SYLLABLE STRUCTURE IN SIGN LANGUAGE PHONOLOGY

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1. INTRODUCTION

In this paper we will deal with the *signed syllable*, a unit of increasing interest in sign language phonology since the early 1980's. In general, we aim to give an overview of the syllable's nature and role in sign languages, focusing especially on the research done on American Sign Language (ASL) and Finnish Sign Language (FinSL). More specifically, our goals are: (i) to introduce the concept of the syllable, and argue for the existence of the syllable, in signed language; (ii) to present and compare, on a general level, the main models of the structure of the signed syllable; and, (iii) to contrast and compare the signed syllable with its spoken language counterpart. As regards a theoretical framework, most work on the signed syllable has been influenced by *generative phonology* (Kenstowicz 1994). Consequently, all the theories and models discussed in this paper also belong to this school.

The syllable has already been investigated in a number of sign languages, most notably in ASL (e.g. Wilbur 1991; Perlmutter 1992; Sandler 1993; Brentari 1998), but also, for example, in Sign Language of the Netherlands (van der Kooij 2002) and Israeli Sign Language (Nespor & Sandler 1999). Recently, the syllable has also begun to be studied in FinSL (Jantunen 2005, 2006, 2007). From the point of view of exploring similarities and differences between sign languages, the data from FinSL, which we will present in this paper, adds to our understanding of the crosslinguistic nature of the signed syllable.

2. SYLLABLE – THE BASICS

2.1 Defining the Spoken Syllable

In everyday speech, a spoken language *syllable* is perhaps most often, and certainly rather easily, characterized as a short sequence of vowel (V) – "sonant" – and optional consonants (C); for example, CV or CVC.[1] However, empirically (i.e. phonetically) the syllable has proved to be an extremely difficult unit to define. In the history of linguistics several

[1] Typologically, despite of the fact that most descriptions of spoken syllable use the structure CVC as an example, the most common syllable type in spoken language is CV (Maddieson 2005).

definitions of the syllable have been put forward (see Ladefoged 1975) but so far no single one of them has been found to be complete. Some researchers have invoked this trait of the syllable to escape empirical definition to deny its existence altogether, but the current state of our knowledge suggests that this view is overly pessimistic: the ability of most speakers to intuitively identify syllable boundaries and, for example, to assign stress to words according to these boundaries, as well as the existing syllable-based writing systems, all favor the existence of the syllable as a unit in spoken language. Further support, more linguistic in nature, for the existence of a spoken syllable is also provided by the fact that it is often the most convenient unit to refer to when one needs to make generalizations, for example, of a phonological nature.

Although there are no watertight definitions of syllable available, and although in the end it might be that the syllable is an abstract "unit that exist[s only] at some higher level in the mental activity of a speaker" (Ladefoged 1975: 221), many spoken language researchers still approach and define the syllable in terms of *sonority*, that is, a property traditionally assigned to sound segments and understood as their intrinsic loudness. From this perspective it has been claimed (e.g. Blevins 1995) that the spoken syllable is a unit which includes only one *sonority peak* – that is, a segment whose inherent value of loudness is relatively high, meaning typically a vowel – and in which the segments as a whole are organized so that their sonority values first increase and then decrease. As a typological generalization this sonority-based definition of the spoken syllable has stood the test of time well, but language-specifically there are certain well-known exceptions to it. One such exception comes from English and deals with monosyllabic words beginning (and ending) with the consonant clusters /sp st sk/: the word *spill*, for example, includes two sonority peaks since the inherent loudness, or sonority value, of segments /s/ and /i/ is higher than the loudness of the segments or the parts of the signal immediately preceding and following them.[2]

During the past decades researchers (e.g. Ohala & Kawasaki 1984; Ohala 1990) have departed from the classical view according to which sonority is simply equated with loudness and redefined the concept as an inherent property of a sound segment which contributes to the *perceptual salience* of that segment. Superficially, the change may seem to be a minor or merely philosophical one, since loudness and perceptuality are obviously related concepts. However, on the level of principle the consequences of this redefinition have been more far reaching: the breaking of the conceptual link between sonority and "hearing" has opened up

[2] Specific solutions have been devised for these problems in English (Fudge 1969) and Spanish (Harris 1983).

the possibility for researchers to begin investigating sonority – and syllable – also in signed language.

2.2 On Sonority

The close relationship between the syllable and sonority has been noted in most current theories dealing with the spoken syllable, and consequently sonority has become a key concept also in the study of the signed syllable. With the basic understanding that sonority has mostly to do with perceptual salience, signed language researchers – including Corina (1990), Perlmutter (1992), Sandler (1993), and Brentari (1998) – have proposed that the property which most contributes to the perception – or visibility – of a signed signal and its parts is *movement*,[3] and that movements therefore function as the sonority peaks of signed syllables. In the field of signed syllable research, this view has now become the dominant one, as has the idea which follows from it, that signed syllables are units formed around movement "pulses", identified in turn with the dynamic lexeme-internal and underspecified – i.e. phonological – parts of the signal. This latter stand is captured, for example, in the following rough criteria by Brentari (1998: 6) for the identification of signed syllables (FinSL examples added; see Figure 1):

a. The number of sequential phonological dynamic units in a string equals the number of syllables in that string (e.g. the sign MUSTA 'black' includes one syllable and the sign TIETÄÄ 'to know' two syllables).[4]
   i. When several shorter dynamic units co-occur with a single dynamic element of longer duration, the longer unit is the one to which the syllable refers (cf., for example, the monosyllabic sign VÄHETÄ 'to decrease').
   ii. When two or more dynamic units are contemporaneous, they count as one syllable (cf., for example, the monosyllabic sign KULTTUURI 'culture').

[3] The term movement has been used in different senses by different researchers (for two overviews, see Brentari 1998 and Crasborn 2001). In this section, unless otherwise directly indicated, the term movement is used in the general sense referring to the dynamic properties of a sign stream.

[4] In general, it is possible to analyze lexical signs that have a repeated movement either as true disyllabic forms or as forms that are derived from monosyllables by reduplication. Regarding the FinSL sign TIETÄÄ 'to know' (see Figure 1), we do not find the (formal, semantic, or etymological) evidence to support the reduplication analysis. In other words, we consider TIETÄÄ to be similar to the disyllabic Finnish word *koko* 'size'.

b. If a structure is a well-formed syllable as an independent word, it must be counted as a syllable word-internally (cf. MUSTA 'black', VÄHETÄ 'to decrease', and KULTTUURI 'culture').

