Sign language corpora and the problems with ELAN and the ECHO annotation conventions

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Abstract

Corpus projects require logistic, technical and personal expertise and most importantly a conventionalized annotation system. Independently of its size, each project should use similar technical methods and annotation conventions for comparative reasons. To further enhance a unified conventionalization of sign language annotation, this paper addresses problems with ELAN annotation and the ECHO transcription conventions, shows imprecise usage examples and focuses on possible solutions. While building a corpus for a cross-linguistic sign language project in Germany, Ireland, and the Netherlands, various issues arose that ask for clarification. An appropriate time span annotation of signs is discussed as well as the need for a clear distinction of separate tiers. I will give transcription proposals for pointing/indexical signs and so called poly-componential or classifier constructions. Annotation should be as a-theoretical as possible without losing descriptive accuracy. In addition, I argue for a meticulous annotation of the eye gaze tier, as this is necessary for an adequate prosodic analysis. Finally the paper will show the usefulness of an additional tier to specify non-manuals that are concerned with adverbial, attitudinal and expressive facial expressions. The paper contributes to the important process of conventionalizing linguistic sign language annotation and the coding of signed video data.

1. Introduction

Large corpus projects with sign language data have recently received special attention. Sign languages are particularly endangered languages, as the social and cultural situation with regard to language acquisition and medical issues is a complex matter. In addition, linguistic research on languages in the visual-gestural modality and also cross-linguistic studies of sign languages world-wide, can give remarkable insights in the nature of language and cognition in general. Therefore, the documentation and preservation of signed data, either natural or elicited, is of enormous importance. However, relatively small corpus projects that investigate specific research issues and rely on a definite set of data can also be an invaluable contribution to linguistic sign language research. All these projects have to transcribe the video data and break down the visual signing stream into units that are evaluable and therefore available for analysis. This should be done in a comparable way for all sign languages and all projects.

Sign language annotation conventions have not yet been uniformly developed on an international level, let alone been conventionalized for a European community. In an attempt to unify annotation conventions for sign languages the paper contributes to an ongoing standardization process and builds upon the ECHO annotation conventions, which proofed to be well selected and highly sophisticated. These conventions evolved from the 'Case Study 4: sign languages' project, which is part of ECHO (European Cultural Heritage Online)[1] and since then became more and more established.

This paper elaborates on possible solutions for technical sign annotation and specifically looks at problematic cases of certain sign language constructions that challenge an a-theoretical and cross-linguistic annotation of video data. To guarantee a most effective usage of search tools across various corpora a number of regulations and standards should be maintained and followed consistently.

The paper intends to stipulate clearly how to annotate specific aspects of signing and how to clarify some vague and problematic cases, constructions and components. In chapter 2 I will give some short introductory remarks about the project, the participants and the technical methodology. The following section (chapter 3) summarizes some important aspects of the annotation tool that is used and lists examples from the ECHO annotation system. Section 4 provides the core part of the paper and discusses specific annotation problems in six different paragraphs. I will address issues like time span annotation, accuracy of tiers that deal with eye gaze or aperture and indexical signs. With regard to comprehensive conventions, I will also give suggestions how to cope with the so called classifier constructions and also argue for the inclusion of an additional tier for specific non-manuals. After some short supplementary remarks, a last section giving an outlook (chapter 5) will conclude the paper.

2. The project

The subject of the dissertation project that I am currently working on in Germany, Ireland and the Netherlands requires the elicitation of specific signed sentences, contexts and dialogues. Therefore, I decided to create an annotated sign language video corpus for my own studies to guarantee comparative analysis. The study investigates how speaker's attitude and focus particles are realized in sign languages (cf. Herrmann, 2007). In this project, data from three European sign languages (DGS, ISL and

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[1] See http://echo.mpiwg-berlin.mpg.de for more information about the ECHO project in general.

NGT)[2] and altogether 20 native signers yield a set of over 900 sentences and short dialogues. Two video camcorders are used to provide a torso perspective as well as a smaller frame view showing the face of the respective signer. This facilitates annotation and is particularly important for research with regard to non-manual facial expressions.

