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Non-manuals and tones: A comparative perspective on suprasegmentals and spreading

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ABSTRACT: Sign languages, i.e. language in the visual-gestural modality, are known to make abundant use of grammatical non-manual markers (NMMs) that fulfill functions at all linguistic levels. NMMs constitute a layer on top of the segmental layer, which consists of sequences of locations and movements, and they are capable of spreading over domains of varying size. Their suprasegmental nature as well as their ability to spread suggests a comparison to tones in tone languages, which may also function at the lexical, morphological, and syntactic level. In this paper, I offer a detailed comparison of the behavior of suprasegmentals in sign and spoken languages. I argue that they are functionally equivalent in the two modalities, but that non-manual spreading also displays some modality-specific properties. I tentatively claim that spreading of different types of NMMs targets prosodic domains of varying size: the prosodic word for lexical NMMs, the phonological phrase for morphological NMMs, and the intonational phrase for syntactic NMMs. In addition, I suggest that eye blinks function like boundary tones.

KEYWORDS: sign language, non-manual marker, tone, suprasegmental, prosodic domain, spreading

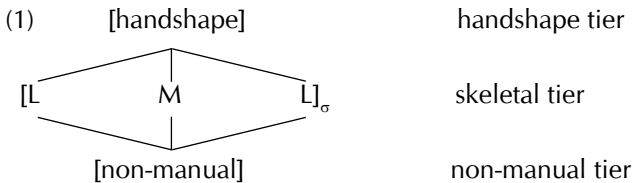
1. Introduction¹

It has long been realized that sign languages, that is, languages in the visual-spatial modality, are not just “languages of the hands”. Rather, research on a considerable number of sign languages from all parts of the world has revealed that non-manual markers (NMMs) play a crucial role in all components of grammar. NMMs, such as eyebrow positions and mouth, head and body movements, may be lexically specified for specific signs, they may function as morphemes, and they may fulfill various syntactic and pragmatic functions. In addition, and partly overlapping with some of

¹ I am indebted to Enoch Aboh, Annika Herrmann, Bernhard Köhler, and Markus Steinbach for providing helpful feedback concerning syntactic and typological issues. I thank an anonymous reviewer for constructive critique that helped me improve the paper.

these functions, NMMs have been argued to also fulfill a prosodic role, comparable to intonational contours in spoken languages (see Pfau & Quer, 2010, for an overview). Studies on Al-Sayyid Bedouin Sign Language, a rural sign language that emerged in a Bedouin village in Israel, even suggest that NMMs may acquire a grammatical role before a phonological system has crystallized (Sandler, Aronoff, Meir & Padden 2011), thus highlighting the crucial role of NMMs.

As for the manual composition of signs, it has been demonstrated that signs are characterized by sequential and simultaneous structure (Stokoe 1960; Liddell 1984). It is generally assumed that the segmental layer (i.e. the skeleton) consists of sequences of Locations² and Movements (Liddell & Johnson 1989; Sandler 1989; Brentari 1998), and that a combination of Location (L) segments with a Movement (M) segment defines a syllable. The maximal syllable has the structure L–M–L, where M constitutes the syllable nucleus (see Sandler, 2008, for a discussion of modality-independent and modality-specific properties of sign language syllables). Some scholars argue that M is the most sonorant element within the syllable – where sonority is understood as visual salience – and that M can thus be considered the sign language equivalent of vowels (Perlmutter 1992). The third manual building block (or parameter) of signs is Handshape. Handshape introduces simultaneity in the structure, as it is usually argued to be an autosegment that associates with skeletal positions (Sandler 1986), as indicated in the representation in (1). Note that the handshape node may have branching structure in case the sign involves a handshape change.



In Figure 1, this structure is illustrated by means of the sign PORTUGAL from Austrian Sign Language. The first location segment involves contact

² What I, following Sandler (1989), refer to as “Location” is labeled “Hold” in Liddell & Johnson (1989) and “Position” in Perlmutter (1992) – in the context of the present article, these terminological differences are irrelevant.

with the forehead. The hand then executes a downward movement in the center of the face and ends with final contact on the chin, which constitutes the second L segment. The handshape – a 1-handshape with extended index finger – is associated with all three skeletal positions.



FIGURE 1 – Video stills illustrating the L–M–L structure of the Austrian Sign Language sign PORTUGAL; the stills also illustrate the use of the accompanying mouthing (last row). Video stills from <https://www.spreadthesign.com/>.

The representation in (1) also includes a non-manual tier. With very few exceptions, NMMs are articulated simultaneously with L and M segments; that is, they do not usually appear by themselves (see Dively, 2001 for possible exceptions in American Sign Language). They are thus suprasegmental in the sense that they constitute a layer *on top of* the segmental layer. (1) illustrates that I assume that NMMs associate with the skeletal tier, as is evidenced by the fact that, whenever possible, NMMs tend to be synchronized with the movement of the sign(s) they accompany; as for lexical NMMs, Woll (2001) refers to this phenomenon as “echo phonology”.³ In Brentari’s (1998) model, the synchronization of manual and non-manual movements is captured by representing both under the prosodic feature branch in the structure (while handshape and location features are represented under the inherent feature branch). The simultaneous occurrence of a NMM can also be seen in Figure 1, as the sign is accompanied by a mouthing, the silent articulation of the word ‘Portugal’ (see Section 3.1). The onset of the first syllable (*p*) coincides with the first L-slot, the rhyme of the final syllable (*al*) with the final L-slot;

³ Woll (2014) offers interesting speculations about the possible role of echo phonology in language evolution.

at the moment when the hand reaches the nose, the signer articulates the nucleus of the second syllable (*u*).

Given the suprasegmental character of NMMs, it is tempting to compare them to tone in tone languages – and this is indeed the line of reasoning I will pursue in this article (and which has previously been pursued in Pfau (2002, 2008), Köhler & Herrmann (2009), and Weast (2011)). Just like NMMs, tones have to be associated with the segmental layer, and they are known to fulfill lexical, morphological and syntactic functions. Unlike tones, however, NMMs do not only associate with a syllable nucleus (the M segment in (1) and Figure 1). Also, various NMMs can be layered (Wilbur 2000) for the simple reason that different NMMs employ different (sets of) articulators. To give just one example: a lexically specified mouth movement may co-occur with a specific eyebrow position realizing a syntactic interrogative feature.

In the following, I will offer an account for the behavior of different types of NMMs, in particular, their spreading properties. Given the suprasegmental nature of NMMs, I will compare the attested spreading patterns to those described for tone spreading in spoken languages. To that end, I will start my investigation by discussing functions of tone in spoken languages in Section 2. In Sections 3–5, I will then address the behavior of phonological, morphological, and syntactic NMMs in turn. In all three sections, I will include a discussion of spreading patterns, and I will argue that non-manual spreading generally targets prosodic domains. Section 6 adds to the picture eye blinks, a NMM that does not spread.

