Head movements in Finnish Sign Language on the basis of Motion Capture data
A study of the form and function of nods, nodding, head thrusts, and head pulls

Anna Puupponen\textsuperscript{a}, Tuija Wainio\textsuperscript{a}, Birgitta Burger\textsuperscript{b}, and Tommi Jantunen\textsuperscript{a}\textsuperscript{*1}
\textsuperscript{a}Department of Languages (Sign Language Centre), University of Jyväskylä
\textsuperscript{b}Department of Music, University of Jyväskylä

This paper reports a study of the forms and functions of head movements produced in the dimension of depth in Finnish Sign Language (FinSL). Specifically, the paper describes and analyzes the phonetic forms and prosodic, grammatical, communicative, and textual functions of nods, head thrusts, nodding, and head pulls occurring in FinSL data consisting of a continuous dialogue recorded with motion capture technology. The analysis yields a novel classification of the kinematic characteristics and functional properties of the four types of head movement. However, it also reveals that there is no perfect correspondence between form and function in the head movements investigated.

Keywords: non-manuals, head movements, prosody, Finnish Sign Language, Motion Capture

1 Introduction

This paper presents the first in-depth study on various movements produced by the head in a sign language: an investigation of head movements produced primarily in the dimension of depth (i.e. the sagittal plane) in Finnish Sign Language (FinSL). Specifically, the movements in focus in the present paper are the head nod, nodding, head thrust, and head pull. The goal of the study is to investigate both the phonetic forms and the prosodic, communicative, and syntactic functions of these movements. In signing, the head also moves along the horizontal and vertical dimensions. The forms and functions of head movements in these dimensions (e.g. headshakes, tilts) are not dealt with in the current paper but are to be discussed in the future. For observations on such movements in sign languages other than FinSL, see, for example, Liddell (1980), Winston (1991), Bahan (1996), Wilbur (2000), and Zeshan (2004, 2006).

\textsuperscript{1} The corresponding author of the current paper is Anna Puupponen, and the study presented here is a part of her PhD dissertation. The corresponding author has carried out the most significant part of the research, including the writing of the manuscript. The co-authors have been involved in the study especially in the process of collecting and processing the data. All co-authors have also contributed to scientific discussions concerning the content of the paper, and have accepted the final version of the manuscript.
In the field of sign language linguistics, the study of different articulations produced by the torso, the head, and the upper and lower parts of the face, that is, non-manual elements, has been an area of increasing interest over the past few decades (see e.g. Wilbur 2000; Pfau & Quer 2010; Herrmann & Steinbach 2011; Sandler 1999ab, 2012). Some of the ongoing research concerns the methods of annotation and analysis of different non-manuals as well as the prosodic vs. grammatical vs. affective nature of non-manuality. The multi-layered articulation and form-function relationship of different non-manual elements are other topic areas with many unanswered questions (see e.g. Herrmann & Steinbach 2011). With regard to FinSL, non-manuals and their functions are for the most part still unexplored. One exception to this is the actions produced by the lower face, i.e. mouthing and mouth gestures, which have been investigated (Pimiä 1987; Rainò 2001). There are also a few single references to other non-manual cues in FinSL, such as the articulation of the head in different functional sentence types (Rissanen 1985) or in equative sentences (Jantunen 2007); the articulation of the head and face in interrogative and negative constructions (Savolainen 2006); and head or body movements and eye gaze in role shift (Rissanen 1992; Luckasczyk 2008). Recently, the study of non-manuals in FinSL has started to include the detailed analysis of the activity of the head (Puupponen 2012; Puupponen et al. 2013). The results of the present paper draw partly on this recent work.

One of the shortcomings in work done so far in the study of different non-manuals is the lack of a detailed description of the forms of, for example, different head movements. Our approach in this study differs from previous studies in that it has a strong phonetic basis: the investigation of the forms and functions of different sagittal head movements was carried out utilizing data derived from two FinSL dialogues recorded with Motion Capture (mocap) technology. As Crasborn (2012) has noted, the phonetic description of sign languages is still in its beginnings, although several phonological models have been developed in order to make it possible to understand the structure of sign language utterances in more detail. Recent technological developments in video recording, motion tracking, and 3D computer animation, however, offer new possibilities for research on sign language phonetics. By utilizing, for instance, mocap technology in collecting and analyzing sign language data, researchers can base their study upon reliable empirical data in a manner hitherto unparalleled in detail and accuracy (see Wilbur 1990; Wilcox 1992; Duarte & Gibet 2010ab; Tyrone et al. 2010; Jantunen et al. 2012). It is our conviction that the study of non-manuals has a lot to gain from this technical progress.

This paper focuses on a description of the forms of nods, nodding, head thrusts, and head pulls on the basis of their movement amplitude as well as on a meaning-based analysis of their functions. The manner of the investigation is descriptive and functional: the study aims to describe the different forms and functions of FinSL head movements from the premises of the language in question, without the use of any specific formalism, and with the goal of (eventually) forming a theory of the nature of this particular sign language (cf. Dixon 2009; Dryer 2006). In this way, this current research follows the tradition in which most of the existing studies on the basic structure of FinSL have been conducted to date, that is, Basic Linguistic Theory (ibid.). In the analysis and classification of different head movements, we see the
functions of head movements as grammatical, communicative, prosodic, and/or textual in nature. These functions correspond closely to the experimental, interpersonal, and textual metafunctions in language proposed by Halliday (1976; see also Thompson 1996): representing the external world or our inner worlds in the contents of our language use; interacting and communicating with each other while influencing each other’s behaviour; and constructing our communication so that the messages we express are situated in the narrower and wider contexts of other messages and information. Consequently, continuous dialogue data has been chosen in order to study the actions of the head in situations which are common and offer typical examples of actual language use.

The paper is organized as follows: Section 2 presents some findings of earlier work on different head movements and their functions in various sign languages. Section 3 describes the data and methods used in the analysis of FinSL head movements produced in the dimension of depth. The results of the study are presented in the following sections: the forms of sagittal head movements in Section 4 and the different functions of these movements in Section 5. This is followed by a discussion and conclusion in Sections 6 and 7, respectively.

2 Forms and functions of head movements in sign languages

Different head movements and other non-manual elements have received attention in the investigation of sign languages since the early research on American Sign Language (ASL) syntax (e.g. Baker & Padden 1978; Coulter 1979; Liddell 1986). Head movement types frequently referred to in the existing literature are the following: nod, nodding (i.e. repeated nod), head thrust, head pull, sideways tilt of the head, head turn, and headshake. In the current study, we examine the first four of these head movements. These head movements are said to have several phonological, morphological, syntactic, textual, communicative, and prosodic functions in different sign languages. Section 2.1 presents a few general remarks on non-manuality, prosody, and grammar, and in Sections 2.2–2.5, we provide a brief overview of the different types of head movements and their functions.

2.1 On non-manuals in sign languages

Traditionally, non-manual elements have been divided into linguistic and affective non-manuals (e.g. Baker & Padden 1978; McIntire & Reilly 1988; Reilly et al. 1990; Anderson & Reilly 1997; Wilbur 2000). According to Pfau and Quer (2010), affective non-manuals are linguistically insignificant facial expressions or head movements that express, for example, disgust, disbelief, or surprise, and which are used by both speakers and signers. According to the standard view, linguistic non-manuals, on the other hand, are non-manual articulations that have grammatical functions, prosodic functions, or both (Wilbur 2000; Pfau & Quer 2010; Herrmann & Steinbach 2011; Sandler 2012). Examples of phonological non-manuals are, for instance, single sideways head movements (i.e. head turns) accompanying negative
signs, or mouth gestures that are essential in the production and comprehension of a particular lexeme. Non-manuals such as combinations of certain mouth gestures and head movements have been said to be morphological and to convey adjectival or adverbial information when accompanying nominal or verbal signs. However, the morphemic status of mouth gestures has also been questioned in recent research on, for example, Australian Sign Language (Johnston & van Roekel 2014). Examples of syntactic non-manuals are, for example, headshakes or head nods in negation or affirmation, as well as distinct eyebrow positions and head or shoulder movements in polar and content questions, conditionals, and relative clauses. Non-manuals that are traditionally classified as pragmatic are, for example, the head and body movements that mark contrastive focus (Wilbur & Patschke 1998; Van Der Kooij et al. 2006) or the body shifts, head movements, changes in the direction of eye gaze or facial expressions that occur when a signer produces a quotational or non-quotational role shift2 (e.g. Liddell 1980; Padden 1990; Engberg-Pedersen 1995; Lillo-Martin 1995; Emmorey & Reilly 1998). The meaningful use of the three-dimensional signing space, which is a well-known and frequent characteristic of all the sign languages studied so far (see e.g. Winston 1991; Engberg-Pedersen 1993; Bahan 1996; Neidle et al. 2000; Liddell 2003), includes non-manual means of making signed texts coherent. In FinSL, text cohesion is produced with head tilts, head nods, body leans, and changes in the direction of the eye gaze in addition to directing the motion of the hands towards predetermined referents (Lautala 2012; Puupponen 2012).

Other features that create cohesion and organize signed utterances, texts and discourses, are different prosodic cues. The prosodic functions of non-manuals in sign languages have traditionally been divided into domain markers and edge markers (see e.g. Wilbur 2000; Pfau & Quer 2010, Neidle et al. 2000). In domain marking, non-manuals spread across syntactic domains such as topics and questions or construct prosodic units such as prosodic words or intonational phrases (Wilbur 2000; Sandler 2012). Edge markers are said to be punctual cues occurring at the borders of syntactic and/or prosodic sequences. According to Wilbur (2000) and Sandler (1999ab, 2011, 2012), non-manuals form a layered structure in which simultaneous changes in the actions of different non-manual articulators mark the boundaries and domains of prosodic and/or syntactic units. Pfau & Quer (2010:400) state that “prosodic structure frequently aligns with syntactic constituency” in sign languages. However, as it has been pointed out by e.g. Nespor & Vogel (1986), Nespor & Sandler (1999), and Sandler (2012), this alignment is not one-to-one, which means that prosodic and syntactic structures are autonomous parts of grammar that are in close relation but are not fully isomorphic.

