates, denoting both an action and a salient participant in the action, and often a property as well. This is, of course, also true of many spoken languages. Secondly, morphological inflection is almost exclusively restricted to predicate positions. Nominal inflections such as case and gender are almost entirely lacking (for number see chapter 6, Plurality). Thirdly, space plays a role in determining sub-classes within the class of verbs; although not all sign languages have the tri-partite verb classification into agreement, spatial, and plain verbs, only sign languages have it.

It is important to note that there are also differences between individual sign languages. The sequential affixes determining word classes are clearly language specific, as are the co-occurrence restrictions on function words. Inflectional modulations, which

Tab. 5.2: Main diagnostics used for word classification in different sign languages

		Nouns	Verbs	Adjectives
semantic	Concept class	Entity	Event	Property
syntactic	Syntactic position	Argument Predicate	Predicate	Modifier Predicate
	Syntactic co-occurrences	Quantifiers Specific negators Determiners	Specific negators Pronominal object clitic	
morphological	Formational characterization	Short and/or reduplicated movement (with respect to comparable verbs)	Longer non-reduplicated movement (with respect to comparable nouns)	
	Inflectional modulations	Plurality	(a) Encoding arguments: verb agreement; reciprocal; multiple; exhaustive. (b) Aspect: habitual; durational; continuative; iterative; protractive; delayed completive; gradual.	Predispositional; susceptative; continuative; intensive; approximative; iterative; protractive.
	Word-class determining affixes	SASS suffixes	'sense'-prefixes	Negative suffix ('not-exist')
	Co-occurrence with facial expressions	Mouthing	Adverbial facial expressions	

are pervasive in sign languages, also vary from one language to another. Not all sign languages have verb agreement. Aspectual modulations of verbs and adjectives have been attested in several sign languages. Specific modulations, such as the protractive, predispositional, and susceptative modulations, have been reported of ASL, but whether or not they occur in other sign languages awaits further investigation.

5. Word formation

Morphology makes use of three main operations: compounding, affixation, and reduplication. These operations can be instantiated sequentially or simultaneously. The visuo-spatial modality of sign languages favors simultaneity, and offers more possibili-

ties for such structures and operations, which are highlighted in each of the following sub-sections.

Three additional means for expanding the lexicon are not discussed in this chapter. The first is borrowing, which is discussed in chapter 35. The second is conversion or zero-derivation, that is, the assignment of an already existing word to a different word class. As mentioned above, many words in sign languages are multifunctional, serving both as nouns and verbs or adjectives. It is difficult to determine which use is more basic. Therefore, when a sign functions both as a noun and as a verb, it is difficult to decide whether one is derived from the other (which is the case in conversion), or whether the sign is unspecified as to its word-class assignment, characteristic of multi-functionality. Finally, backformation is not discussed here, as I am not aware of any potential case illustrating it in a sign language.

5.1. Compounding

A compound is a word composed of two or more words. Compounding expands vocabulary in the language by drawing from the existing lexicon, using combinations of two or more words to create novel meanings. Compounding seems to be necessarily sequential, as new lexical units are formed by the sequential co-occurrence of more basic lexical items. Yet sign languages may potentially offer simultaneously structured compounds too. Since the manual modality has two articulators, the two hands, compounds may be created byarticulating two different signs simultaneously, one with each hand. We will discuss sequential compounds first, and then turn to examine several structures that could be regarded as simultaneous compounding.

5.1.1. Sequential compounding

Compounds are words. As such, they display word-like behavior on all levels of linguistic analysis. They tend to have the phonological features of words rather than phrases. For example, in English and many other languages, compounds have one word stress (e.g., a *gréenhouse*), like words and unlike phrases (*a greén hóuse*). Semantically, the meaning of a compound is often, though not always, non-compositional. A greenhouse is not a house painted green, but rather "a building made mainly of glass, in which the temperature and humidity can be regulated for the cultivation of delicate or out-of-the season plants" (*Webster's New World Dictionary*, Third College Edition). It is usually transparent and not green. Syntactically, a compound behaves like one unit: members of a compound cannot be interrupted by another unit, and they cannot be independently modified. *A dark greenhouse* is not a house painted dark green. These properties of compounds may also serve as diagnostics for identifying compounds and distinguishing them from phrases.