The metadata information about participants and the recording situation will be edited along the lines of the IMDI metadata set (cf. Crasborn & Hanke, 2004), but cannot claim to be complete. The ELAN tool (Eudico Linguistic Annotator [3] provides the most adequate annotation software for my purposes, especially because one of the main interests of the study lies in the use of non-manuals. This annotation tool from the MPI in Nijmegen[4] is widely used for sign language annotation, but is mostly distributed in Europe. See Neidle (2001) and references for information on a different, but similar sign language annotation tool from the ASLLRP group, namely *SignStream*. Hanke (2001) presents the interlinear editor *syncWRITER*, but also shows that this software is not well-suited for large scale corpus projects.

Besides working with ELAN, I try to ensure comparability by mainly adopting the ECHO annotation system for sign languages (cf. Nonhebel et al., 2004), of which I will give some examples in the following section. Researchers, of course, may add coding to their individual needs and focus on specific tiers or aspects. However, some even basic adaptations to the ECHO conventions are considered to be necessary, as the given definitions are less than sufficient and should be clarified.

3. ELAN and the ECHO system

ELAN is perfectly suitable for theoretically independent transcription and annotation of multi-media and multi-channel based data, especially sign languages. Up to four videos can be time aligned and played simultaneously. The data can be clicked through frame by frame and a self defined number of tiers can be organized to guarantee precise annotation. The ECHO group of the 'Case Study 4: sign languages' has collected and defined a set of abbreviations and conventions to annotate video data of different sign languages. They agreed on approximately 16 tiers, plus minus one or two, as it might be necessary to have more than one translation or gloss tier in cases the text, apart from English, should also be displayed in another language. It is proposed that the tiers have a certain hierarchy resulting in parent tiers and child tiers. However, it is not the most important point to precisely adopt the number of tiers or the hierarchy, but to follow the defined designations and their short forms. Abbreviations for descriptive vocabulary within the tiers mostly rely on initials of the respective words like 'b' for *(eye) blink*, 'r' for *raised (eyebrows)*, etc. These abbreviations can be fed into an ELAN dictionary that can always be retrieved and used for new files. It is possible to constantly adjust and fine-tune the entries of the dictionary, save the template and use it again.

4. Problematic cases and possible solutions

In the following sections I will provide examples that show some problematic cases and also annotation trials that were incorrect or misleading. I will present suggestions and show how these cases can be avoided or should be dealt with. First, I argue for a continuous annotation of the signing stream (4.1). In a second paragraph (4.2), I will contemplate a continuous annotation of the eye gaze tier, its combination with the eye aperture layer and how this information can be usefully searched for analysis. A third section (4.3) discusses some approximation towards an at least minimally distinguished annotation of pointing signs. The fourth section (4.4) is dedicated to the most diversely discussed topic of classifiers and how they can be annotated without adopting a specific theoretical framework. In a fifths paragraph (4.5), I will argue for the integration of an additional tier for certain facial expressions that cannot be segmented or described adequately by the available tiers. The last section (4.6) adds some final remarks on abbreviations that lack distinctness.

4.1 Time span

Assuming Sandler's (2006) Hand Tier model, signs consist of an onset or starting point (L), movement (M) and an endpoint location (L). A preparation phase precedes the sign and a relaxation phase follows it. As the syllable structure, however, is not always LML, it is often hard to define the start and endpoint of a sign. Where exactly does a movement end in case of an LM syllable? So, how are the on- and offsets of signs determined? Shall we annotate the separate signs or a signing stream integrating the transition periods?