2. Suprasegmentals in spoken languages: tone languages

In the introduction, I already alluded to the fact that NMMs may fulfill functions at all levels of grammar. The same holds for tones, and I will therefore briefly address lexical, morphological, and syntactic functions, respectively, in Sections 2.1–2.3. Given that the focus of the present study is on the spreading of NMMs, I will provide some background information on tone spreading in Section 2.4.

2.1. Lexical tones

In tone languages, the pitch quality of a word's vowel(s) can change the meaning of that word, that is, it is not uncommon to find minimal pairs that are only distinguished by tone. Tone languages may distinguish between two and four/five tone levels, for instance, the level tones high (á), low (à), and mid (ā) tone. The examples in (2) and (3) exemplify lexically contrastive tones: a two-tone system in Dagaare (Gur; Ghana) in (2) (Yip 2002: 2), a three-tone system in Punjabi (Indo-Aryan; India) in (3) (Yip 2002: 26).⁴

- | | | | | | | |
|--------|-------------|----|-------------|-----------|-----------|-----------|
| (2) a. | yùòrí (L–H) | b. | yúórí (H–L) | [Dagaare] | | |
| | 'penis' | | 'name' | | | |
| (3) a. | kòRaa (L) | b. | kōRaa (M) | c. | kóRaa (H) | [Punjabi] |
| | 'horse' | | 'whip' | | 'leper' | |

Level tones may combine in contour tones, yielding rising (LH: â) and falling (HL: ã) tones. The Cantonese examples in (4) illustrate that lexically specified contour tones (4c,d) may also participate in the creation of minimal pairs (adapted from Yip 1995: 478).

- | | | | | |
|--------|---------|----|---------|-------------|
| (4) a. | sí (H) | b. | sì (L) | [Cantonese] |
| | 'poem' | | 'try' | |
| c. | sî (HL) | d. | sî (LH) | |
| | 'silk' | | 'cause' | |

2.2. Tonal morphemes

Besides lexical functions, tones can also fulfill morphological functions. The Hausa (Chadic; Nigeria) examples in (5) illustrate that derivational processes may be realized by means of a tone change: as evidenced by the examples on the right side of the arrow, the N-forming suffix is a low tone

⁴ In the context of spoken language examples, the abbreviations L, H, and M stand for low, high, and medium tone, respectively (while in the context of sign language examples, L and M stand for Location and Movement). If two tone values are combined by a hyphen, then we are dealing with a sequence of tones associated with different tone-bearing units; if they appear adjacent without hyphen, then we are dealing with a contour tone associated with a single segment.

which attaches to the stem, yielding a falling tone in both cases (Newman 1992; in Yip 2002: 106).

- | | | | | |
|--------|------------|---|--------------------------|---------|
| (5) a. | sháa (H) | → | shâa (HL) | [Hausa] |
| | 'to drink' | | 'drinking _N ' | |
| b. | cí (H) | → | cîi (HL) | |
| | 'to eat' | | 'eating _N ' | |


Inflectional processes, too, may be marked and/or accompanied by tone changes. In Suma (Ubangi; Central African Republic), for instance, aspectual distinctions are signaled by tone: verb roots are lexically toneless and receive their tone from a tense-aspect suffix that is specified for tone: high tone in the imperfective, mid-tone in the perfective (6) (Odden 2007: 66). That is, we are dealing with tone spreading from the suffix to the root (see Section 2.4).

- | | | | |
|--------|-----------------|---------------|--------|
| (6) a. | kír-í (H–H) | kîr-ā (M–M) | [Suma] |
| | look.for-IMPERF | look.for-PERF | |
| b. | ďáf-í (H–H) | ďāf-ā (M–M) | |
| | make-IMPERF | make-PERF | |

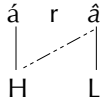
2.3. Syntactic functions of tone: tonal particles & clitics

Finally, tones may also contribute meaning at the level of syntax. As illustrated in (7), in Gungbe (Kwa; Benin), yes/no-questions require the presence of a sentence-final low tone. Compare the declarative in (7a) with its interrogative counterpart in (7b). The two examples only differ in the tone carried by the verb. The falling tone on the verb in (7b) derives from a combination of the lexical high tone of *wá* ('come/arrive') and the sentence-final floating low tone that triggers the question reading (Aboh & Pfau 2010: 92). Note that the floating tone does not necessarily attach to the verb; it attaches to the last syllable of the clause.

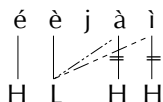
tone prefix *kú-* onto all syllables except the last one (Bickmore 1996: 11). (9b) illustrates the spreading process for the third example in (9a), where spreading targets three syllables.

- (9) a. kú-vúl-à 'to be enough' [Chilungu]
 kú-sáákúl-à 'to comb'
 kú-sóóbólól-à 'to sort out'
- b. kú – sóóbólól – à


Second, a tone may spread and combine with a specified tone of an adjacent tone-bearing unit, resulting in a contour. In Yoruba, a tonal constraint prevents H and L from combining in bisyllabic words. Instead, the tone of the first syllable spreads onto the second syllable surfacing in either a [L–LH] sequence (10a) or a [H–HL] sequence (11b) (Yip 2002: 47). In (10c), this process is illustrated for the H–L case.

- (10) a. /àlá/ 'dream' → [àlǎ] [Yoruba]
 L–H L–LH
- b. /rárà/ 'elegy' → [rárâ]
 H–L H–HL
- c. r á r â


Third, tone sandhi may involve spreading and delinking, which implies that a tone-bearing unit may lose its underlyingly specified tone value. For instance, in Barasana (Tucanoan; Colombia) compounds, the last tone of the first part spreads onto all tone-bearing units of the second part, be it H (11a) or L (11b) (Gomez-Imbert & Kenstowicz 2000: 433). Note that the lexically specified high tone in (11a) is not affected. The representation in (11c) illustrates the delinking (marked by '=') and spreading process for (11b).

- (11) a. héá + g t t̃-á à → héág t̃-á à ‘flint stone’ [Barasana]
 H-H L-H-L H-H-H-H-H
- b. hèè + jáí → héejàì ‘shaman (ancestor-jaguar)’
 H-L H-H H-L-L-L
- c. h é è j à ì


All of the above examples exemplify word-internal sandhi, be it within a root (10) or within a morphologically complex word, as in (9) and (11). However, word-external sandhi phenomena are also attested; these will be addressed in the context of sign language examples in Sections 4.1 and 5.2.

3. Lexical non-manual markers

As already explained in the introduction, besides consisting of manual building blocks, signs may also be lexically specified for NMMs. In this section, I consider two types of lexical NMMs and their spreading behavior: the so-called mouthings (Section 3.1) and non-manuals signaling negation (Section 3.2), implicitly assuming that other lexical non-manuals such as mouth gestures and facial expressions show similar distributional patterns. Note that the negative headshake is particularly interesting, as it has been argued to function at different linguistic levels, depending on the sign language. It will therefore make another appearance in Section 4, where we address morphological NMMs.