It has been pointed out that distinguishing between purely affective and linguistic non-manuals is not always easy (Pfau & Quer 2010; Herrmann & Steinbach 2011; see also De Vos et al. 2009). However, studies on non-manuals suggest that the scope and timing of linguistic non-manuals is more constrained than the scope and timing of affective non-manuals (Baker-Shenk 1983; Wilbur 2000; Pfau & Quer 2010). Furthermore, it has been argued that in the acquisition of (American) sign language, children use affective non-manuals from an early

---

2 Role shift is produced in situations which include constructed discourse (reported speech) or constructed/reported action. In FinSL, role shift has been noted to occur in both formal/informative signing and narratives (Lukasczyk 2008; Lautala 2012).
stage, but only later use non-manuals for linguistic purposes (Anderson & Reilly 1997; Reilly & Bellugi 1996). It should be noted that the division of non-manuals into linguistic and affective ones seems to be based on facial articulation (movements and positions produced by the upper and lower face). Affective and linguistically significant head and body movements, however, have received far less attention in the sign language literature. In Sections 2.2–2.5, we will give a short overview of the forms and functions of different head movements in sign languages according to the existing literature.

2.2 Nod and nodding

Nods are head movements in which a signer moves his/her head up and down (Liddell 1980; Wilbur 2000). The prototypical movement path of a nod is a tilt movement in the dimension of depth: the signer’s chin moves up and down and the orientation of the signer’s face changes accordingly (see Figure 1). According to Puupponen (2012), head nods consist of three movement-internal phases: preparation, stroke, and recovery. During preparation, the position of the head changes slightly in order to prepare for the stroke phase, in which the signer’s chin moves towards the chest. The movement amplitude is largest during the stroke, after which, during the recovery, the head movement becomes smaller again and the head moves towards a ‘neutral’ position or a subsequent head movement.

![Figure 1. The prototypical movement path of nods and nodding.](image)

According to the standard view, head nods perform a large variety of functions, such as emphasis, assertion, affirmation, and existence (Liddell 1980; Wilbur 2000; Pfau & Quer 2010). It has been argued that in ASL, nods perform as existential markers when occurring with lexical signs in verbless assertions (Liddell 1980, Aarons 1994). Liddell (1980:30,37) offers the following examples of a verbless simple sentence (1), and an elliptic utterance, in which the signer conveys information in the form of a list (2) (‘hn’ = headnod).

_______hn
(1)    JOHN DOCTOR
       ‘John is a doctor.’
HAVE WONDERFUL PICNIC. PRO.1 BRING SALAD, JOHN BEER, SALLY CHICKEN, TED HAMBURGER.

‘We had a wonderful picnic. I brought the salad, John (brought) the beer, Sandy (brought) the chicken, and Ted (brought) the hamburger.’

According to Liddell, if sentence (1) was produced without a head nod, it would convey the meaning ‘John’s doctor’. Liddell states that also in (2), the head nods are obligatory markers of existence. Wilbur (1991), on the other hand, has suggested that nods, like voluntary blinks, mark focus when they occur with lexical signs in structures such as the one in (2).

Head nods have not been reported in elliptic structures in FinSL (Jantunen 2013), although Puupponen (2012:3) presents the example shown in (3), which involves a series of vertical movements of the head (‘hn’), combined with side-to-side head tilts (‘hts’ = head tilt sideways), which were used to organize an utterance with a list structure without the use of a list buoy (i.e. a manual listing sign; cf. Liddell 2003). However, nods have been found in FinSL utterances similar to the one presented above in (1). Jantunen (2007) observed that head nods occur in equative sentences, which are assertive utterances with naming, defining, and identifying functions, such as the sentence in (4) (Jantunen 2007:123; ‘ews’ = eyes widened/squinted; ‘brw’ = brows raised/wrinkled; ’b’ = blink).

EXAMPLE BOARD INDEX CHAIRPERSON MONEY HANDLE SECRETARY

‘For example, in the board, there is a chairperson, a treasurer, and a secretary.’

A-N-I-S PI SPICE PLANT

‘Anis is an aromatic herb.’ (Suvi 350/1)

Jantunen notes that it is difficult to draw any overall conclusions about the syntactic function of the head nod because of its ambiguity. Head nods often co-occurred in Jantunen’s equative data with the sign PI, and they can be seen as copying the manual path movement of this specific sign (cf. Woll 2009).

In ASL, head nods have also been associated with the edges of syntactic units. Nods have been said to occur after clause-final signs marking syntactic boundaries (Wilbur 1999; 2000). According to Wilbur (2000), the then existing research implied that single head nods

---

3 The glosses in examples (3) and (4) have been translated into English; in (4) mouthings from the original example are neglected.

4 The sign PI in equative sentences is a modal element that expresses certainty. The gloss is based on the mouth gesture accompanying the sign. For a discussion, see Jantunen (2007).
perform as boundary markers whereas slow (i.e. ‘deliberate’) single head nods are used as focus markers for lexical signs. The occurrence of nods as boundary markers after clause-final signs or as focus markers with lexical signs has not yet been investigated for FinSL.

In addition to single nods, signers also produce nodding movements of the head while signing. Nodding movements are head movements consisting of repeated nods and they are longer in duration than for example head thrusts or single nods. According to Puupponen’s (2012) data, nodding is made up of six to seven movement phases, of which two or three are downward-directed stroke movements. Nodding has generally been associated with the positive polarity of clauses, as in the following Italian Sign Language example from Geraci (2005; see also Liddell 1980:27).

```
(5)    hm
SOMEONE ARRIVE
‘Someone did arrive.’
```

Wilbur (2000, see also Liddell 1986) states that large and deliberate nodding performs the function of strong assertion, whereas rapid nodding is present in counterfactual conditionals, or signals cautiousness or vagueness in ASL utterances. When performing such tasks, nodding has been said to have a smaller movement amplitude and a higher frequency of repetition than nods (Wilbur 2000). According to Wilbur (2000:230), a “repetitive head nod conveys what semanticists refer to as the speaker’s commitment to the truth of the assertion”. Also in FinSL, nodding movements have been said to perform strongly affirmative functions (Puupponen 2012). However, the presence of nodding in counterfactual conditionals or to signal cautiousness has not yet been investigated in FinSL.

2.3 Head thrust and head pull

Head thrusts are movements of the head in which the signer’s head is pushed forward in the dimension of depth. In a typical thrust the signer’s chin moves forward without a substantial change in the orientation of the face. Wilbur (2000:231) states that a head thrust is “separated from the other non-manual markers by virtue of its articulators” in addition to differences in scope. Wilbur does not, however, specify this difference in articulation except by mentioning that the sideways tilt, nod and shake of the head all involve the neck muscles, whereas a head thrust is produced with the neck muscles “that move the lower jaw or chin forward” (Wilbur 2000:227). The prototypical movement pattern of a head thrust is presented in Figure 2.
Wilbur (2000) and Liddell (1986) have found that head thrusts occur with clause-final signs in conditional and time clauses in ASL. Wilbur suggests that the function of a head thrust is semantic, not syntactic or prosodic, and it expresses the signer’s commitment to the certainty of the assertion. Wilbur states that thrusts differ from other syntactic or edge-marking non-manuals: they are punctual and do not spread across entire syntactic domains like non-manual domain markers (e.g. brow lowering in content questions), but neither do they occur after clause-final signs as other non-manual edge markers do (head nods or inhibited periodic eye blinks), but rather during them.

Although Wilbur states that head thrusts in ASL are punctual and do not spread, thrusts are also familiar elements when discussing the marking of interrogatives in sign languages. In the non-manual marking of polar (yes/no) questions in several sign languages, thrusts accompany brow raise and usually movements of the shoulders, and the non-manual marking accompanies the entire clause (Pfau & Quer 2010). This is known to be the case, for instance, in ASL (Liddell 1980; Fischer 2006), Flemish Sign Language (van Herreweghe & Vermeerbergen 2006), and New Zealand Sign Language (McKee 2006). In addition to polar questions, however, thrusts occur with brow lowering also in the non-manual marking of content (wh) questions in some sign languages, such as Indo-Pakistani Sign Language (Aboh, Pfau & Ze-shan 2005) and British Sign Language (BSL; Sutton-Spence & Woll 1999). In content questions, non-manuals can accompany the entire clause or only the interrogative signs if they are in sentence-final position.

The status of the head thrust as a punctual movement during clause-final signs and/or as a domain marker spreading across interrogative structures is still open for discussion. More research on the issue is needed in order to establish whether these two types of thrusts are different in their form and function, and further, if these differences exist in other sign languages besides ASL. It should be noted that the use of head movements varies from sign language to sign language, and it has been argued that, for example in polar questions in BSL, the head moves backward, not forward, as mentioned above for several other languages (Sutton-Spence & Woll 1999). In addition, the form of the head movement in questions can vary, due to the fact that thrusts can be accompanied by several other head movement features, such as chin-up, chin-down, or a sideways tilt of the head.
According to Savolainen (2006), in FinSL both polar and content questions are marked with the same head movements: a head tilt forward or a head thrust with optionally a slight chin-up as in (6) (Savolainen 2006:286; ‘htf’ = head tilt forward, ‘re’ = raised eyebrows).

\[(\text{extra}) \text{htf} \quad \text{htf + re}\]

\(\text{(6)} \quad \text{POSS2 BICYCLE STEAL}\)

‘Has your bicycle been stolen?’

Savolainen states that the above-mentioned head movements and specific eyebrow positions are obligatory for the production of content and polar questions in FinSL. Also Puupponen (2012) noticed the production of head thrusts in question structures in FinSL. However, Puupponen stated that in her data, thrusts were produced also with a sideways tilt of the head in interrogatives. Savolainen (2006) argues that in polar questions, non-manual articulation occurs either during the whole utterance or during the questioned element (the focus of the question). In content questions, non-manual articulation is produced either during the whole question or accompanying the interrogative sign (Savolainen 2006).

