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Sign language prosody

1. INTRODUCTION

Prosody is the study of suprasegmental features in language. For spoken languages, these features include pitch, length, loudness and rhythm. These features can be used to effectively mark lexical items in focus, indicate whether the underlying function of an utterance is declarative or interrogative, or to indicate boundaries in speech (Cruttenden, 1995). They also play an important role in facilitating communication: for example, speakers use prosody to disambiguate between sentence meanings (Snedeker and Trueswell, 2003) and to convey when they are about to finish speaking (Geluykens and Swerts, 1994). Listeners are very sensitive to these prosodic cues produced whilst speaking and studies such as those referred to in the previous sentence have shown that attending to these cues can make a significant contribution to comprehension (see Cutler et al., 1997, for an overview).

Although sign languages are conveyed in the visual-gestural modality, it is clear that they have a prosodic system that is similar to spoken languages in function but quite a bit different in form (Nespor and Sandler, 1999; Pfau and Quer, 2010; Sandler, 2012; Sandler and Lillo-Martin, 2006; Wilbur, 1999b, 2000). That is, sign language can be structured into prosodic constituents that are systematically marked by a number of manual and non-manual features and these features play a similar role as has been documented for spoken languages. In this chapter, we describe prosody as it relates to sign languages. In doing so, we will draw upon a wide range of studies encompassing theoretical and experimental approaches and focusing on several (unrelated) sign languages. We also conclude this chapter with a brief discussion on sign language prosody and audio-visual prosody since, more recently, studies have highlighted the importance of the face and body in the production and comprehension of prosody in spoken languages (e.g., Krahmer and Swerts, 2007). Such studies have important implications for theoretical descriptions of prosody with regard to sign languages.

2. THEORETICAL DESCRIPTION

A range of manual and non-manual markers have been identified as relevant when describing sign language prosody. These include non-manual markers such as the brows (Dachkovsky and Sandler, 2009; Nespor and Sandler, 1999), blinks (Sze, 2008; Wilbur, 1994), head nods (Nespor and Sandler, 1999), and the lower face (Brentari and Crossley, 2002). Manual markers include lengthening/holds (Nespor and Sandler, 1999), pauses (Grosjean and Lane, 1977), and transitions (Duarte, 2012). These markers each make a contribution to the prosodic structure of a sentence. Generally speaking, non-manual markers contribute to intonation (i.e., they add semantic/pragmatic meaning), while manual prosodic cues are for marking constituent boundaries (Brentari et al., 2015; Sandler, 2012). In the following section, we describe the role of these markers in the context of the prosodic hierarchy as developed by Nespor and Vogel (1986) for spoken languages.

It is important to note that, although we describe the prosodic function of a variety of markers in sign languages, they are not limited to such functions. Pfau and Quer (2010) provide a cross-linguistic overview of non-manual markers in sign languages and their various grammatical and prosodic roles. They describe how non-manuals can play a role at the phonological (e.g., some signs are lexically specified for a non-manual feature and these can be contrastive although examples are not frequent) and morphological (e.g., the use of headshake to mark negation) level. In some cases, grammatical and prosodic interpretations of a specific marker appear to be in conflict with one another. This issue is discussed in detail in Section 2.1.5.

2.1 The prosodic hierarchy

Much of sign language prosody have been described with reference to theories and work associated with Prosodic Phonology (in particular, Nespor and Vogel, 1986). This theory outlines how a speech stream can be divided into prosodic constituents, which are hierarchically organized. This prosodic hierarchy, as outlined by Nespor and Vogel (1986), is generally set out as in (1):

(1) mora < syllable < foot < prosodic word < clitic group < phonological phrase < intonational phrase < phonological utterance

The smallest prosodic constituent is the mora and the largest constituent is the phonological utterance. A prosodic constituent at one level can be divided into prosodic constituents at the next level below it without skipping levels. This means that a phonological utterance consists of one or more intonational phrases and that these phrases, in turn, consist of one or more phonological phrases (this is known as the Strict Layer Hypothesis). This hierarchy of prosodic constituents was developed after observing that morpho-syntactic constituents are an insufficient point of reference when describing phonological rules. Nespor and Vogel (1986) demonstrate that each level of the prosodic hierarchy serves as the domain of application for specific phonological rules and phonetic processes and these domains are non-isomorphic with the morpho-syntactic constituent (i.e., they are independent from syntax). This prosodic hierarchy has been applied to sign languages, and likewise, the morphosyntactic and prosodic levels have been shown to be related, but non-isomorphic (Brentari, 1998; Sandler and Lillo-Martin, 2006). Beginning with the smallest units, the mora and the syllable, a description of the sign language prosody and how each unit is attested is provided below.

2.1.1 The syllable and mora

The syllable in sign languages is defined with reference to movement. That is, one path movement is equivalent to a syllable in sign language (Brentari, 1998). Although most signs are monosyllabic, there are disyllabic monomorphemic signs, such as ASL DESTROY, which show that the syllable and morpheme not isomorphic (Brentari, 1998). Generally, in several approaches to phonological representation movement has been described as analogous to vowels in spoken languages (e.g., the Hold-Movement model (Liddell and Johnson, 1989), the Hand Tier model (Sandler, 1989), and the Prosodic Model (Brentari, 1998)). Parallels between the two can be seen when one considers that vowels and movements are perceptually the most salient feature within a word or a sign and that they function as the medium by which words and signs are made more audible and visible respectively (Brentari, 2002). In fact, researchers have proposed that more visually salient movements are more sonorous; therefore wiggling the fingers is less ‘sonorant’ than twisting of the radial/ulnar joint

(forearm), which is less 'sonorant' than a path movement (Brentari, 1993; Corina, 1990; Perlmutter, 1992; Sandler, 1993). Additionally, fingerspelled letters or number signs produced in stasis have been observed to add an epenthetic movement in some sign languages when used as an independent word (Brentari, 1990; Geraci, 2009). Just as in spoken languages where an operation of vowel epenthesis ensures that a syllable is well-formed, movement is inserted where necessary to ensure that the signed output is a well-formed syllable (Brentari, 1990). These parallels suggest that movement plays a central organizing role at the phonological level forming a unit similar to the syllable nucleus in spoken languages.