3.1. Mouthings

A mouthing is the silent articulation of (a part of) a spoken word that corresponds to the meaning of the sign. In some sign languages, mouthings commonly accompany lexical elements (mostly nouns). It should be noted that their status as part of the sign language lexicon is debated; however, I shall not enter this discussion here (see Bank, 2014, for a recent overview).

The three examples from Sign Language of the Netherlands (*Nederlandse Gebarentaal*– NGT) given in (12) illustrate different types of mouthings (see

Schermer (2001) for discussion). In (12a), the sign is accompanied by a full mouthing (*bloem* being the Dutch word for ‘flower’). In contrast, in (12b), we observe a reduced mouthing: *va* is the first syllable of the Dutch word *vakantie* (‘holiday’); it is repeated as the sign also contains a repeated movement. That is, the non-manual is synchronized with the manual articulation, and (12b) thus is an example of echo phonology (Woll 2001). In (12c), the relation between manual part and mouthing is different. In this case, the manual part by itself would be ambiguous, and it is only the mouthing which disambiguates the meaning of the sign (*zus* means ‘sister’).⁵

(12) a. $\frac{\text{/blu:m/}}{\text{FLOWER}}$ ‘flower’	b. $\frac{\text{/vava/}}{\text{HOLIDAY}}$ ‘holiday’	c. $\frac{\text{/zys/}}{\text{BROTHER/SISTER}}$ [NGT] ‘sister’
------------------------------------------------------------	--------------------------------------------------------	-------------------------------------------------------------------

What makes mouthings interesting in the present context is the fact that they are capable of spreading onto adjacent functional elements. This type of spreading often goes hand in hand with manual changes, such as handshape assimilation and movement reduction, and it has been suggested that it is indicative of cliticization, whereby a lexical and a functional element combine to form a prosodic (or phonological) word (Sandler 1999; Nespor & Sandler 1999). Boyes Braem (2001) refers to this phenomenon as *prosodic binding*. Note that I assume that prosodic binding may occur independent of the linguistic status of a specific mouthing: it may involve mouthings that are lexically specified (such as (12c)) as well as mouthings that are redundant or optional and which thus are probably not part of the sign language lexicon.

In the German Sign Language (*Deutsche Gebärdensprache* – DGS) example (13a), for example, the mouthing associated with the adjectival predicate (*stolz* ‘proud’) spreads onto the sentence-final agreement auxiliary *PAM* (*person agreement marker*; Steinbach & Pfau 2007: 323). In an interesting cross-linguistic study, Crasborn, van der Kooij, Waters, Woll & Mesch (2008) compare spreading of mouth actions in NGT, British Sign Language (BSL), and Swedish Sign Language (SSL). They find that in NGT and BSL spreading almost exclusively proceeds rightwards

⁵ Note that I refrain from glossing the manual part as *SIBLING* because it is never used without a mouthing to mean ‘sibling’.

(progressive), while in SSL a fair amount of leftward (regressive) spreading is observed. In the NGT example (13b), we observe three instances of progressive spreading of mouthings from lexical onto functional signs, two pointing signs (INDEX) targeting the same location in the signing space and one person classifier (*dorp* means ‘village, *jongen* ‘boy’, and *woon* is the stem of the verb ‘live’). In the SSL example in (13c), the mouthing associated with the verb ‘understand’ (*förstå*) spreads onto a preceding pointing sign, a first person pronoun (Crasborn *et al.* 2008: 59).

- (13) a. INDEX₁POSS₁BROTHER INDEX_{3a} PROUD[^]₁PAM_{3a} /stolts/ [DGS]
 ‘I am proud of my brother.’
- b. /doep/ INDEX /jɔŋən/ BOY PERSON /wo:n/ LIVE INDEX [NGT]
 ‘There was a boy who lived in a village.’
- c. neg
/förstå/
 INDEX₁ UNDERSTAND [SSL]
 ‘I don’t understand.’

Hence, what we observe in (13) is spreading of a suprasegmental marker onto an adjacent functional element under cliticization. Since cliticization is post-syntactic, spreading is not constrained by syntactic hierarchy. A mouthing, for instance, might also spread onto a clause-final right-dislocated pronoun (e.g. a subject pronoun copy).⁶

In (8), I cited a Yoruba example in which a tone spreads from a clitic onto a stem. Given the above reasoning, cases in which a tone spreads from a host onto a clitic are more interesting in the present context. Such a phenomenon is attested in Degema (Niger-Congo; Nigeria), where clitics (and affixes) are toneless and are prosodically integrated within the host they attach to. Hence, in example (14a), the proclitic receives its high tone from the verb, in

⁶ Note that I do not claim that all spreading of mouthings necessarily defines or targets a prosodic domain; I only argue that it commonly does. In particular, in cases of code-blending between a sign and a spoken language (where words are usually articulated with voice; cf. Emmorey, Borinstein, Thompson & Gollan 2008), misalignments between the two channels are commonly observed. I am grateful to the reviewer for bringing up this point.

(14b) from the emphatic auxiliary (Kari 2002: 94, 99). Given regressive tone spreading, these examples are comparable to the SSL example in (13c).

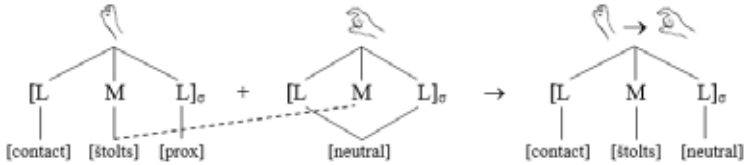
- (14) a. mɔ́ = mɔ́n mɛ́ [Degema]
 3.SG.PROCL = see me
 ‘S/he will see me.’
- b. má = gá jí ínínə
 2.PL.PROCL.Q = EMPH.AUX come today
 ‘Are you really going to come today?’

However, what is noteworthy about at least some of the mouthing cases is that the manual part of the resulting prosodic word may be phonologically reduced. In (13a), for instance, the resulting host-clitic combination is monosyllabic. The sign PROUD is signed at the nose with a short forward movement, while the auxiliary is articulated in neutral space with a forward movement from close to the signer’s body (location 1) towards the locus associated with the third person object (location 3). In the host-clitic combination, the two movements are fused into one, that is, the movement proceeds from the nose to location 3 in neutral signing space; the resulting segmental structure is L–M–L, as shown in the simplified representation in (15). During the movement, the handshape changes from the handshape of PROUD to the handshape of PAM.⁷ Further research is necessary in order to determine the exact relation between phonological reduction and spreading of mouthing. A reviewer mentions the possibility that spreading might trigger reduction, rather than just commonly going hand in hand with it. Data reported in the literature suggest that phonological reduction is possible without mouthing (e.g. Sandler 1999), but, obviously, sign languages might differ from each other in this respect.

⁷ Occasionally, a mouthing spreads from one lexical element onto another, thus binding/linking a prosodic unit larger than a prosodic word; an example from Swiss-German Sign Language (*Deutsch-Schweizerische Gebärdensprache* – DSGS) is given in (i): the mouthing associated with WORK (German *arbeiten*) does not only spread onto the adjacent pointing sign but also over another verb (Boyes Braem 2001: 117). However, these cases appear rather exceptional. Crasborn et al. (2008) assume that, in these cases, the mouthing marks a larger prosodic unit, the phonological phrase.