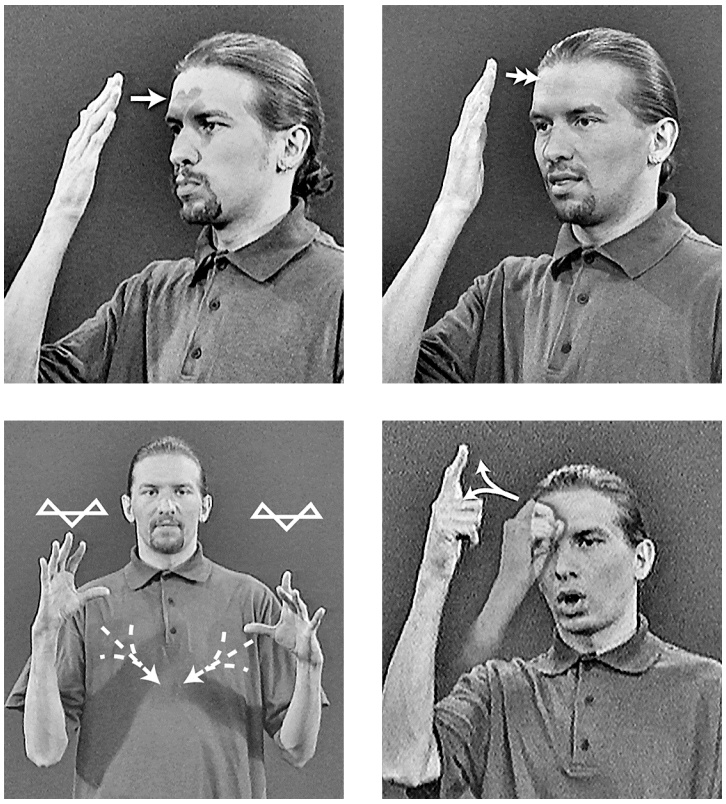

Figure 1. FinSL signs MUSTA 'black' (top left), TIETÄÄ 'to know' (top right), VÄHETÄ 'to decrease' (bottom left), and KULTTUURI 'culture' (bottom right). All signs are produced with a Finnish mouthing. (Original photographs from Malm 1998; by permission of FAD.)[5]

Paradoxically, there is no direct evidence available to support the view that the parts of the signed signal which include (phonological or any other kinds of) movement are indeed the most salient and therefore also the most sonorous parts of the signal. However, indirectly the claim can be supported, for example, by the studies of Allen, Wilbur, and Schick (1991), Wilcox (1992), and Crasborn (2001). First, in their study of rhythm in ASL, Allen, Wilbur and Schick found that the rhythmical beats, i.e. "those events that are felt to be more

[5] In photographs from Malm (1998), simple straight arrow(s) indicate(s) the path or trajectory of the movement (see MUSTA 'black' in Figure 1; see also Figures 3 and 7). Two arrows indicate repetition (see TIETÄÄ 'to know' in Figure 1). The design above the hands in the sign VÄHETÄ 'to decrease' (Figure 1) indicates wiggling; a dashed line indicates that the movement is produced in a slowed manner. Double or triple direction lines indicate that the handshape either closes or opens (see VÄHETÄ and KULTTUURI 'culture' in Figure 1; see also Figures 7 and 8).

forcefully produced and around which the other events in the sequence are organized" (Allen et al. 1991: 197), are associated with sign internal movements. Secondly, Wilcox's study on ASL fingerspelling has shown that perception is enhanced by an increase in movement velocity. Finally, Crasborn has provided phonetic evidence in support of the positive correlation between "visual loudness" and the amplitude (i.e. the size) of a sign's movement. In addition to these studies, the link between salience and movement can also be strengthened by the general research that has beeb carried out into visual perception (e.g. Bruce & Green 1990); the research suggests, for example, that movement enhances the possibility of perceiving the object, and that movement contributes positively also to the identification of the object.

In a coherent treatment of sonority, the question of its articulatory basis must also be addressed. With regard to this issue it has been suggested that with spoken language the degree of sonority of a sound correlates articulatorily with the openness of the vocal tract. The main idea is that a sound generated in an open vocal tract is more sonorous than a sound generated in a closed tract since the larynx sound resonates differently in the vocal cavity depending on the degree of openness of the tract; the larynx sound going through an open tract produces a stronger – and thus better perceived – signal than one going through a closed tract. Traditionally, this view of the articulatory basis of sonority has been used to explain, for example, the greater sonority of vowels over consonants: vowels are always produced in a relatively open vocal tract whereas in the production of consonants there is always a closure of some sort.

As far as we are aware, the articulatory basis of sonority in signed language has not been investigated in a level comparable to that in spoken language. However, an exception is Brentari (1998) who uses the physiologically, socially, etc. motivated weakening and strengthening phenomena of lexical movements to argue that sonority in signed language correlates with the proximality of the joint used in the production of the movement. According to this view, movements produced from more proximal (or larger) joints of the arm are more sonorous than movements produced from distal (or smaller) joints because proximal joints are able to produce larger and thus more visible – i.e. better perceived – movements than distal joints. For the proximality hierarchy of the joints of the arm Brentari suggests the following, listed from the most proximal to the most distal (Brentari 1998: 75):[6]

[6] Brentari's (1998) hierarchy of joints is a bit simplified for there are actually two joints that can be manipulated at the "elbow" – one producing movement as in the ASL sign THANK-

shoulder > elbow > wrist > base [finger] joints > nonbase [finger] joints.

Like the proposal for the articulatory basis of sonority in spoken languages, Brentari's view of the articulatory basis of sonority in signed languages has also been criticized. For example, Sandler & Lillo-Martin (2006) take the view that connecting sonority with the amplitude of movement is to confuse sonority with another property, namely *loudness*; indeed, we think that it is not always easy to distinguish between these two properties in signed language and that their relationship should be investigated further. Jantunen (2005; see also Jantunen 2006, 2007), on the other hand, in campaigning for the phonological commensurability of manual and nonmanual movements (see section 3.2.2), points out that Brentari's view deals explicitly only with *manual sonority*, i.e. only with movements produced with manual articulators, hands and arms.[7] However, unlike Sandler & Lillo-Martin, Jantunen does not abandon Brentari's proposal, but instead chooses to modify it. On the basis of FinSL signs which contain only nonmanually produced phonological movement (e.g. KYLLÄ 'yes', ON-KUULLUT 'has heard', and MUKAVA 'nice'; see section 3.2.2) and the *trans-articulatory movement migration processes* – i.e. processes in which responsibility for the production of the abstract shape of a movement is shifted, for example, from a manual articulator to a nonmanual articulator, such as the upper body – Jantunen argues that there is also *nonmanual sonority*, and that sonority in signed language also correlates with the size of the articulator, a bigger articulator entailing greater sonority than a smaller one (for additional discussion of the range of nonmanuals in sign languages see Pfau & Quer, this volume). For the hierarchy of articulators, Jantunen suggests, on the basis of FinSL data, the following (Jantunen 2005: 56):

upper body & head > hands [incl. Brentari's hierarchy] > mouth.