Several representations have been made with regard to the internal structure of the syllable. The differences between these proposals stem from opposing views regarding the role of movement within phonological representation. Some models argue for a sequential representation where movement is represented as a segment (e.g., Liddell and Johnson, 1989; Perlmutter, 1992; Sandler, 1989) while other models argue for a simultaneous representation where movement is represented as an autosegment (e.g., Brentari, 1990, 1998; van der Hulst, 1993). Within sequential models, signs consist of sequences of static and dynamic movements (e.g., LML in the Hand Tier Model). Since dynamic movement segments are understood to be more sonorous than static segments, parallels can be drawn with the internal structure of syllables in spoken languages, which consist of an onset, and a rime with latter being further divided into a nucleus and a coda. Furthermore, like the spoken language syllable, the internal structure is organized around a sonority peak so that the most sonorous element occupies the nucleus and less sonorous elements occupy neighbouring segments (a type of Sonority Sequencing Principle). The phonological rule known as 'phrase-final lengthening' makes reference to, and is argued as evidence for, this sequential structure. In ASL, phrase-final lengthening is accounted for by a phonological rule of mora-insertion where lengthening is applied not to the syllable nucleus (movement) but on the final segment (location) in some signs (Perlmutter, 1992). See, however, Tyrone et al. (2010) who argues using motion-capture data that the entire final syllable is longer in Phrase-final Lengthening, not only the final segment or mora.

Within simultaneous representations such as the Prosodic Model, movement, handshape and location, are treated as autosegments that are simultaneously layered in its internal organization (Brentari, 1998). Sequential segments do not have a central role in this representation and are instead derived from the type of movement specified within a sign (represented as timing segments in the terminal nodes within the prosodic features branch). Crucially, this argues that the internal organization of a syllable in sign languages is

fundamentally different to syllables in spoken languages (e.g., segments are not organized around a Sonority Sequencing Principle). Brentari (1998) demonstrates how this simultaneous organization is referred to in a morphological process from which nominal forms are derived. Signs containing one movement element (e.g., a movement generated by the hand, wrist, or elbow, such as ASL SIT) are permitted to undergo modifications (e.g., the path movement in ASL SIT is repeated to derive the nominal form CHAIR) in contrast to signs consisting of more than two movements such as ASL THROW (which contains both a movement produced by the hand and the elbow). This suggests that forms allowing reduplication have one simultaneous movement component and are light syllables (i.e., consist of one mora) whilst those that disallow reduplication have two or more simultaneous movement elements (i.e., consist of two moras) and are therefore heavy.

2.1.2 Prosodic word

The prosodic word is a unit in the prosodic hierarchy that is larger than the syllable, smaller than the phonological phrase, and exhibits non-isomorphism with the morphosyntactic word (e.g., *I've* in *I've not seen that film* is one prosodic word but two morphosyntactic words). Several constraints are associated with the prosodic word in sign languages. Examples include the Selected Fingers Constraint (Brentari, 1998), the Monosyllabicity Constraint (Coulter, 1982; Sandler, 1999); and the Symmetry Constraint (Battison, 1978) and are described below with reference to ASL.

INFORM

WIFE

SIGN

Figure 1. Three signs from ASL demonstrating constraints on the prosodic word: The Handshape Sequencing Constraint (top), the Monosyllabicity Constraint, and the Symmetry Constraint

The Selected Fingers Constraint specifies that a sign only has one set of selected fingers in its articulation; note that ASL INFORM, despite having a handshape change, has the same number of selected (or extended) fingers at the beginning and end of its articulation. The Monosyllabic Constraint refers to the strong tendency in sign languages generally for signs to consist of one syllable (i.e., one movement). Evidence for this tendency can be seen in compounds such as ASL WIFE (WOMAN^MARRY) in which the outward movement associated with SAY is deleted so that the resulting compound has the appearance of a monosyllabic sign. This monosyllabic tendency is also retained when signs are meaningfully modified in a number of ways (i.e., modifications are simultaneously layered onto a sign rather than added sequentially). Finally, the Symmetry Constraint refers to two-handed signs that both move during the articulation of a sign. In such cases, the non-dominant hand is specified for the same handshape, location and movement as the dominant hand as in ASL SIGN. All three constraints are said to operate on the prosodic word.

The prosodic word has been demonstrated to be the domain of application for a phonological process known as Coalescence in Israeli Sign Language (ISL) (Sandler, 1999, 2012). In this process, a prosodically weak function sign undergoes restructuring so that it is attached to a lexical sign and produced as a single prosodic word as in Figure 2.

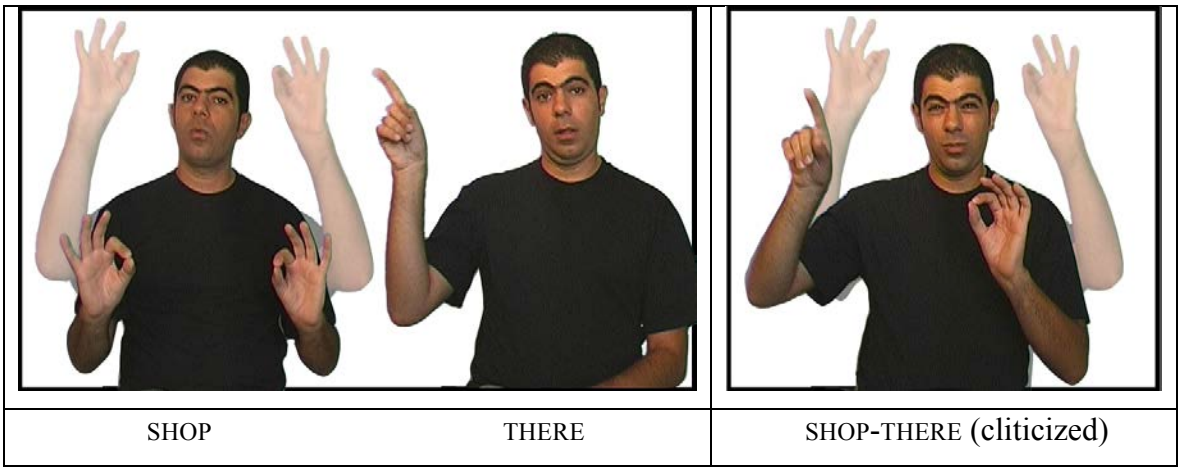

Figure 2. Coalescence in a prosodic word in ISL (image from Sandler and Lillo-Martin, 2006: 249)

In Figure 2, the pronoun THERE has cliticized to a double-handed host sign, SHOP, and the outward movement associated with the pointing sign THERE is omitted so that the resulting output has the appearance of a single monosyllabic sign. This process is considered to post-lexical since it is non-structure preserving; that is, the resulting output violates a constraint observed at the lexical level: the Symmetry Constraint (Sandler, 1999). It is also optional; its occurrence is determined primarily by rhythmic position. That is, coalescence is triggered by the appearance of two signs - a lexical and a functional pointing sign - in phrase-final position of a phonological phrase. Since stress assignment is conducted with reference to lexical categories, and pronouns in phrase final position are not stressed (Wilbur, 1999b), it is the lexical item that is stressed and the pronoun that is reduced (i.e., it loses it syllabicity and attaches to a neighboring lexical host).