(i) INDEX₁ GO-TO INDEX₁ /arbaitn/
 WORK INDEX GO-THERE [DSGS]
 ‘I went to where I work.’

(15)



In (16), I provide comparable examples from Yoruba, in which we observe tone spreading in combination with the deletion of segmental material. In both examples, the verb *wá* ('look (for)'), which carries a high tone, combines with an object. In the output, the vowel of *wá* disappears, but its tone survives and associates with the first vowel of the object noun (Akinlabi & Liberman 2001). That is, just as in (15), we observe syllable deletion and suprasegmental spreading.

- (16) a. *wá* (H) + *òṅṅè* (L-L) → *wòṅṅè* (H-L) [Yoruba]
 look (for) way 'look for a way'
 b. *wá* (H) + *òwó* (M-H) → *wówó* (H-H)
 look (for) money 'look for money'

3.2. Negative headshake and backward head tilt

All sign languages studied to date mark sentential negation by means of manual negative particles in combination with a NMM, the most common NMM being a side-to-side headshake (Zeshan 2004; Quer 2012). Interestingly, however, sign languages differ from each other with respect to the distribution of manual and non-manual markers. In some sign languages, the so-called manual dominant sign languages, the use of a manual negator is obligatory, while in others, the non-manual dominant ones, clauses are commonly negated by only a headshake (Zeshan 2006a; Pfau 2015). In this section, I will only be concerned with a sign language of the former type; sign languages of the latter type will be addressed in Section 4.1.

Turkish Sign Language (*Türk İşaret Dili – TİD*) is a manual dominant sign language that features various negative particles which usually occupy a clause-final position (other sign languages of this type are, for instance,

Italian Sign Language (Geraci 2005) and Hong Kong Sign Language (Tang 2006)). TĪD employs two negative NMMs, depending on the movement properties of the manual negator, more specifically, the plane on which the hand moves: a side-to-side headshake and a backward head tilt– that is, the manual and the non-manual movement are synchronized.⁸ Consequently, the sign NO-NO in (17a), which involves a side-to-side movement on the frontal plane, is accompanied by a headshake ('hs'), while the sign NOT in (17b), which is specified for a single movement on the midsagittal plane, is accompanied by a backward head tilt ('bht') (examples adapted from Zeshan (2006b: 156) and Gökgöz (2011: 60)).

- (17) a. CHILD + BEAT INDEX₁ ^{hs} NO-NO [TĪD]
'(I) don't beat my children.'
- b. INDEX₁BANANA THROW_{front} ^{bht} NOT
'I did not throw the banana to the front.'

Generally, the NMM is only co-articulated with the obligatory negative particle. It has therefore been suggested that these particles are lexically specified for the respective NMM (Gökgöz 2011; Pfau 2015). In this sense, the TĪD examples in (17) are comparable to the Musgu (Chadic; Cameroon) example in (18) (Meyer-Bahlburg 1972, in Dryer 2005: 454): both languages make use of a clause-final negative particle that is specified for a suprasegmental feature (a low tone in Musgu).

- (18) à sǎdǎ cécébé pǎy [Musgu]
3SG.M know jackal NEG
'He didn't see the jackal.'

In Section 3.1, we have shown that lexically specified NMMs are capable of spreading in cliticization contexts. We thus expect that the TĪD

⁸ Both NMMs can be traced back to culture-specific negative co-speech gestures. The backward head tilt is used by speakers in countries of the Eastern Mediterranean area, and it is therefore not surprising that sign languages in that area (e.g. TĪD, Greek Sign Language, Jordanian Sign Language) also employ this NMM. Still, all these sign languages also make use of a negative headshake. See Pfau (2015) for the grammaticalization of headshake and Loon, Pfau & Steinbach (2014) for the grammaticalization of gestures in general.

headshake / head tilt, which is generally confined to the manual negator, may also spread in such contexts – and this is indeed the case. In (19), for instance, the negative particle cliticizes to the verb KNOW, and the backward head tilt spreads regressively onto the verb; also, as in (15), the two signs are fused into a single syllable (Zeshan 2006b: 154).

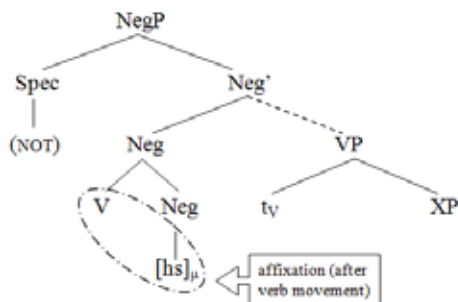
(19) INDEX₁ SPEAK $\frac{\text{KNOW}^{\text{bht}}}{\text{NEG}}$ [TİD]
'I cannot speak.'

It should be pointed out that the description we offer here is simplified. Crucially, it is not necessarily the case that all manual dominant sign languages behave in exactly the same way. For instance, Geraci (2005) argues for LIS that the manual negator is not lexically specified for the headshake but receives the headshake under Spec-head agreement from a syntactic [neg]-feature residing in the head of a negative phrase (NegP). Also, TİD allows for negative concord involving two manual negators, while the same is impossible in LIS (see Pfau (2016) for a syntactic account of some of the differences, and Oomen & Pfau (in press) for a typological comparison).

4. Non-manual morphemes

In Section 2.2, we demonstrated that, in spoken languages, tones may contribute derivational (word class) and inflectional (e.g. tense, aspect) meanings. Similarly, in sign languages, suprasegmentals may fulfill morphological functions. Two NMMs will be considered in this section. First, continuing the discussion from the previous section, I will address the use of the negative headshake in sign languages that are typologically different from TİD (Section 4.1). Secondly, I will turn to non-manual adverbials (Section 4.2).

(21)



When the manual negator is present, it follows the verb (e.g. WINE LIKE NOT), and it is also accompanied by a headshake. However, as in TĪD, the headshake accompanying the manual negative sign is lexically specified. When the sentence is articulated, the lexical and the morphological headshake will be realized as a continuous contour. This line of argumentation also suggests that DGS has split negation, whereby a negative particle combines with a negative affix (Pfau 2008, 2015).

Cases in which negation is realized by only a suprasegmental feature are rare in spoken languages. Yet, they are attested, and Dahl (2011) provides one such example from Mbembe (Niger-Congo; Nigeria). As illustrated in (22), in this language, a tone change alone may change the polarity of the sentence (Barnwell 1969, in Dahl 2011: 17). The example in (22b) thus comes close to the DGS example in (20a), one difference being that the suprasegmental morpheme attaches to the verb in DGS, but to an inflectional prefix in Mbembe.