While in head thrusts, the signer’s head moves forward in the dimension of depth, the head has also been said to move backwards in different ways while signing. When describing different non-manual articulations accompanying different types of topics in ASL, Aarons (1994) mentions a backward movement of the head as one of the features. Backward head movements are also said to occur in polar questions in BSL (Sutton-Spence & Woll 1999) as well as in content questions in ASL (Liddell 1980; Pfau & Quer 2010). Puupponen (2012) mentions that in her data, a backward movement of the head occurred in a content question in which the signer was expressing disbelief. Crasborn & Van der Kooij (2013), on the other hand, found that backward and/or upward head movements\(^5\) accompanied the object in information and contrastive focus. In the current paper, we refer to these types of movements as head pulls. The prototypical movement pattern of a head pull is demonstrated in Figure 3.

\[\text{Figure 3. The prototypical movement path of head pulls.}\]

\(^5\) Another example of a backward movement of the head is a backward head tilt, also referred to as a raised chin or chin-up. In this movement, the head tilts in the dimension of depth so that the chin is lifted and the orientation of the signer’s face moves up. The similarities in the forms and functions of head pulls and chin-ups should be investigated further in future research.
In addition to what has been stated earlier, head thrusts and head pulls are also associated with different focus constructions in the sign language literature. Forward movements of the head, the shoulders, or the whole upper body have been said to occur as a primary feature of stress-for-focus in information or completive focus sentences in ASL (Wilbur & Patschke 1998), and in Sign Language of the Netherlands (NGT), the same has been noted for focused subjects in information focus (Van der Kooij, Crasborn & Emmerik 2006; Crasborn & Van der Kooij 2013). These prosodic body movements have no specific meaning in themselves. In addition, forward-backward head and/or body movements have been found in the prosody of contrastive focus constructions in ASL and NGT. Corrective focus is expressed with a backward head/body movement on the utterance that is corrected, followed by a forward movement on the utterance which replaces the earlier one. Head and/or body movements marking contrastive focus may also convey meanings related to the semantics of inclusion and exclusion on the lexical level. These movements can appear with both nominal and verbal signs and they have been found in both ASL and NGT. Inclusive movements are produced with signs conveying meanings of, for example, participation, involvement and agreement, and exclusive movements with signs conveying meanings such as rejection, avoidance, resistance, and disagreement.

According to Wilbur & Patschke (1998), ASL signers also produce forward-backward (or side-to-side) head and/or body movements in so-called parallel focus constructions. In utterances with parallel focus, signers use these head/body movements in order to contrast two or more elements with each other, to make identification of the elements easier. Wilbur and Patschke argue that parallel focuses are commonly list structures in which signers also produce manual list buoys. As stated earlier, a structure in which several elements are contrasted with a combination of head nods and side-to-side head movements has been observed in FinSL (Puupponen 2012; see Section 2.2) without a manual list buoy. Also Jantunen (submitted) states that in clausal co-ordination in FinSL, the basic strategy is asyndetic (juxtaposition without manual co-ordinators), and the co-ordinants are typically separated by changes in the actions of the head and/or body.

According to Sutton-Spence and Woll (1999), in BSL, head and/or body movements forward and backward may express information about the time frame in which a certain action or event is placed. For example, when making an enquiry, a signer may produce manually articulated signs conveying meanings regarding an action or event, while a forward head and/or body movement indicates that the event is placed in future time, and a backward head and/or body movement signals that the action or event is related to the past. However, as Sutton-Spence & Woll (1999) underline, interpreting these head articulations as temporal mark-

---

6 In NGT, however, this contrast is expressed more frequently with head/body movements from side-to-side rather than forwards and backwards.

7 Wilbur and Patschke present ASL utterances in which forward-backward body leans contrast two elements in conjunctive co-ordination (‘and’), and side-to-side leans contrast elements in disjunctive co-ordination (‘either-or’).
ers would be misleading as they spread across the whole utterance, not only across the verbal sign (on an opposing view, see e.g. Zucchi 2009).

2.4 Summary

Sections 2.2 and 2.3 dealt with the characteristics of nods, nodding, head thrusts and head pulls in different sign languages. An overview of the functions of these movements is given in Table 1.

Table 1. Overview of the different functions of nods, nodding, head thrusts, and head pulls in different sign languages, as identified in previous studies.

<table>
<thead>
<tr>
<th></th>
<th>Nod</th>
<th>Nodding</th>
<th>Thrust</th>
<th>Pull</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prosodic stress</strong></td>
<td>Stress-for-focus</td>
<td></td>
<td>Stress-for-focus</td>
<td>Replaced utterance</td>
</tr>
<tr>
<td><strong>Contrastive stress</strong></td>
<td></td>
<td></td>
<td>Corrected subject</td>
<td></td>
</tr>
<tr>
<td><strong>Copying manual movement</strong></td>
<td>With sign PI in equative sentences</td>
<td>After clause-final signs</td>
<td>Replacing utterance</td>
<td></td>
</tr>
<tr>
<td><strong>Boundary marking</strong></td>
<td></td>
<td></td>
<td>Parallel focus/listing</td>
<td></td>
</tr>
<tr>
<td><strong>Domain marking</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Semantic content</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As is evident from the discussion in Section 2.3, the movements of a signer’s head and torso are often dealt with as one unit: as the articulators are physically connected, many head movements may be produced together with the torso or shoulders. However, in their research on focus structures in NGT, Van der Kooij et al. (2006) found an expression in which a body movement expressed contrastive focus when going from side to side, whereas a headshake negated the repeated item and a thrust marked the corrected subject during the correct item.
This NGT example illustrates the potential of head and body to move differently, performing mutually connected but independent functions. Similar observations were made of FinSL by Puupponen (2012).

3 Data and method

3.1 Description of the data

The investigation of head movements described in the current paper was done on the basis of two FinSL dialogues recorded in the motion capture laboratory of the Department of Music at the University of Jyväskylä, Finland (see Jantunen et al. 2012). These recordings consist of altogether 2:15 minutes of mocap data of two continuous dialogue situations (Data 1 & Data 2), in which two native FinSL signers (Signer A & Signer B) talk about their work, studies, and everyday language use. The relatively small amount of data in the current study is explained by the fact that mocap data includes a large amount of numerical articulator-specific location information. The processing and use of mocap data is a time-consuming process, with its own technological demands (see Jantunen 2012). In the data collection, the signing of the informants was recorded with an eight-camera optical motion capture system (Qualisys ProReflex MCU120). The cameras recorded the motion of the signers at the frame rate of 120 Hz by tracking the three-dimensional locations of ball-shaped markers attached to the signers’ hands, arms, head, and torso (Figure 4a). In addition, digital video cameras recorded the signers from different angles, and provided video material (Figure 4b) that was synchronized with the motion capture system.

Figure 4. (a) A skeleton image of the marker setup in the data-recording situation; (b) a screenshot of the digital video material (Jantunen et al. 2012).

Of the total number of thirty-one markers per signer in the setup, shown in Figure 4a, four were attached to the upper part of each signer’s head and one to the chin. Two markers were attached to the shoulders of each signer, two markers to the upper torso, and six to the lower
torso. The rest of the markers were attached at the main joints in the arms and hands of both signers.

Mocap data is generally considered to be the most accurate type of data available for phonetic research into sign languages (e.g. Jantunen et al. 2012). The results of the mocap recording are produced as a numerical co-ordinate matrix, which can be used when analyzing the kinematic properties of the movements of signers’ articulators. In addition to the phonetic analysis, mocap data can be used in several other research areas when accompanied with video. For the present study, mocap data was used in the analysis of the phonetic properties of different head movements as well as in the investigation of phonetic differences between different types of head movements. In our analysis of the head movements, we used the recordings of the markers attached to the right forehead of each of the two signers. We investigated the amplitude (displacement) of movements of the signers’ head in the dimension of depth on the basis of the numerical data received from the recordings of these markers. When examining the amplitude of head movements in a specific dimension, one marker, in this case the right forehead marker, provides highly detailed location information related to that specific marker (mm/Hz; recording speed of 120 Hz). In this way, the numerical information received from one marker provides sufficient data for evaluating the characteristics of movement amplitude in different head movement phenomena.

3.2 Data processing, annotation, and analysis

The collected mocap and video data were imported into ELAN for the identification and annotation of the different head movements. This process was carried out in several different stages. The starting point of the identification process was the different head movement types found in the existing sign language literature, as described in Section 2. First, each head movement in both of the dialogue data sets was given an empty annotation cell by two annotators. From these annotations, we took for investigation the ones where the head movement was recognized as representing a nod, nodding, thrust, or pull of the head, described in the literature. These empty ‘raw annotation’ cells of the forms of different head movements were then specified concerning, for example, the beginning and ending of the different head movements, with the help of the visualizations of numerical mocap data in ELAN. Subsequently, the annotations were given values according to their head movement type and individual numbers according to their chronological appearance in the data (e.g. Nod-3, Thrust-5, etc.). In situations where a signer produced multiple head movements at the same time, annotations were also created for the simultaneous head movements. Information concerning the movement characteristics of the head movements or the relationship between actions of the head and manual articulation was added as ‘form remarks’ in a specific annotation tier when necessary.

The movement analysis of the data was done in Matlab using the MoCap Toolbox developed by Burger & Toiviainen (2013). For each identified head movement, we created an annotation cell in ELAN with the movement-specific frame number information. With the
frame number information, we could locate the movements from the mocap data and calculate information concerning the amplitude of the movement. The numerical data of the amplitude of different head movements was then used in Excel to study the kinematic properties of different head movement types, variation between head movements of a certain type (different nods, thrusts, etc.), and the overall differences between different head movement types. For details in collecting and processing mocap data for sign language research, see, for example, Jantunen et al. (2012).

Thorough annotations were also created for the functions of different head movements in the data. Firstly, raw annotation cells were created for each function of the different head movements in the data. The data-driven annotation values of these cells were based on the observations and intuition of a native FinSL signer. The fundamental question behind the raw annotation was simply, “What is the role or function of this specific head movement in this context?” On the basis of the raw annotations, a more systematic annotation that could be used for purposes of classification was then developed. Finally, on the basis of the two-level annotation process, the different functions of the head movements were classified and categorized into different functional groups. Each head movement in the data was given an annotation cell in ELAN containing information about the function type. If the head movements were considered to have several overlapping functions, all the necessary functions were marked in the annotations. Finally, the annotation matrix (minus the ‘in-progress’ level annotations) for each head movement consisted of annotations in six different tiers: head movement type (form) and individual number, frame number information, simultaneous head movements, form remarks, function type, and function remarks.