Patterns of mouth spreading have been used as further evidence that the cliticized forms mentioned above constitute a single prosodic unit. In the ISL example, the sign SHOP was simultaneously produced with the (silent) mouthing of the Hebrew word *xanut* meaning ‘shop’. Although mouthings are typically articulated with the production of its corresponding manual sign, the mouthed Hebrew word *xanut* corresponded with the beginning and end of the ISL sign SHOP and the neighbouring sign THERE providing further evidence that this combination should be viewed as a single prosodic unit (similar claims have been made for

Swiss German Sign Language (DSGS), Boyes Braem 2001). Brentari and Crossley (2002) also observe similar spreading behavior with mouth gestures in their ASL dataset and formulate a constraint of one specification for the lower-face per prosodic word. Cross-linguistic variation in mouth spreading behavior have also been reported in Crasborn et al. (2008). Here, the direction of spreading for mouthings appears to be: strictly rightwards in BSL; rightwards in Sign Language of the Netherlands (NGT) with some evidence of bidirectional spreading; and in both directions in Swedish Sign Language (SSL). In each case, spreading was not always from content sign to function sign and there was not always evidence that neighbouring signs had cliticized to a host sign. Crasborn et al. (2008) tentatively suggest that their findings are indicative of language specific differences although further research with larger populations is required. They also note that the domain of mouth spreading can span more than two signs suggesting that it is not limited to the prosodic word but can span larger prosodic constituents.

2.1.3 Phonological phrase

The next level in the prosodic hierarchy above the prosodic word is the phonological phrase. Nespor and Vogel (1986) define the phonological phrase as consisting of a lexical head (X) and all the elements on its nonrecursive side up to another head outside the maximal projection of X. In other words, phonological phrases tend to correspond with syntactic constituents such as noun and verb phrases. The existence of these phrases in spoken languages is often argued for with reference to phonetic correlates and phonological rules that have this constituent as its domain (e.g., Raddoppiamento Sintattico in Italian, see Nespor and Vogel, 1986: 165).

Phonological phrases are attested in sign languages, although much of the work to date has stemmed from research involving ISL and ASL. Only one phonological process has been claimed to have the phonological phrase uniquely as its domain—i.e., Non-dominant Hand Spread in ISL (Nespor and Sandler, 1999; Sandler, 2012). This is an optional post-lexical phonological process where systematic spreading behavior is observed on the non-dominant hand with the phonological phrase as its domain. In such cases, when it occurs, the non-dominant hand can spread either leftwards, rightwards, or in both directions beyond its lexically specified sign but not beyond the boundary of a phonological phrase. In some cases

the non-dominant hand may not always spread up to a phonological phrase boundary because it may be interrupted by the articulation of a two-handed sign. An example of this spreading behavior in ISL is provided below (from Sandler, 2012).

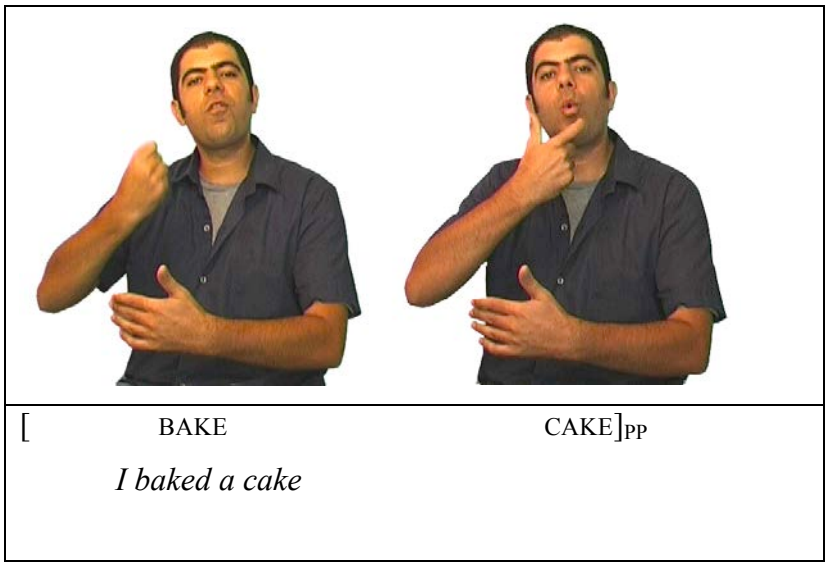

Figure 3. Example of non-dominant hand spreading behavior in an ISL phnological phrase (image adapted from Sandler and Lillo-Martin, 2006: 253)

In Figure 3, BAKE is a two-handed sign in ISL and the non-dominant hand (the signer's left hand in Figure 3) involved in its articulation is held in position over the production of the sign CAKE, a one-handed sign and not over TASTY since this would extend across a phonological phrase boundary. Brentari and Crossley (2002) report examples to the contrary for ASL at least. In their data, there are cases where the non-dominant hand can spread beyond a phonological phrase boundary or fails to spread to a phonological phrase boundary when expected.

At this level, several manual cues have been observed to mark phonological phrase boundaries as well. In ASL, signs in phrase-final position are noted to be lengthened repeated or held in position longer making them more prominent than phrase-medial signs (Brentari and Crossley, 2002; Wilbur, 1999b). This would imply that ASL conforms to the tendency underlying relative prominence and phonological phrases set out for spoken language (Nespor and Vogel, 1986) in that the rightmost element of a phrase (since ASL is a head-complement language) is marked for prominence. Such markers are present in both phonological and intonational phrases, but they are present to a lesser degree at phonological phrase boundaries and to a greater degree at intonational phrase boundaries.

2.1.4 The intonational phrase

The next phrase above the phonological phrase is the intonational phrase. Intonational phrases typically correspond with the root sentence although constructions that are structurally external to the sentence (such as parentheticals, non-restrictive relative clauses and topicalizations) often form intonational phrases on their own. In spoken languages, intonational phrases are the domain of application for intonational contours and other segmental phonological rules (Nespor and Vogel, 1986). These intonational contours, in turn, are associated with a wide range of pragmatic meanings. For example, a contour that rises towards the end of an utterance is typically associated with interrogatives and one that falls towards the end of an utterance is associated with declaratives. The edges of intonational phrases are typically marked with pauses and phrase-final lengthening. The latter has been noted for many spoken languages cross-linguistically and is suggested to be a feature independent of any specific language (Vaissiere, 1983). As in spoken languages, similar constructions (e.g., parentheticals, non-restrictive relative clauses, and topicalized elements) in ASL also tend to form intonational phrases (Sandler and Lillo-Martin, 2006). Several manual and non-manual markers have been associated with these constituents for many sign languages. These prosodic markers do not always occur independently but combine with one another sequentially and simultaneously (i.e., prosodic layering, see Wilbur, 2000).

