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Aspects of the rhythm in FinSL and SSL

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Rhythm

- The **rhythm** is the organization of units in time.
- To have a rhythm means that there are some sort of **sequences** (with a beat, a peak of prominence), that is, (structured) events that occur **in temporal succession**; the sequencing may be **regular** or **irregular**.
- Languages are sequenced by syllables, words/signs, phrases, sentences; a linguistic sequence may be marked for its **borders** or/and for its **area** and the **phonetic characteristics** of these markers contribute to **the rhythmic feel of a language**.



Rhythm of speech

ALLEN, George D., Wilbur, Ronnie B. & Schick, Brenda B. (1991). Aspects of Rhythm in ASL. *Sign Language Studies* 72:435-483. – LOEHR, Daniel (2007). Aspects of rhythm in gesture and speech. *Gesture* 7(2):179-214. – PATEL, Aniruddh D. (2006). Musical Rhythm, Linguistic Rhythm, and Human Evolution. *Music Perception* 1(24):99-104. – PATEL, A. D. & Daniele, J. R. (2003). An empirical comparison of rhythm in language and music. *Cognition*, 87:B35–B45. – RAMUS, Franck, Nespor, Marina & Mehler, Jacques (1999). Correlates of linguistic rhythm in the speech signal. *Cognition* 73:265-292.



Rhythm of blinking (addressee's eye aperture changes)

On rhythm in SLs

- Rhythmically central **border** and **area** markers in spoken language include durational lengthening, pitch changes, and the ordering of vowels.
- In SL, the existence of **manual** and various **nonmanual** articulators makes the number of phonetic correlates of border and domain markers higher than that in spoken language.
- In SL, the areas and borders of rhythmical sequences have been claimed to be marked by **durations** and/or temporal balancing of **sequence final elements**, **velocity peaks**, side-to-side **body movements**, sentence final **nods**, **blinks**, etc.
- Native signers have an **inner feel of the rhythm** of signing.



Rhythm of dominant hand index finger velocity

ALLEN, George D., Wilbur, Ronnie B. & Schick, Brenda B. (1991). Aspects of Rhythm in ASL. *Sign Language Studies* 72:435-483. – BOYES Braem, Penny (1999). Rhythmic Temporal Patterns in the Signing of Deaf Early and Late Learners of Swiss German Sign Language. *Language and Speech* 42(2-3):177-208. – LOEHR, Daniel (2007). Aspects of rhythm in gesture and speech. *Gesture* 7(2):179-214. – RAMUS, Franck, Nespor, Marina & Mehler, Jacques (1999). Correlates of linguistic rhythm in the speech signal. *Cognition* 73:265-292. – SANDLER, Wendy (2012). Visual prosody. In R. Pfau, M. Steinbach & B. Woll (Eds.), *Sign language: An international handbook*, 55–76. Berlin: Mouton De Gruyter.

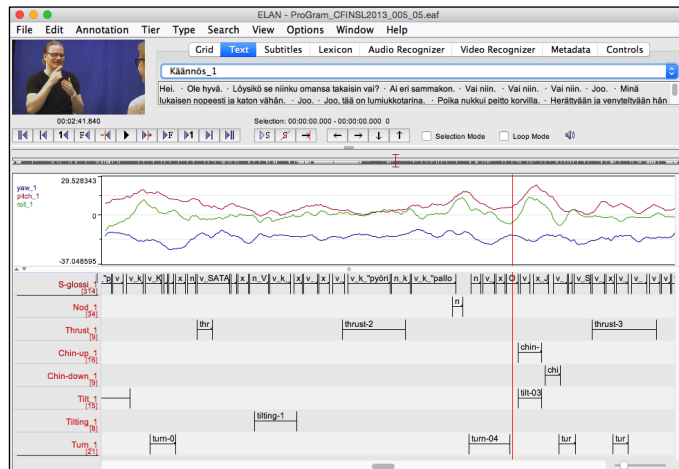
Hypothesis & research questions

The rhythm of signing is different between FinSL and SSL.