Finally, the information given in the annotations (shown in Figure 5) of both data sets was gathered in a table in Excel. The table included information about each head movement of each data set according to their chronological appearance in the data: head movement type, individual number, simultaneous head movements, comments or remarks on the form of the movement, functional category, and comments or remarks concerning the function(s) of the movement. The functions and forms of different head movements were then cross-tabulated and evaluated generally, movement-type specifically, and concerning the relation between different movement types. In the results, several regularities and irregularities arose, which are discussed in Sections 5 and 6.
3.3 Methodological observations

The kinematic information received from the numerical mocap data was found to be useful in the annotation and analysis of different sagittal head movements. The visualization of the motion of the head made it possible to investigate in detail the inner structure of different head movements and to identify more precisely changes in the direction of the movement of the head. In this way, the mocap data usefully complemented the traditional frame-by-frame investigation of the data. Occasionally, the movement produced by the head was so subtle that it was difficult to detect and annotate it by merely looking at the video material (movements appear in the video on a much smaller scale than in real life). The visualization of the different head movements (i.e. the mocap data imported into ELAN) illustrated the differences between different head movement events. This allowed a more thorough and detailed examination of variation in the forms of different head movements belonging to a specific movement type, as well as comparison between movements of different types.

Assigning a function to a specific head movement was not always easy. Differentiating between the function of a head movement or posture and the function of the whole expression (or the functions of other non-manual articulations) was in some cases found to be tricky. Also, the overlapping of several (2–3) different functions resulted in the fact that defining a clear ‘main function’ for a particular head movement was not always clear-cut. It was important to examine the functions of head movements throughout the annotation process, that is, already when annotating the forms of the movements. We therefore came to the conclusion that a na-
tive signer is in many ways required for the annotation of head movements, for example in order to distinguish the linguistically significant and interesting phenomena from the overall activity of the head. It should also be noted that some functional categories, described in Section 5, are wide, as the categorization was done on the basis of a wide view of what is considered language.

Physiologically, the connection between the movements produced with the head and the torso is obvious: the cervical spine and neck muscles participate in the motion of both the head and the body. In the current research, we have analyzed the forms and functions of different types of head movement regardless of whether they are produced together with the torso and shoulders. The status of the head and the upper body as independent articulators as well as connections between the functions produced by the actions of these articulators are important issues for forming a theory of non-manuality in FinSL. These questions will be dealt with in future research.

4. Head movements in the dimension of depth in FinSL

Four types of head movement produced in the dimension of depth were identified from the data: the nod, nodding, thrust, and pull. A summary of the characteristics of these four head movement types is given in Table 2.

Table 2. Basic information about head movement types: their overall number, duration, amplitude, shape of visualization, and simultaneous head movements.

<table>
<thead>
<tr>
<th></th>
<th>N (Data 1 + Data 2)</th>
<th>Average duration (sec)</th>
<th>Average amplitude (mm)</th>
<th>Shape of the average movement</th>
<th>Variation in amplitude min-max (mm)</th>
<th>Most common simultaneous head movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nod</td>
<td>36 (21+15)</td>
<td>1.3</td>
<td>43</td>
<td>V</td>
<td>15-55</td>
<td>tilt</td>
</tr>
<tr>
<td>Thrust</td>
<td>19 (15+4)</td>
<td>1.5</td>
<td>50</td>
<td>U</td>
<td>35-60</td>
<td>tilt</td>
</tr>
<tr>
<td>Nodding</td>
<td>34 (18+16)</td>
<td>2.1</td>
<td>n/a</td>
<td>Wavy</td>
<td>n/a</td>
<td>tilt, thrust</td>
</tr>
<tr>
<td>Pull</td>
<td>9 (5+4)</td>
<td>1.6</td>
<td>56</td>
<td>Upside down J</td>
<td>40-65</td>
<td>turn</td>
</tr>
</tbody>
</table>

As can be seen from Table 2, the total number of nods, nodding, head thrusts, and head pulls in the data was 98. Of these, 56 movements were produced by Signer A and 42 by Signer B. The most common type of head movement in the data was the nod: the data consisted of altogether 36 nods, 21 in Data 1 and 15 in Data 2. The average duration of nods was 1.3 seconds and the average amplitude of movement in the dimension of depth was 43 millimetres. When comparing the visualizations of the 36 nods, presented in Figure 6, it is clear that there was a lot of variation between different nods in the data. Typical variation between the movement amplitude of different nods was from 15 to 55 millimetres. The differences between the phonetic forms of different nods may be explained by differences in both the preceding and following context in signing and in the functions of the nods. The highest amplitudes of move-
ment produced in nods occurred with Signer B in Data 2, which might also indicate signer-specific (idiolectic) variation. On average, nods formed a relatively symmetrical V-shape in the visualizations of head nods (calculated in Excel on the basis of the mocap data) (red line in Figure 6). This indicates that the change of direction between the first and second movement phases in nods is quite abrupt.

![Figure 6](image)

**Figure 6.** Visualization of the movement amplitudes of different nods on the basis of the mocap data. The average nod is calculated from motion during the strokes and recovery phases of different nods, and it is marked in the figure with a red line. The axes present the amplitude of the movements (y) in the function of time (x).

Turning to head thrusts, the data included altogether 19 instances, of which 15 were found in Data 1 and 4 in Data 2. The total number of thrusts was therefore considerably smaller than that of nods. The average duration of head thrusts was 1.5 seconds, which makes them slightly longer in duration than nods. The average movement amplitude in thrusts was 50 millimetres, indicating that thrusts are larger movements than nods in terms of depth; a fact which is somewhat self-evident, considering that nods are produced with an axial tilt forward resulting in the lowering of the chin towards the chest, whereas in thrusts the chin and the whole head move forward (although some of the thrusts in the data were accompanied by a slight chin-down and/or a head tilt). As with nods, there was a lot of variation between different head thrusts in the data. However, the range of typical variation between the movement amplitude in thrusts is somewhat smaller than in nods, varying from 35 to 60 mm. The average thrust (red line in Figure 7) forms a relatively symmetrical U-shape, which indicates that the change of direction in thrusts is relatively smooth (longer in duration) when compared to that of nods.
Just like nods, also nodding movements were one of the most common head movements in the dimension of depth in the data. Altogether 34 nodding movements appeared in the data, 18 in Data 1 and 16 in Data 2. Nodding movements involved repetition and they were longest in duration, the average nodding lasting for approximately 2.1 seconds. As with nods and thrusts, there was also a lot of variation between the forms of different instances of nodding in the data (see Figure 8). Noddings consisted of four forward-directed movement phases on average, of which the first forward movement was largest, with an average amplitude of 13 mm. On average, the amplitude of the second movement phase in nodding was much smaller (ca. 5 mm) than the first movement phase, as were subsequent movement phases (5-10 mm). However, as can be seen in Figure 8, there were differences in the amplitude of the movement phases during the repetition on different occasions. This may be a result of several different factors, such as the motion of the head copying the manual articulation of the signer (see Section 5.4). This connection can be found in situations where the head emphasizes something signed by the person producing the nodding, as well as in situations where the nodding is produced by the addressee, and the emphatic (stress) features are produced in connection with the signing of the other party.
Head pulls were the most infrequent head movements in the dimension of depth in the data. The total number of head pulls in the data was nine, five of which were found in Data 1 and four in Data 2. The average duration of different pulls in the data was 1.6 seconds, which makes them slightly longer in duration than thrusts. Also head pulls exhibited variation, typical variation ranging from 40 to 65 millimetres in amplitude. The average pull was approximately 56 millimetres in amplitude and it formed an upside-down J-shape (see Figure 9). This indicates that the change in the direction of the movement in head pulls resembles that in head thrusts: the transition is smooth and less abrupt than in, for example, head nods. Finally, as can be seen in Figure 9, the first movement phase in pulls is larger in amplitude than the second one. That is, in head pulls the movement is larger at the beginning and it diminishes towards the end.
In conclusion, four different types of head movements were found in the data in the dimension of depth. Of these, the nod was the most frequent and the pull the most infrequent. All of the different types of head movements exhibited a lot of variation, and this was particularly the case with nods. As is shown in Table 2, on average the pull was the largest movement and the longest in duration of the three non-repetitive movement types. The first movement phase of nodding was generally smaller than the other movements (including nods), but in duration nodding was, due to its repetitive nature, longer than the other three movements. The simultaneous production of two different head movements was very common in our data. A common combination of two simultaneous head movements was a head nod or a head thrust with a sideways tilt movement of the head.

Comparison of the forms of head pulls and nodding with the motion of nods and thrusts does not provide us with any useful information, as the direction of movement in pulls and the repetitiveness of nodding differ substantially from the movement patterns in the other two head movement types. However, when comparing the characteristics of nods and thrusts, we found a very strong correlation between the average nod and average thrust (correlation coefficient 0.9743324). Nevertheless, when examining the whole group of instances of nod and thrust movements, statistical analysis signals very significant difference (p=0.0002). This result indicates that while the average nod and thrust are similar in form, the instances of nods and thrusts include more movements that are notably different in form than those which are similar.
5. Functions of nods, thrusts, nodding, and pulls in FinSL

The head nods, head thrusts, nodding, and head pulls in our data had several different functions on different levels of language structure and use. In the examination, we categorized these functions into groups according to their syntactic, semantic, pragmatic, and prosodic features. The categorization of the head movements was done inductively from the annotations that were based on the observations of native FinSL signers. We distinguished the following seven functions.

- **E-function**: Emphasis: the signer produces prosodic stress giving emphasis to signs articulated by the hands, produces contrastive stress between elements in an utterance, or moves the head to separate members of a list or “textual catalogues”, e.g. ‘either-or’ (Section 5.1);
- **B-function**: Boundary marking: a head movement marks or emphasizes a syntactic and/or prosodic boundary (Section 5.2);
- **D-function**: Domain marking: a head movement marks a prosodic and/or a syntactic domain, such as a topic (Section 5.3.1);
- **A-function**: Affirmation: the signer declares his or her positive attitude towards the truth value of the proposition or aims to convince the addressee of the truth value of the proposition. The addressee reacts positively or gives positive feedback to the proposition produced by the other signer. (Section 5.3.2);
- **Q-function**: Interrogative: the signer produces a polar question, a content question or a ‘declarative question’ (Section 5.3.3);
- **C-function**: Copying: the signer’s head copies the manual movement (Section 5.4);
- **X-function**: Indicating: pointing with the head (Section 5.4).