In Jantunen's hierarchy, the upper body and the head are treated together since in FinSL – although capable of moving independently, and in certain contexts (e.g. when negating) even required to do so – they in many cases move as one (cf. Woll 2001 for British Sign

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YOU and another producing forearm rotation as in the ASL sign TREE. For more see Mirus, Rathmann, and Meier (2001).

[7] Brentari's (1998) Prosodic Model includes a built in option to deal also with nonmanual movements.

Language).[8] Movements produced by the upper body and head are taken by Jantunen to be more sonorous than movements produced by the hands since, for example, the default manual movement of the FinSL sign HÄMMÄSTYÄ 'to be surprised' (see Figure 2) can be enhanced with a nonmanual body and head movement of similar shape. Movements produced with the mouth – or to be more precise, only *mouth gestures* (Sutton-Spence & Boyes Braem 2001)[9] – Jantunen considers to possess the lowest sonority. The basis of this decision is the observation that, for example, the default movement of the sign LINNUN-NOKKA-AUKEAA 'the bird's beak opens' – i.e. the change of the handshape  to  – can be weakened to be articulated with the mouth alone (i.e. the mouth opens). The weakening analysis is based on etymological knowledge according to which the origin of similar descriptive signs (e.g. LEUAT-LOKSAHTAVAT-AUKI 'jaw-drop') is on descriptive nonmanual gestural activity (e.g. the opening of the mouth), and that only later that activity has become to be imitated (i.e. "enhanced") manually.

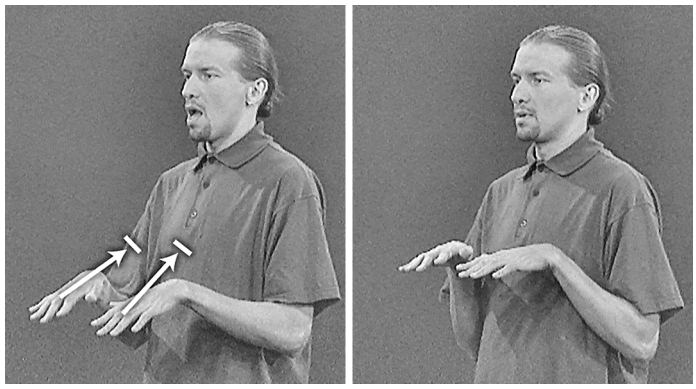

Figure 2. FinSL sign HÄMMÄSTYÄ 'to be surprised' produced with the default manual movement. The sign includes a Finnish mouthing. (Photographs from Malm 1998; by permission of FAD.)[10]

Our opinion is that both Brentari's and Jantunen's claims about the articulatory basis of signed language sonority include open questions. Why, for example, the most frequent movement in

[8] Jantunen's (2005) study is conducted in a slightly modified framework of Brentari's (1998) Prosodic Model. In this framework, head and upper body movements are separated, if necessary, in the IF-branch under the nonmanual-node.

[9] The other type of mouth movements, i.e. *mouthings,* Jantunen (2005, 2006) considers to be spoken language induced code-mixing with no phonological relevance. The analysis follows that of Hohenberger and Happ (2001).

[10] In Figure 2, as well as in all the other photographs from Malm (1998), the small straight line in front of the arrow head indicates a clear stop (see also Figure 7).

signs is the straight movement articulated from the elbow joint (Brentari 1998, Jantunen 2005) and not one of the allegedly most sonorous movements articulated from the shoulder?[11] And are the upper body, head, and mouth really the only nonmanual articulators whose movements contribute to sonority?[12] Such questions need exploration in the future. Consequently, this means that research into the signed syllable cannot be based solely on the relationship that seems to exist between movement and sonority – more grounding for the existence of the signed syllable is needed.

2.3 More Arguments for the Claim that Sequential Dynamic Units Formed Around Phonological Movements Are Syllables

In the following sections we present two more arguments to support the view that sequential phonological dynamic units are syllables (cf. section 2.2). The first argument (see section 2.3.1), called here the Minimal Word argument, is widely cited in the literature (e.g. Perlmutter 1992; Sandler 1993; Brentari 1998; Jantunen 2007) and deals with the well-formedness of prosodic words (signs). The second argument (see section 2.3.2), called here the Babbling-argument (cf. Brentari 1998), is based on the functional similarities in the language acquisition process between deaf and hearing children.

2.3.1 The Minimal Word Argument

The basis of the *Minimal Word argument* is in the spoken language-based generalization that all well-formed (prosodic) words must contain at least one syllable (e.g. McCarthy & Prince 1993). The argument states that sequential phonological dynamic units are syllables since no surface form of any sign is well-formed unless it has a phonological movement.

If the Minimal Word argument is valid, then it can be assumed that signs which do not inherently contain a movement are given one by the grammar in their production. According to Brentari (1998) and Jantunen (2007), this is exactly what happens at least in ASL and in FinSL. In ASL, Brentari has observed that inherently movementless signs such as the numeral signs 1 to 9 are given an extra short straight epenthetic movement when used as independent

[11] Obviously, the principle of ease of perception conflicts here with the principle of ease of articulation.

[12] Jantunen (2005) gives the status of nonmanual articulator to the *mouth*, *head* and *torso* on the grounds that they are the only nonmanual articulators found in Malm (1998; Basic Dictionary of FinSL) which are independently responsible for the production of a lexical movement (cf. KYLLÄ 'yes', ON-KUULLUT 'has/have heard', and MUKAVA 'nice', respectively).

words. Jantunen states that the same is true also with the movementless FinSL numerals 0 to 8, as well as with fingerspelled letters containing no movement in their base-form.

We take the observations concerning the movement epenthesis in inherently movementless signs to be synchronic evidence to support the Minimal Word argument. Additionally, the argument can be grounded also diachronically. For example, Jantunen (2003) has shown that the origin of FinSL signs is in many cases in pantomimic gestures and postures. However, in the historical developement of signs many pantomimic features have disappeared from the system, and consequently, many originally movementless signs (e.g. the FinSL sign LÄMPÖ 'heat', see Figure 3) have come to be produced with a phonological movement.