1. Are the sign duration and signing speed different in FinSL and SSL?
2. Are head nods aligned differently in terms of syntactic units in FinSL and SSL?
3. Are the movements of the head distributed differently in terms of their amplitude (bigness, smallness) in FinSL and SSL sentences?

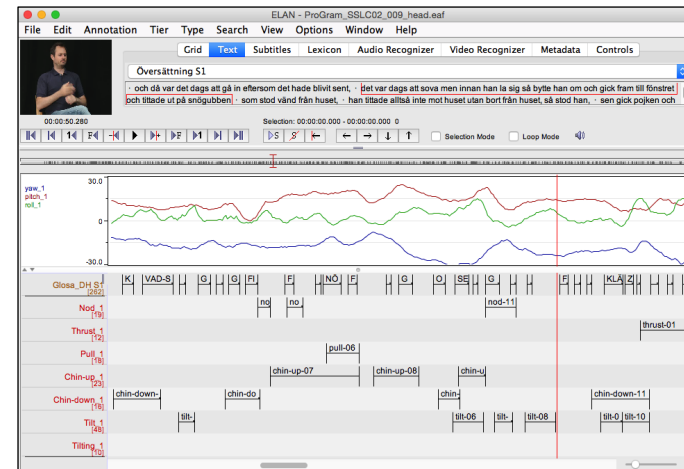
Main data

FinSL



- 10 signers (4 male, 6 female), age 20-30
- Task: signing a cartoon
 - Snowman (3 male, 2 female)
 - Frogstory (1 male, 4 female)
- Duration of video: 35 min, 18 sec
- Annotated for signs, translations and head movements in ELAN.
- Computer-vision data on head pose angle.

SSL



- 10 signers (4 male, 6 female), age 30-40
- Task: signing a cartoon
 - Snowman (1 male, 4 female)
 - Frogstory (3 male, 2 female)
- Duration of video: 29 min, 35 sec
- Annotated for (signs,) translations and head movements in ELAN.
- Computer-vision data on head pose angle.