As can be seen from the list above, head movements in our data have functions related to prosodic stress, contrastive stress and listing (E), boundary marking (B), domain marking (D), affirmation (A), and interrogatives (Q). Other functions found in the data were copying head movements (C) and indicating head movements (X), to which we did not find any reference in the literature. It is not uncommon for head movements to function as a part of prosody as well as to perform other functions. Some, even many of these head movements are also common in the context of speech, while others are more specific to sign language communication. All in all, these functional categories or types can be seen as forming a series of different continuums, depending on the point of view and on aspects of the functions that are emphasized.

5.1 Emphasis: prosodic stress, contrastive stress & listing

Sagittal head movements in the data include emphatic head movements, which are markers of prosodic stress (Section 5.1.1), contrastive and/or exclusive movements marking contrast between manually signed elements or conveying meanings of exclusion (Section 5.1.2), as well
as listing movements separating conjunctively or disjunctively co-ordinated elements that may include ellipsis (Section 5.1.3; see also Jantunen submitted).

5.1.1 Prosodic stress

Some head movements in the data are produced as prosodic cues giving emphasis to signs articulated by the hands, that is, they are involved in making a specific sign prominent in an utterance. This type of movement, a head thrust, is presented in the utterance in Figure 10. The utterance also includes a boundary-marking head pull (see Section 5.2) and an affirmative sentence-final head nod (see Section 5.3.2).

![Figure 10](image)

**Figure 10.** An utterance with an emphatic head thrust, a boundary-marking head pull and an affirmative, sentence-final nod. [Data 1, Signer B, Thrust-5, Pull-3 & Nod-5]

The head thrust in Figure 10 puts emphasis on the sentence-initial sign SENSE-BY-EAR. The head thrust marks focus in the information structure of the sentence (and potentially the beginning of a new syntactic unit).

The sign demonstrated in Figure 11 is an example of an expression in which a head pull together with a facial expression emphasizes the manual articulation of the sign DURING-ONE-DAY with which it co-occurs. The whole utterance in which the expression occurs is demonstrated in Figure 27 in Section 5.3.3.

![Figure 11](image)

**Figure 11.** The sign DURING-ONE-DAY together with an emphatic head pull

In addition to emphasizing manual articulation, head movements may give emphasis to other head movements. The example in Figure 12 demonstrates an utterance where the signer produces a combination of a head thrust and nodding together with specific articulation of the lower face (the corners of the mouth lowered and the lower lip protruded) at the end of the sentence. The utterance also includes an affirmative head nod, discussed in Section 5.3.2.

---

8 In Figure 10 and in the following figures, we demonstrate example utterances with screenshots from ELAN that include annotations for head movements, manual signs, and a translation. The graphs above the annotation tiers show the visualised mocap data of the movement amplitude of the signer’s head in the dimension of depth (mm/Hz; recording speed of 120 Hz).
An utterance with an affirmative nod marking existence and a head thrust emphasizing the simultaneously produced nodding. [Data 1, Signer B, Nod-3 & Thrust-4]

The head thrust in the utterance in Figure 12 puts emphasis on the articulation of the strongly affirmative nodding movement produced during the thrust. The head thrust, nodding, and the mouth gesture are produced without the presence of a manual sign and together they construct a gestural predicate with the meaning of ‘yes, sure [I use Finnish]’. When highlighting the articulation of the nodding and the mouth action, the head thrust marks the domain of a comment (‘yes’) on a topic (‘Finnish’).

5.1.2 Contrastive stress and exclusion

In the data, we also found head movements which either mark contrastive stress between elements in an utterance (Figure 13) or convey meanings of exclusion (Figure 14).

The head pull in Figure 13 emphasizes the contrast between elements which are semantically associated within a time frame. The head pull occurs at the border of two sentences: a nega-
tive declarative sentence and an affirmative declarative sentence. The head pull marks the transition between the sentences as well as emphasizing the contrast between the contents of the two sentences: something that is declared as a fact in an earlier time (*I didn’t want a permanent position*) and something that is declared as a fact in the present time (*now I have a permanent position*). The head pull is produced together with a backward body lean and it is an example of the non-manual marking of contrastive focus in FinSL.

In the utterance in Figure 14, the head pull marks semantic exclusion in a negative expression. The utterance is an incomplete negative sentence, with which the signer rejects any potential misinterpretation of her previous statement by the addressee. After the utterance, the signer continues with amplifying statements. The head pull is produced with a backward body lean, with which it conveys the semantics of exclusion, and they are both produced simultaneously with a headshake. The headshake, negative manual sign, head pull, and backward body lean altogether result in a negative construction, which functions as a corrective element in the discourse.

5.1.3 Listing

Emphatic head movements in the data include head movements which (i) appear in co-ordinated structures in which the head and body movements mark contrastive parallel focus in an ‘either-or’ structure (disjunctive co-ordination), or (ii) separate parts of manually produced elements that form a list (multiple co-ordination) (cf. Wilbur & Patschke 1998). Like the movements discussed in the Section 5.1.2, listing movements are one way of producing contrast between units of information in signing. The most common form of listing movement was a head thrust and the co-ordination was produced either sentence-internally or in larger discourse episodes.

In the ‘either-or’ structure in Figure 15, a head movement emphasizes the disjunctive co-ordination expressed syndetically, that is, with a manual co-ordinator sign (see Jantunen, submitted).

![Figure 15. Interrogative head thrusts in a content question consisting of a co-ordinated ‘either-or’ structure.](data1 signer B Thrust-2 & Thrust-3)

The example in Figure 15 consists of two parts, an interrogative sentence with co-ordinated elements and a positive response to the interlocutor’s answer (‘Right’). The two head thrusts in the utterance mark the interrogative (see Section 5.3.3) and, together with movements of the body, emphasize the contrast between the co-ordinand clauses (‘speaking’ and ‘reading’), which are in disjunction. The disjunctive co-ordination is performed by the manual sign *or*
(see Jantunen, submitted). The second thrust continues after the interrogative sentence and spreads over the subsequent affirmation. The manual and non-manual articulation results in a parallel focus structure in FinSL.

In the several utterances with multiple co-ordination found in the data, the movements of the head, together with temporal features in, and breaks between, the manually produced signing sequences, separate the different parts of the list (Figures 16 and 17). The list structures did not include list buoys.

![Figure 16](image1.png)

**Figure 16.** Three head movements separating parts of a list in a sentence with multiple co-ordination. [Data 1, Signer A, Thrust-1, Thrust-2, Nod-4]

![Figure 17](image2.png)

**Figure 17.** Two head thrusts with a listing function with a sentence-final assertive nod. [Data 1, Signer A, Thrust-3, Thrust-4, Nod-6]

In the sentence in Figure 16, the signer produces head movements – two thrusts and one nod—during co-ordinated nominal signs (NEWSPAPER, BOOKS, OTHER-THINGS). The head movements mark parallel contrastive focus in the utterance: they separate parts of the list, making the contents of the utterance clear and understandable. This type of articulation is closely related to the emphatic marking of prominence. In the example in Figure 17, the signer produces two sentences consisting of two listing head thrusts and a sentence-final assertive nod. The head thrusts separate the co-ordinated elements (‘at home’, ‘at the university’). The first head thrust in the example does not align with the syntactic structure and spreads over the transition between the two sentences. The sentence-final assertive nod is shorter in duration and the movement is smaller in amplitude than the two head thrusts.

5.2 Boundary marking

Head movements with boundary-marking functions occurred in the data at the borders between syntactic, prosodic, or textual sequences, for example at the beginning or end of a
clause, utterance, or larger text episode. Boundary-marking head movements were produced either with manual discourse markers (Figure 18) or without them.

Figure 18. A boundary-marking head nod. [Data 1, Signer B, Nod-7]

In the utterance in Figure 18, the signer produces a head nod, which emphasizes the prominence of the manual sign PALM-UP, which functions as an indicator of transition from one subject to another in the discourse. The preparation of the nod is long in duration, and the stroke is produced simultaneously with the stroke of the manual sign. In addition to boundary marking, the nod may therefore also be an example of a copying head movement (see Section 5.4).

In the data, head nods often occurred at the boundaries of syntactic units, as has also been observed for nods in, for example, ASL (see Section 2.2). However, in the current data, nods did not occur after sentence or clause-final signs but instead were produced together with them. Of the head nods produced by the active signer (not by the addressee), 37.04% were produced sentence-finally (46.15% in Data 1; 28.27% in Data two). Although the sentence-final nods in the data may be interpreted as boundary markers, the syntactic placement alone does not automatically allow us to classify them as such. Some of these nods were not punctual but spread across several manual signs at the ends of sentences. Moreover, some of the sentence-final head nods also performed other functions, such as affirmation (see Section 5.3.2), or they were movements copying manual path movements (see Section 5.4).

All in all, the difference between punctual boundary markers and more deliberate head movements was not always clear in our data. The utterance in Figure 19 is a sentence consisting of two co-ordinated clauses. In the sentence, a head pull marks prosodically the transition between the first and second clauses as well as the contrast between these two co-ordinated elements in the sentence.

Figure 19. A head pull marking a boundary and giving emphasis on the sign RETURN. [Data 2, Signer A, Pull-1]
The head pull in Figure 19 is clause-initial and marks the beginning of a new syntactic unit. As well as performing as a boundary marker, it can be seen as an emphatic marker which increases the visibility of the sign return with which it is produced. Moreover, in addition to marking boundary or emphasis, the head pull in Figure 19 may also be a result of the articulation of the hands. The head pull is a countermovement (i.e. is produced in opposite direction) to the manual movement in the sign return: it may be a result of physical phenomena, the neck muscles reacting to the movement of the hands. However, the head pull is relatively large in amplitude, which indicates that it is more deliberate than a physically driven ‘recoil movement’ occurring as a co-product of the manual movement. This strengthens the interpretation that the movement emphasizes a transition between elements in the utterance, and by doing so performs as a stress-for-focus marker for the sign return.

It should be noted that in our data, we also found cases where the prosodic and syntactic structures were not isomorphic in an utterance. In the example in Figure 10, in Section 5.1.1, a transition between a head thrust and a head pull marks a prosodic boundary which is not at the edge of a syntactic unit but rather occurs in the middle of a clause.