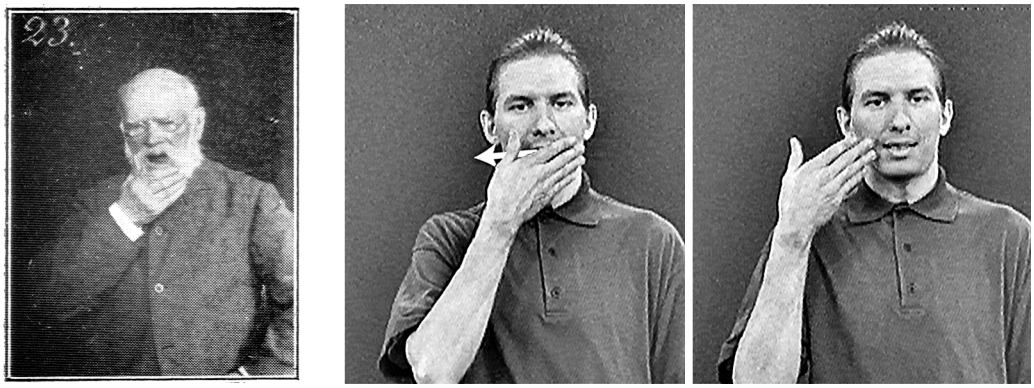

Figure 3. The old (left) and modern (right) form of the FinSL sign LÄMPÖ 'heat'. The old form is produced pantomimically by blowing "warm air" to the palm. The modern form includes a straight sequential phonological movement, and a Finnish mouthing. (Photographs from Hirn 1910 and Malm 1998; by permission of FAD.)

2.3.2 Babbling Argument

In addition to the Minimal Word argument (and the relationship which seems to exist between movements and sonority; see section 2.2), the claim that signed syllables form around sequential phonological movements can be supported also with the *Babbling argument*. This argument is based on studies which have investigated the prelinguistic development of deaf children (e.g. Petitto & Marentette 1991) and it can be formulated in the following way: a sequential dynamic unit formed around a phonological movement is a syllable because a deaf child starts to produce such units at the same time as hearing children start to produce syllabic

babbling[13] (e.g. *dadadada*) and because the distributional and phonological properties of such units are analogous to the properties usually associated with syllabic babbling.

Petitto and Marentette (1991) call this developmental phase *manual babbling*, which starts from the appearance of sequential dynamic movement units to a child's language, e.g. a repeating change of the handshape. According to them, manual babbling evolves at the same time as syllabic babbling with hearing children, i.e. usually by the age of 10 months. Like syllabic babbling, manual babbling includes a lot of repetition of the same movement, and also like syllabic babbling, manual babbling makes use of only a part of the phonemic units available in a given language. Petitto and Marentette's research also shows that manual babbling develops without interruption into the first signs (just as syllabic babbling continues without interruption into the first words), and that manual babbling is different from other co-existing non-linguistic gestures.

We accept the evidence presented above to support the existence of syllables in signed language. However, for the proper study of the signed syllable it is not enough simply to be able to show that syllables exist; one also needs to show that they are actually needed to describe phonological operations. This is an issue we will consider briefly in the next section.

2.4 On the Need for the Unit Syllable in Signed Language

In spoken languages the need for the syllable as a linguistic unit has often been justified on the grounds that in many cases the syllable is the "simplest" unit to be referred to in phonological or morphological constraints (Blevins 1995; see also section 2.1). Following this line of argumentation, constraints which rely on the syllable unit have been presented also with regard to signed language (see, for example, Corina & Sandler 1993; Brentari 1998; Sandler & Lillo-Martin 2006). One often cited (e.g. Brentari 1998; Jantunen 2007) example of these is the one dealing with the phonological length of lexemes in the core lexicon, according to which core lexemes may contain minimally one but maximally two syllables.

That the constraint limiting the phonological length of signed lexemes to two syllables[14] is indeed relevant in the study of signed language phonology has been

[13] Other studies have shown that, particularly in the earliest stages, hearing non-signing children produce manual babbles very similar to those produced by deaf children, suggesting that in the beginning, motoric development might be playing more of a part than phonology (e.g. Meier & Willerman 1995).

[14] It should be noted that although core lexemes may include two syllables, there is a strong tendency in signed language lexemes in general to be monosyllabic (e.g. Wilbur 1990; Jantunen 2007).

demonstrated, among others, by Brentari (1998). According to her, the pressure to obey the constraint is seen, for example, in the discourse-situated ASL *local lexicalization* process, through which long sequences of fingerspelled letters reduce to independent lexeme-like forms containing only a maximum of two sequential phonological movements, i.e. two syllables. Also, the constraint is taken by her to be of importance in the description of non-nativity of certain compound-like ASL signs which include fingerspelling (e.g. SUN+ B-U-R-N).

A crucial question is why the constraint on the phonological length of signed lexemes must refer precisely to the syllable and not to some other phonological unit? A recent answer to this question comes from Jantunen (2007), who claims that the other theoretically relevant units, such as the segment, are definitionally too ambiguous to meet the purpose (on the nature of segments, see also Wilbur & Petersen 1997). To back up this view in particular, Jantunen discusses the segmental representation of the FinSL sign MUSTA 'black' which, for example in the updated version of Liddell's and Johnson's (1989) *Hold-Movement* model, consists of three segments (XMH) but in Brentari's (1998) *Prosodic Model* of only two segments (two x-slots). On the grounds of the obvious differences in these representations Jantunen argues that the segment cannot be accepted as the optimal point of reference in the description of lexemes' phonological length; reference to the (dynamic phonological unit argued in previous sections to be a) syllable is required.

According to current understanding, the syllable is a necessary unit in sign language phonology. However, consensus about the syllable dies when more specific questions about its structure are taken into consideration. These are the questions we turn to next.

3. SYLLABLE STRUCTURE

The following sections first briefly present the two most influential views about syllable structure in spoken language (3.1). After this, the structure of signed syllables is considered in more detail (3.2); it is discussed both with respect to the present main models of sign language phonology (i.e. Liddell & Johnson 1989; Sandler 1989; Perlmutter 1992; Brentari 1998) and with respect to spoken language-based views about syllable structure.

3.1 Syllable Structure(s) in Spoken Language

Views about the internal structure of the spoken syllable have exhibited some variation (for an overview, see Blevins 1995). However, in analysis, two models have proved to be especially useful: the classic *hierarchic model* (e.g. Selkirk 1982) and the *moraic-model* (e.g. Hyman

1985). Both models have also been applied to sign languages (e.g. Wilbur 1990 and Perlmutter 1992, respectively; see section 3.2).

The hierarchic model view of the spoken syllable is given in Figure 4a. In this model, the syllable (σ) is divided first into constituents *onset* (o) and *rhyme* (r), of which the latter is further divided into *nucleus* (n) and *coda* (c).