Signing consists of a cohesive articulation stream with a certain prosodic structure. Even though the on- and offsets of signs can be defined more precisely than for words, the sign syllable not always has clear boundaries. Therefore, I argue that signing should be annotated as a continuous process that is interrupted when there is a hold or a significant pause. The transition from one sign to the other is often clearly visible through hand shape change, which seems to be the more adequate marker for the annotation domain. Figure 1 shows the continuous annotation of the glosses in the hand or gloss tier.
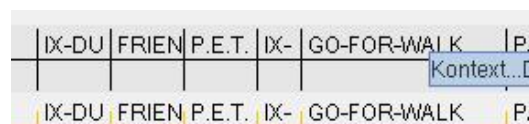

Figure 1: time span annotation ELAN

The only problem left is the fact that sign duration will not be precisely analyzable. However, this issue cannot entirely be solved by the vague separate sign annotation either, as sign boundaries are difficult to grasp. With regard to the rhythmic structure, holds, for example, are marked by (-h) and, of course, pauses or clear interruptions of the signing stream have to be indicated by a gap in the annotation line. The rest of the utterance, however, should be annotated continuously.

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[2] DGS (Deutsche Gebärdensprache = German Sign Language), ISL (Irish Sign Language) and NGT (Nederlandse Gebarentaal = Sign Language of the Netherlands)
[3] cf. Hellwig (2008) for the latest ELAN manual
[4] www.mpi.nl/lat

4.2 Accurate eye gaze aligned with eye blinks

Similar to the section above, I will also discuss the advantages of an accurate annotation of the tiers that are concerned with eye gaze and eye aperture. It seems only logical that the eye gaze tier should not exhibit any breaks except for eye blinks or closed eyes. The signer definitely has to look somewhere, whether it is linguistically significant or not. In addition, it is important to note that while a person closes the eyes or blinks, the eye gaze annotation should be interrupted, as it is physically impossible to blink and simultaneously look. Compare the following annotation examples, where the first tier shows eye aperture and the second tier below marks eye gaze.
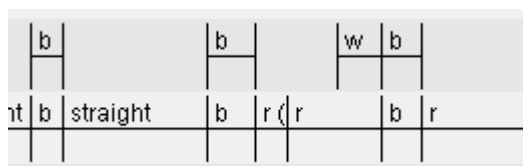

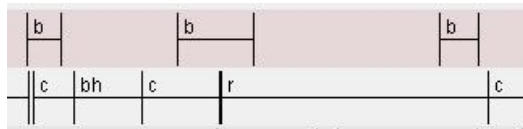Figure 2: accurate eye gaze annotation

Figure 3: inconsistent eye gaze annotation

The 'Signs if Ireland' corpus project, conducted by the Centre for Deaf Studies in Dublin[5], has annotated these tiers in a similar way, using '//' for blinks and slightly different eye gaze abbreviations. Copying the blink domains would have been more accurate and also less difficult, but the method is basically the same.
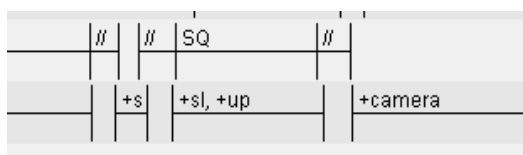

Figure 4: ISL annotation of eye gaze tier

The roles of eye gaze and eye blinks in sign language have not been studied extensively, but a few studies have focused on possible functions and occurrences of certain constructions.[6] If a lot of data is annotated like suggested, reliable assumptions can be made concerning incidences or spreading domains of eye gaze (e.g. their function for agreement or role shift).

In addition, eye blinks should be included in the eye gaze tier, although they are also supposed to be annotated in the eye aperture tier. They can easily be copied to the gaze tier which then also avoids a gaze annotation that co-occurs

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[5] www.tcd.ie/slscs/cds/research/featuredresearch_signcorpus.php and also cf. Leeson & Nolan this workshop

[6]See Thompson et al. (2006) for studies of eye gaze in relation to verb agreement or indexicals and Wilbur (1994) as well as Nespor and Sandler (1999) for eye blinks and prosodic issues.

with a blink in the eye aperture tier (see Figures 2 and 3 above). The continuous annotation of the eye gaze tier including blinks is also useful to exactly determine whether an eye gaze change occurs with or without an eye blink and the other way round. The duration and timing of blinks may also be important and should be accurate. Of course nobody can be forced to annotate every small detail. However, if it is decided to incorporate those tiers in the annotation, I argue for the above described way, though being time consuming, the precise annotation of both tiers can be especially relevant for prosodic analysis (cf. Wilbur, 1994, 1999; Nespor and Sandler, 1999) and all the according interfaces that exist.