Research question 1

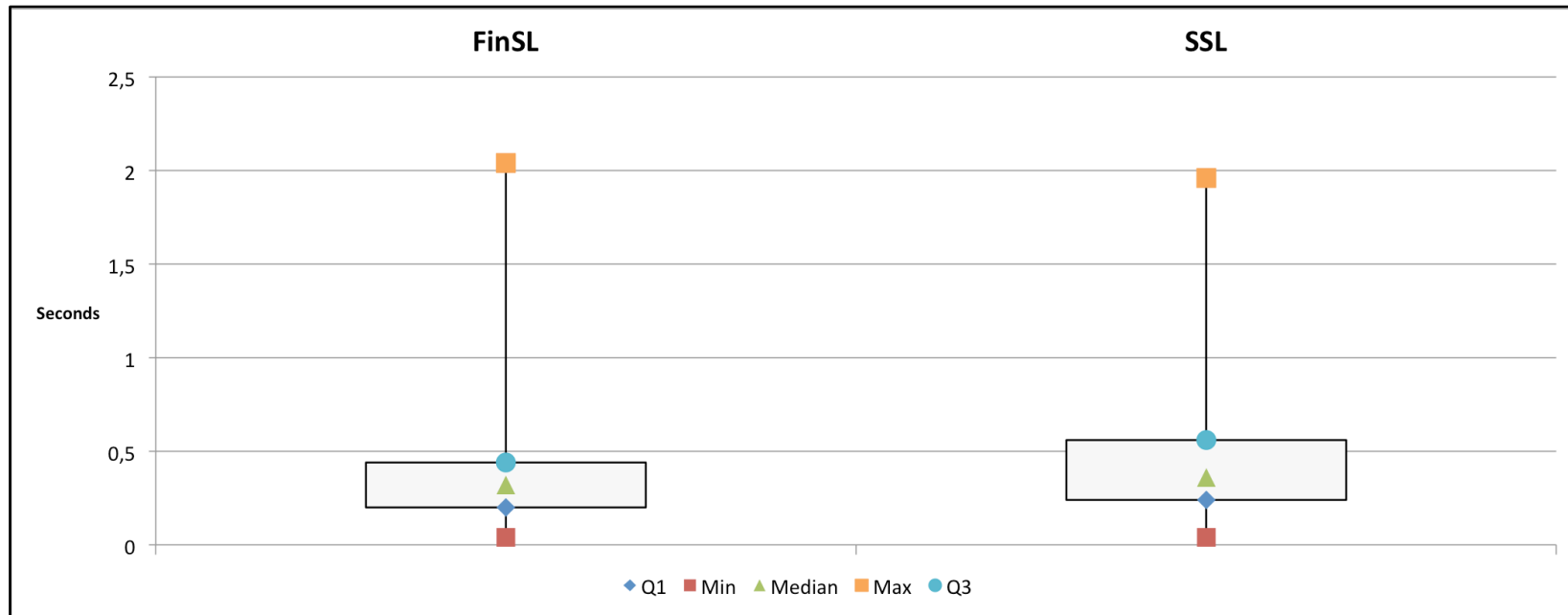
**ARE THE SIGN DURATION AND SIGNING
SPEED DIFFERENT IN FinSL AND SSL?**

Data & method

- Direct comparison of sign durations and signing speed not possible due to differences in annotation conventions.
- **30 second stretch of signing** from each signer (5+5 minutes, 10+10 signers), extracted from the **middle of the story**.
- Durations of signs annotated in ELAN by **one annotator** who was familiar with both languages.
- Altogether **645** FinSL signs and **572** SSL signs.

Jantunen, T. (2015). How long is the sign? *Linguistics* 53(1), 93-124. – WALLIN, Lars & Johanna Mesch (2015). *Annoteringskonventioner för teckenspråkstexter*. Version 6. Stockholms universitet, Institutionen för lingvistik, Avdelningen för teckenspråk.

Results – sign duration



FinSL average duration 0.37 secs (SD=0.26), SSL average duration 0.42 secs (SD=0.27). The difference is statistically very significant ($p=0.0019$; unpaired two-tailed t test).

Results – signing speed

- Signing speed = number of signs / 30 seconds
- **FinSL: 64.5 signs per 30 seconds** in average (SD=15.34)
- **SSL: 57.2 signs per 30 seconds** in average (SD=8.19)
- The difference is **not statistically significant** (p=0.2008; unpaired two-tailed t-test)
- Signing speed in both FinSL and SSL is ca. **2 signs per 1 second**

Discussion

- Plenty of individual variation in both languages.
- FinSL signers were **younger** than SSL signers in average.
- FinSL signers tended to **tell** the stories, SSL signers tended to **present** the stories.
- The observed (rhythmical) similarities and differences may be linked to signers' age and presentation style.

FERRARA, L. & Johnston, T. (2014). Elaborating Who's What: A Study of Constructed Action and Clause Structure in Auslan (Australian Sign Language). *Australian Journal of Linguistics* 34:2, 193-215. – JANTUNEN, Tommi (2013). Signs and transitions: Do they differ phonetically and does it matter? *Sign Language Studies* 13:2, 211-237. – MESCH, Johanna & Börstell, Calle (2015). Vem tecknar fortast? Temadag *Det händer med händer igen*. Stockholms universitetet, 8 maj 2015.

Research question 2

**ARE HEAD NODS ALIGNED DIFFERENTLY IN TERMS
OF SYNTACTIC UNITS IN FinSL AND SSL?**

Data & method

- Data = **the main data** (ca. 30+30 minutes of video material including signing from 10+10 signers, with annotations).
- On the basis of the annotations in the data, the nods were classified by one of the researchers as either **nods occurring on syntactic boundaries** (i.e. on-boundary nods) or **other sentence/clause-internal nods**; the two categories were further divided into subcategories.