Properties of sign language compounds: Sign languages have compounds too. In fact, this is the only sequential morphological device that is widespread in sign languages. Some illustrative examples from different languages are given in Table 5.3. As in spoken languages, sign language compounds also display word-like characteristics. In their

seminal study of compounds in ASL, Klima and Bellugi (1979, 207−210) describe several properties that are characteristic of compounds and distinguish them from phrases. Firstly, a quick glance at the examples in Table 5.3 shows that the meaning of compounds in many cases is not transparent. The ASL compound BLUE^SPOT does not mean 'a blue spot', but rather 'bruise'. HEART^SUGGEST (in Israeli SL) does not mean 'to suggest one's heart' but rather 'to volunteer', and NOSE^FAULT ('ugly' in Auslan) has nothing to do with the nose. Since the original meaning of the compound members may be lost in the compound, the following sentences are not contradictory (Klima/ Bellugi 1979, 210):

(5)   BLUE^SPOT GREEN, VAGUE YELLOW   [ASL]
      'That bruise is green and yellowish.'

(6)   BED^SOFT HARD
      'My pillow is hard.'

Compounds are lexicalized in form as well. They tend to have the phonological appearance of a single sign rather than of two signs. For example, they are much shorter than the equivalent phrases (Klima/Bellugi 1979, 213), because of reduction and deletion of phonological segments, usually the movement of the first segment. The transitory movement between the two signs is more fluid. In some cases, the movement of the

Tab. 5.3: Examples of compounds in sign languages

ASL (Klima/Bellugi 1979)	BED^SOFT	'pillow'
	FACE^STRONG	'resemble'
	BLUE^SPOT	'bruise'
	SLEEP^SUNRISE	'oversleep'
BSL (Brennan 1990)	THINK^KEEP	'remember'
	SEE^NEVER	'strange'
	WORK^SUPPORT	'service'
	FACE^BAD	'ugly'
Israeli SL (Meir/Sandler 2008)	FEVER^TEA	'sick'
	HEART^OFFER	'volunteer'
	RESPECT^MUTUALITY	'tolerance'
Auslan (Johnston/Schembri 1999)	CAN'T^BE-DIFFERENT	'impossible'
	RED^BALL	'tomato'
	NOSE^FAULT	'ugly'
ABSL (Aronoff et al. 2008)	CAR^LIGHT	'ambulance'
	PRAY^HOUSE	'mosque'
	SWEAT^SUN	'summer'
IPSL (Zeshan 2000)	FATHER^MOTHER	'parents'
	UNDERSTAND^MUCH	'intelligent'
	POTATO^VARIOUS	'vegetable'
New Zealand Sign Language (NZSL) (Kennedy 2002)	NO^GERMS	'antiseptic'
	MAKE^DEAD	'fatal'
	READY^EAT	'ripe'

THINK   MARRY   BELIEVE

L1   M   **L2**   +   L3   M   **L4**   ➜   L2   M   L4
[prox] **[contact]**   [medial] **[contact]**   [contact]   [low]

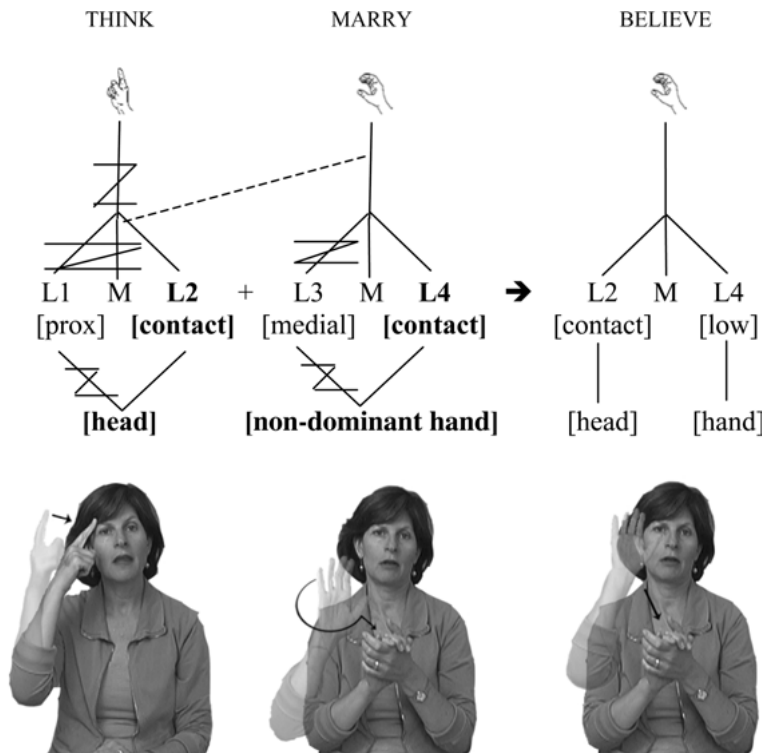**[head]**   **[non-dominant hand]**   [head]   [hand]

