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The kinematics of constructed action in sign language narration: A motion capture study

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Definition of constructed action (CA)

- CA is a form of gestural enactment in which the signers use their hands, face and other parts of the body to represent the actions, thoughts, feelings or sayings of someone they are referring to in the discourse (Cormier & al. 2015).

CORMIER, Kearsy, Sandra Smith & Zed Sevcikova Sehyr (2015). Rethinking constructed action. *Sign Language & Linguistics* 18:2, 167–204. doi 10.1075/sll.18.2.01cor

Example of CA

‘He gets an idea, walks to the oven and picks up some coal with him. He puts the pieces of coal on the snowman as eyes and mouth. He looks at what he has done and is very satisfied.’

Types of CA

- CA has degrees (Cormier & al. 2015):

Overt
Many articulators,
Full character perspective

Reduced
Many articulators,
Partial character perspective

Subtle
Few articulators,
Partial character perspective

”snowman pulls back” ”snowman” LOOK-AT WAKE-UP (”eyes”)

CORMIER, Kearsy, Sandra Smith & Zed Sevcikova Sehyr (2015). Rethinking constructed action. *Sign Language & Linguistics* 18:2, 167–204. doi 10.1075/sll.18.2.01cor – JANTUNEN, Tommi (forthcoming). Viittomakielet hybridisysteemeinä: hämärärajaisuus ja epäkonventionaalisuus osana viittomakielten rakennetta [Sign languages as hybrid systems: Gradience and unconventionality as a part of the structure of sign languages]. *Puhe ja kieli*.

Motivation

- Our corpus-based work (e.g. Jantunen 2017, Puupponen & Jantunen 2017, Puupponen 2018) has shown that narration with CA involves relatively more activity of the whole body, while narration without CA is associated with increased activity of the head.
- However, apart from these findings we still know very little about **what is the activity of the body and the head like in regular narration and CA**(**?**).
- Moreover, the movements of the body and the head have not been researched at all with respect to the three CA types (see Stamp & al. 2018).
- In order to better understand the role the body and the head have with CA in sign language narration we investigate the issue from the kinematic (phonetic) perspective with motion capture data from Finnish Sign Language (FinSL).

JANTUNEN, T. (2017). Constructed action, the clause and the nature of syntax in Finnish Sign Language. *Open Linguistics*, 3, 65–85. – PUUPPONEN, A. & Jantunen, T. (2017). Head movements, body movements and constructed action in FinSL narratives. Paper presented at the *Language as a form of action* conference, organised in Rome, Italy, June 21–23, 2017. – PUUPPONEN, A. (2018). The Relationship between Movements and Positions of the Head and the Torso in Finnish Sign Language. *Sign Language Studies* 18(2), 175–214. – STAMP, R., Cohn, D., Hel-Or, H., Raz, S. & Sandler, W. (2018). Kinect-ing the dots: How can motion capture technologies contribute to our understanding of sign and gesture? Paper presented at the workshop *Signed language linguistics: Taking stock*, organised as a part of ICL 20 in Cape Town, South Africa, July 2–6, 2018.

Data

1. Signers

- 5 native FinSL signers (2 female)
- Ages between 30–60 years
- MoCap markers & head-mounted eyetracker

2. Content

- Textless *Ferdinand* comic strips
- 3 strips per a signer
- ”Sign as vividly as you can."

3. Statistics

- Altogether 15 stories
- Total video duration 10 min and 45 sec.
- Ca. 500 million characters of numerical data

4. Processing in ELAN

- Synchronization of video and numerical data*
- Annotation of signs, translations and CA**
- Extraction of frame number information
- Sampling: altogether 137 durationally commensurable tokens of CA and non-CA