PUUPPONEN, A.; Wainio, T.; Burger, B. & Jantunen, T. (2015). 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. *Sign Language & Linguistics* 18(1), 41-89.

The subcategories of nods

On-boundary nods

Sub-category	Explanation
Sentence-final	During or after the last sign(s) of a sentence
Sentence-initial	During the first sign(s) of a sentence
Sentence border	On the border between two sentences
Inter-sentential	During a pause between two sentences
Sentence-internal boundary	During a clause or phrase boundary
Sentence-internal listing	Separating elements in multiple co-ordination

Other clause/sentence-internal nods

Sub-category	Explanation
Sentence-internal other	Functions such as emphasis or affirmation
Whole sentence	During a whole sentence
Sentence-internal X	Unclear cases

Results (1)

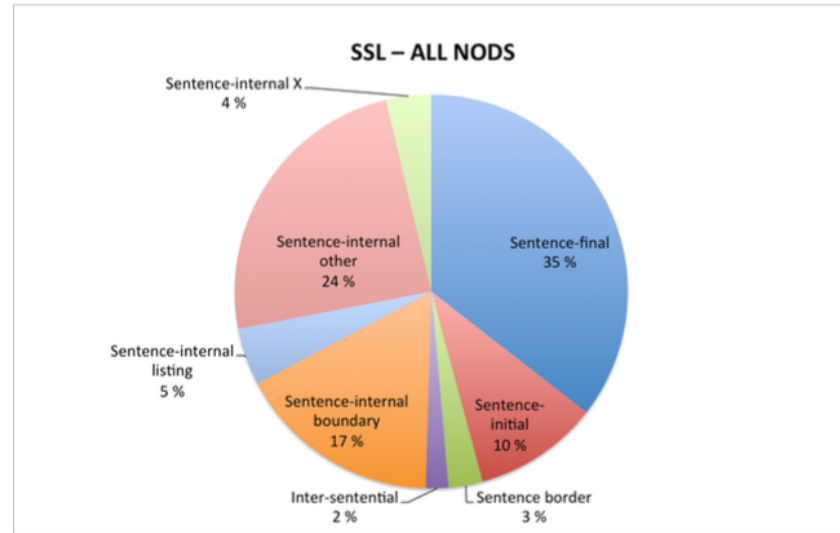
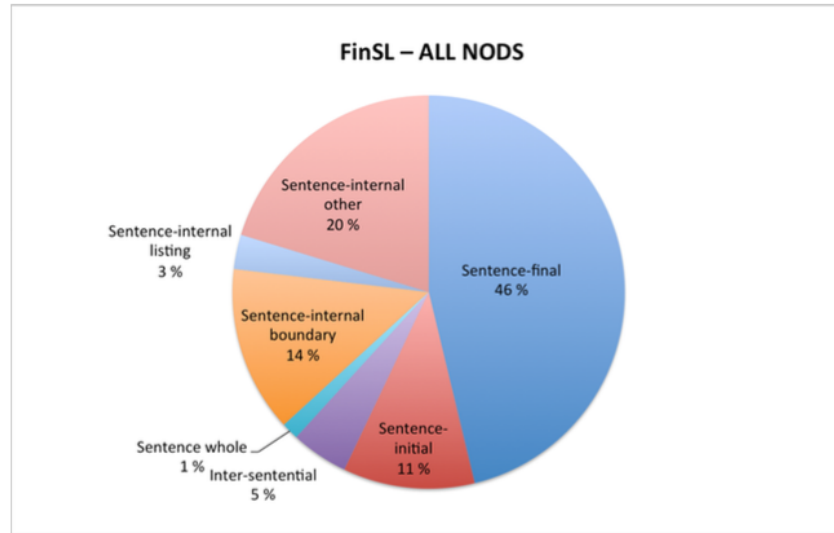
FinSL

- The total number of nodes in all ten stories was **212**.
- The number of nodes per story in average was 21.2.
- NB! In average, FinSL stories were durationally **longer** than SSL stories.
- In average, **80%** of all nodes were produced on a syntactic border.