5.3 Prosodic, syntactic, and/or communicative domain marking

Sagittal head movements in the data also included movements which marked prosodic, syntactic, or communicative domains in signing. Head movements with a domain-marking function either marked prosodic contours or syntactic domains without performing, for instance, interrogative or affirmative functions, or they had a contour-like ‘element-binding’ effect in signing in addition to other (syntactic) functions. Domain marking of topics, affirmation, and interrogatives are discussed in Sections 5.3.1–5.3.3

5.3.1 Topics
In the data, we found head movements which marked the domain of syntactic units that formed a topic. The example in Figure 20 demonstrates two different types of domain marking produced with head movements: marking the domain of a topic and binding together manually produced signs into a contour, which forms a comment on the topic.

![Figure 20. Domain-marking thrust and head pull. [Data 1, Signer B, Thrust-6 & Pull-4]](image-url)
In the example in Figure 20, the signer produces two head movements: a head thrust together with facial articulation (eyes widened, eyebrows raised), and a head pull produced together with a backward body lean and a horizontal headshake. The sentence-initial head thrust together with the facial articulation produces stress on the signs SWEDISH and LANGUAGE, which form the topic (‘Swedish’) in the example. In doing this, it also prosodically marks the domain of the topic. The head pull is long in duration and it is in alignment with the manually produced signed sentence with which it co-occurs. The head pull is a recovery movement from the position of the head after the thrust movement. The pull is, however, large in amplitude and longer than the thrust movement, and it differs from the head thrust also in that the upper body participates in the backward movement. These phonetic features indicate that the head pull is deliberate and that it functions as an emphatic marker for the prominence of the manually signed sequence, which comments on the topic produced at the beginning of the utterance. Therefore the head pull is not merely a recovery movement, but it also performs a prosodic domain-marking function. The headshake produced with the head pull conveys meanings of disbelief or diminishing; the polarity of the sentence does not become negated by the headshake.

5.3.2 Affirmation
Most of the sagittal head movements in the data had functions relating to affirmative declaratives and positive responses in discourse. By ‘affirmative declaratives’ we mean sentence types that are “used for speech acts, such as asserting, describing, complaining, bragging about, predicting or promising something etc.” (Velupillai 2012:346). Head movements were present in speech acts such as agreement or as an indication of engagement in the discourse, and they also conveyed meanings related to propositional modality9, i.e. “the speaker’s attitudes towards the truth value of the information given in the proposition” (Velupillai 2012:217). The affirmative function was the most common function of sagittal head movements in our data, and the head movements conveying meanings of affirmation were most frequently head nods and nodding movements.

We propose that there are at least three sorts of affirmation related to the head movements in the data: neutral affirmation, strong affirmation, and affirmation as feedback. The relationship between the three functional subtypes is gradual as they all represent different types of affirmation. Neutrally affirmative movements convey the meaning of a positive attitude, and they may also mark existence, which is also done with strongly affirmative movements – only more strongly. Strongly affirmative movements also convey the signer’s strong belief in, or commitment towards, the truth of the signed information. Feedback movements can convey both kinds of affirmative meaning, but they are produced by the addressee and they signal participation and engagement in the conversation. Many of these affirmative head movements are generally known and are also common communicative gestures in different spoken languages (see e.g. McClave 1999; Aoki 2014).

---

9 With modality, we refer to what Velupillai (2012) defines as “semantic labels of attitudes towards events”, not the verbal category of mood.
Head movements with neutral affirmation convey meanings connected to the signer’s positive attitude towards a proposition or towards the truth value of a proposition in an utterance. In the example in Figure 21, a neutrally affirmative nod is produced as a positive response to an utterance on the part of the interlocutor.

![Figure 21. A neutrally affirmative nod produced as a positive response. [Data 2, Signer B, Pull-1, Thrust-1 & Nod-1]](image)

The example in Figure 21 shows three sentences: an affirmative declarative sentence, an interrogative sentence, and a non-manual predicate which forms an affirmative declarative sentence. In the non-manual predicate, the signer produces a neutrally affirmative head nod during a (relatively long) hold in the sign YOU. This affirmative non-manual utterance is produced partly simultaneously with the last sign of the second sentence and it forms an affirmative declarative statement (‘yes’) in itself. The emphatic head-pull in the first sentence is discussed in Section 5.4 and the interrogative head thrust in Section 5.3.3.

In the current data, neutrally affirmative head movements were also found in situations where the signer declared the existence of something. In addition, head movements with neutrally affirmative functions often performed overlapping functions, such as boundary marking (see Section 5.2). The examples in Figures 10 and 12, presented earlier in Section 5.1, include neutrally affirmative head nods. In the assertive utterance in Figure 10, the sentence-final nod and the sign ALWAYS connect the second clause of the utterance with positive polarity. The head nod may also be a marker of existence and perform as a predicate in the existential clause. Together with a pause in the manual articulation, it also performs a prosodic boundary-marking function (see Section 5.2). In the utterance in Figure 12, the head produces a slow and deliberate neutrally affirmative head nod at the beginning of the sentence, which may also function as a marker of existence. The head nod is produced with a slow stroke phase and it is rhythmically in line with the manually articulated signed phrase during which it occurs. The nod marks prosodically the domain of the phrase, after which the signer produces new information.

Head movements with strong affirmation expressed the signer’s firm commitment to the truth value of the proposition (Figure 22) or her strong support for or commitment towards something (Figure 23). With a ‘strongly affirmative statement’, we refer to what is called in the investigation of propositional modalities deductive epistemic judgement: a firm statement in which the signer is “quite convinced of the truth of the proposition” (Velupillai 2012:219). Expressing ‘firm commitment’ to a future action is an example of what we call deontic event
modality, more specifically a commissive, in which the signer is “certifying that the action will take place” (Velupillai 2012:223). The most common head movement type with a strongly affirmative function was nodding, although in the data, single head nods also performed strongly affirmative functions.

![Figure 22](image)

**Figure 22.** An example of strongly affirmative nodding related to deductive epistemic judgement. [Data 2, Signer A, Nodding-3]

![Figure 23](image)

**Figure 23.** An example of strongly affirmative nodding related to deontic event modality. [Data 2, Signer A, Nodding-8]

The example in Figure 22 consists of two sentences, the first of which is a characterizing sentence. During the first sentence, the head produces a small nodding movement, which functions as a strongly affirmative element: it conveys the signer's firm commitment towards the truth of her utterance. In the example in Figure 23, the signer produces an assertion which conveys the meaning of following through an activity (‘studies’) in the future. With the nodding, the signer expresses her commitment to the future task.

Affirmation as feedback was the most frequent type of affirmation in the data, and over two thirds of such cases were instances of nodding. In continuous dialogue, the participants showed each other that they were paying attention and potentially that they were in agreement about what the speaker was saying. Figure 24 gives an example, in which Signer B, in the role of the addressee, produces a feedback nodding movement while Signer A is signing.
Figure 24. An example of head nodding with a feedback function. [Data 2, Signer B, Nodding-3]

Half way through the nodding in Figure 24, the head movement becomes more pronounced and the affirmation becomes stronger: the interlocutor is responding to the signer’s utterance by showing agreement. Signer B does not produce any manual signs with the nodding. The example illustrates a feedback movement in which the interlocutor is first merely showing participation or attention and then shows strong agreement in response to the signer’s statement. The difference between the two situations is that in strong agreement, the interlocutor has a more active role and the head movement functions as a statement rather than merely indicating participation.

The forms of affirmative head movements were in some cases ‘hybrids’ of nods and short rapid stretches of nodding. In the example in Figure 25, the signer produces a small rapid nodding movement, which is produced during a larger movement in which the signer’s chin moves towards her chest.

Figure 25. A sentence-final hybrid form of a nod and nodding. [Data 2, Signer A, Nodding-7]

The nod-nodding hybrid in Figure 25 is clearly affirmative, but it is difficult to define whether it is particularly strong or whether it merely marks the signer’s positive attitude towards the information in the assertion. The hybrid is sentence-final, which indicates that it functions also as a prosodic boundary marker. It should be noted that no other nodding movement in the data functioned as a boundary marker, which reinforces the interpretation of a nod-nodding hybrid in this case.

5.3.3 Interrogatives

In the data, signers also produced head movements in questions. Head movements together with facial articulation, and optionally with manual interrogative signs, made the utterances
interrogative. Two of the total of nine interrogative head movements in the data were produced in content questions (Figures 26 and 27) and nine in polar questions (Figure 28). The most common head movement with interrogative (Q) function was a head thrust.

**Figure 26.** An interrogative head thrust between two content questions. [Data 2, Signer A, Thrust-1 & Nod-1]

**Figure 27.** An interrogative head pull (pull-1) in an embedded content question, which forms a complex interrogative sentence. [Data 1, Signer B, Pull-1 & Pull-2]

In the example in Figure 26, the signer produces two interrogative sentences, both of which are content questions. The interrogative head thrust begins towards the end of the first sentence and spreads over the transition between the two sentences. The thrust is considerably shorter in duration than the raised brows with which it co-occurs. The head nod produced subsequently in the same sentence functions as an indexical element (see Section 5.5). The example in Figure 27, on the other hand, contains a complex interrogative sentence. The first part of the sentence forms an introductory polar question (‘have you ever thought?’) and is followed by an interrogative transitive clause, which is an embedded content question (‘how many languages you use in a day?’). The interrogative head pull occurs before the question sign HOW in the transition between the polar and content question. It is accompanied by a chin-down position and a brow raise. Later the addressee answers to both of the questions: “Yes, I have thought about it several times. If you start to count them you’re surprised how many there are: two, three, even four languages every day.” The second head pull produced in the utterance is emphatic and was presented earlier in Figure 11 in Section 5.1.

In polar questions, the interrogative tone of the structures was conveyed solely by the articulation of the head and face. The example in Figure 21 presented earlier in Section 5.3.1, included an interrogative sentence (IT-SEEMS YOU SAME YEAR YOU), which is a polar question. During the interrogative head thrust, the signer also raises her eyebrows. An interrogative head thrust occurred also in the polar question described in Figure 28 this time with a brow lowering.
The utterance in Figure 28 consists of a polar question followed by two affirmative declarative sentences. The interrogative head thrust begins before the start of the question and ends in the beginning of the subsequent declarative sentence. The head thrust is followed by a nod with a positive (affirmative) function.