Fig. 5.5: The ASL signs (a) THINK and (b) MARRY, and the compound they form, (c) BELIEVE. Reprinted with permission from Sandler and Lillo-Martin (2006).

second component is also deleted, and the transitory movement becomes the sole movement of the compound, resulting in a monosyllabic sign with only one movement, like canonical simplex signs (Sandler 1999).

Changes contributing to the 'single sign' appearance of compounds are not only in the movement component, but also in hand configuration and location. If the second sign is performed on the non-dominant hand, that hand takes its position at the start of the whole compound. In many cases, the handshape and orientation of the second member spread to the first member as well (Liddell/Johnson 1986; Sandler 1989, 1993). Similar phenomena have been attested in Auslan as well (Johnston/Schembri 1999, 174). They point out that in lexicalized compounds often phonological segments of the components are deleted, and therefore they might be better characterized as blends.

As a result of the various phonological changes that can take place, a compound may end up looking very much like a simplex sign: it has one movement and one hand configuration. In the ASL compound BELIEVE (in Figure 5.5), for example, the first location (L1) and the movement (M) segments of the first member, THINK, are deleted. The second location (L2) becomes the first location of the compound, and the movement and final location segments are those of the second member of the compound,

MARRY. The only indication that BELIEVE is a compound is the fact that it involves two major locations, the head and the non-dominant hand, a combination not found in simplex signs (Battison 1978). These phonological changes are represented in (7), based on Sandler (1989):

(7)   The phonological representation of the ASL compound BELIEVE

Morphological structure: Compounding takes advantage of linear structure, but it also involves reorganization and restructuring. The members of a compound may exhibit different types of relationship. Endocentric compounds are those that have a head. The head represents the core meaning of the compound and determines its lexical category. The English compound *highchair* is endocentric, headed by the noun *chair*. Semantically, a highchair is a type of a chair, and morphologically it is a noun, the lexical category of its head. A compound such as *scarecrow* is exocentric: it is neither a 'crow' nor a 'scare'. Endocentric compounds are further classified according to the position of the head in the compound: right-headed (the head occurs in final position, as in *highchair*) and left-headed (the head occurs in initial position, as in Hebrew *gan-yeladim* 'kindergarten', literally 'garden-children'). It is commonly assumed that the position of the head in compounds is systematic in a language (Fabb 1998). English, for example, is characterized as right-headed, while Hebrew is left-headed.

Not much has been written on headedness in sign language compounds. Of the ASL examples presented in Klima and Bellugi, many are exocentric, e.g., SURE^WORK 'seriously', WILL^SORRY 'regret', WRONG^HAPPEN 'accidentally', FACE^STRONG 'resemble', WRONG^HAPPEN 'fate'. Most of the endocentric compounds described there are left-headed, EAT(FOOD)^NOON 'lunch', THINK^ALIKE 'agree', FLOWER^GROW 'plant', SLEEP^SUNRISE 'oversleep', but at least one, BLUE^SPOT 'bruise', is right-headed. In Israeli SL, compounds that have Hebrew counterparts are usually left-headed (PARTY^SURPRISE 'surprise party'), though for some signers they may be right-headed. Compounds that do not have Hebrew counterparts are often exocentric, e.g., FEVER^TEA 'sick', SWING^PLAY 'playground'. Verbal compounds are often right-headed, as in HEART^SUGGEST 'volunteer', and BREAD^FEED 'provide for'.