4.3 Pointing signs

The question underlying this section is: How should pointing (signs) be transcribed? As the debate about the status of indexical signs is not clearly sorted out yet, we cannot adopt an annotation that distinguishes pronouns, articles, demonstratives or locatives etc. as it would favor a certain analysis and theory. For any kind of pointing, ECHO suggests the coding IND for index or indexical, and even though I use the widely accepted abbreviation IX, there is no further difference with regard to the underlying definition. However, for the standardized annotation I would like to offer a more detailed distinction of those pointing usages without taking a theoretical framework. No matter if researchers analyze indexicals as a grammatical system or as gestural pointing (Liddell, 2000, 2003), whether they argue for a three part pronominal system (Berenz, 2002; Alibašić Ciciliani & Wilbur, 2006), a first and non-first person distinction (Meier, 1990; Engberg-Pedersen, 1993) or a spatial deictic referents system (McBurney, 2002, 2005), it is still possible to specify the description in some more detail. At least the following distinctions ought to be made:

IX-1	for the index finger pointing to the signer's chest
IX	for any other pointing by the index-finger
IX-dual (incl.)	pointing by the use of two extended fingers, if the signer is included
IX-dual (excl.)	pointing by the use of two extended fingers, if the signer is excluded
IX-(thumb)	pointing performed by extended thumb

Table 1: index/pointing (IX)

This differentiation would facilitate scouring the corpus for specific indexicals. If researchers are interested in any indexical, they can search for IX, but if they wish to look at index finger based pointing only, they can leave out the thumb examples. They can decide whether dual pointing may be relevant and so they do not have to go through every listed IX-example.

It is up to the annotator whether to add more information that can be attached to IX. Personally I prefer to indicate clear cases of locative pointing by the letter –a and use –pl for 'plural' pointing, marking a certain movement of the index-finger rather than pointing to just one location. However, this cannot be demanded of a general annotation convention, even though it does not make a difference with regard to the use of the search tool.

4.4 Classifier signs are poly-componential

Sign languages can depict motion, location and information about the shape of objects and referents within the signing space and exhibit constructions that simultaneously represent nominal features within the verb. This has led Supalla (1986) to compare the constructions to classification systems found in many spoken languages. The handshapes represent the units that are analyzed as classifiers. However, with respect to signed languages, the notion 'classifier construction' has been challenged by authors, who claim that the link to spoken language classifier systems is weaker than expected and they suggest different terms and analysis (cf. Schembri, 2003, 2005; Liddell, 2003; Engberg-Pedersen, 1993; Edmondson, 2000). Classifiers are rather called complex predicates, poly-morphemic verbs, reference marker etc., and their status is being debated. Aronoff et al. (2003) and also Sandler & Lillo-Martin (2006), however, still accept the category 'classifier construction' in the sense of a definition given by Senft (2000) that the components should be morphemes that classify nouns according to semantic criteria. They argue that the differences and peculiarities of those constructions in sign languages are not enough to ask for a new terminology. Spoken language classifier systems, they say, are not always very similar to each other, too. Many researchers still use the traditional term and work on a precise distinction of various classifier categories.[7] This debate shows that an annotation of the so called 'classifiers' is a delicate issue.[8] As the annotation of signed video material should be most detailed and at the same time as much a-theoretical as possible, annotators cannot use specific notions like Handle-, Class/Entity-, or SASS-Classifier etc. However, it is clear that the constructions under discussion have to be marked as such, be it (cl-), traditionally for classifiers in general (as the BSL group of the ECHO data set has chosen), or be it (p-) for poly-componential (like in the NGT data)[9]. This, I do not intend to dictate. However, in the following I will adopt the (cl-) abbreviation just to decide for one option throughout the paper.