5. Processing the sample in Matlab & SPSS

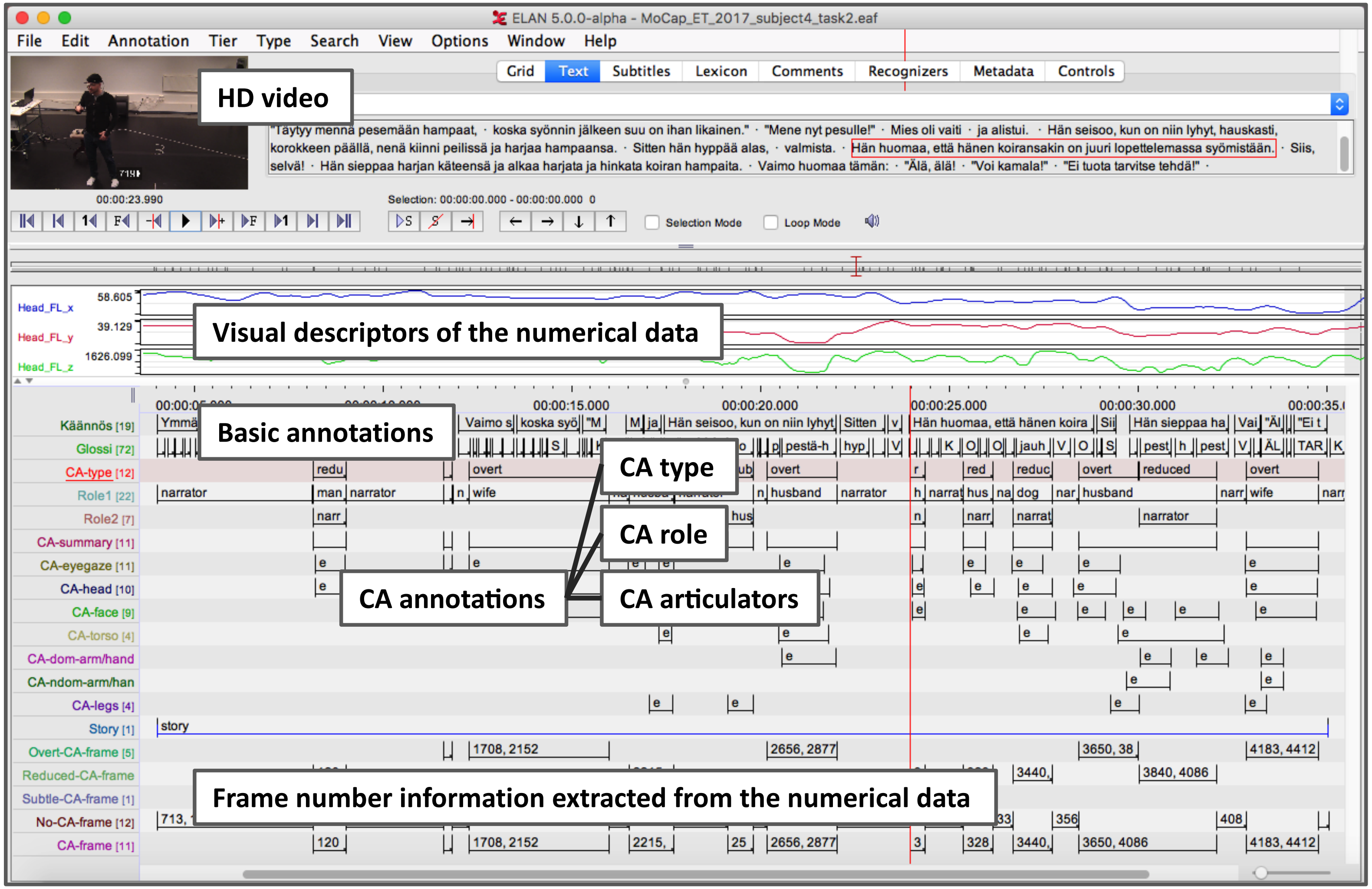
- Data transformation
- Calculation of the horizontal movement area, rotation range and velocity & acceleration magnitude of the head and the torso movements
- Statistical analysis with Kruskal–Wallis test

* BURGER, B., T. Jantunen & A. Puupponen (2018). Synchronizing eye tracking and optical motion capture: How to bring them together. *Journal of Eye Movement Research* 11(2):5. doi 10.16910/jemr.11.2.5 – ** CORMIER, Kearsy, Sandra Smith & Zed Sevcikova Sehyr (2015). Rethinking constructed action. *Sign Language & Linguistics* 18:2, 167–204. doi 10.1075/sll.18.2.01cor