Manual markers associated with the intonational phrase include stressed signs (or signs in focus) produced in phrase-final position (Nespor and Sandler, 1999; Wilbur, 1997, 1999b; Wilbur and Zelaznik, 1997), lengthened pauses (Grosjean and Lane, 1977) and phrase final lengthening (or holds) (Brentari et al., 2011). Signs that are stressed are produced higher in the signing space, display increased muscle tension, and sharp transition boundaries (Wilbur, 1999b). In contrast to languages like English where stress can be shifted to the lexical item in focus, sign languages are said to prefer prominence in phrase-final position (Nespor and Sandler, 1999; Wilbur, 1997). The length of a pause can also be correlated with the strength of a boundary (Grosjean and Lane, 1977). In an examination of pauses produced by five native signers of ASL, the mean pause duration was highest between sentences (229ms) and lower at lower-level boundaries (e.g., 134ms between conjoined clauses) as noted for spoken languages, although sign language pauses are shorter overall (for spoken languages: > 445ms between sentences; 245 to 445ms between conjoined sentences).

Some non-manual markers such as blinks have been associated with the boundaries of intonational phrases. Different categories of blinks have been proposed in the literature although we focus on boundary blinks here.[1] Blinks at intonational phrase boundaries have been attested for many sign languages including ASL (Baker and Padden, 1978; Wilbur, 1994) and ISL (Nespor and Sandler, 1999). A cross-linguistic analysis of the distribution of blinks documented in Tang et al. (2010) reveal that, although blinks in ASL, Swiss German Sign Language (DSGS), Hong Kong Sign Language (HKSL), and Japanese Sign Language (JSL) consistently occur at intonational phrases boundaries, blinks in HKSL were also noted to frequently occur at lower-level prosodic boundaries. The fact that blinks consistently occur at IP boundaries has led researchers to liken blinking to the act of breathing in spoken languages. However, Sze (2008) notes that the two differ in that markers for IP boundaries in spoken languages are directly related to the articulation of speech whilst blinks produced during signing are not and questions its reliability as a consistent marker to IPs..

In contrast to the markers described above which are associated with the edges of intonational phrases, other markers are associated with the domain of the intonational phrase (i.e., they typically span the entire phrase). These markers are typically produced on the face although other larger non-manual markers such as the head or the torso are also associated with the domain of the intonational phrase. Facial expressions produced when signing have been described as being analogous to intonation in spoken languages in terms of their function (Nespor and Sandler, 1999). For example, the use of furrowed or raised eyebrows with a constituent can mark an interrogative statement as in Figure 4 just as a rising intonational contour does in spoken languages.

Furrowed brows

Raised brows

Figure 4. Interrogative facial expressions for questions seeking information (wh-questions; left) and confirmation (yes/no questions; right).

Facial expressions produced whilst signing have often been described as componential. That is, different components each provide a specific contribution to the overall meaning of the sentence. An example of the facial expression associated with counter-factual conditionals in ISL will illustrate this point. In ISL, raised brows 'signal continuation and forward directionality' indicating that the phrase it spans is linked to following the following phrase. Additionally, lower-lid squint is said to designate shared information between the speaker and the addressee. When these two markers are combined, they typically characterise counter-factual conditionals as in (2):

(2) br + sq
IF GOALKEEPER HE CATCH BALL, WIN GAME WIN
If the goalkeeper had caught the ball, they would have won the game

(Dachkovsky and Sandler, 2009: 306)

Here, the brow raise and the lower-lid squint make a contribution to the overall meaning of the sentence. The lower-lid squint acknowledges that the signer is aware that the event did not happen and the brow raise predicts the information in the following clause (what would have happened if the first clause was true) (Dachkovsky and Sandler, 2009; Sandler and Lillo-Martin, 2006). The fact that these markers are similar to intonational tunes since they can be broadly interpreted when viewed independently but gain specificity when produced in combination with other features and with the sentences they are co-articulated with lends support to the argument that these markers perform a similar function to intonational tunes in spoken languages.

2.1.5 Relationship between syntactic and prosodic structure

Our description of sign language prosody in this chapter has made explicit reference to syntactic structure. For example, phonological phrases typically correspond with noun phrases and verb phrases and intonational phrases can be associated with clauses. Although there is agreement that these constituents are non-isomorphic with one another (sometimes an

intonational phrase may consist of two syntactic clauses) and are autonomous, there are differences of opinion in how the two systems interface with one another.

On the one hand, syntax and prosody may have a direct link and non-isomorphic cases are exceptions to the general principles of alignment (e.g., Selkirk, 2011). Within the field of sign language linguistics, this view is reflected in work such as Petronio and Lillo-Martin (1997), Neidle et al. (2000) and Pfau and Quer (2010). Earlier descriptions of sign languages (notably ASL) were quick to observe that non-manual features could be associated with specific constituent types (Liddell, 1980). For example, yes/no questions are marked with raised eyebrows, widened eyes and the head and shoulders are moved forward while wh-questions are marked with a furrowed brow and (sometimes) combined with a backward head tilt noted. Raised eyebrows were also noted to be associated with topicalized constituents, relative clauses, and conditionals. An examination of the literature reveals similar behavior cross-linguistically (see Pfau and Quer, 2010). It has often been the case, that these non-manual components are presented within the literature as being intrinsically associated with specific syntactic constructions (Liddell, 1980; Neidle et al., 2000). Working within this viewpoint, researchers have examined the distribution of these non-manual markers to make a case for underlying syntactic structure. For example, linguists have of attended to the position and (or lack of) spreading of non-manual markers to make a case for the direction of movement for wh-elements (e.g., Cecchetto et al., 2009). Others have incorporated non-manuals within their representation as the head of functional projections and make explicit reference to this hierachial structure to account for spreading behavior observed (e.g., the spread of non-manual markers may be limited to its c-command domain) (e.g., Neidle et al., 2000).