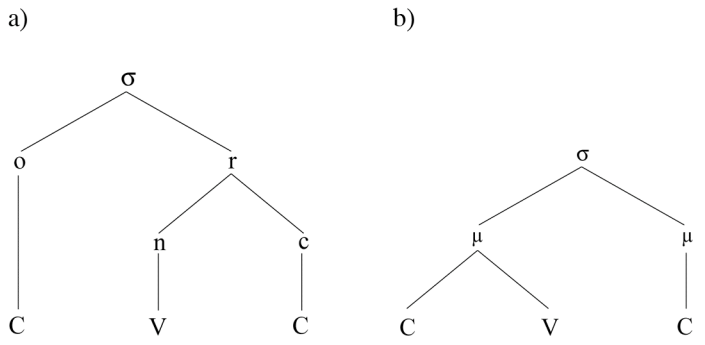

Figure 4. The representation of the spoken syllable structure in the hierarchic model (a) and in the moraic-model (b).

The nucleus is the phonological unit which corresponds to the syllable's sonority peak. It usually consists of one or more non-consonantal segments, that is, typically of a vowel or a short sequence of vowels (cf. section 2.2), although occasionally also consonants can be nucleic. Of the other terminal units, the onset is the consonant (cluster) which (optionally) precedes the nucleus, and the coda is the consonant (cluster) which (again, optionally) follows the nucleus. Functionally, with respect to their information-carrying ability, there is a disparity between the onset and the coda: in the standard case, only the onset can carry all the lexical contrast, the coda being limited in this sense to only a subset of these contrasts.

The rhyme constituent is an important unit in the analysis of metrical properties such as stress. In quantity-sensitive languages (e.g. English), the internal structure of the rhyme decides the *weight* of the syllable, that is, whether syllables are *light* or *heavy*. Syllables with no coda and whose nucleus does not consist of more than one segment (prototypically CV) are interpreted as light, whereas syllables with a coda (prototypically CVC), or those whose nucleus has more than one segment (prototypically CVV), are labelled as heavy. Typologically, heavy syllables are stressed (e.g. Blevins 1995; Maddieson 2005).

In the hierarchical syllable model, an increase in syllable weight is equated first and foremost with an increase in the syllable's duration. However, the increase in weight can also be seen as the result of another type of phenomenon, that is, as a result of the increase in the number of *moras* (μ), prosodic weight units (more on mora, see Perlmutter 1995). A model of the spoken syllable built on the concept of mora is the moraic-model. In this model, the (light) CV syllable is taken to include one mora and the (heavy) CVC/CVV syllable two moras. Hyman's (1985) view of the canonical moraic structure of the spoken language syllable is given in Figure 4b.

In Hyman's view, the syllable initial CV cluster has the status of *core syllable* and it forms the first mora. The core syllable can be followed by a V or a C, the second mora. Structurally, the second mora is simpler than the first one, but its addition to the first mora makes the syllable as a whole more complex. Since moras are prosodic units, the addition of the second mora also increases the syllable's overall prosodic complexity.

The two models briefly presented above address different aspects of the spoken syllable structure. The hierarchical model approach of dividing the syllable into onset and rhyme constituents reflects perhaps most clearly the empirical fact that hearers identify rhythmical beats in between the syllable initial consonant (cluster) and the vowel (Wilbur & Allen 1991). Hyman's moraic view, on the other hand, captures perhaps more effectively the typological generalization that, in quantity-sensitive languages, it is the CVC/CVV-style syllables, i.e. prosodically complex two-moraic syllables, which are typically stressed.

3.2 The Structure of the Signed Syllable

As with views about the structure of the spoken syllable (cf. section 3.1), so also views about the structure of the signed syllable exhibit variation, and in some sense this variation is even more fundamental than that in spoken language. One reason for this "fundamentality" is the fact that there is no agreement among sign language researchers as to what kind of unit the phonological movement, functioning as the sonority peak of the syllable, is in phonological theory (cf. Liddell & Johnson 1989; Sandler 1989; Perlmutter 1992; Brentari 1998). Consequently, before the structure of the signed syllable can be discussed, an overview of the main ways of treating phonological movements must first be given.

Currently, there exist, in principle, two views about how phonological movement should be represented in phonological theory. According to one view, movements are dynamic *segments* defined by a change in articulator posture, contrasting to static segments during which the posture of the articulators does not change; this is the view taken, for

example, by Liddell and Johnson (1989) in their *Hold-Movement* model and by Sandler (1989) in her *Hand Tier* model. According to the other view, movements are *autosegmental* prosodic units, analogous to the contrastive tone found in certain spoken languages, such as Mandarin Chinese; this is the view taken by Brentari (1998) in her *Prosodic Model*. A diagram illustrating these two views and their mutual relationship is given in Figure 5.

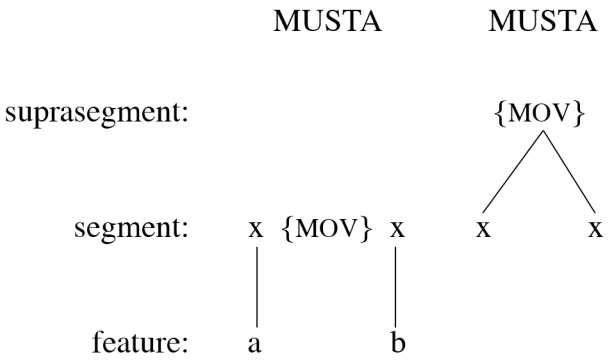

Figure 5. The phonological movement {MOV} of the FinSL sign MUSTA 'black' (see Figure 1) represented as a segment (left) and as an suprasegment (right).

Whether movements are seen as a segment or as a tone-like autosegment directly affects what kind of unit the syllable is considered to be in signed language. Accepting the segmental view of movement means that signed syllables are seen as sequences of static and dynamic segments, such as the sequence LML (i.e. Location-Movement-Location) in Sandler's *Hand Tier* model, that is, basically as units resembling spoken language syllables (cf. CVC). Accepting the autosegmental view, on the other hand, entails the ontological view that the relationship between a signed and spoken syllable is not so much a formal but rather a functional one, a signed syllable being perhaps most easily characterized as one sequential phonological movement with a more paradigmatic internal structure. Both of these views – labelled here, respectively, as *the sequentially oriented approach to signed syllable* and *the simultaneously oriented approach to signed syllable* – are discussed further in the following (sections 3.2.1 and 3.2.2).