There was also one polar question in the data with a co-ordinated (disjunctive) ‘either-or’ structure, which was presented in Figure 15 in Section 5.1.3. Two head thrusts produced in the utterance function as interrogative markers while at the same time they are involved in the separation of the two co-ordinated elements. The question in the utterances described in Figure 15 forms an interrogative structure in which the head thrusts mark contrastive focus.

5.4 Other functions: copying, indicating, and time-reference

Sagittal head movements in the data also included copying and indicating head movements as well as head movements with possible reference to past or future time. Copying head movements were usually instances of head nods or nodding in which the motion of the head copied the temporal pattern of global manual (path) movements. In copying head movements, the stroke in the head movement was produced simultaneously with a stroke in the manual movement. Copying can be a form of emphasis in which the movement of the head increases the visibility of the manual sign. On the other hand, copying may also be a result of non-deliberate co-articulation. Examples of head movements with features that may be seen as copying are given in Figure 18 and Figure 29.

In the data, we found three cases in which the head was used in referential pointing (X function). In the interrogative sentence introduced in Figure 26 in Section 5.3.3, the signer produced an indicating head nod, which functions as a reference towards the addressee (‘you’). No manual indexical signs were produced to refer to the 2nd person. The utterance is an intransitive sentence, in which the head nod performs as the S argument (cf. Velupillai 2012). An indicating head nod occurred also in the utterance presented in Figure 29.
In the utterance in Figure 29, the signer’s head points and nods towards the location where the signer had previously placed a manual (indexical) sign. In the example, the head first nods during the existential clause in the beginning of the sentence, binding together the signs ENTRANCE^EXAM and INDEX. The first nod is then followed by an indicating head nod during the last two signs of the sentence. In the second nod, the position of the signer’s head is different: the chin is closer to the chest and the orientation of the face (and later the forehead) is directed towards the end location of the sign COME. This indicates that the second head nod is indexical and points towards the location which refers to the meaning ‘here’. The nod can also be seen as copying the movement of the hands in the sign COME.

In one occasion in the data, a head pull was produced in an utterance with reference to an event in a specific time frame. A head pull in the example in Figure 21, in Section 5.1, was produced when referring to past time. When signing the utterance “The first time I came here was ninety-eight”, the head pull together with the facial articulation (eyes wide & eyebrows raised) functions as an emphatic marker: it emphasizes the prominence of the signs FIRST-TIME, ME, and NINETY-EIGHT during which it occurs. The head pull is produced without any noticeable movement of the upper body, and the combination of the head pull and facial articulation emphasizes that the signer is referring to a situation which is the very first of its kind.

However, it would be a rather strong claim to say that the non-manual articulation in itself functions as a marker of past time in this instance. In the example in Figure 21, the articulation of the signer's head and face emphasizes the manually produced sign FIRST-TIME, which already (taken in context) expresses that the event is situated in past time. Moreover, the data also includes an utterance in which a head pull occurs in an utterance with a quite different meaning: in Figure 13 in Section 5.1.2, a head pull gives emphasis to something that is declared about the present time, in contrast to something that has been stated earlier about past time. Taken together, according to our data, the head movement can emphasize or mark contrast between elements in signing which already have a reference to past, present, or future time. Whether the direction of a head movement can refer to time, or the order of events, by reference to a visual “timeline” in the signing space, is an issue for future research.
5.6 Summary

An overview of the form-function combinations of head movements in our data is presented in Table 3. The numbers in the table are based on those functions, which have been analysed as primary functions for the head movements.

Table 3. Form-function combinations of head movements in the data

<table>
<thead>
<tr>
<th></th>
<th>E</th>
<th>B</th>
<th>D</th>
<th>A</th>
<th>Q</th>
<th>C</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nod</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>26</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Thrust</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nodding</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>31</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Pull</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>3</td>
<td>2</td>
<td>58</td>
<td>9</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

The most frequent function in the data was the affirmative (A) function. Different emphatic (E) functions, such as listing and putting prosodic stress to manually produced signs, were also common. All functions except indicating (X) were expressed with more than one type of head movement, especially emphasis, which occurred with all four head movement types. The prosodic/syntactic domain marking (D) and the copying (C) functions were the most infrequent functions in the data, but also the indicating and the boundary marking (B) functions were rare. However, several head movements were analyzed as, for example, copying or boundary-marking movements in addition to other functions (i.e. boundary-marking or copying as a secondary function).

In Table 4 we present again the form-function combinations of different head movements but this time the numbers include both the instances in which a function has been analysed as primary and the instances in which a function has been analysed as secondary (i.e. occurring in addition to other functions). Due to the overlapping of several functions for single head movements, the total numbers of the form-function combinations in Table 4 do not represent the actual amount of head movements in the data (cf. Table 3).

Table 4. Form-function combinations of head movements in the data including primary and secondary functions

<table>
<thead>
<tr>
<th></th>
<th>E</th>
<th>B</th>
<th>D</th>
<th>A</th>
<th>Q</th>
<th>C</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nod</td>
<td>6</td>
<td>12</td>
<td>6</td>
<td>29</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Thrust</td>
<td>13</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nodding</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>32</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Pull</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>16</td>
<td>9</td>
<td>62</td>
<td>9</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>
A summary of the central functions of nods, nodding, head thrusts, and head pulls is presented below:

- **Nods**  Their central function is neutral affirmation and giving positive feedback (A). Tend to occur sentence-finally.
- **Thrusts**  They tend to be used in questions (Q). Also emphatic functions of listing and prosodic stress (E) are central.
- **Pulls**  Most mark emphasis (E), including contrast and semantic exclusion.
- **Nodding**  Its central function is to signal positive feedback (A); often occurs during the receptive phase of the discourse. Nodding can also copy the manual motion (C).

6. **Discussion**

6.1  The relation between form and function

Layering and overlapping of the forms and functions of head movements and other manual and non-manual articulations was common in the data. Firstly, the overlapping of independent manual and non-manual articulations occurred in the data. This can be seen, for instance, in Figure 21, in Section 5.3.2, in which a non-manual predicate (a head nod) is produced during a hold in the co-occurring manual sign. Secondly, the overlapping of several head movements also occurred in the data. This is demonstrated, for example, in the utterance in Figure 12 (Section 5.1.1), where a simultaneous head thrust and nodding movement form a unit in which the head thrust emphasizes the strongly affirmative nodding. The same example also illustrates the overlapping of several non-manual articulations, and the difficulties in separating their functions. The head thrust and nodding are produced with a specific mouth gesture, and together these three elements form a gestural unit in which the meanings conveyed by the mouth gesture can easily be confused with the functions of the action of the head. Separating the meaning of a head movement (if there is one) from the meaning of a whole utterance is a problem which needs to be explored by a detailed annotation of the activities of different non-manual articulators. The individual annotations can then be compared and the similarities and differences between the functions evaluated.

We also frequently observed overlapping of several functions for a single head articulation. If one head movement is seen to perform several functions, we need to consider whether any function can be seen as more or as less central than any other. The questions that follow are how this is defined and, at a later stage, how it is incorporated into the annotation and analysis of head movements and their functions. In the analysis of the functions of single head movements, it is also necessary to observe the preceding and following context of the non-manual and manual elements produced in the signing.

The form of head movement is not always the same for each function. For example, nods, thrusts, pulls, or nodding can all mark prosodic or syntactic domains. The form of the
movement may also vary even though the function is the same. For instance, head thrusts and head nods both perform as markers of lists, sometimes even in the same utterance (see the example in Figure 16 in Section 5.1.3). The fact that one sentence can include both thrusts and a nod as listing movements raises two questions. Firstly, is it necessary to differentiate between a nod and a thrust in list structures? It might be that the distinction between them is merely coincidental: a position of the jaw which is the result, perhaps, of the previous or following context in the signing. Or it might be that the idiolectic characteristics of individual signers influence the articulation. Secondly, is it even possible in every case to differentiate between forms such as nods and thrusts? The head can move forward in the dimension of depth with or without lowering the jaw, and the characteristics of the movement may be very subtle. It is sometimes difficult to determine whether the movement is a thrust or a nod, especially when observing video material only with the naked eye. The same applies in some instances also with nods and nodding: in the data, nods and nodding formed hybrid forms (see Figure 25 in Section 5.3.2). Linguistically, the difference between the form of the movements is in some cases insignificant; it may be enough that something is happening (changing) in the action of the head, whatever the specific form of the head movement is. However, there are also situations in which the difference in the form of the head movement is significant. For example, nodding is different from nods in that it does not mark boundaries or lists, as nods do.

The functional types presented in Section 5 are not mutually exclusive but they overlap. For example, a head nod producing affirmation can also function as a boundary marker. Another example of a gradual relationship between two function types is boundary and domain marking (see Section 5.2.3). According to the traditional view, differentiation between boundary and domain marking is done on the basis that boundary markers are punctual and do not spread (see Section 2.1). However, the difference between a boundary and domain marker is often more obscure. The head pull in the complex sentence presented in Figure 19 in Section 5.2 clearly marks a sentence-inner transition between two elements. However, it is not punctual but gives emphasis to the sign with which it is produced. If the sign in question would be a depicting verbal, would the head movement still be classified as a boundary marker instead of a domain marker? Also, in cases in which a single sign constitutes a “domain” (e.g. a topic), a head movement giving it emphasis at the same time is marking the domain. It has also been stated for ASL that boundary markers (all except head thrusts) occur after the last sign of a syntactic unit. In our data, however, head movements such as nods and pulls appeared as boundary markers before, during, and after the transition between phrases, clauses, or utterances. In other words, on the basis of our data, head movements in FinSL are not always simply \textit{either} boundary \textit{or} domain markers. The difference between the two prosodic functions is not so clear cut; in the end, the significant factor is that different units are separated, or that the elements inside different units are bound together into contours.