The opposing view is that prosodic structure primarily interacts with syntax indirectly via semantics (e.g., Pierrehumbert and Hirschberg, 1990; Truckenbrodt, 2012) which is reflected in the sign language literature by Wilbur (1999a), Nespor and Sandler (1999), Dachkovsky and Sandler (2009), and Sandler (2010). One of the main arguments in support of this view, outlined in detail in Sandler (2010), is that prosodic constituents do not always correspond to syntactic constituents (i.e., they are non-isomorphic). Therefore, it follows that referring to prosodic, rather than syntactic, structure provides a more fitting description of the scope of these markers. In (3), a case of non-isomorphism between the non-manual marker and the syntactic constituent is presented.

y/n

(3) IX2 LIKE ICE-CREAM VANILLA OR CHOCOLATE

Do you like vanilla ice cream or chocolate ice cream?

(from Sandler and Lillo-Martin, 2006: 463)

In order to support the translation given above (as opposed to a choice between vanilla ice cream or some chocolate), the non-manual marking associated with yes/no questions in ISL is completed after the articulation of VANILLA. If the brow raise was functioning as a syntactic marker, then one might expect that the scope of the marker to span the entire phrase. Instead, reference to prosodic (and not syntactic) structure accounts for the behavior of this non-manual.

Secondly, prosodic phrasing of an utterance appears to be determined by signing rate. Like spoken languages, a given utterance can have different prosodic readings depending on the speed at which it is signed. Wilbur (1999b, 2009) reports that, when asked to vary signing rate, ASL signers demonstrate prosodic reorganization at phrase level and consequently in placement and production of non-manual features (such as blinks and brow movement) and duration and number of pauses. This variability in intonational phrasing reinforces the viewpoint that sign language prosodic structure exhibits at least some degree of non-isomorphism with syntactic structure. Furthermore, it can be expected that the prosodic phrasing of an utterance and the production of features may vary between signers depending on their style (idiolectal variation), as has been reported between sign language interpreters in the production of boundary markers (Nicodemus, 2009) and between Swiss German Sign Language (DSGS) signers (Boyes Braem, 1999), Variability in intonational phrasing depending on style and rate of speech is a characteristic that has also been observed for intonation in spoken languages (Cruttenden, 1995).

Lastly, work on ISL in particular has demonstrated that componential, non-manual behavior appear in a range of structures; raised brows are associated with topics, relative clauses, yes-no questions, and conditionals. Dachkovsky and Sandler (2009) refer to descriptions of spoken languages to show that the meaning of brow raises correlates closely with the meanings associated with high boundary tones (e.g., Pierrehumbert and Hirschberg, 1990). In each case, the broader meaning of brow raise gains a specific interpretation when combined with other non-manual features and when associated with syntactic structures, just as intonational tunes in spoken languages do. They differ, however, in that intonational tunes

in spoken languages 'consist of sequences of tones that cluster on stressed syllables and at prosodic boundaries' and in sign languages 'intonational arrays often characterize whole prosodic constituents' (Sandler, 2010:311).

3. EXPERIMENTAL STUDIES

A range of experimental studies within the field of sign language prosody has been conducted. These studies underline the significance of prosodic markers produced at different levels of the prosodic hierarchy and demonstrate that, like related spoken language studies, signers attend to these markers carefully. For example, signers are able to identify which sign is receiving stress in an utterance (Wilbur and Schick, 1987), indicate boundaries in a signed stream accurately (Fenlon et al., 2007), and are even sensitive to affective prosody encoded on the hands when markers from the face are absent (Hietanen et al., 2004; Reilly et al., 1992).

These studies provide weight to theoretical perspectives of the underlying structure of prosodic units. For example, in a study of rhythmic perception in signing, native signers tapped along to five short ASL narratives (Allen et al., 1991). A close examination of the placement of these taps revealed that they were not associated with a specific part of a signed syllable. This is in contrast to spoken languages where beats are typically placed between the onset and the rime and lends some support to the idea that the underlying structure of a sign language syllable is fundamentally different to its spoken language counterpart. This perceptual study is backed up by another study on backward signing by Wilbur and Petersen (1997) illustrating the way signers reverse their signing does not parallel the reversal of segments in spoken languages. For example, reversing the segments in the sign THINK ASL would predict a form where the index contacts the forehead followed by movement *towards* the forehead (ASL THINK is produced with an initial movement segment where the index moves towards the forehead and a final hold segment where the index contacts the head). Instead, signers also reverse the direction of the movement rather than the segment alone. Based on their study, Wilbur and Petersen (1997) suggest that a model of the syllable that refers specifically to movement and specifications relating to beginning and end points and that no further distinctions (e.g., onset, rime, etc.) is needed, which concurs with the Prosodic Model of the syllable (Brentari, 1998).

Experimental studies have also included groups of participants with differing language experiences (e.g., those who have not been exposed to a sign language). In doing so, these studies have been able to reveal the extent to which language experience is essential for full appreciation of sign language prosody. For example, with regard to syllable structure, Berent et al. (2013) demonstrated that signers as well as non-signers more readily associate syllable nuclei with movement rather than handshape. An early study on pauses by Grosjean and Lane (1977) reports significant agreement between two ASL judges and a non-signer in the placement and judgment of pauses in a signed stream. In a study of rhythmic perception, native signers and hearing non-signers rhythmically tapped along to five short ASL narratives in a similar way (Allen et al., 1991). Additionally, both native signers and hearing non-signers are reported to respond in a similar way when asked to indicate whether a sentence break has occurred in a signed stream in adults (Brentari et al., 2011; Fenlon et al., 2007). Brentari et al. (2011) showed matched pairs of strings of signs, where one was a complete IP and one was piece of 2 IPs (e.g., [GREEN VEGETABLES RABBITS EAT] vs. [GREEN VEGETABLES][RABBITS EAT THEM]) to typically developing hearing 9-mo. old babies with no exposure to a sign language. Even without sign language exposure, the babies had significantly longer looking times for strings that were complete IPs. These studies suggest that knowledge of a sign language is not prerequisite for the detection of some sign language prosodic cues.

However, it should come as no surprise that non-signers are able to detect prosodic cues within a signed utterance. There have been studies involving spoken languages illustrating how speakers are able to identify boundaries in languages that they do not know. For example, Carlson et al. (2005) reports how speakers of American English are able to detect *upcoming* boundaries in Swedish even when obvious cues such as pauses are removed from the stimuli. Additionally, it would misleading to assume that non-signers have no experience with the visual modality. Linguists working with speech prosody have observed that several visual markers (such as the brows, head nods, and the hands) are correlated with prosodic cues in speech (e.g., Flecha-Garcia, 2006; Krahmer and Swerts, 2007). Therefore, speakers may be relying (to some degree) on their experience in interpreting audio-visual cues to prosody in speech communication when confronted with tasks involving sign languages.