First of all it has to be clarified whether these constructions should be transcribed as a modified verb construction or by a paraphrase. I find it much more attractive to have a sign that is glossed in small capitals and then give the additional information that the construction reveals. Compare the following DGS examples where the additional information (*info*) is not yet specified.

| a) EMMA LENA FLOWER GIVE-cl:*info* |
| b) EMMA LENA FLOWER (cl-) give-*info* |

Table 2: annotation for cl-constructions

The a) example marks the action as the basic part of the construction and then adds the meaning of the modifications. Of course, in b) the verb appears as well,

but in many cases the paraphrasing method leads to a far too detailed and often superfluous description of what is performed by the signer. The important thing is that the expressions and words following the categorization do not contain information that cannot be derived by examining the construction in isolation. The verb GIVE changes according to the object that is given, but the give-construction alone cannot mean *give-a-flower*. The noun has to be introduced into the discourse, so the construction itself can only mean *give-a-small-thin-object*. Therefore it should not be transcribed GIVE-cl:flower, but rather GIVE-cl:small-thin-object or something like GIVE-cl:flower-shape-object. In cases where a construction represents a certain class of objects or specific entities that are conventionalized, this must, of course, be indicated differently (WALK-cl:person, STAND-cl:tree [10]). The unclear definitions have led annotators to even transcribe a regular verb BLEAT as *(p-) bleating-sheep*, while sheep was already introduced. Annotations like *(-p) walk* or *(-p) stick in hand* do not seem very convincing, as they lack specification and information about what is done with the stick for example. [11] Temporal information like the ing-form should not be included in the sign language hand tier glossing either. These vague examples could be avoided when it is considered to first annotate the verbal root and then attach the additional information that the construction conveys. This is also desirable, because in cases where both hands represent different entities or objects (e.g. *The bird sits on a tree.*), the hands (right: RH, left: LH) can be glossed independently.

| RH | SIT-ON-cl:bird |
| LH | STAND-cl:tree |

Table 3: independent RH and LH annotation

This is much more descriptive than *(cl-) a-bird-sits-on-a-tree* or similar paraphrases. However, if the 'verb plus modification' annotation is not accepted to be convincing or adequate for general conventions, annotators nevertheless have to consider the different highly important points indicated in this section. Repeating a previously introduced noun in the (cl-) paraphrase, using a noun for information about the shape of objects, calling regular verbs (cl-) constructions etc. is not how systematic annotation should look like.

4.5 Additional tier for 'looks'

While annotating the data that I have elicited, I came across many cases where a certain relevant facial expression could not be described by entries or the sum of entries within the available tiers.

Especially when working in the area of semantics and pragmatics as well as prosodic phenomena, it seems necessary to have a separate tier, where non-manual adverbials, specific facial expressions, looks, and contoured or tense signing can be annotated. How should the non-manual realization of certain attitudes, expressive meaning, information structure etc. be annotated?

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[7] See Benedicto and Brentari (2003) and (2004) for an overview of different classifier analysis and their own approach.

[8] See Morgan & Woll (2007) for perspectives on classifiers with regard to acquisition, use in discourse, and impairment studies.

[9] cf. the NGT and BSL data (Crasborn et al., 2004 and Woll et al., 2004) from the ECHO project for sign languages

[10] STAND could also be glossed as BE-LOCATED

[11] Examples of annotations from the NGT data set: cf. Crasborn et al. (2004)

Sometimes even adverbial information is found in the GLOSS tier, which should only be used for manual signs or gestures. Examples like WALK-PURPOSEFUL are not desirable. Therefore it is useful, at least for studies focusing on non-manuals, to incorporate an additional tier that leaves space for such expressions that are difficult to describe but are nevertheless relevant. In the present study I have not included such an additional tier in the annotations yet, but used the notes tier for these instances so far. However, this is not very satisfying as overlaps occurred and the information discussed above does not belong to the category of notes. Just to give a few suggestions, the tier could be named *other NMFs, looks* or *extra facial expressions* for example.