3.2.1 The Sequentially Oriented Approach to the Signed Syllable

The basis of the sequentially oriented approach to signed syllable structure is the ontological assumption that movements are segments, and that syllables are, consequently, short

sequences of static and dynamic segments. Advocates of this view are, for example, Perlmutter (1992) and Sandler (1993). According to Perlmutter, the prototypical syllable in signed language is a PMP sequence, P corresponding to the Position of the articulator and M to its (path) Movement (the term *path movement* refers, in general, to movements which are produced from the elbow or from the shoulder); other syllable types recognized by Perlmutter are MP, PM, and M, as well as a plain P consisting of (in contrast to a path movement) a *local movement*, i.e. a movement produced from the wrist joint or from the finger joints. The trisegmental syllable is the prototypical syllable also for Sandler. However, in her framework the segments used are Ls and Ms (L is the Location, M is, again, the path Movement), the overall structural representation of the syllable prototype thus being LML. In addition to this type, Sandler also recognizes the syllable type L, which includes, like Perlmutter's P-type, a local movement. By analogy with the overall organizational principle of the spoken syllable, both Perlmutter and Sandler claim that also signed syllables can be understood in such a way that their segments form rising and falling "sonority cycles" (see section 2.1), static segments having, by definition, lower sonority value than dynamic segments (for an overview, see Brentari 1998; also Corina & Sandler 1993).[15]

In general, quite direct analogies to the spoken syllable have been drawn by the "sequentialists" also with regard to the internal structure of the signed syllable (see section 3.1). On the one hand, it has been proposed (see Wilbur 1990; Corina & Sandler 1993; Sandler 1993) that, like spoken syllables in the hierarchical model, signed syllables are also internally organized into units like onset (the syllable initial static segment) and rhyme, the latter branching, like the spoken counterpart, into nucleus (the dynamic segment) and coda (the syllable-final static segment); models in which rhyme does not exist have also been presented. On the other hand, it has been argued (e.g. Perlmutter 1992) that the structure of the signed syllable includes moras, and corresponds to the structure proposed by the moraic-model (see Figure 4b).

One important observation to be made about the views held by supporters of the sequentially oriented approach to the signed syllable is, we think, that they are in many cases not built on any direct phonetic evidence as far as the structure of the syllable is concerned. In fact, in many cases phonetic research, although scarce, has even provided results which seem

[15] Both Perlmutter (1992) and Sandler (1993) take the trisegmental PMP/LML-type syllable to be the prototypical syllable in signed language. This breaks down their analogue between signed and spoken syllables since in spoken languages it is the two segmental CV-type syllable which must be treated as prototypical (e.g. Maddieson 2005).

to contradict some of the sequentialists' claims. For example, the view that there is an onset-rhyme dichotomy in the signed syllable seems unreasonable in the light of the tapping experiment conducted by Allen, Wilbur, and Schick (1991): in their experiment, rhythmical beats were not associated with any particular part of signed syllables, as they are with spoken language (i.e. with the border between onset and rhyme). Equally unlikely seems to be even the slightly modified view that the nucleus and the coda are independent constituents directly related to the syllable node: for example, the research on backward signing by Wilbur and Petersen (1997) suggests that there is no spoken syllable-like information-carrying disparity between the beginning and the end of the syllable (i.e. between the onset and the coda) but rather that both the beginning and the end of the syllable carry an equal load of information; the postulation of an intermediate level of representation between the segment and syllable (i.e. the level of onset, nucleus, and coda) is thus unnecessary. The only sequentially oriented view about the structure of the signed syllable which may be taken to be directly based on phonetic evidence, i.e., on the phenomenon known as the *phrase-final lengthening*, is Perlmutter's (1992) mora-view, according to which signed syllables are composed of one or two moras. However, criticism has also been leveled against this view (e.g. Wilbur & Allen 1991; Corina & Sandler 1993; Brentari 1998; Tang et al., this volume; see also the next section).

3.2.2 The Simultaneously Oriented Approach to the Signed Syllable

The basis of the simultaneously oriented approach to the structure of signed syllables is the assumption that movement is not a segment but a tone-like suprasegment, and that the signed syllable is, unlike the spoken syllable, therefore more simultaneously composed – or layered – than sequentially composed – or mono-level. The main advocate of this view is Brentari (1998), and her view is now presented in more detail.

In contrast to sequentialists like Perlmutter (1992) and Sandler (1993), Brentari considers that spoken and signed syllables are not formally comparable. Instead, in the framework of her Prosodic Model, Brentari argues that signed syllables are sequential phonological movements, basically corresponding to phonologically relevant dynamic sequences of the sign stream, during which the static, inherent features describing the shape and main location of the articulator (e.g. the features used to describe the static properties of, for example, the selected fingers and the major plane of articulation) remain unchanged. More formally, Brentari represents the prototypical signed syllable as a sequence of two timing units (x-slots; segments), tied together by the suprasegmental, hierarchically organized

autosegmental group of dynamic – i.e. prosodic – features. In general, Brentari's view means, for example, that there are no rising and falling sonority cycles in signed syllables (cf. the stands taken by Perlmutter and Sandler), since there are no categorically different types of segments in the syllable, and since there is only one sequential suprasegmental movement per syllable.

Brentari argues that the internal structure of the signed syllable cannot be analyzed using conceptual machinery developed for the spoken language. She says, for example, in unspoken agreement with the studies of both Allen, Wilbur, and Schick (1991) and Wilbur and Peterson (1997), that there is no onset-rhyme or comparable dichotomy in the signed syllable,[16] and goes even further to claim that the notion of mora is also not a feasible concept for analysis. The basis for this latter position is her view that, although an abstract prosodic unit of weight, the term mora refers also to physical duration; according to Brentari, weight and duration are two separate things in sign languages.

Instead, Brentari suggests that signed syllables are composed internally of *weight units*. The number of weight units correlates directly with the complexity of the syllable's nucleus, i.e. the movement: the more complex the syllable's movement, the more weight units there are per syllable. *Complex movements* are defined by Brentari as movements involving more than one co-occurring local or path movement; a movement involving a single local or path movement is *simple* in Brentari's terms. In practice, the complexity of movement correlates in Brentari's framework with the number of joints used in the production of the (phonological) movement. Basically this means that, for example, the movement in the monosyllabic ASL sign THROW is more complex than the movement in the monosyllabic sign UNDERSTAND because in the sign THROW the movement is produced simultaneously with the elbow and the finger joints (cf. the straight path movement and the handshape change), whereas in the sign UNDERSTAND the movement is reducible only to the finger joints (cf. the handshape change). Consequently, in Brentari's framework, the sign THROW is a (mono)syllable including two weight units and the sign UNDERSTAND a (mono)syllable including one weight unit (see Figure 6).

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[16] In the earlier version of the *Prosodic Model* (Brentari & Goldsmith 1993), dominant and non-dominant hands were treated as being functionally analogous to spoken syllable internal units onset and coda, respectively. In the current version of the model (Brentari 1998) this analogy is dropped since, for example, the data from disyllabic compounds suggests that the non-dominant hand is a word-level appendix-like unit.