But language experience makes a valuable contribution. Native signers are better positioned to interpret these cues than non-signers by virtue of being life-long users of these languages. For example, in the rhythmic perception study previously mentioned involving Allen et al. (1991), the location of taps produced by signers and non-signers coincided with repeated signs, signs with primary stress and phrase-final signs (these signs being crucial to

rhythmic structure). However, the non-signers tapped more often to signs with secondary or weak stress than the ASL signers. This tendency to respond more often to signs with secondary or weak stress indicates that experience of ASL is required in order to accurately judge rhythm in signing. In the Brentari et al. (2011) study, ASL signers and non-signers were asked to (a) judge whether a sentence break occurred in an utterance presented to them and (b) mark how confident they were in their decision. ASL signers were not statistically more accurate in boundary detection than non-signers, but the two groups differed in their boundary marking strategies: ASL signers relied on a single marker to indicate boundaries (pauses) whilst non-signers relied on several markers to indicate boundaries (pauses, holds, and drop-hands). Therefore, even though non-signers can be accurate at indicating boundaries, they still perform differently to experienced ASL signers.

The studies described above all show clearly that sign language prosody can be reliably perceived and have, in some studies, highlighted the importance of language experience in being able to do this accurately and confidently (e.g. Allen et al., 1991; Brentari et al., 2011). However, these findings in turn raise further questions as to the effectiveness of a particular marker when viewed in isolation or in combination with other markers particularly when signed languages are known to layer markers simultaneously and sequentially (cf. Wilbur, 2000) and particularly since preference for a particular cue over others by signers is reported. It is not yet clear how these markers compare with one another and with other information from lexical and grammatical structure (i.e., which markers are reliable indicators of upcoming boundaries in spoken languages?) More studies are needed that investigate how boundaries are perceived and the extent to which different visual markers and other cues available to the observer can contribute to the signal (particularly when signed languages are demonstrated to layer markers sequentially and simultaneously at boundaries).

3.1 Acquisition

There have been many studies on language acquisition that have illuminated our understanding of sign language prosody and provided further justification for some of the viewpoints expressed in this chapter. For example, the importance of movement in the definition of a sign syllable is supported by the observation that the repetition of movement appears as a rhythmic sequential unit produced by deaf infants at a similar milestone to vocal

babbling observed in hearing children (Pettito and Marentette, 1991). Age of acquisition plays a role in the timing and distribution of prosodic markers with early learners demonstrating more proficient use of such cues. Early learners of DSGS were found to use a side-to-side movement of torso marking discourse units more frequently than later learners who instead preferred to use prosodic markers from their first language: German. Differences in the timing and layering of multiple cues between early and later learners have also been reported in Stone (2009) and Brentari et al. (2012). Brentari et al. (2012) analyzed the narratives of three groups of highly fluent signers (native (L1) Deaf, L1 hearing, and second-language (L2) hearing), and found that some features, such as brow raise, are more prevalent in L1 signers (both hearing and Deaf), while some other features, such as the alignment of torso leans with constituent boundaries, are more prevalent in hearing signers (both L1 and L2). Their findings suggest that language experience has an effect on prosodic expression, and suggest that experience with co-speech gesture may produce a specific type of prosodic pattern in hearing signers, even highly fluent ones. Together, these findings suggest that the alignment and mastery of non-manual features is learned at an early age and that there may be a critical period for the acquisition of sign language prosody.

Language acquisitions studies have generally demonstrated that the developmental milestones and time course of first language acquisition for deaf children acquiring a sign language are similar to hearing children acquiring a spoken language (see Chen Pichler, 2012, for an overview). Early acquisition studies involving ASL syntax have typically focused on non-manual markers associated with specific syntactic structures such as interrogative and topicalized constituents. These studies have not always referred explicitly to prosodic structure since the presiding view at the time indicated that these markers were derived from syntactic structure. For example, Reilly et al. (1991) explain how children demonstrate an understanding of conditional clauses at 3;0 but prefer to use manual rather than non-manual markers to indicate them in their productions (e.g., ASL IF). Research on the acquisition of interrogatives in ASL suggests that the acquisition process is gradual taking several years. Children learning ASL appear to produce both manual and non-manual markers for WH-questions as young as 18 months but do not combine the two appropriately until the age of 6 or 7 (Lillo-Martin, 2000; Reilly et al., 1991). These studies lend support to the prosodic interpretation of these markers since they demonstrate how prosodic cues are acquired compositionally in a gradual and analytic manner.

Chen Pichler (2010) suggests that acquisition of prosodic elements may be much earlier than assumed since studies looking at topicalised constituents are typically limited to a

single non-manual marker: the eyebrows. If the domain of inquiry is expanded to include all other possible markers, then it is possible to observe earlier indicators of prosodic structuring in deaf children learning to sign. Building on Nespor and Sandler's (1999) analysis which suggest that prosodic markers such as widened eyes, head nods, and holds may also delimit topicalized constituents, Chen Pichler (2010) describes how utterances produced by a single child learning ASL display evidence of simple prosodic breaks, characterized by repetition or holding of the topic sign and followed by a change in head position, at 24.5 months, nearly a year earlier than that suggested by Reilly et al. (1991).

Few acquisition studies of prosody have focused on the later stages of language acquisition. Brentari et al. (2015) investigate the distribution of prosodic cues at boundaries in ASL across three age groups: two younger children (5;0–6;1), five older children (7;8–8;5) and four adults (aged between 35-58). As with earlier acquisition studies, they find evidence that prosodic cues are acquired compositionally. Whilst there is no difference between groups in the use of sign duration, blinks, head position, and eyebrows to mark boundaries, the younger children produced longer transition durations in IP and utterance final position, the older children had a lower proportion of holds in similar positions, and both groups of children had a lower proportion of changes in body positions at boundaries. This finding suggests that boundaries markers are distributed appropriately as early as 5 but complete integration of all cues with prosodic structure requires more time. Furthermore, the statistical findings in this study also indicate that manual cues are more predictive of prosodic boundaries than non-manual cues for all groups. For the younger children and the adults, both manual and non-manual cues together are more predictive than manual cues alone, which is a logical finding (i.e., the more cues there are available, the better). For the older children, however, manual cues alone are more predictive of prosodic boundaries than all cues types combined. The authors reason that this group may be acquiring additional complex language (e.g., the use of depicting constructions in which the body and the face may be recruited as a mimetic device) and that non-manual features become more variable and undergo re-organziation as a consequence. Additionally, Brentari et al. (2015) refer to several acquisition studies involving spoken language which demonstrate that mastery of durational cues (e.g., syllable-final lengthening) appear to precede intonational cues (e.g., fundamental frequency) which parallel the general observation here that manual durational markers precede intonational non-manual markers in the acquisition process.