A third type of compound structure is the coordinate compound, where the members are of equal rank, as in *hunter-gatherer*, someone who is both a hunter and a gatherer. In a special type of coordinate compounds, the members are basic category-level terms of a superordinate term. The meaning of the compound is the superordinate term. This class of compounds, called also *dvandva* compounds (etymologically derived from Sanskrit *dvamdva*, literally, a pair, couple, reduplication of *dva* two), is not productive in most modern European languages, but occurs in languages of other families. Such compounds exist in ASL (Kilma/Bellugi 1979, 234−235): CAR^PLANE^TRAIN 'vehicle', CLARINET^PIANO^GUITAR 'musical instrument', RING^BRACELET^NECKLACE 'jewelry', KLL^STAB^RAPE 'crime', MOTHER^FATHER^BROTHER^SISTER 'family'. Like other compounds, they denote one concept, the movement of each component sign is reduced, and transitions between signs are minimal. However, there is a lot of individual variation in form and in the degree of productivity of these forms. Younger signers use them very little, and consider them to be old-fashioned or even socially stigmatized.

5.1.2. Simultaneous compounding

In principle, simultaneous compounding in sign languages can be of two types. In the first, each hand may produce a different sign, but the production is simultaneous. The second type combines certain phonological parameters from two different sources to create a single sign. In the latter type not all the phonological specifications of each compound member materialize, and therefore they may also be characterized as blends.

Examples of the first type are exceedingly rare. Two BSL examples are mentioned in the literature: MINICOM (a machine which allows typed messages to be transmitted along a telephone line, in Brennan 1990, 151), and SPACE-SHUTTLE (Sutton-Spence/Woll 1999, 103). The compound MINICOM is composed of the sign TYPE and the sign TELE-PHONE produced simultaneously: the right hand assumes the 🤙 handshape of the sign TELEPHONE, but is positioned over the left hand that produces the sign TYPE.

However, according to some analyses, simultaneous compounding is very wide-spread in sign languages. Brennan (1990) uses the term 'classifier compounds' for signs in which the non-dominant hand, and sometimes both hands, assumes a handshape of a classifier morpheme. For example, in the sign AQUADIVER the non-dominant hand in a 🖐 handshape represents a surface, and the dominant hand in an upright ✌ handshape moving downwards represents a person moving downwards from the surface. According to Brennan's analysis, any sign containing a classifier handshape on the non-dominant hand is a compound, even some so-called 'frozen' lexical items. A sign such as WRITE (in Israeli SL and many other sign languages), whose dominant hand has a ✍ handshape depicting the handling of a long thin object and moving it over a flat surface (represented by the non-dominant hand) is also a classifier compound under this account. Johnston and Schembri (1999, 171) refer to such constructions as "simultaneous sign constructions" rather than compounds, because they point out that such constructions may be phrasal or clausal. It should be pointed out that however these signs originated, they are lexical signs in every respect, and under most analyses, they are not regarded synchronically as compounds.

Two types of word formation process combine handshape from one source and movement and location from another: numeral incorporation, where the handshape represents a number (Stokoe et al. 1965; Liddell 1996 and works cited there), and initialization, in which the handshape is drawn from the handshape inventory of the manual alphabet (Stokoe et al. 1965; Brentari/Padden 2001). In addition, these processes are not usually analyzed as compounds, but rather as some kind of incorporation, affixation, or combination of two bound roots (e.g., Liddell 1996 on numeral incorporation). Whatever the analysis, they both combine elements from two sources, and in this they resemble compounding, but they do so simultaneously, a possibility available only for languages in the signed modality.

Numeral incorporation is usually found in pronominal signs and in signs denoting time periods, age, and money. In these signs the number of fingers denotes quantity. For example, the basic form of the signs HOUR, DAY, WEEK, MONTH, and YEAR in Israeli SL is made with a 👆 handshape. By using a ✌, 🤟, 🖖, or 🖐 handshape, the number of units is expressed. That is, signing the sign for DAY with a ✌ handshape means 'two days'. A 🤟 handshape would mean 'three days', etc. This incorporation of number in the signs

is limited in Israeli SL to five in signs with one active hand, and to 10 in symmetrical two-handed signs. Number signs in many sign languages have specifications only for handshape, and are therefore good candidates for participating in such simultaneous compounding (but see Liddell 1996 for a different analysis). But there are also restrictions on the base sign, which provides the movement and location specifications: usually it has to have a ✊ handshape, which can be taken to represent the number one. However, some counter-examples to this generalization do exist. In DGS, the sign YEAR has a 🖐 handshape, but this handshape is replaced by the above handshapes to express 'one/two/three etc. years'. Numeral incorporation has been reported on in many sign languages, e.g., ASL, BSL, Israeli SL, DGS, Auslan, and IPSL, among others. But there are sign languages that do not use this device. In ABSL numeral incorporation has not been attested, maybe because time concept signs in the language do not have a ✊ handshape (for numeral incorporation see also chapters 6 and 11).