- | | | | | |
|---------|---------------|----|----------------|----------|
| (22) a. | mó-tá (H-H) | b. | mò-tá (L-H) | [Mbembe] |
| | 3.FUT-go | | 3.NEG-go | |
| | 'He will go.' | | 'He won't go.' | |

Other comparable examples that have been reported in the literature have a somewhat exceptional status. In Ógbrù (Kwa; Ivory Coast), negation is usually realized by the post-verbal particle *mú* (with high tone) in combination with a high-tone featural affix which attaches to the aspectual

characteristics of sign languages might favor such more extensive spreading. First, in sign languages, signs tend to be monosyllabic (Sandler 1999, 2008), and therefore, spreading of the headshake over, for instance, an object NP containing a modifier often only targets two syllables. Secondly, and more importantly, the nature of suprasegmental spreading is different, as no other suprasegmental feature is overwritten. Except for the cases in which tone spreading targets segments that are underlyingly toneless, as in (9), tone sandhi generally involves spreading and delinking, that is, an underlyingly specified tone value is changed – as is true in (25) and (26) (also see the representation in (11c)). Clearly, this is not the case in the DGS example in (24), as WINE is not specified for a suprasegmental feature that would have to be delinked in order for the headshake to spread.¹⁰

As for the domain of spreading, I tentatively suggest that, in DGS, spreading of the suprasegmental marker headshake is confined to the phonological phrase (PhP), a prosodic domain situated between the prosodic word and the intonational phrase in the prosodic hierarchy (Nespor & Vogel 1986). This assumption may help us explain (i) why non-pronominal subjects usually fall outside the scope of the headshake and (ii) why headshake does not usually spread onto relative clauses that modify an object.

As for pattern (i), it can be argued that pronouns, as prosodically light elements, are more easily integrated into the rest of the clause. In a corpus-based study on NGT, another non-manual dominant sign language, Oomen & Pfau (in press) observe that a headshake spreads onto the subject in 23 out of 78 negative clauses that contain an overt subject; interestingly, in 21 of these cases, the subject is a pronoun (27a). The same line of reasoning may explain why clause-final subject pronoun copies are generally accompanied by headshake (27b).¹¹ Note that both instances of spreading cannot be accounted for in terms of syntactic spreading (e.g. in terms of c-command domains, as suggested by Neidle, Kegl, MacLaughlin, Bahan & Lee (2000) for American Sign Language): both the subject and the right-dislocated

¹⁰ FLOWER might, however, be specified for another suprasegmental feature, such as mouthing. Crucially, in sign languages, different suprasegmental features involve different articulators, and they may therefore be layered (Wilbur 2000) – in striking contrast to tone.

¹¹ The same holds for other right-adjacent functional elements, such as, for example, the sign PALM-UP. Note, however, that PALM-UP commonly cliticizes to the preceding sign. Consequently, in this case – just as in the cases discussed in Section 3 – the relevant prosodic domain may be the prosodic word.

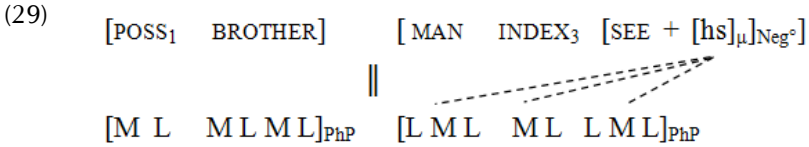
pronoun occupy a position higher in the structure, that is, a position above the head of NegP, which we assume to be source of the headshake. It is well-known that prosodic constituents are not necessarily isomorphic to syntactic constituents (Nespor & Vogel 1986; Truckenbrodt 1999), and this is clearly true for (27b).

- (27) a. $\overline{\hspace{10em}hs}$
 INDEX₂ MATCH PALM-UP [NGT]
 'You didn't match (with him).'
- b. INDEX₁ INDEX₃ $\overline{\hspace{10em}hs}$ REACT INDEX₁
 'I don't react to it / reply to it.'

As for pattern (ii), we have to note that DGS relative clauses are head-external and follow the head noun (Pfau & Steinbach 2005). Consider the contrast in (28): while spreading of the headshake over the direct object is possible in (28a), the grammaticality of (28b), where the direct object MAN is modified by a relative clause (RC), is questionable.

- (28) a. POSS₁ BROTHER $\overline{\hspace{10em}hs}$ MAN INDEX₃SEE₃ [DGS]
 'My brother didn't see the man.'
- b. ? POSS₁ BROTHER $\overline{\hspace{10em}hs}$ MAN (INDEX₃)[RELPRO₃BOOK STEAL]_{RC}SEE₃
 'My brother didn't see the man who stole a book.'

In (29), we illustrate the spreading process for example (28a). After verb movement, the headshake affix attaches to the verb SEE. Subsequently, it spreads onto the movement segments within the PhP. The double vertical line indicates the prosodic boundary which the spreading process cannot cross. Note that once again, there is a tendency for the NMM to be synchronized with manual movement.



4.2. Non-manual adverbials

As the name suggests, non-manual adverbials are NMMs that contribute adverbial meaning. Liddell (1980) was the first one to describe non-manual adverbials in some detail. In his seminal study on American Sign Language (ASL), he distinguished three adverbials, which he glossed as ‘th’ (lack of control, inattention), ‘mm’ (relaxed manner), and ‘cs’ (proximity); all of these adverbials involve specific mouth configurations (see Bridges & Metzger (1996) and Anderson & Reilly (1998) for additional non-manual adverbials). Use of the first adverbial is illustrated by the ASL example in (30a) (Liddell 1980: 52), use of the second one by the NGT example in (30b). Note that ‘th’ is characterized by tongue protrusion, while ‘mm’ involves a specific configuration of the lips (lips pushed out a little but kept together).

- (30) a. _____th
 INDEX₁ GO-ACROSS. WRONG, ACCIDENT [ASL]
 ‘I crossed the street carelessly. Whoops! There was an accident.’
- b. _____mm
 POSS₁ FATHER NEWSPAPER READ [NGT]
 ‘My father is reading the newspaper in a relaxed manner.’

Interestingly, it has been reported that non-manual adverbials usually do not spread beyond the predicate they modify– in contrast to what we described in the preceding section for the headshake in non-manual dominant sign languages. Liddell (1980: 46), for instance, points out that the non-manual “was found to be coterminous with the verbs”, and Neidle et al. (2000: 42) stress that “such adverbial expressions are coextensive with the items they modify and do not spread over other signs” (such as the direct object of the verb with which the NMM is associated, e.g. NEWSPAPER in (30b)). Still, non-manual adverbials do spread in cases in which

the predicate is reduplicated, for instance to express habitual aspect, as in the NGT example in (31). Clearly, this is not surprising, as aspectual reduplication takes place first, and the adverbial modification then scopes over the inflected predicate.¹²

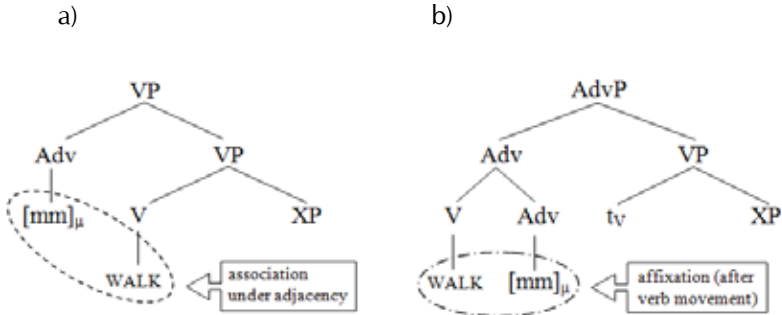
- (31) SATURDAY POSS₁ FATHER NEWSPAPER mm
 READ + + [NGT]
 ‘On Saturdays, my father is always reading the newspaper in a relaxed manner.’