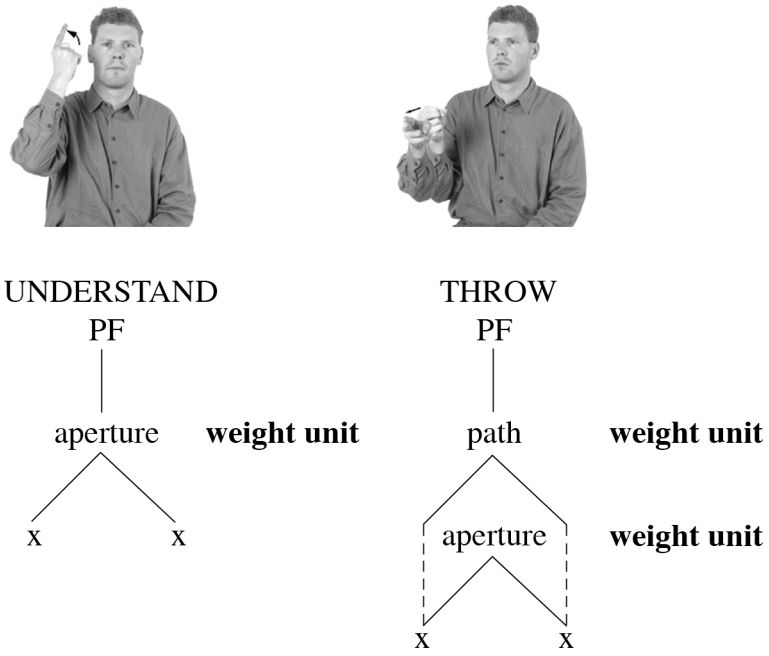

Figure 6. Prosodic Model representations of the syllable structure in ASL signs THROW and UNDERSTAND. (Photographs from Brentari 1998: 5-6; by permission of MIT Press.)

In his work on FinSL, Jantunen (2005, 2006, 2007) argues that the definition of complexity given by Brentari (1998) is not sufficient, since it deals only with manual movements. In order to cover also nonmanual movements, which, it is argued, are relevant in FinSL phonology (see below and section 2.2), he suggests that the definition be expanded so that a movement is taken to be complex also when it is produced with more than one articulator. This suggestion depends on the following arguments for the commensurability of manual and nonmanual movements: (1) signs containing only nonmanual movements (e.g. KYLLÄ 'yes', ON-KUULLUT 'has/have heard', and MUKAVA 'nice'; see Figure 7) are in FinSL as well-formed as signs containing only manual movements; (2) in signs containing both manual and nonmanual movements (e.g. LÄHTEÄ 'to go'; see Figure 7), the nonmanual movements are structurally as essential as the manual ones; and (3) the production of the abstract shape of a movement does not in all cases depend upon the articulator (cf. the trans-articulatory movement migration phenomenon discussed in section 2.2). In practice, Jantunen's suggestion means that the movement in the monosyllabic FinSL sign UJO 'shy' (see Figure 7), for example, is more complex than the movement in the monosyllable MUSTA 'black' (see Figure 1), since UJO 'shy' contains both a local movement and a phonological head movement whereas MUSTA 'black' has only a path movement. Consequently, Jantunen takes UJO 'shy'

to be a (mono)syllable consisting of two weight units and MUSTA 'black' to be a (mono)syllable consisting of one weight unit.

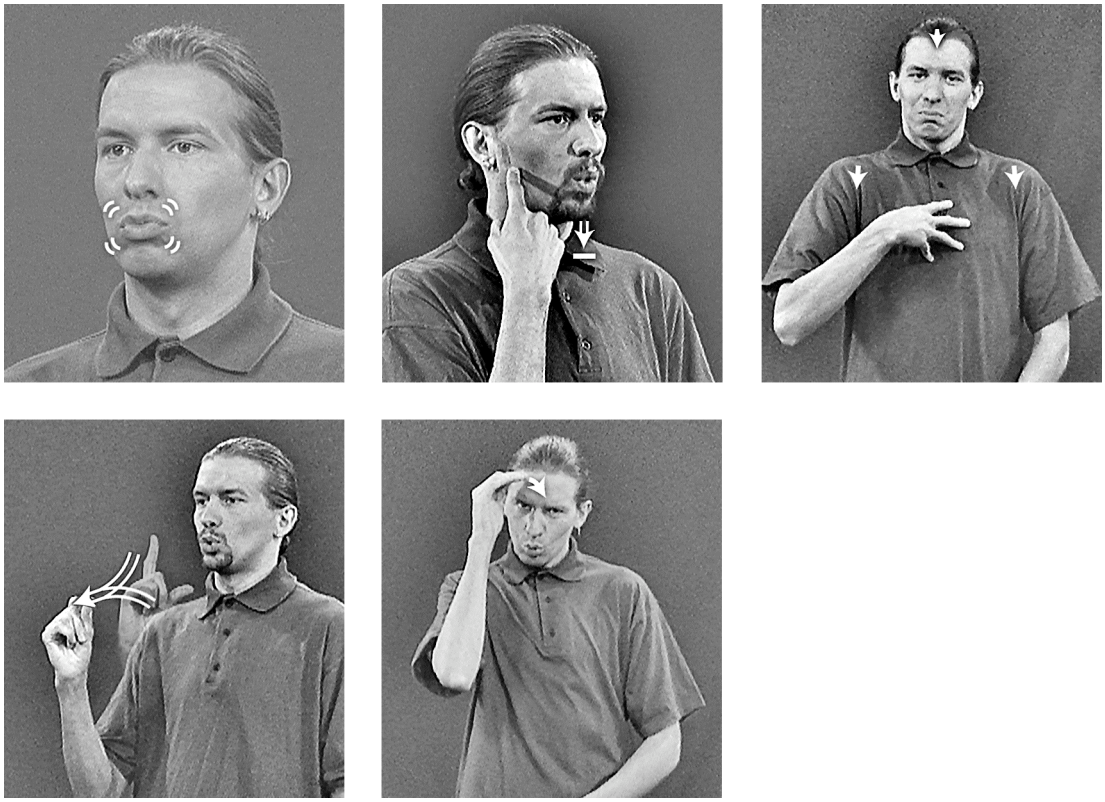

Figure 7. FinSL signs KYLLÄ 'yes' (top left), ON-KUULLUT 'has/have heard' (top centre), MUKAVA 'nice' (top right), LÄHTEÄ 'to go' (bottom left), and UJO 'shy' (bottom right). The sign KYLLÄ is a simple repeated mouth gesture (cf. kissing gesture). The sign LÄHTEÄ includes a mouth gesture resembling spoken sequence [viu]. All other signs are produced with a Finnish mouthing. (Original photographs from Malm 1998; by permission of FAD.)[17]

Brentari (1998) discusses only ASL syllables with one or two weight units. However, with regard to FinSL, Jantunen (2007; also 2005, 2006), using Brentari's framework and considering manual and nonmanual movements as commensurable, has also identified syllables with three or four weight units and shown that there is a clear tendency in FinSL to prefer structurally simple syllables.[18] A summary of the frequency of occurrence of Jantunen's

[17] Small double arc lines (as in KYLLÄ 'yes', see Figure 7) indicate small or rapid movement. Two narrow lines attached to one arrow head indicate rapid movement as well (see ON-KUULLUT 'has/have heard' and LÄHTEÄ 'to go' in Figure 7).