Initialization is another type of simultaneous combination of phonological specifications from two different sources: a spoken language word and a sign language word. The handshape of an initialized sign represents a letter of the fingerspelled alphabet, corresponding to the first letter of the written form of an ambient spoken language word. This initialized handshape is usually added to a sign that already exists in the language, lending it an additional − often more specific − meaning for which there is no other sign. For example, the ASL signs FAMILY, ASSOCIATION, TEAM, and DEPARTMENT all share the movement and location of the sign GROUP, and are distinguished by the handshapes F, A, T, or D. As Brentari and Padden (2001, 104) point out, some initialized signs in ASL are not built on native signs, but they still form a semantic and a formational 'family'. Color terms, such as BLUE, PURPLE, YELLOW, and GREEN, are characterized by the same movement and location, although there is no general color sign on which they are based. The same holds for color terms and kinship terms in LSQ (Machabee 1995, 29−61, 47). In other cases, the movement and location may present iconically some feature of the concept. In LSQ, the sign for 'Roman' is performed with an R handshape tracing the form of a Roman military helmet above the head (Machabee 1995, 45). Initialization is found in other sign languages as well, e.g., Irish Sign Language (Ó'Baoill/Matthews 2002) and Israeli SL (Meir/Sandler 2008, 52). However, it is much less common in languages with a two-handed fingerspelling system, such as BSL, Auslan, and New Zealand Sign Language. In a one-handed fingerspelling system, each letter is represented solely by the handshape, which may then be easily incorporated in other signs, taking their location and movement features. In a two-handed system, each letter is identified by a combination and location (and sometime movement as well), so that it is much less free to combine with other phonological parameters (Cormier/Schembri/Tyrone 2008). More common in these languages are single manual letter signs, which are based on a letter of an English word, but with very limited types of movement of the dominant hand against the non-dominant hand.

5.2. Affixation

Though compounding is common in all studied sign languages, sequential affixation is very rare. This is partly due to the general preference in manual-visual languages for

more simultaneous structures. However, since compounds are not uncommon, simultaneity cannot be the sole factor for disfavoring sequential affixation. Another explanation, suggested by Aronoff, Meir and Sandler (2005), is the relatively young age of sign languages. Sequential derivational affixes in spoken languages are in many cases the result of grammaticalization of free words. Grammaticalization is a complex set of diachronic changes (among them reanalysis, extension, phonological erosion, and semantic bleaching) that take time to crystallize. Sign languages as a class are too young for such structures to be abundant (but see chapter 36). In addition, it might be the case that there are more affixal structures in sign languages that haven't been identified yet, because of the young age of the sign linguistic field.

How can one identify affixes in a language? What distinguishes them from compound members? First, an affix recurs in the language, co-occurring with many different base words, while compound members are confined to few bases. The suffix -*ness*, for example, is listed as occurring in 3058 English words (Aronoff/Anshen 1998, 245), while *green* (as in *greenhouse*, *greengrocer*, *greenmail*) occurs in about 30. In addition, affixes are more distant from their free word origin. While members of compounds usually also occur as free words in the language, affixes in many cases do not. Therefore, a morpheme that recurs in many lexical items in a language and in addition does not appear as a free form is an affix and not a compound member. Finally, allomorphy is much more typical of affixes than of compound members. This is to be expected, since affixes are more fused with their bases than compound members with each other. However, the difference between an affix and a compound member is a matter of degree, not a categorical difference, and can be hard to determine in particular cases.