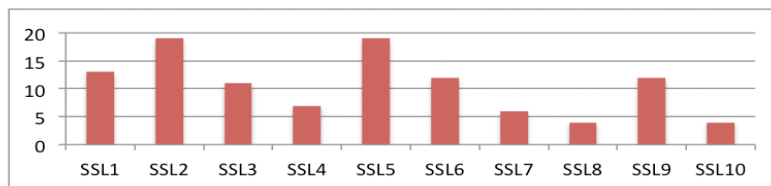
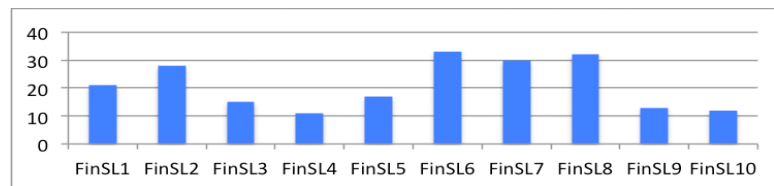
SSL

- The total number of nodes in all ten stories was **107**.
- The number of nodes per story in average was 10.7.
- NB! In average, SSL stories were durationally **shorter** than FinSL stories.
- In average, **73%** of all nodes were produced on a syntactic border.

Results (2)



- A tendency to produce a head nod **sentence-finally** in both languages (FinSL 46%, SSL 35%) although nod were found from other (e.g. sentence-initial) positions too.
- Plenty of **individual variation** in the occurrence frequency of nod:



Discussion

- The patterns in which head nods aligned with syntactic units were very **similar** in both languages.
- However, also some differences were found – **Do these differences indicate about a rhythmic difference between the two languages?**
- We consider that the differences are explainable by the **individual variation** found in the data and by the differences in the **strategy** signers used in the construction of their stories (telling vs. showing).
- The indicated differences are **signer-specific**, not language-wide.

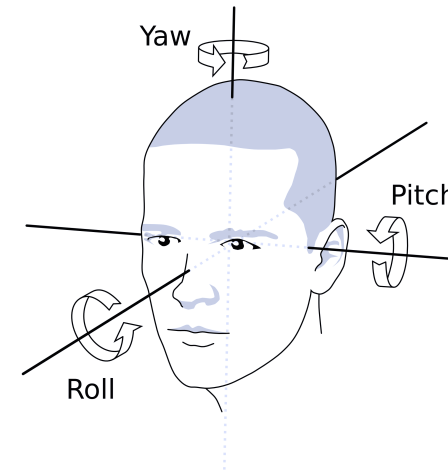
PFAU, R. & Quer, J. (2010). Nonmanuals: Their prosodic and grammatical roles. In D. Brentari (Ed.), *Sign Languages: A Cambridge language survey*, 381-402. Cambridge: CUP. – PUUPPONEN, A.; Wainio, T.; Burger, B. & Jantunen, T. (2015). Head movements in Finnish Sign Language on the basis of Motion Capture data: a study of the form and function of nods, nodding, head thrusts, and head pulls. *Sign Language & Linguistics* 18(1), 41-89. – WILBUR, R. B. (2000). Phonological and prosodic layering of nonmanuals in ASL. In K. Emmorey & H. Lane (Eds.), *The signs of language revisited: An anthology to honor Ursula Bellugi and Edward Klima*, 215-244. Mahwah, New Jersey (USA): LEA.