3.2 Emergence of prosodic structure

Sign languages also provide us with a unique opportunity to look at how a language emerges with relatively little input. We describe two such studies with a focus on prosody suggesting that it plays an important role in the early stages of language creation. The first study looks at the development of prosodic structure in a single homesigner whilst the second study looks at its development in newly emerging sign language that has developed within a community of signers.

Homesigners refer to children who have not been able to learn a spoken language despite intensive oral education or a sign language since their parents may not have exposed them to one. Due to this lack of input, homesigners use gesture in order to communicate with others. Several studies have illustrated how homesign systems develop language-like properties such as recursion and hierarchical structure over time (see Goldin-Meadow, 2012 for an overview). Although studies have often focused on a single homesigner, similar patterns have been observed when comparing homesigners across different cultures (Goldin-Meadow and Mylander, 1998). This cross-cultural similarity suggests that homesigners are not learning a gestural system from their parents.

Applebaum et al. (2014) investigate the frequency and distribution of prosodic cues in the spontaneous output of a younger American homesigner known as David to investigate whether homesigning displays the characteristics of a prosodic system typically associated with sign languages. They focus their attention on both manual features (holds, repetitions, and emphatic movements) and non-manual features (head tilts and nods) occurring at boundaries of different types (utterance or lower-level boundaries related to propositions) at three periods in David's childhood (at 3 years and 5 months, 3 years and 11 months, and 5 years and 2 months). Their results indicated that both manual and non-manual markers (as a single category) were more frequent at the end of utterance boundaries when compared to lower-level boundaries. However, no differences were noted in the mean number of prosodic features over the two-year period in which David was observed. Although these findings suggest that prosodic features in homesign pattern in a similar way to those of sign languages and that they can be observed in the early stages of an emerging system, the authors propose that the lack of change in the use of these features over the period of study suggest that a larger number of signers (or even a intergenerational language transmission pattern) is required for a fully-fledged prosodic system to emerge.[2]

An additional study illustrates this point. In Sandler et al. (2011) the emergence of prosodic and syntactic features in a young sign language, Al-Sayyid Bedouin Sign Language (ABSL) is described. ABSL differs from sign languages such as ASL and BSL in that it is a sign language that has developed in the past 75 years in a Bedouin village with a high incidence of genetic deafness. It is also believed that this language developed in relative isolation from other languages and therefore without a language model (although see Kisch, 2012, for a detailed description of the sociolinguistic situation in this community). The first generation of signers were four deaf children born to a single family who would have used a form of homesign like that mentioned above although this system would have been shared amongst them (unlike David who was the only person using homesign). As it is passed to subsequent generations, languages like ABSL offer a unique opportunity to witness how language structure emerges; an opportunity that one does not have with spoken languages (even pidgin speakers are initially native speakers of a language and may be influenced by their mother tongue). In their analysis of ABSL narratives by two pairs of signers separated by a period of 15 years, the older signers favour timing cues to mark prosodic constituents and display limited use of intonational cues, whilst younger signers use non-manual intonational cues more frequently and their cues typically spanned the domain of intonational phrases. The authors also observe an increase in syntactic complexity alongside prosodic complexity: younger signers produced more noun phrases overall and these noun phrases were clearly associated with predicates via the prosodic structure. In contrast, the signing by the older signers were described as having a listing prosody which meant that their signing was difficult to comprehend overall (i.e., it was difficult to determine which arguments were to be associated with which predicate). Sandler et al. (2011) analysis also reveals prosodic complexity amongst the younger signers since they are able to signal dependency between clauses in the absence of manual markers (e.g., such as using the sign for IF to signal a dependent, conditional clauses). The absence of such manual markers means that prosody is the sole marker of clause dependency. This ability means that the younger signers can link clauses, such as *If the goalkeeper had caught the ball, they would have won the game* (as in (2)), in a way that the older signers do not. In other words, the latter's output consists of simple clauses whilst the younger signers' show increased complexity. This study illustrates that prosodic complexity emerges alongside (or may even precede) syntactic complexity. The study also indicates that the emergence of a fully-fledged prosodic system is a gradual process, requiring time and generations to develop.

3.3 Neurolinguistic studies

Thus far the experimental studies we have described have been included typically developing populations of signers or typical cases of ontological or historical development. Lastly we turn to neurolinguistic studies. There has been little published in this area with respect to sign language prosody. Brain-imaging studies have revealed that, like spoken languages, sign language processing is asymmetric with a strong preference for the left hemisphere (see Emmorey, 2002, for an overview). Within such studies traditional languages areas associated with speech (e.g., Broca's and Wernicke's area) are also active when watching someone sign illustrating that these areas are for processing language *regardless of modality*. Neurolinguistic studies have also ascribed a right-hemisphere role for prosody (e.g., Ross and Mesulam, 1979). Although there have been no brain-imaging studies looking specifically at prosody, this has been attested for sign languages in a study involving atypical signers described below.

In a study involving BSL signers with right and left hemisphere lesions, the perception of manual and non-manual features of negation was tested (Atkinson et al., 2004). Using a picture selection task, signers were asked to match the correct picture to a signed statement. Each statement varied according to whether they featured a lexical and non-manual marker of negation, or a non-manual marker alone. Results showed that the right-lesioned signers were unable to fully understand negative statements when negative information was only available through non-manual features (lexical information was absent). Results suggest that non-manual features of negation are processed in the right hemisphere, unlike syntactic elements of sign language, and therefore may be, in part, prosodic. Such a study has important consequence for our understanding of underlying syntactic structure since these markers feature heavily in syntactic representations (e.g., Neidle et al., 2000). Additionally, descriptions of sign language prosody have often neglected to mention negation focusing instead on facial expression as intonation and its association with prosodic constituents. This study clearly indicates that the descriptive scope perhaps should be widened to include non-manual negation.