4.6 Some additional remarks

Finally I would like to further indicate something trivial, which I nevertheless find very helpful and worth considering. Even though it is possible to specifically search tier by tier, identical abbreviations for different expressions or annotations should be avoided. In the ECHO conventions 's', for example, stands for *(head) shake* in the head tier and for *squint* in the eye aperture tier. This inadequacy can simply be solved by adding an 'h' to the abbreviations in the head tier, so it becomes 'hs' for *headshake*, 'hn' for *head nod* and 'ht' for *head tilt*, which seems to be used by many sign language researchers already. Further specifications like 'ht-f' for *head tilt forward* or 'ht-b' for a *backward head tilt* are optional and do not influence the searching process. On the long run, however, they could easily be included in the conventions as well.

5. Outlook

All these problems and cases of vague definitions and inaccurate usage came into view during the process of finding an appropriate annotation for my corpus and made me decide for certain options, for comparable and independent abbreviations, etc. The workshop and the examples in this paper show that even though many people are currently working on the annotation of sign language data, coding is far away from being conventionalized. Even within the ECHO project the groups worked with varying annotation short forms and slightly different opinions on how to annotate certain aspects of signing. However, a uniform annotation system is essential for various above mentioned reasons: for comparative analysis of different sign languages, simplified handling of search tool functions, comprehensive data exchange etc. It can also be helpful for future research with regard to machine translation and avatar usage for example (cf. among others Morrissey & Way, 2005; Stein et al., 2007).

The ECHO conventions show, that it is possible and eligible to agree on basic notions, and the effort currently undertaken to improve and extend those agreements is well justified. Some vague definitions and false usages have been disclosed, but the ECHO system is highly sophisticated and builds the fundament for all discussed examples. The suggestions I presented shall contribute to the ongoing development of adequate conventions. The paper supports a unified approach and promotes solutions that might be seen as still open to discussion.

Wide-ranging collaborations and comparable cross-linguistic data exchange on a basis of such unified annotation conventions may extremely improve linguistic discussions and the analysis of sign language data.

6. Acknowledgements

7. References

Alibašić Ciciliani, Tamara, Wilbur, Ronnie (2006). Pronominal system in Croatian Sign Language. *Sign Language & Linguistics 9*, pp. 95--132.

Aronoff, Mark, Meir, Irit, Padden, Carol & Wendy Sandler (2003). Classifier Constructions and Morphology in Two Sign Languages. In Karen Emmorey (ed), *Perspectives on Classifier Constructions in Sign Language*. Mahwah, NJ: Erlbaum, pp. 3--34.

Benedicto, Elena, Brentari, Diane (2003). *Choosing an Analysis for Verbal Classifiers in Sign Language. A comparative Evaluation*, Ms., Purdue University.

Benedicto, Elena, Brentari, Diane (2004). Where did all the arguments go? Argument-Changing Properties of Classifiers in ASL. *Natural Language and Linguistic Theory 22.4*, pp. 743--810.

Berenz, Norine (2002). Insights into person deixis. *Sign Language & Linguistics* 5 (2), pp. 203--227.

Crasborn, Onno, Hanke, Thomas (2004). *Metadata for sign language corpora. Background document for an ECHO workshop. May 8 + 9, 2003,* Radboud University Nijmegen.

Crasborn, Onno, van der Kooij, Els, Nonhebel, Annika & Wim Emmerik (2004). *ECHO data set for Sign Language of the Netherlands (NGT)*. Department of Linguistics, Radboud University Nijmegen.

Edmondson, William (2000). *Rethinking Classifiers. The Morpho-phonemics of Proforms.* Ms., University of Birmingham, UK.

Engberg-Pedersen, Elisabeth (1993). *Space in Danish Sign Language*. Hamburg: Signum.

Hanke, Thomas (2001). Sign language transcription with syncWRITER. *Sign Language and Linguistics 4:1/2*, pp. 275--283.

Hellwig, Birgit (2008). *ELAN Linguistic Annotator. Version 3.4.* Manual.

Herrmann, Annika (2007). Modal Meaning in German Sign Language and Irish Sign Language. In Perniss, Pamela, Pfau, Roland & Markus Steinbach (eds.), *Visible Variation. Comparative Studies on Sign Language Structure.* Berlin: Mouton de Gruyter, pp. 245--278.