Given that adverbial non-manuals are also affixed to verbs, the question arises why, in contrast to the headshake, they cannot spread. Here, I want to offer two possible explanations. On the one hand, given that the relevant adverbials are typical VP-adverbials, one may assume that they adjoin to VP. In order to combine with the adverbial, the verb must be in (or must move into) a position sufficiently close to the adverbial. This configuration is illustrated in (32a), where association takes place under adjacency. Note that this configuration is different from the one in (21), where the verb adjoins to the NMM. Crucially, in (32a), the non-manual and the verb are not combined under a single head. It might be argued that in such a configuration, a NMM is generally incapable of spreading beyond the adjacent sign.

¹² In spoken languages, a tone associated with a base may spread onto the reduplicant, as is illustrated in the Kirundi (Bantu; Burundi) examples in (i) in which adjectival reduplication expresses emphasis (Brassil 2003: 47). However, this process is different from the one in (31), as the suprasegmental feature tone is specified prior to reduplication, while in (31), reduplication precedes non-manual marking.

- | | | | | | |
|-----|----|----------------------|---|-------------------------------|-----------|
| (i) | a. | bà-tóó
cl2-small | → | bátóó + bātó
small.EMPH | [Kirundi] |
| | b. | mà-gúfi
cl6-short | → | màgúfi + màgúfi
short.EMPH | |

(32)



Alternatively, non-manual adverbials could be argued to project adverbial phrases above VP (Cinque 1999) with the verb moving and adjoining to the adverbial head (32b). Obviously, this structure is reminiscent of (21), as it involves affixation of a NMM after verb movement. In order to account for the impossibility of spreading in examples like (30), we would then have to resort to semantic factors. After all, the adverbial non-manual, in contrast to the headshake, can only be interpreted as a verbal modifier. Still, semantic factors alone cannot explain the absence of spreading. After all, from a semantic point of view, what is modified in (30b) is the entire predicate, not just the verb.¹³

5. Syntactic non-manuals

Last but not least, it has been observed in basically all sign languages studied to date that NMMs are also systematically employed to mark certain syntactic functions or operations. For instance, they mark sentence type (Cecchetto 2012; Donati, Barberà, Branchini, Cecchetto, Geraci & Quer, in press), accompany various types of embedded clauses (Pfau & Steinbach 2016), and are used to express information structure related notions (Wilbur 2012; Kimmelman & Pfau 2016). When it comes to syntactic functions, it is generally assumed that the NMMs that are associated with them are the

¹³ I thank the reviewer for raising this point, which actually makes an explanation in terms of syntactic structure (as in (32a)) more promising.

overt realization of abstract syntactic features residing in functional heads (e.g. Neidle et al. 2000). As exemplars of constructions that involve syntactic NMMs, I will consider topics (Section 5.1) and yes/no-questions (Section 5.2).¹⁴

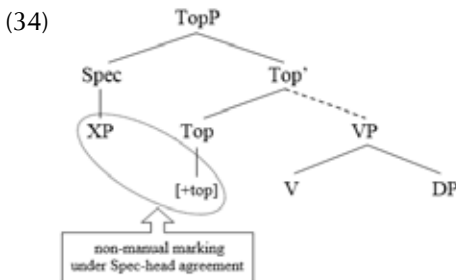
5.1. Topic marking

Topics in sign languages occupy a left-peripheral position and are commonly accompanied by raised eyebrows, sometimes in combination with specific chin and/or head positions; in the following examples, the relevant NMMs are abbreviated as ‘top’. The ASL example (33a) and the NGT example (33b) contain topicalized DPs. In both cases, the topic does not constitute an argument of the verb but is related to an element within the clause. In (33a), the topic bears a semantic relationship to the noun *CORN*, which is an argument of the verb (Aarons 1996: 66); in (33b), the topic is co-referential with a pronoun in subject position (Kimmelman & Pfau 2016: 816) – the latter type of construction thus exemplifies ‘left dislocation’. In the Catalan Sign Language (LSC) example (33c), a clause occupies the topic position (Quer 2004).

- (33) a. _____ top
VEGETABLE, JOHN LIKE CORN [ASL]
‘As for vegetables, John likes corn.’
- b. _____ top
POSS₁ BROTHER INDEX₃, EVENING INDEX₃ VISIT₁ [NGT]
‘As for my brother, he will visit me tonight.’
- c. _____ top _____ hs
ARTICLE TODAY FINISH IMPOSSIBLE [LSC]
‘As for finishing the article today, that’s impossible.’

¹⁴ Negation, i.e. the negative headshake, could have made yet another appearance in this section. In Section 3.2, I already mentioned in passing that Geraci (2005) argues that in LIS, the headshake is neither lexically specified (as in TlD) nor a featural affix (as in DGS). Rather, he assumes that the headshake spells out a syntactic feature [+neg] that occupies the head of NegP and associates with the manual negator in SpecNegP under Spec-head agreement. This line of reasoning is similar to what Neidle et al. (2000) argue for ASL, a non-manual dominant sign language, a crucial difference being that in ASL, the headshake that spells out [+neg] can spread. In a comparison of DGS, ASL, and Catalan Sign Language negation, Pfau & Quer (2002) relate different spreading behaviors to the morphological versus syntactic nature of the headshake.

Following Rizzi (1997), Aboh (2004), and others, I assume that topics occupies a position within the left periphery of the clause, that is, the specifier of a topic phrase (SpecTopP). The head of TopP hosts a syntactic topic feature which is realized by the respective non-manual(s). The non-manual associates with the XP in SpecTopP under Spec-head agreement, as is illustrated in (34).¹⁵ Hence, in all cases, the whole XP is marked non-manually. Non-manual marking is expected to proceed in the same way for base-generated and moved topics, as the syntactic configuration in which non-manual marking applies is the same in both cases.¹⁶ Note that, in principle, one could also argue that the non-manual topic marker is morphemic in nature, similar to what we argued for the negative headshake in Section 4.1. One would then have to assume that the topic morpheme attaches to the last sign within the topicalized constituent and then spreads over the entire phrase in SpecTopP. Remember, however, that – given verb movement to the head of NegP – spreading of the headshake is optional. In order to account for this difference, I therefore maintain for the time being that NMMs markers that obligatorily spread in a Spec-head configuration result from syntactic features, while morphological markers either spread optionally or do not spread at all (as is true for the non-manual adverbials; cf. Section 4.2).