Further studies involving atypical signers have also provided insights into underlying phonological structure. Poizner et al. (2000) describe how production is impaired in a group of 6 ASL participants diagnosed with Parkinson's disease. These signers, each ranging in

severity (from mild to severe), were able to demonstrate a clear understanding of ASL's syntax and morphology but were impaired at the phonetic level demonstrating simplification the complexity and timing properties of a sign. Studies involving Parkinsonian signers build on our understanding of the role of the basal ganglia in language processing by providing a different perspective, and these studies are able to directly observe the articulators involved in sign language production and how they are affected as the disease progresses. Poizner et al. (2000) outline a number of characteristics observed in their dataset. For example, facial masking (i.e., decreasing use of non-manual features on the face) increases with the severity of Parkinson's and path movement is transferred from a proximal to more distal joint. There is also a notable disruption to the timing cues such as pauses; pause length does not appear to be correlated with boundary type (i.e., the difference in pause length between word-final, phrase-final and utterance-final pauses are reduced) leading to a lack of rhythmic variation typically observed the control group. Movement in between signs was also affected. Handshape change and movement are closely coordinated within a sign in contrast to between signs. This contrast was notably absent in Parkinsonian signers. These characteristics have been used to make a case for underlying phonological structure within the Prosodic Model (Brentari, 1998). For example, movement migration (from a proximal to more distal joint) lends support to the view that there is an internal hierarchical structure for the representation of movement that refers to the joints typically used to articulate signs.

4. FUTURE DIRECTIONS

4.1 The relationship between audio-visual prosody and sign language prosody

An important area for future enquiry is the relationship between audio-visual prosody and sign language prosody. There is a growing body of literature demonstrating that audio-visual markers produced during speech are aligned with spoken prosody. Head movements have been linked to the production of suprasegmental features of speech such as prominence (e.g., Graf et al., 2002; Hadar et al., 1983). Eyebrow raises align with the intonational contour during speech by occurring with pitch accents (Flecha-Garcia, 2006; Guaïtella et al., 2009).

The timing of body movements (such as the head and the hands) and underlying prosodic structure are closely related. For example, manual gestures are noted to coincide with an accented syllable (e.g., McNeill, 1992). These studies have illustrated that the use of particular markers in production tend to be idiosyncratic in degree or strength but for each case are consistently time-aligned with prosodic features in speech.

In addition, a number of studies have explored the perception of these audio-visual markers in experimental settings demonstrating that these markers are not simply redundant features but make an important contribution to communication. For example, speakers can use head movements to determine which word in a sentence is receiving emphatic stress and to discriminate statements from questions (Bernstein et al., 1998) and have learnt where to direct their attention for different aspects of speech spending more time focusing on the upper part of the face when asked to make decisions regarding intonation in vision-only conditions (Lansing and McConkie, 1999). When these visual cues are not aligned appropriately with speech, they can have a negative effect on reaction times (e.g., Swerts and Krahmer, 2005). Manual gestures have also been demonstrated to act as an important cue to prosodic structure by assisting in resolving sentence ambiguities (Guellai et al., 2014). Studies comparing responses in audio-only, vision-only, and audio-visual conditions have sometimes reported that participants do best in audio-visual conditions. Barkhuysen et al. (2008) found that when participants were asked to indicate the end of an utterance (presented in full or fragmented), participants were more successful in the audio-visual condition than the audio condition. The researchers suggest that a bimodal presentation enhances perception since more cues are available to the participants. This may not always be the case. Krahmer et al. (2002) report a stronger effect for audio-only condition in the perception of prominence in a synthesized talking head. They reason that, since speakers have learned to pay more attention to cues in speech than on the face, speech has a more dominant role in language perception but in cases where audio cues are unclear, visual markers can make a valuable contribution to processing.

What do these studies mean for sign language prosody? Since there is growing evidence supporting a role for audio-visual prosody in language production and perception, future work on spoken language prosody will adopt a multi-modal analysis of language production and routinely include properties of the face and body. As Guellai et al. (2014) state: '…spontaneous gestures and speech form a single communication system where the suprasegmental aspects of spoken languages are mapped to the motor-programs responsible for the production of both speech sounds and hand gestures.' Such conclusions will lead to opportunities in which the production of sign language prosody can be directly compared to a

multi-modal analysis of speech communication. Such a comparison is appropriate since, here, like is being compared with like—i.e., focusing on non-manual prosodic material in both signed and spoken languages. Very few studies have been conducted within the sign language field that incorporate such an approach. One such study in which blinks produced by signers are compared with blinks produced by the surrounding speaking community is presented by Tang et al. (2010). Whilst they found a difference in blink rate between ASL signers and American speakers, they did not find a difference in blink rate between HKSL signers and Cantonese speakers. They also observed that the distribution of blinks differed between signers and speakers, with blinks in the latter group not correlated with the edge of prosodic phrases. The authors conclude that the mixed statistical findings indicate that some influence of the surrounding spoken language community (at least for HKSL) cannot be ruled out. When further studies comparing sign language prosody with audio-visual prosody are conducted, we will be in a position to highlight what is unique to sign language's prosodic structure and what is characteristic of face-to-face communication generally.

5. SUMMARY AND CONCLUSIONS

In both signed and spoken languages, prosody plays an important role in meaning and, for both types of languages, displays a similar type of hierarchical prosodic structure. Across sign languages, reference to both non-manual and manual markers have proven to essential in our understanding of sign language prosody. As explained, manual markers generally provide timing cues to prosodic constituents whilst non-manual markers provide intonational cues. The importance of these markers in the prosodic organization of sign languages have also been demonstrated in studies focusing on typically developing populations of signers as well as atypical signers and cases of ontological or historical development. Although studies focusing on spoken languages have revealed that cues on the face and body are closely aligned with spoken prosody, signed languages differ from spoken languages because the visual channel is its primary channel for communication. For users of spoken languages, both the audio and visual channel is available in face-to-face communication and both make a contribution to language production and comprehension. Therefore, the extent to which the spoken and sign languages differ in their use of visual cues to prosody allow us to understand

how visual markers of prosody (such as cues on the face) are further recruited to convey prosodic information when the visual channel is the only available means for communication.

The survey of the field presented here also suggests that there are some cross-modal communicative patterns that may underlie certain prosodic patterns in all languages, such as phrase-final lengthening and adding cues for prominence and that signers and non-signers can detect some basic prosodic structures in foreign languages, even ones in another modality. Research on sign languages (as well as work on audio-visual prosody), therefore, encourages us to look beyond speech when defining prosody. In doing so, we can begin to uncover and understand some of the fundamental ways that we structure complex streams of information.

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[1] In addition to boundary blinks, other blink types include voluntary lexical blinks performing a semantic/prosodic function marking emphasis, assertion or stress, physiologically induced blinks (by the hands moving too close to the eyes), blinks associated with a change in gaze or head position, and blinks associated with hesitation.

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[2] The authors also note that their findings may be obscured by the characteristically short utterances (consisting of two or three signs) David produces. Utterances of longer length may reveal more patterns in prosodic distribution.