Motion capture

- Optical *Qualisys Oqus* motion capture system
- 8 infra-red cameras, recording speed 120 Hz
- Tracking 25 reflecting markers attached to the body
- For more info, visit *http://www.qualisys.com /cameras/oqus/*

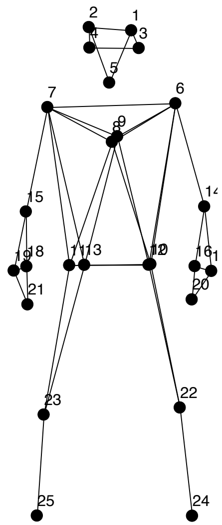
Annotations and visual descriptors in ELAN



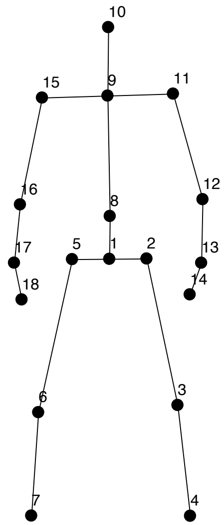
Data transformation in Matlab

Marker data

- Four upper head markers (1–4).
- Several upper torso markers (6–13).
- Two markers attached to both wrists (16–19).



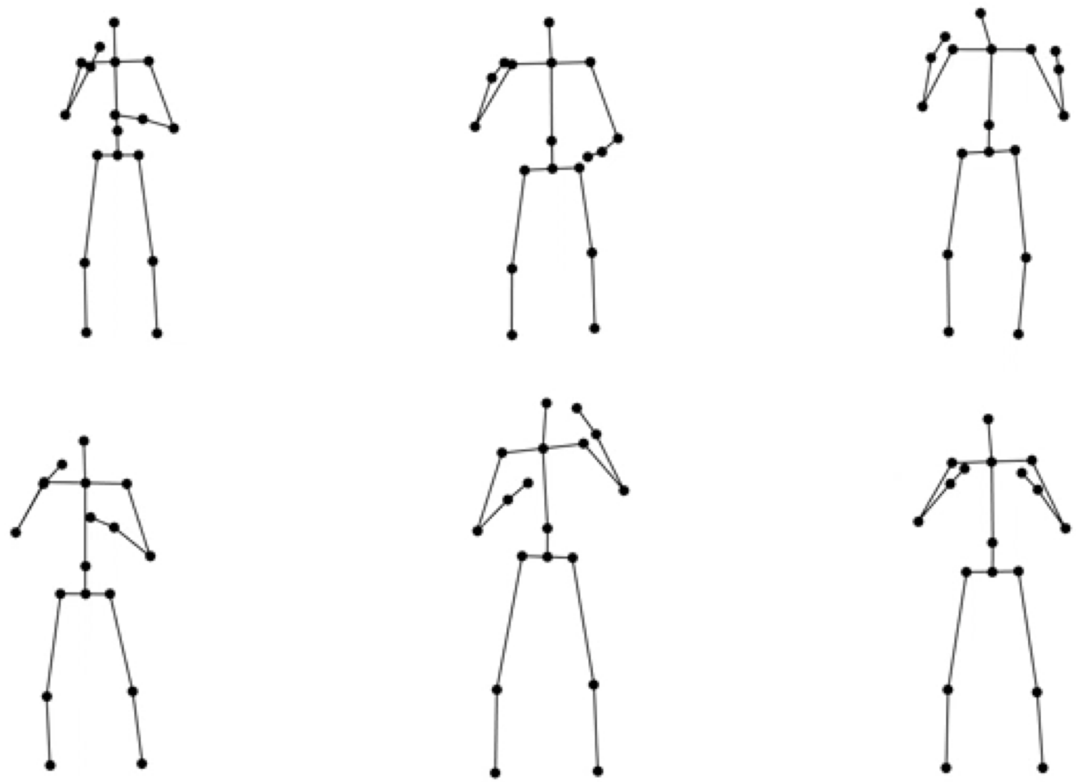
Joint data



- Head joint derived from the upper head markers (10).
- Upper torso joints derived from the markers (1, 8, 9, 11 and 15).
- Wrist joints derived from the wrist markers (13 and 17).