[18] According to Brentari (1998), simple syllables, i.e. syllables with only one weight unit, seem to be the most frequent syllables also in ASL. In a study of signs described in the *Dictionary of American Sign Language on Linguistic Principles* (*DASL*; Stokoe, Casterline, and Croneberg 1965) she found that 82 percent of the signs had simple movement.

four FinSL syllable types among the one-handed monomorphemic monosyllables in the Basic Dictionary of FinSL (Malm 1998) is given in Table 1.

monosyllable type	**n**	**%**
one weight unit	131	57
two weight units	80	35
three weight units	19	8
four weight units	1	-
∑	*231*	*100*

Table 1. The distribution of different FinSL monosyllables in Jantunen's (2006, 2007) data.

In Jantunen's data, syllables with one (e.g. MUSTA 'black') and two (e.g. KULTTUURI 'culture') weight units were the most typical manually produced syllables. However, maximally the number of weight units in a manually produced syllable could be three (e.g. MIES 'a man', consisting of a straight path movement, orientation change, and handshape change), although in general syllables with three weight units tended to occur with two manual and one nonmanual movement components, the latter type being typically a mouth gesture (e.g. LÄHTEÄ 'to go', including a mouth gesture resembling the spoken sequence [viu]). Syllables with four weight units (e.g. EI-TUNNE 'does not know him/her', consisting of three manual components and one nonmanual component, i.e. the mouth gesture resembling the opening *b* where the opening manifests as slightly opened mouth; see Figure 8) were identifiable only if nonmanual movements were taken into consideration and treated as commensurable with manual movements. In general, these types of syllables were rare in Jantunen's data, which can perhaps be explained by the tendency of complex forms to reduce in complexity in their production (Jantunen 2006).

Conversely, 18 percent of *DASL* signs were characterisable as containing a complex movement.

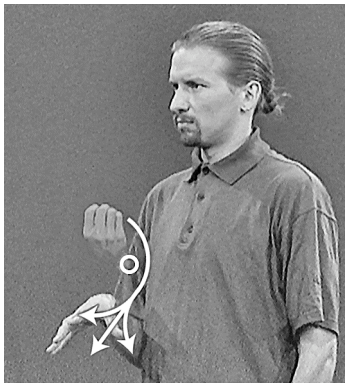

Figure 8. The FinSL monosyllable EI-TUNNE 'does not know him/her' including four weight units. (Original photograph from Malm 1998; by permission of FAD.)[19]

With regard to nonmanually produced syllables, the type including only one weight unit (e.g. ON-KUULLUT 'has/have heard', MUKAVA 'nice') occurred more frequently than the type including two weight units (e.g. KOVIN-PIENI 'rather/very small' containing a simultaneous head nod and a mouth movement resembling the spoken sequence [ka] or [sha]); two was the maximum number of weight units in a nonmanually produced syllable.

Analogously with the spoken language, Brentari claims that ASL syllables including one weight unit are light (cf. syllables with one mora) and those including more than one weight unit are heavy (cf. syllables with two or more moras). This light-heavy weight distinction in ASL syllables is supported by Brentari with two functional arguments. Firstly, referring to Supalla's and Newport's (1978) study on ASL noun-verb pairs, she argues that just like only the light syllables in certain spoken languages, e.g. Nootka, so also only the ASL syllables including one weight unit can be reduplicated in order to nominalize them. Secondly, just like phonologically heavy material in spoken languages, also heavy syllables in ASL tend to occur sentence finally.

Again, in Brentari's framework, Jantunen (2007) has observed that also in FinSL only syllables consisting of one weight unit tend to be inputs of grammatical reduplicative processes, basically the nominalizing reduplication. However, although this tendency in FinSL corresponds to that described by Brentari (and Supalla & Newport) for ASL, Jantunen does not accept it as sufficient evidence to posit a light-heavy weight distinction in FinSL. The main reason for this is that, in FinSL (Rissanen 1998), the nominalizing reduplication is not at all the productive process it has been said to be, for example, in ASL and therefore it

[19] The circle in Figure 8 (see EI-TUNNE 'does not know him/her') indicates the pivot point of the movement that changes the orientation of the hand.

cannot be used as a ground for argumentation (see also Johnston 2001 for Australian Sign Language). The syntactic behaviour of syllables consisting of more than one weight unit has not been researched in FinSL (cf. the tendency of phonologically heavy material to occur sentence finally).

In general, with respect to the views presented about spoken syllable structure, Brentari's view about the structure of signed syllables can be seen to be functionally analogous with Hyman's (1985) moraic view: both associate an increase in syllable weight with an increase in prosodic complexity (cf. section 3.1; see Brentari 1998: 79-80). With Hyman, this means an increase in the number of moras (manifested by an increase in the syllable's physical duration). With Brentari, this means an increase in the number of weight units (manifested by an increase in the movement's subcomponents). Another general observation that can be made about Brentari's view is that it is a model of signed syllable structure that seems to be most supported by syllable-related phonetic research (e.g. Wilbur & Allen 1991; Wilbur & Petersen 1997).

4. CONCLUSION

We consider that there are syllables in signed language, identified as short dynamic sequences of sign stream containing one sequential phonological movement. Such movements function as sonority peaks of syllables, sonority (cf. perceptual salience) in turn being the most important empirical property defining both spoken and signed syllables. Grammatical evidence (cf. the Minimal Word argument), as well as evidence from sign language acquisition (cf. the Babbling argument), further supports the interpretation of sequential phonological movements as syllables. With regard to the signed syllable's internal structure, there exist almost diametrically opposed opinions. However, regardles of these differences, the syllable, as we have applied the notion in this paper, must nevertheless be considered an important unit in capturing phonological generalizations in sign languages. A prime example of these is the generalization that limits the phonological length of core lexemes to two syllables.

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