Research question 3

**ARE THE MOVEMENTS OF THE HEAD DISTRIBUTED
DIFFERENTLY IN TERMS OF THEIR AMPLITUDE
(smallness, bigness) IN FinSL AND SSL SENTENCES?**

Data

- **16 declarative sentences** (8 for FinSL, 8 for SSL) produced by **8 signers** (4+4).
- All the sentences extracted from the **Snowman story**, in which the sentences occurred story-initially.
- **Syntactically**, the productions of each signer correspond to coordinated two-sentence sequences.
- **Semantically**, all the sequences express the same contents (roughly: 'the boy wakes up and sees that it is snowing outside').

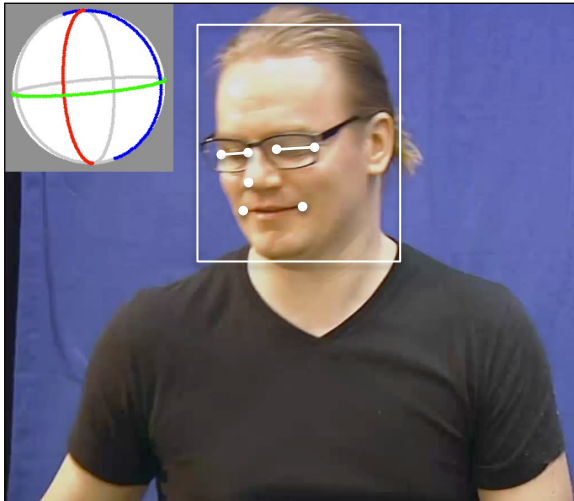


- **3D numerical data** on the head movements of signers describing the motion of the head in the **yaw, pitch, and roll** dimensions.

JANTUNEN, T. (forthcoming). Clausal coordination in Finnish Sign Language. *Studies in Language* 40. – KARPPA, M., V. Viitaniemi, M. Luzardo, J. Laaksonen and T. Jantunen, "SLMotion - An extensible sign language oriented video analysis tool," in *Proceedings of LREC 2014*. Paris: ELRA, pp. 1886–1891, 2014. – LUZARDO, M., M. Karppa, J. Laaksonen, T. Jantunen, "Head pose estimation for sign language video," in J.-K. Kamarainen and M. Koskela (eds.), *Image Analysis*. Springer, Lecture Notes in Computer Science, Vol. 7944, pp. 349–360, 2013.

SLMotion detection of head pose angles

Yaw: 17.999
Pitch: 6.788
Roll: 3.397



Yaw: -0.516
Pitch: 3.897
Roll: 0.145



Yaw: -17.585
Pitch: 0.329
Roll: -12.961



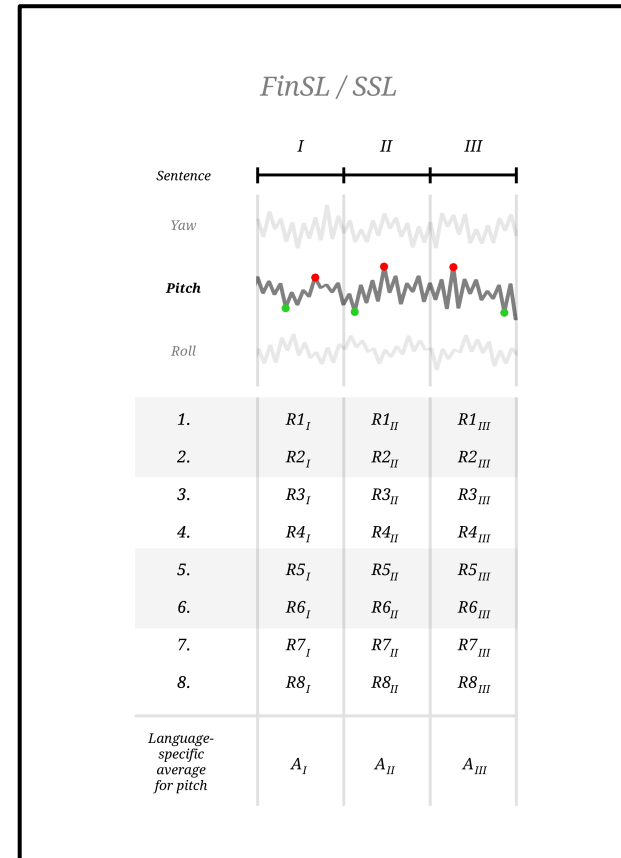
See SLMotion homepage @ <http://research.ics.aalto.fi/cbir/software/slmotion/>