BURGER, B. & Toiviainen, P. (2013). MoCap Toolbox: A Matlab toolbox for computational analysis of movement data. In R. Bresin (ed.), *Proceedings of the 10th Sound and Music Computing Conference*, 172–178. Stockholm, Sweden.

Motion capture animation



Variables

Head movement

- Horizontal movement area of the head (*bounding rectangle*)
- Rotation range of the head
- Speed of the head movement (*velocity magnitude*)
- Acceleration of the head movement (*acceleration magnitude*)

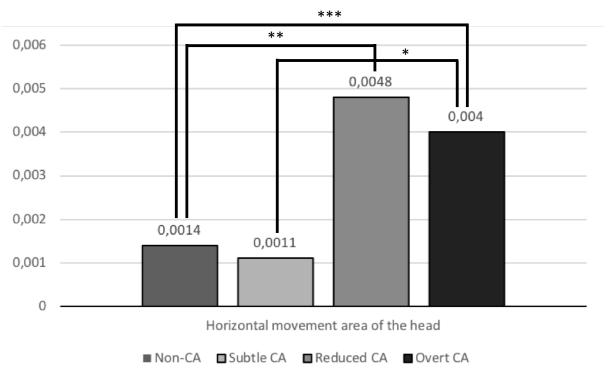
Torso movement

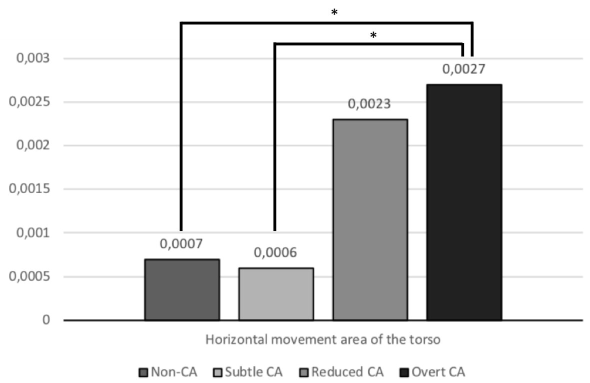
- Horizontal movement area of the upper, middle and lower torso
- Rotation range of the upper torso
- Speed of the upper, middle and lower torso movement
- Acceleration of the upper, middle and lower torso movement

Independent variables: **non-CA** (i.e. no constructed action; N=56), **subtle** CA (N=19), **reduced** CA (N=34) and **overt** CA (N=28).

BURGER, B., Saarikallio, S., Luck, G., Thompson, M.R. & Toiviainen, P. (2013). *Relationships between perceived emotions in music and music-induced movement. Music Perception* 30(5), 519-535. – BURGER, B. & Toiviainen, P. (2013). MoCap Toolbox: A Matlab toolbox for computational analysis of movement data. In R. Bresin (ed.), *Proceedings of the 10th Sound and Music Computing Conference*, 172–178). Stockholm, Sweden.