¹⁵ Note that TopP can be recursive, that is, many languages, including sign languages, allow for topic stacking (cf. Rizzi 1997; Aarons 1996; Puglielli & Frascarelli 2007).

¹⁶ Aarons (1996) observes that in ASL, different types of topics (e.g. moved vs. base-generated topics) are accompanied by slightly different sets of NMMs. Furthermore, recent studies on Hong Kong Sign Language (Sze 2011), NGT, and Russian Sign Language (Kimmelman 2014) suggest that not all topics receive non-manual marking. For Hong Kong Sign Language, Sze observes that non-manual marking is much more likely for scene-setting topics than for aboutness topics. Similarly, Kimmelman reports that in both NGT and Russian Sign Language, topics are not consistently marked non-manually. In fact, only shifted topics are marked by brow raise and head tilt.

I further assume that non-manual marking under Spec-head agreement generally defines an intonational phrase (IntP), that is, a prosodic constituent that is clearly separate from the rest of the clause. This is in line with Nespor & Sandler (1999: 164), who argue that “topicalized elements [...] obligatorily form intonational phrases of their own”. As for non-manual marking, they observe a change in head position and a radical change in facial expression at the edge of the IntP, often in combination with an eye blink at the boundary (see Section 6). As for manual cues, the boundary may be marked by holds and pauses. Note that this property, too, clearly distinguishes topic marking from the negative headshake, which does not necessarily accompany an IntP. In Section 4.1, I suggested that the spreading domain for the headshake may be a prosodic domain that is lower on the prosodic hierarchy, the phonological phrase. Nespor & Sandler (1999: 161) provide the Israeli Sign Language (ISL) example in (35), which illustrates that a topic may indeed contain more than one PhP (example slightly adapted and simplified).

- _____ brows up, head tilt & body lean
 _____ squint _____ mouth: ‘O’
- (35) [[BOOK[^]THERE]_{PhP} [INDEX₃ WRITE]_{PhP}]_{IntP} [[INTERESTING]_{PhP}]_{IntP} [ISL]
 ‘The book he wrote is interesting.’

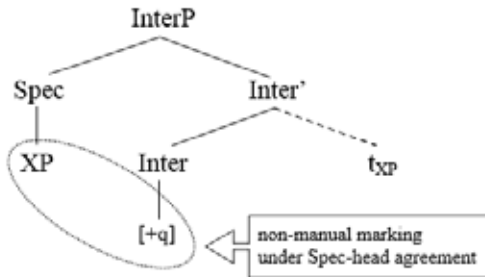
5.2. Marking of yes/no-questions

The question feature [+q] is another syntactic feature occupying the head of a functional projection in the left periphery, namely the head of an interrogative phrase (InterP) (Rizzi 2001; Aboh 2004). Just like the topic feature, it is realized by a non-manual marker (or a set of non-manual markers). For ASL, Liddell (1980) points out that the fullest form of the relevant NMM consists of brow raise, head forward, and body forward, but that a brow raise alone is often sufficient to signal a yes/no-question. He further stresses the fact that “the string is not wellformed if the non-manual signal accompanies only part of the question” (1980: 3). Use of the yes/no-question marker (‘y/n’) is illustrated by the ASL example in (36a) (Liddell 1980: 3) and the Hong Kong Sign Language (HKSL) example in (36b) (Tang 2006: 201).

- (36) a. $\frac{\text{y/n}}{\text{WOMAN FORGET PURSE}}$ [ASL]
 'Did the woman forget her purse?'
- b. $\frac{\text{y/n}}{\text{INDEX}_2 \text{ GO WATCH-MOVIE}}$ [HKSL]
 'Will he go to watch movies?'

Presumably, in y/n-questions, the [+q]-feature in the head of InterP attracts the whole clause into its specifier (Wilbur & Patschke 1999; Aboh & Pfau 2010) and consequently, the whole clause is non-manually marked under Spec-head agreement, as illustrated in (37). Note that this configuration is the same as the one sketched in (34) for topics, one difference being that yes/no-questions always involve movement.

(37)



Interestingly, in some sign languages, manual question particles may occupy the [+q]-head. HKSL has two different particles that both occupy the clause-final position but appear in different contexts. The example in (38a) exemplifies the use of the particle glossed as HAVE + NOT-HAVE. Note that, in this case, the NMM only accompanies the particle. In fact, Tang points out that in the presence of a particle, spreading leads to ungrammaticality (38b) (Tang 2006: 206) – unlike what we observed in (36b). In contrast, in other sign languages, the NMM may extend over the whole clause even in the presence of an (optional) question particle. This pattern is illustrated by the NGT example in (38c).

- (38) a. INDEX₂ YESTERDAY NIGHT WATCH-MOVIE ^{y/n} **HAVE + NOT-HAVE** [HKSL]
 'Did you watch the movie last night?'
- b. * ^{y/n} TIN INDEX₃ BISCUIT **HAVE + NOT-HAVE** [HKSL]
 'Are there any biscuits inside the tin?'
- c. ^{y/n} INDEX₃ PARTY CANCEL **Q-PART** [NGT]
 'Is the party cancelled?'

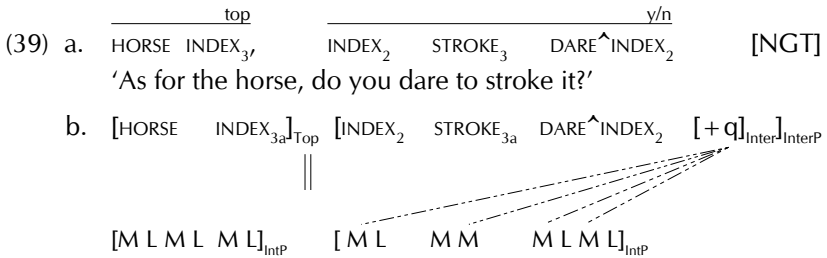
Given that question particles typically occur clause-finally, I assume that they occupy the head of the interrogative phrase and that the non-manual that spells out [+q] associates with the particle with which it shares a node. Still, the proposition moves to SpecInterP, as illustrated in (37). Apparently, sign languages differ from each other with respect to whether spreading under Spec-head agreement is still possible once the NMM combined with a manual sign.

The analysis we sketch here is similar to the one provided for the Gungbe example in (7b) by Aboh & Pfau (2010). In Gungbe, a low tone particle occupies the head of InterP and attaches to the last syllable of the proposition that has moved to SpecInterP.¹⁷ The crucial difference between the Gungbe and the sign language examples is that in Gungbe, the suprasegmental feature does not spread. Presumably, this is due to the fact that in Gungbe, the tone-bearing units within the clause are underlyingly specified for tone values. Hence, spreading of the low tone would require repeated delinking of tone values. In contrast, as already pointed out in our discussion of headshake spreading in Section 4.1, skeletal positions in sign languages are not inherently specified for the relevant suprasegmental feature. Consequently, non-manual spreading does not imply a feature change, but rather adds a suprasegmental feature to the featural make-up of a sequence of signs.