5.2.1. Sequential affixation in sign languages

Very few sequential affixes have been mentioned in the sign language literature. As they are so rare, those affixes that were found were assumed to have evolved under the influence of the ambient spoken language. In ASL the comparative and superlative affixes (Sandler/Lillo-Martin 2006, 64) and the agentive suffix were regarded as English loan translations. However, recently Supalla (1998) argued, on the basis of old ASL films, that the agentive suffix evolved from an old form of the sign 'person' in ASL.

For three affixes it has been explicitly argued that the forms are indeed affixes and not free words or members of a compound: two negative suffixes, one in ASL and the other in Israeli SL, and a set of 'sense' prefixes in Israeli SL. All of these affixes have free form counterparts that are nonetheless significantly different from the bound forms, so as to justify an affixational analysis. The affinity between the bound and the free forms may indicate how these affixes evolved.

The suffix glossed as ZERO in ASL has the meaning 'not at all', and apparently evolved from a free sign with a similar meaning (Sandler 1996; Aronoff/Meir/Sandler 2005). However, the suffix and the base it attaches to behave like a single lexical unit: they cannot be interrupted by another element, and for some signers they are fused phonologically. As is often the case, some combinations of word+ZERO have an idiosyncratic meaning, e.g., TOUCH+ZERO 'didn't use it at all', and there are some arbitrary gaps in the lexical items it attaches to. What makes it more affix-like than compound-like is its productivity: it attaches quite productively to verbs and (for some signers) to

adjectives. Yet its distribution and productivity vary greatly across signers, indicating that it has not been fully grammaticized.

The Israeli SL negative suffix, mentioned in section 4.4.3, was apparently grammaticized from a negative word meaning meaning 'none' or 'not exist'. In addition to other characteristics typical of affixes, it also has two allomorphes: a one-handed and a two-handed variant, the distribution of which is determined by the number of hands of the base.

Another class of affixes is the 'sense' prefix described above. Similar forms have been reported in other sign languages, e.g., BSL (Brennan 1990), where they are treated as compounds. Indeed, such forms show that sometimes the distinction between compounds and affixed words is blurred. The reason that Aronoff, Meir and Sandler (2005) analyze these forms as affixes is their productivity. There are more than 70 such forms in Israeli SL, and signers often use these forms to create new concepts. In addition, signers have no clear intuition of the lexical class of prefixes; they are not sure whether pointing to the eye sign should be translated as 'see' or 'eye', or pointing to the nose 'smell' or 'nose' etc. Such indeterminacy is characteristic of affixes, but not of words. The fact that these forms are regarded as compounds in other languages may be due to lesser degree of productivity in other languages (for example, they are less prevalent in ASL), or to the fact that other researchers did not consider an affix analysis. However, their recurrence in many sign languages indicates that these signs are productive sources for word formation.

Two potential suffixes exist in ABSL. They were mentioned in section 4.4.3: the locative pointing signs, and the size and shape signs. At present, it is hard to determine whether these are affixed words or compounds, since not much is known about the structure of lexical items in ABSL. However, since these signs recur in a number of complex signs, they have the potential of becoming suffixes in the language.

5.2.2. Simultaneous affixation in sign language

The term 'simultaneous affixation' may seem to be contradictory, since affixation is usually conceived as linear. However, by now it should be clear that morphological information may be added not by *adding* segments, but rather by *changing* features of segments. Therefore, all the processes described above in which morphological categories are encoded by a change in the movement parameters of the base sign may be regarded as instances of simultaneous affixation.

All inflectional processes identified in the sign language literature to date make use of this formal device, and a few were described in section 4.4.2 above. But sign languages use this device for derivational purposes as well, as exemplified by the noun-verb pairs in section 4.4.1. Quite a few of the derivational processes involve reduplication, to which we turn in the next section. Here we mention derivational processes that involve changes to the movement component with no reduplication.

ASL has the means for deriving predicates from nouns. Klima and Bellugi (1979, 296) describe a systematic change to the movement of ASL nouns, forming predicates with the meaning of 'to act/appear like X', as in 'to act like a baby' from BABY, 'to seem Chinese' from CHINESE, and 'pious' from CHURCH. The derived predicates have a fast and tense movement with restrained onset.