KARPPA, M., V. Viitaniemi, M. Luzardo, J. Laaksonen and T. Jantunen, "SLMotion - An extensible sign language oriented video analysis tool," in *Proceedings of LREC 2014*. Paris: ELRA, pp. 1886–1891, 2014. – LUZARDO, M., M. Karppa, J. Laaksonen, T. Jantunen, "Head pose estimation for sign language video," in J.-K. Kamarainen and M. Koskela (eds.), *Image Analysis*. Springer, Lecture Notes in Computer Science, Vol. 7944, pp. 349–360, 2013.

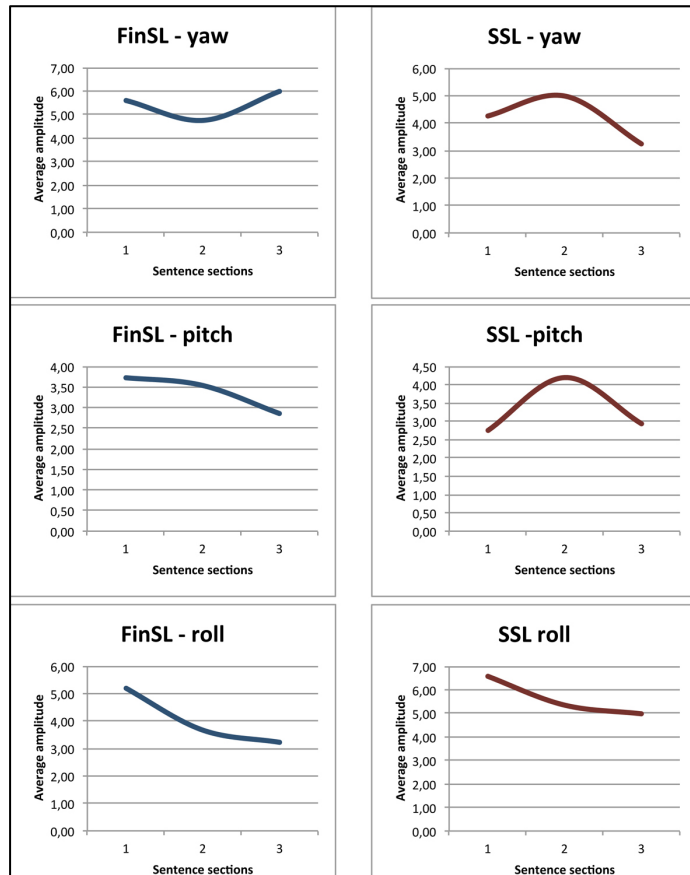
Method

“Recipe”

- Take a **sentence**.
- Divide it into **three sequences** in ELAN.
- Calculate the **numerical range** (R) for yaw, pitch and roll in each sequence.
- Repeat for each sentence in FinSL/SSL.
- For each sequence of both languages, calculate the **average range** for yaw, pitch and roll.
- Investigate the similarities and differences between the two languages via **visual observation** and with the linear **correlation co-efficient** (r).



Results



- **Yaw:** the shapes of the language-specific amplitude curves were almost **diametrically opposed** to each other ($r=-0.95$, a near perfect negative correlation)
- **Pitch:** the shapes of the curves were simply **different**, showing no linear correlation at all ($r=0.19$).
- **Roll:** A notable similarity in the results, that is, the tilting-like movement was larger in the opening section of sentences than in the closing section in both FinSL and SSL ($r=1.0$, a **perfect positive correlation**).