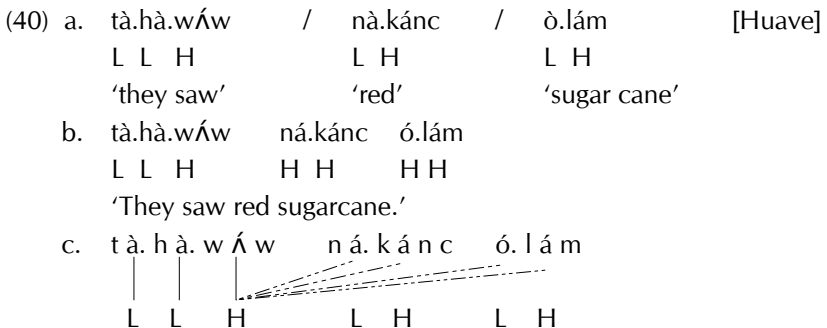
¹⁷ Data from Fongbe, another Gbe language, support this characterization. Example (i) illustrates that Fongbe employs a full morpheme in yes/no-questions: a sentence-final particle which is specified for a low tone (Aboh & Pfau 2010: 93).

(i) Kòkú yró Àsibá à? [Fongbe]
 Koku call Asiba INTER
 'Did Koku call Asiba?'

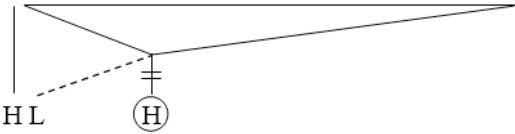
The representation in (39b) illustrates the spreading process for the NGT sentence in (39a). In this example, a topic precedes the y/n-question, and as pointed out in Section 5.1, topics generally constitute their own IntP (the boundary is again marked by the double vertical line). Consequently, the topicalized constituent is outside of the spreading domain of the prosodic marker associated with [+q].



Lack of tone spreading thus distinguishes the Gungbe example from the sign language examples. Still, tone spreading across multiple words is not unattested in spoken languages. In Huave (isolate; Mexico), for instance, a high tone spreads rightward off a stressed syllable, the domain of spreading being the verb phrase or the clause – Yip (2002) refers to this as “unbounded spread”. (40a) illustrates the tone values for the isolated forms, (40b) shows the tone values for the elements when combined in a clause. All tone-bearing units to the right of the first H receive high tone. The spreading process is further illustrated in (40c) (Noyer 1992; in Yip 2002: 225).



For Kipare (Bantu; Tanzania), Odden (1995: 462f) describes an instance of “across-the-board lowering”. Underlyingly, each word in (41a) contributes only high tones. At the phrasal level, adjacent Hs combine into one multiply-linked H. Odden further assumes the presence of a floating L tone. Across-the-board lowering is taken to be the result of delinking of the multiply-linked H and subsequent L-spreading, as illustrated in (41b).

- (41) a. /vá'ná vékijílá nkhúkú ndórí nkhúndú jángú/ [Kipare]
 H H H H H H H H H H H H H H
 children while.3PL.eat chickens little red my
- b. vãnà vèkijilà nkhùkù ndòrì nkhùndù jàngù
- 
- ‘while the children eat those little red chickens of mine’

I thus suggest that the sign language cases discussed in this section are instances of across-the-board spreading, whereby spreading (i) is constrained by prosodic phrasing and (ii) is facilitated by the fact that the relevant skeletal positions are not underlyingly specified for suprasegmental features.

6. Eye blinks as boundary tones

All of the NMMs discussed in the previous sections are capable of spreading – and be it just onto an adjacent functional element (mouthings) or a reduplicant (non-manual adverbials). However, not all NMMs have the dynamic properties required for spreading; there are also so-called punctual markers that cannot spread and that commonly function as edge markers. Here, I will briefly consider eye blinks.¹⁸

Studies on the use of eye blinks in ASL (Wilbur 1994), HKSL (Sze 2008), and DGS (Herrmann 2010) suggest that different types of (voluntary and involuntary) eye blinks have to be distinguished. Of interest in the present

¹⁸ See Liddell (1980) and Wilbur (2000) for various uses of single head nods.

unit, while eye blinks may occur by themselves. In fact, of all the NMMs addressed in this paper, eye blink is the only one that is not obligatorily co-articulated with a manual sign. Note, however, that Sze (2008) observes that in HKSL, an eye blink may also co-occur with the final sign within an IntP.

7. Conclusion

Non-manual markers in sign languages are suprasegmental, that is, they constitute a layer on top of the sign skeleton, which consists of location and movement segments. In this article, I proposed to take the suprasegmental nature of NMMs seriously and to compare them to tones in spoken languages. I am not the first one to make this comparison (e.g. Köhler & Herrmann 2009; Weast 2011). The novel contribution of the present study is that it offers a fine-grained discussion and typological comparison of various functions of NMMs as well as of their spreading behavior. Just like tones, NMMs may fulfill functions at the lexical, morphological, and syntactic level. They associate with syllable positions (tone-bearing units in spoken languages), and they are capable of spreading. Interestingly, however, spreading domains differ from one NMM to the other. I have tentatively argued that all relevant domains can be defined in prosodic terms.

- Mouthings (as well as headshake and backward head tilt in some sign languages) are lexical NMMs; they spread onto (right- or left-adjacent) functional elements under cliticization; the relevant prosodic domain is the prosodic word.
- Syntactic NMMs, such as those accompanying topic and yes/no-questions, are the realization of features occupying functional heads in the left periphery; they associate with XPs in their specifier under Spec-head agreement, and they define intonational phrases.
- Morphological NMMs show a more variable behavior. I have argued that in some non-manual dominant sign languages, the headshake is a featural (suprasegmental) affix that attaches to the verb after verb movement; spreading is optional and presumably targets a phonological phrase. The fact that non-manual adverbials do not spread is either due to structural (adjunction to VP) or semantic (verb modifiers) differences.

A comparison to tone sandhi phenomena in spoken languages revealed interesting parallels. Still, there are also modality-specific features: (i) given that different NMMs make use of different articulators, they can be layered, and (ii) spreading appears to be less constrained – at least for the headshake in non-manual dominant sign languages and for syntactic NMMs.

Taken together, our line of reasoning suggests that most NMMs can at the same time fulfill various linguistic as well as prosodic functions. The linguistic function is primary, as it results from lexical specification, affixation (after verb movement), or syntactic features residing in functional heads.¹⁹ The present study thus also contributes to an ongoing discussion concerning the syntactic vs. prosodic nature of certain NMMs (e.g. Wilbur & Patschke 1999; Sandler 2011) by claiming that these two types of accounts are not mutually exclusive: one and the same marker may at the same time have a syntactic origin (i.e. be triggered by a certain feature) and properties that are best defined in prosodic terms.

¹⁹ From a phrase structure point of view, it is interesting to note that the three types of NMMs can be related to different structural layers (Rizzi 1997): lexical NMMs are part of lexical items that are merged in the lexical layer, morphological NMMs are associated with positions in the inner functional layer, and syntactic NMMs originate in the outer functional layer.

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