There were also situations in which the head movement marked a larger prosodic contour which was not aligned with the syntactic structure of the utterance (cf. example (3) in Section 5.1). In this way, the results in our data support the observation that prosodic and syntactic structures in sign languages are closely related but not isomorphic (cf. Nespor &
Vogel 1986; Wilbur 2000; Pfau & Quer 2010; Sandler 2012). All in all, the division of linguistic non-manuals into ‘prosodic’ and ‘grammatical’ proves to be somewhat controversial in the light of the head movements in our data. For instance, listing is an example of both prosody and grammar: a list structure can simultaneously be syntactic, happen on a larger textual scale (themes/episodes), and be an example of producing prosodic stress for creating contrast (separation, parallel focus) between elements that are in multiple co-ordination. Also boundary marking can involve smaller syntactic borders or larger textual episodes. For example, assertive head nods appear when moving from one textual subcategory to another, in changes, or in transitions between larger episodes.

The concept of a continuum may be beneficial to an understanding of the different forms and functions of head movements. As is evident from Figures 6 and 7 in Section 4, nods and thrusts are generally phonetically similar but not identical. There are forms of nods and thrusts that clearly differ from each other, and on the other hand, there are head movements which are difficult to classify with any certainty as one or the other. It may thus be useful to view the relationship between, for example, nods and thrusts or border marking and domain marking as a continuum. At one end of the continuum, there is a clear case of a head nod or a border-marking function and at the other end a clearly formed thrust or a clear case of domain marking. In between the polar extremes of the continuum are several forms and functions with characteristics of both extremes. The functions of head movements form overlapping continuums, such as gestural-grammatical, communicative-syntactic, textual-syntactic, prosodic-communicative, prosodic-grammatical, and so on.

6.2 Comparison with previous theoretical observations

The results of the present study are partly in line with, and partly differ from, observations made regarding head movements and their functions in other sign languages. The most frequent head movements in the data, head nods, were used for all seven functions. Just like nods in other sign languages, the nods in our data, too, fulfilled affirmative functions and they appeared in lists and verbless utterances, comparable to examples (1) and (2) in Section 2. Head nods in the data could also form a domain when occurring as positive responses (‘yes’). As has been stated for nods in ASL (see Section 2.2), some of the nods in our data occurred close to the boundaries of syntactic units: 37.04% of the head nods, produced by the active signer, were sentence-final. The status of head nods as boundary markers should be investigated further based on a larger corpus of FinSL. In addition, we found one function for head nods in FinSL which has not been mentioned in relation to other sign languages: in the data, nods were used to point towards referents in signing.

Compared to nods, head thrusts in our data had fewer different functions. Predictably, thrusts occurred in content and polar questions, as has been stated for several sign languages, including FinSL (see example (6) in Section 2.3). However, contrary to what has been stated of questions in FinSL so far, thrusts in our data did not occur in all of the interrogative clauses in the data, which indicates that head thrusts are not obligatory for the production of FinSL
questions (cf. Savolainen 2006). As has been observed for ASL (Wilbur & Patschke 1998) and NGT (Van der Kooij et al. 2006), head thrusts in our data also marked list structures (parallel contrastive focus) and performed emphatic functions of putting prosodic stress on the articulation of the hands – either together with body leans or independently. In addition to emphasizing manual articulation, the head thrusts in our data could also emphasize other head movements. Head thrusts in our data did not perform boundary-marking functions (cf. Wilbur 2000), but they did produce emphasis on sentence-initial signs.

Like nods, also nodding in the data had affirmative functions, as has been noted for other sign (and spoken) languages. Nodding was, however, more restricted in the distribution of its different functions than nods. Nodding occurred when strongly affirming something, as has been described for several sign languages such as Italian Sign Language (see example (5) in Section 2.2), and giving positive feedback in the conversation. The examples of strongly affirmative nodding found in the data expressed either epistemic (deductive) propositional modality or deontic (commissive) event modality. In our data, we did not find any instances of nodding which marked boundaries (except for one hybrid form between a nod and nodding), cautiousness, or vagueness (cf. Wilbur 2000). Nodding in our data did, however, include movements in which the motion of the head copied the movement of the hands.

The last of the four movement types, the head pull, was the most infrequent head movement in the data and had a limited number of functions. Head pulls in the data performed emphatic functions of marking contrastive stress and exclusion, as have been noted, for example, for ASL and NGT (cf. Wilbur & Patschke 1998; Van der Kooij et al. 2006). These emphatic head pulls were produced either together with backward body leans or independently. In addition, head pulls in the data gave prosodic stress to manually produced signs. One head pull in the data had an interrogative function and occurred in a content question (see Figure 27 in Section 5.3.3), although head pulls have not been mentioned in previous studies of FinSL questions (see Savolainen 2006). However, head pulls have been found to occur, for example, in ASL content questions (see Liddell 1980; Pfau & Quer 2010). Head pulls in the data did not function as topic markers, as in ASL (cf. Aarons 1994), or mark other question types such as polar questions, as noted for BSL (cf. Sutton-Spence & Woll 1999).

6.3 On the linguistic vs. gestural status of head movements

The observations concerning the overlapping and gradual relationship between the forms and functions of different head movements in the data are interesting when viewed against, for example, Okrent’s (2002) definition of gestures. According to Okrent, gestures are non-conventional in form and the relationships between the forms and functions of gestures are gradient and non-categorical in nature. In addition, Emmorey (1999) has stated that some movements and positions produced by different parts of the body while signing are to be considered gestures rather than signals that are conventionalized in the language system. Moreover, the division of non-manuals into affective or linguistically significant has been based on
the level of sharpness in their on- and offsets. Should we therefore conclude that all head movements in FinSL are gestures?

According to our data, the prosodic, syntactic, and/or gestural head movements show no noticeable differences in form and production. If anything, they seem to be fairly free in combining and layering different functions to apparently uniform movements. The results of this study show that the functions of different head movements are various but not random, as can be seen from the overall regularities of the functions of nods, thrusts, nodding, and pulls listed in Section 5.6. These results suggest that many functions of FinSL head movements are gestural (e.g. affirmative nods and nodding produced along with the discourse, deictic indicating head nods, head pulls conveying meanings of semantic exclusion). Head movements can be situated in different locations on a gestural-grammatical continuum according to their features, such as level of conventionality, iconicity, or idiosyncrasy.

However, on the basis of this study, it would be premature to decide whether head movements are always to be considered gestures. The suggestions made here concerning the nature of FinSL head movements are put forward on the basis of data from two native FinSL signers. Many, if not all, of the results of the study should be tested with a larger corpus of FinSL consisting of data from several different signers and different types of situations in language use. What we can state, though, is that, according to our analysis of head movements, the difference between affective/gestural and linguistically significant non-manuals in FinSL is not clear-cut. Head movements with syntactic or grammatical relevance are not clearly more systematic than, or significantly different in their on- and off-sets from, the head movements which can easily be classified as primarily gestural. The more or less gestural and context-specific nature of head movements does not change the fact that they should be taken into account when examining the structure and use of FinSL. Gestural and gradient features in signing are significant characteristics that, if one takes a non-modular point of view on language, are an inherent part of the language system. The results of the current study serve as a first step towards an in-depth investigation of head movements and the grammatical-gestural role of non-manuality in FinSL.

7 Conclusion

Our examination of head movements has revealed that the actions of the head have several roles when organizing FinSL utterances in discourse. The head moves a lot during signing (see Figure 5, Section 3.2); some of the articulations have syntactic, prosodic, or discourse level functions, while others do not have a specific linguistically significant function. The most common sagittal head movements in the data were nods and nodding, which had affirmative functions that were either neutral or strong or gave positive feedback in the discourse. Other movements were thrusts and pulls, which performed, for example, interrogative, emphatic, and boundary-marking functions.

In our data, consisting of continuous dialogue, the movements of the head and changes in head positions were not predetermined or regular. The results suggest that differentiating
between different head movements by simply observing video data may in some cases be very difficult. It can be hard, for example, to distinguish between nods and thrusts with small movement amplitude when relying only on the traditional observation of two-dimensional video material. For this reason, among others, the motion tracking data was found to be especially useful. The benefits of the quantitative data imply that in the phonetic analysis of non-manuals such as head movements, motion capture and/or automated video analysis is essential.

Another overall conclusion of our study is that the form-function relationship of different head movements is not one-to-one, even though there are clear regularities in the functions of nods, head thrusts, nodding, and head pulls. The data analysis showed that one function (e.g. emphasis) may be expressed by different types of head movements and, conversely, that one type of head movement may have several different functions, depending on the context in which it occurs. These observations are supported by earlier researchers’ general observations about non-manual activity in sign languages (see Herrmann & Steinbach 2011). The forms and functions of head movements overlapped with each other, forming gradient continuums between clear cases. In some cases, the forms and functions of head movements in the data also overlapped with the forms and functions of other manual and non-manual articulations.

The non-categorical nature of the form-function combinations of head movements in the data, as well as the lack of consistency and spreading behaviour of specific head movements, suggest that the general division of non-manuals in sign languages into affective or grammatical is not directly applicable in the interpretation of the functions of head movements in FinSL. A more detailed investigation of the kinematic differences between specific head movements with different functions is needed. Finally, a comparison of the head movements produced by native FinSL signers, L2 learners of FinSL, and speakers of Finnish might offer useful information that would help us to understand the part played by head movements in non-manual articulation and overall communication in FinSL.

Acknowledgements
The authors wish to thank Eleanor Underwood for checking the English of the paper. The financial support of the Faculty of Humanities in University of Jyväskylä, Emil Aaltonen Foundation, and the Academy of Finland under grants 269089 (ProGram), 134433 (3BatS) and 118616 & 141106 (Finnish Centre of Excellence in Interdisciplinary Music Research) is gratefully acknowledged.
References


Jantunen, Tommi, Birgitta Burger, Danny De Weerdt, Irja Seilola & Tuija Wainio. 2012. Experiences from collecting motion capture data on continuous signing. In Onno Crasborn et al. (eds.), *Proceedings of the 5th Workshop on the Representation and Processing of Sign Languages: Interactions Between Corpus and Lexicon* [organized as a part of LREC 2012 at Istanbul, Turkey], 75–82. Paris: ELRA.


Author’s address

Anna Puupponen
Department of Languages (Sign Language Centre)
P.O. Box 35, FI40014 University of Jyväskylä
Finland

anna.puupponen@jyu.fi
http://annapuupponen.wordpress.com