Klima and Bellugi also point out that the figurative or metaphorical use of signs often involves a slight change in the movement of the base sign. A form meaning 'horny' differs slightly in movement from HUNGRY; 'to have a hunch' differs from FEEL. Similarly, differences in movement encode an extended use of signs as sentential adverbials, as in 'suddenly' or 'unexpectedly' from WRONG, or 'unfortunately' from TROUBLE. Yet in these cases both form and meaning relations are idiosyncratic, and appear only in particular pairs of words. These pairs show that movement is a very productive tool for indicating relationships among lexical items. But not all instances of movement difference are systematic enough to be analyzed as derivational.

Not only may the quality of the movement change, but also its direction. In signs denoting time concepts in a few sign languages, the direction of movement indicates moving forward or backwards in time. The signs TOMORROW and YESTERDAY in Israeli SL form a minimal pair. They have the same hand configuration and location, but differ in the direction of movement. In YESTERDAY the movement is backwards, and in TOMORROW it is forwards. Similarly, if a forward or backward movement is imposed on the signs WEEK and YEAR, the derived meanings will be 'next week/year' and 'last week/year'. This process is of very limited productivity. It is restricted to words denoting time concepts, and may be further restricted by the phonological form of the base sign. Furthermore, the status of the direction of movement in these signs is not clear. It is not a morpheme, yet it is a phoneme that is meaning-bearing (see the discussion of sign families in section 2.2). Nonetheless, within its restricted semantic field, it is quite noticeable.

5.3. Reduplication

Reduplication is a process by which some phonological segment, or segments, of the base is repeated. Yet what is repeated may vary. It could be the entire base, as in Walbiri *kurdu-kurdu* ('children', from *kurdu* 'child'; in Nash 1986); a morpheme; a syllable; or any combination of segments, such as the first CVC segment of the base, as in Agta *tak-takki* ('legs', from *takki* 'leg', Marantz 1982). Function-wise, reduplication lends itself very easily to iconic interpretation. Repeating an element creates a string with several identical elements. When a whole base is repeated, the interpretation seems quite obvious. Lakoff and Johnson (1980, 180) refer to this as the principle of "more of form stands for more of content". The most straightforward iconic uses of reduplication are plurality and distribution for nouns (see chapter 6, Plurality); repetition, duration, and habitual activity in verbs (see chapter 9, Tense, Aspect, and Modality); and increase in the size and/or intensity of adjectives. However, it is also used in many various non-iconic or less motivated functions, such as to form infinitives, verbal adjectives, causatives, various aspects, and modalities (Kouwenberg 2003).

The sign modality affords several possibilities of reduplication, some of which do not have counterparts in spoken languages (see Pfau/Steinbach 2006). It may involve several iterations of a sign. These iterations may be produced in the same place, or may be displaced in the signing space. Iterations may be performed by one hand or both hands. If the latter, the two hands may move symmetrically or in an alternating fashion. A circular movement may be added to the iterations, in various rhythmic

patterns. Consequently, some phonological features of the base sign may be altered. Non-manual features may be iterated as well, or a feature may spread over the entire set of manual iterations. Finally, reduplication may also take a simultaneous form: one sign can be articulated simultaneously by both hands.

Sign languages certainly make extensive use of reduplication. As the forms may vary, so can the functions. Reduplication is very common in verbal and adjectival aspectual inflections. Of the 11 adjectival modulations in Klima and Bellugi (1979), seven involve reduplication; 10 of the 12 aspectual modulations exemplified by LOOK-AT and GIVE also involve reduplication. It is also very commonly used to indicate plurality on nouns (see Sutton-Spence/Woll 1999, 106 for BSL; Pizzuto/Corazza 1996 for Italian Sign Language (LIS); Pfau/Steinbach 2006 for DGS as well as LIS and BSL). These inflectional processes are discussed in the relevant chapters in this volume.

Reduplication is also used in a few derivational processes. Frishberg and Gough (1973, cited in Wilbur 1979, 81) point out that repetitions of signs denoting time units in ASL, e.g., WEEK, MONTH, TOMORROW, derive adverbs meaning WEEKLY, MONTHLY, EVERY-DAY. Slow repetition with wide circular path indicates duration 'for weeks and weeks'. Activity nouns in ASL are derived from verbs by imposing small, quick, and stiff repeated movements on non-stative verbs (Klima/Bellugi 1979, 297; Padden/Perlmutter 1987, 343). The verb ACT has three unidirectional movements, while the noun ACTING is produced with several small, quick, and stiff movements. In noun-verb pairs (discussed above) in ASL and Auslan, reduplicated movement (in addition to the quality of the movement) distinguishes between nouns and verbs.