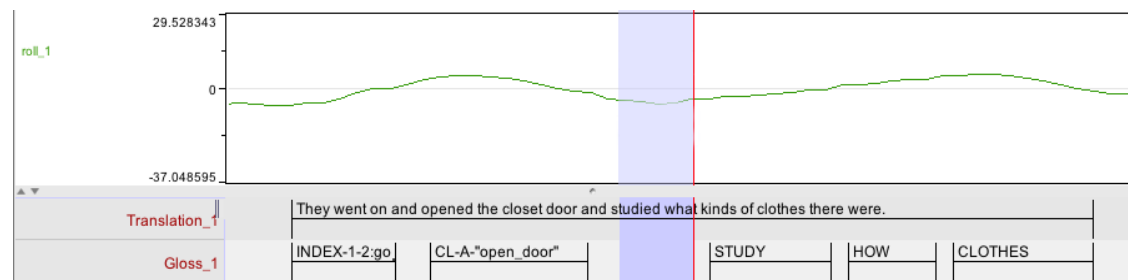
The average amplitude (in degrees) of the movement of the head in yaw, pitch, and roll dimensions for the opening (1), middle (2), and closing (3) sections of 8+8 semantically and structurally comparable FinSL and SSL sentences.

Discussion (1)

- The results show **more differences** (yaw and pitch) **than similarities** (roll) in the movements of the head in FinSL and SSL sentences.
- Concerning the differences, it is possible that they are not instances of language-wide rhythmic differences but the result of the **individual variation** present in the data, or even **deviations caused by the head tracking technology**.
- As far as the similarities are concerned, we find it very interesting that in both languages the movement of the head in the roll dimension was larger in the early parts of sentences than in the final parts: this indicates that there may be **a rhythmic similarity** between the two languages concerning the way they construct (these) sentences.

Discussion (2)

- The roll movements seem to have an important role in the manifestation of **rhythmic cohesion of sentences** also more generally; e.g. work on coordination in FinSL:



The roll descriptor shows that the head tilts to the signer's right and back again during the production of conjunctively coordinated clauses/sentences.

- We speculate that the movements in the yaw and pitch dimensions are used for different purposes; as a **structural part of lexical signs** as well as to express many **elementary linguistic functions** (e.g. negation, affirmation, and emphasis).

JANTUNEN, T. (forthcoming). Clausal coordination in Finnish Sign Language. *Studies in Language* 40. – PUUPPONEN, A. (2012). Horisontaaliset ja vertikaaliset päänliikkeet suomalaisessa viittomakielessä [Horizontal and vertical head movements in FinSL], MA thesis, University of Jyväskylä, Jyväskylä, Finland. – PUUPPONEN, A.; Wainio, T.; Burger, B. & Jantunen, T. (2015). 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. *Sign Language & Linguistics* 18(1), 41-89. – SANDLER, W., I. Meir, S. Dachkovsky, C. Padden & M. Aronoff (2011). The emergence of complexity in prosody and syntax, *Lingua* 121(13), 2014-2033.

Summary – research questions

1. There was a **statistical difference in the sign duration** but **no difference in the average signing speed** between FinSL and SSL; signer's age and presentation style may affect the results.
2. The **alignment of head nods with syntactic units was very similar** in FinSL and SSL; the main differences may be explained by individual variation and presentation style.
3. There were **more differences than similarities** in the way in which the head moved in terms of its amplitude in FinSL and SSL sentences; the similarity of the head movement in the roll dimension may be related to the rhythm.

Conclusion

- We have tested, from several perspectives, the hypothesis that there is a **rhythmic difference** between FinSL and SSL.
- On the basis of the present data and research setup, we cannot find solid evidence to support the hypothesis – we found rhythm-related differences (e.g. sign duration) but also many **similarities** (e.g. nods and roll movements).
- The present work has **focused only on a few aspects of the rhythm** – rhythm is a complex phenomenon and the future work has to explore it also from other perspectives.



Thank you!

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