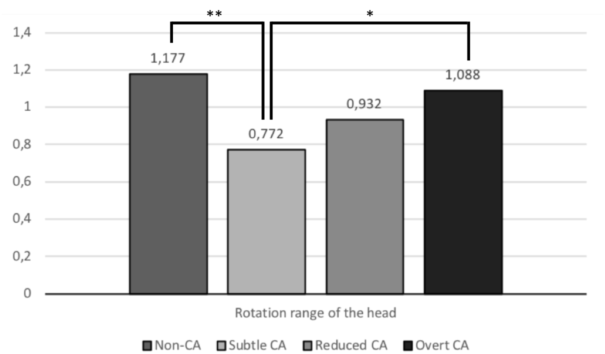
Results

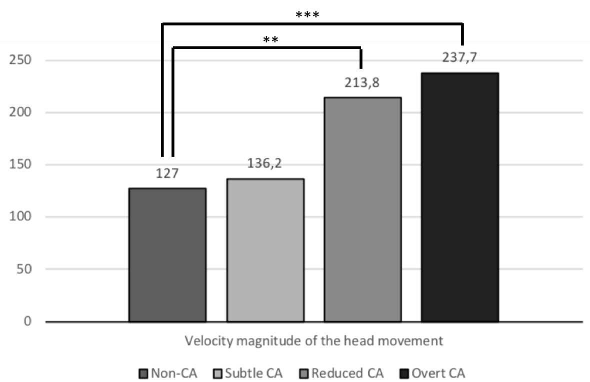


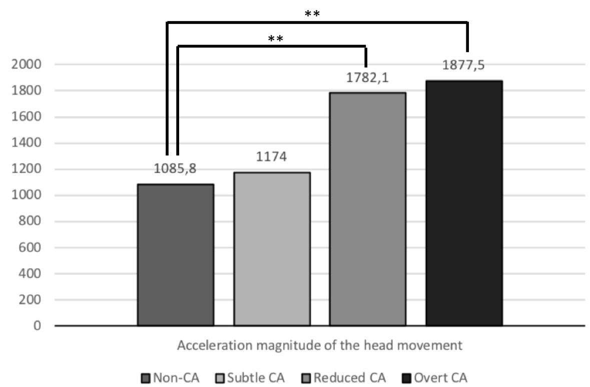


Populations & pairs with significant differences

Results are reported as averages. Statistical signifigance is estimated by using Independent–Samples Kruskal–Wallis test with signifigance level .05.







Results

- The Kruskal-Wallis test indicates significant differences between CA types and non-CA with respect to all variables except those measuring the rotation range and the velocity/acceleration magnitude of the torso.
- On the basis of pairwise comparisons targeted at the populations with the significant differences, we found three main results:
- First, the head and the torso move on a larger area with respect to the floor in strong CA (i.e. overt CA and stronger forms of reduced CA) than in regular narration and weak CA (i.e. subtle CA and weaker forms of reduced CA).
- Second, the movements of the head are faster and more rapid in strong CA than in regular narration.
- Third, subtle CA is distinguished from regular narration and overt CA in terms of the rotation of the head; the rotation of the head in subtle CA is minimal.

Discussion 1

- In general, the results further explicate our previous findings (e.g. Jantunen 2017, Puupponen & Jantunen 2017, Puupponen 2018) concerning the role the head and the torso have in CA and non-CA (see also Stamp & al. 2018).
- As the significant differences are found between the ”extremes” – i.e. typically between non-CA and strong CA, or subtle CA and overt CA – the results seem to provide evidence for a two-way (e.g. weak–strong) typology of CA instead of the three-way one (subtle–reduced–overt; see Cormier & al. 2015).

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Discussion 2

- As the ”middle ground” – i.e. weak CA – is not distinguished from the ”extremes” – e.g. non-CA and strong CA – the results provide additional (phonetic) evidence for the view that the degrees of CA indeed form a continuum with regular narration in language (see e.g. Ferrara & Johnston 2014, Cormier & al. 2015, Jantunen 2017).
- Moreover, as CA is a form of gestural enactment, the results also provide additional (phonetic) evidence for the view that gestural features – e.g. gradience and unconventionality – are an inseparable part of language (see e.g. Kendon 2004, Enfield 2009, Dingemanse & Akita 2016).

CORMIER, K., Smith, S. & Sevcikova Sehyr, Z. (2015). Rethinking constructed action. *Sign Language & Linguistics* 18, 167–204. – DINGEMANSE, M. & Akita, K. (2016). An inverse relation between expressiveness and grammatical integration: On the morphosyntactic typology of ideophones, with special reference to Japanese. *J. Linguistics* (2016), 1–32. – ENFIELD, N. (2009). *The anatomy of meaning: Speech, gesture, and composite utterances*. Cambridge: CUP. – 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, 193–215. – JANTUNEN, T. (2017). Constructed action, the clause and the nature of syntax in Finnish Sign Language. *Open Linguistics*, 3, 65–85. – KENDON, A. (2004). *Gesture: Visible action as utterance*. Cambridge: CUP.

Conclusion

- We used motion capture technology to investigate the movements of the head and the torso in sign language narration with different degrees of CA and without CA.
- We found that there is systematicity in the way the head and the torso move depending on the presence and the type of CA.
- We provided (phonetic) evidence for the view that the degrees of CA – and gestural features – form a continuum with regular narration in language.

Thank you!

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