Liddell, Scott (2000). Indicating Verbs and pronouns: pointing away from agreement. In Karen Emmorey & Harlan Lane (eds.), *The Signs of Language Revisited: An Anthology to Honor Ursula Bellugi and Edward Klima.* Mahwah, NJ: Erlbaum, pp. 303--320.

Liddell, Scott (2003). Sources of meaning in ASL classifier predicates. In Karen Emmorey (ed) *Perspectives on Classifier Constructions in Sign Language*. Mahwah, NJ: Erlbaum, pp. 199--220.

McBurney, Susan Lloyd (2002). Pronominal reference in signed and spoken language: are grammatical categories modality-dependent? In Richard P. Meier et al. (eds.), *Modality and Structure in Signed and Spoken Languages*. Cambridge: CUP, pp. 329--369.

McBurney, Susan Lloyd (2005). Referential morphology in signed languages. Dissertation Abstract. In Anne Baker and Bencie Woll (eds.), *Language Acquisition: Special issue of Sign Language & Linguistics 8:1/2,* pp. 211--215.

Meier, Richard P. (1990). Person deixis in American Sign Language. In Susan D. Fischer & Patricia Siple (eds.), *Theoretical Issues in Sign Language Research.* Chicago: University of Chicago Press, pp. 175--190.

Morrissey, Sara, Way, Andy (2005). An Example-based Approach to Translating Sign Language. In *Proceedings of the Workshop in Example-Based Machine Translation (MT X-05)*, Phuket, Thailand, pp. 109–116.

Morgan, Gary, Woll, Bencie (2007). Understanding sign language classifiers through a polycomponential approach. *Lingua* 117, pp. 1159--1168.

Neidle, Carol (2001). SignStream. A database tool for research on visual-gestural language. *Sign Language and Linguistics 4:1/2*, pp. 203--214.

Nespor, Marina, Sandler, Wendy (1999). Prosody in Israeli Sign Language. *Language and Speech* 42, pp. 143--176.

Nonhebel, Annika, Crasborn, Onno & Els van der Kooij (2004). *Sign language transcription conventions for the ECHO project.* Version 9, 20 January 2004, Radboud University Nijmegen.

Sandler, Wendy, Lillo-Martin, Diane (2006). *Sign Language and Linguistic Universals*. Cambridge: Cambridge University Press.

Schembri, Adam (2003). Rethinking 'Classifiers' in Signed Languages. In Karen Emmorey (ed) *Perspectives on Classifier Constructions in Sign Language*. Mahwah, NJ: Erlbaum, pp. 3--34.

Schembri, Adam, Jones, Caroline, & Denis Burnham (2005). Comparing action gestures and classifier verbs of motion: Evidence from Australian Sign Language, Taiwan Sign Language, and non-signers' gestures without speech. *Journal of Deaf Studies and Deaf Education 10:3*, pp. 272--290.

Senft, Gunter (2000). *Systems of nominal classification: Language Culture and Cognition.* Cambridge: CUP.

Stein, Daniel, Dreuw, Philippe, Ney, Hermann, Morrissey, Sara & Andy Way (2007). Hand in Hand: Automatic Sign Language to English Translation. In *Proceedings of Theoretical and Methodological Issues in Machine Translation (TMI-07)* Skovde, Sweden.

Supalla, Ted (1986). The classifier system in American Sign Language. In C. Craig (ed.), *Noun classes and categorization: Typological studies in language*, Vol. 7 Amsterdam: Benjamins, pp. 181--214.

Thompson, Robin, Emmorey, Karen, & Robert Kluender (2006). The relationship between eye gaze and agreement in American Sign Language: An eye-tracking study. *Natural Language and Linguistic Theory*, 24, pp. 571--604.

Wilbur, Ronnie (1999). Stress in ASL: Empirical Evidence and Linguistic Issues. *Language and Speech* 42 (2.3), pp. 229--250.

Wilbur, Ronnie (1994). Eyeblinks and ASL Phrase Structure. *Sign Language Studies 84*, pp. 221--240.

Woll, Bencie, Sutton-Spence, Rachel, & Dafydd Waters (2004). *ECHO data set for British Sign Language (BSL).* Department of Language and Communication Science, City University London.