Other derivational processes do not change the category of the base word, but create a new (although related) lexical item. It should be noticed that in such cases it is often difficult to determine whether the process is inflectional or derivational. For example, the two adjectival processes described here are referred to as inflections in Klima and Bellugi (1979) and as derivation in Padden and Perlmutter (1987). Characteristic adjectives are derived from ASL signs denoting incidental or temporary states, such as QUIET, MISCHIEVOUS, ROUGH, SILLY, by imposing circular reduplicated movement on the base sign. Also in ASL, repeated tense movements derive adjectives with the meaning of '-ish': YOUNGISH, OLDISH, BLUEISH (Bellugi 1980). In Israeli SL verbs denoting a reciprocal action are derived by imposing alternating movement on some verbs, e.g., SAY − CONDUCT CONVERSATION; SPEAK − CONVERSE; ANSWER − 'conduct a dialogue of questions and answers' (Meir/Sandler 2008).

Simultaneous reduplication, that is, the articulation of a sign by both hands instead of by only one hand is very rare as a word formation device. Johnston and Schembri (1999, 161−163) point out that in Auslan producing a two-handed version of a one-handed sign (which they term 'doubling') very rarely results in a different yet related lexical item. Usually the added meaning is that of intensification, e.g., BAD vs. VERY-BAD/APALLING/HORROR, or SUCCESS vs. SUCCESSFUL/VICTORIOUS, but often such intensified forms are also characterized by specific facial expression and manual stress. Most instances of doubling in Auslan are either free variants of the single-handed version, or mark grammatical distinctions such as distributive aspect on verbs. Therefore they conclude that in most cases doubled forms do not constitute separate lexical items in the language.

5.4. Conclusion

Sign languages make use of word formation operations that are also found in spoken languages, but endow them with flavors that are available only to manual-spatial languages: the existence of two major articulators, and their ability to move in various spatial and temporal patterns. There is a strong preference for simultaneous operations, especially in affixation. Inflection is, in fact, exclusively encoded by simultaneous affixation, while derivation is more varied in the means it exploits.

Both inflection and derivation make use of modulations to the movement component of the base sign. In other words, sign languages make extensive use of one phonological parameter for *grammatical* purposes. Although signs in sign families (described in section 1.2) can share any formational element, systematic relations between forms are encoded by movement. Why is it that the movement is singled out for performing these grammatical tasks and not the other parameters of the sign – the hand configuration or the location?

Using a gating task, Emmorey and Corina (1990) investigated how native ASL signers use phonetic information for sign recognition. The results indicated the location of the sign was identified first, followed quickly by the handshape, and the movement was identified last. These data may suggest that the movement is in a sense 'extra': it adds little to the lexical identity of the sign. But it can be used to add shades of meaning. Moreover, movement is inherently both spatial and temporal. Many inflectional categories encode temporal and spatial concepts, and therefore movement is the most obvious formational parameter to express these notions in a transparent way. Yet the use of movement in derivational processes shows that iconicity is not the entire story. It might be the case that once a formational element is introduced into the language for whatever reason, it may then expand and be exploited as a grammatical device for various functions. The use of movement also has an interesting parallel in spoken languages, in that non-sequential morphology often makes use of the vowels of the base word, and not the consonants. Furthermore, it has been argued that vowels carry out more grammatical roles in spoken languages (both syntactic and morphological) while consonants carry more of the lexical load (Nespor/Peña/Mehler 2003). Both movement and vowels are the sonorous formational elements; both are durational and less discrete. However, what makes them key elements in carrying the grammatical load (as opposed to the lexical load) of the lexeme still remains an open issue.

The ubiquity of compounds shows that sequential operations are not utterly disfavored in sign languages. Signed compounds share many properties with their spoken language counterparts, including the tendency to lexicalize and become more similar in form to simplex signs. Compounding may also give rise to the development of grammatical devices such as affixes. Elements that recur in compounds are good candidates for becoming affixes, but such developments take time, and are therefore quite sparse in young languages, including sign languages (Aronoff/Meir/Sandler 2005). Because of their youth, sign languages actually offer us a glimpse into such diachronic processes in real time.

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