Morphological Complexity Influences Verb–Object Order in Swedish Sign Language

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Abstract

Computational linguistic approaches to sign languages could benefit from investigating how complexity influences structure. We investigate whether morphological complexity has an effect on the order of Verb (V) and Object (O) in Swedish Sign Language (SSL), on the basis of elicited data from five Deaf signers. We find a significant difference in the distribution of the orderings OV vs. VO, based on an analysis of morphological weight. While morphologically heavy verbs exhibit a general preference for OV, humanness seems to affect the ordering in the opposite direction, with [+human] Objects pushing towards a preference for VO.

1 Introduction

Word order is one of the most well-documented grammatical features of the (spoken) languages of the world. One specific case regarding word order is the order of a Verb V and its (direct) Object O in a simple transitive clause. In a sample of 1,519 languages of the world, 46.9% ($n = 713$) of the languages have a dominant OV order, whereas 46.4% ($n = 705$) have a dominant VO order (Dryer, 2013).[1]

For signed languages, the two observed dominant word orders are SOV and SVO, for which the latter has been generalised as a grammatical order in most sign languages. However, a number of factors are said to affect the ordering of O and V, for instance that morphologically complex verbs (e.g., those exhibiting morphological reduplication, handshape or directional object agreement, or coinciding with non-manual marking) prefer a verb-final position, hence occurring *after* its object. One reason for this ordering preference has been suggested to relate directly to the interaction between the verb and its object, since some complexity features involve types of "agreement" with the object. Thus, the idea is that the object needs to be introduced *before* verb agreement with the object is available on the verb (Napoli and Sutton-Spence, 2014). This relates directly to findings from spoken languages, for which it has been noted that the ordering of verb and controller NP affects the agreement realisation, such that verbs preceding their controller NP do not always agree with the controller (Corbett, 2006). Furthermore, among spoken languages, word order also interacts with the presence or absence of morphological marking. For instance, SOV languages generally differentiate Subject and Object on the basis of morphological marking (e.g., case), while SVO languages differentiate these argument roles by word order alone (i.e., by linear distance between the arguments) (Sinnemäki, 2010). In a study looking at young, emerging sign languages, it was argued that humanness as an animacy feature accounts for word order preferences, in that SOV is preferred unless both S and O are [+human], in which case SVO is preferred (Meir et al., in press).

For Swedish Sign Language (SSL), the dominant word order has been identified as SVO (Bergman and Wallin, 1985), which has also been corroborated by a small-scale corpus study more recently (Börstell et al., 2016). Although different types of morphological complexity (e.g., reduplication and agreement) have been suggested to influence word order in SSL (Bergman and Wallin, 1985; Bergman and Dahl,

[1]The remaining 101 languages in the sample allow for both orders, neither being dominant.

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Table 1: Features of morphological complexity in SSL

Handshape	Whether an Object classifier was present in the verb's handshape (Emmorey, 2003).
Directionality	Whether an Object location was present in the verb's movement (Padden, 1988).
Reduplication	Whether the verb was reduplicated (Bergman and Dahl, 1994).
Non-manual	Whether a non-manual morpheme accompanied the verb (Crasborn, 2006).

1994), no study has explicitly addressed this issue. Thus, the aim of this study is to use statistical bootstrapping methods to establish whether morphological complexity affects the order of Object and Verb in SSL. By doing so, we seek to tease apart the different factors influencing word order patterns in SSL, and incorporate the notion of morphological complexity more explicitly as a property of signed language grammar, particularly with regard to the interaction between morphology and syntax. Uncovering the intricacies of this interaction can also be helpful for developing sign language technology, and can serve as a starting point when annotating sign language corpora. Information about the effect of complexity can be used to inform machine learning systems, e.g., by including this information as features, or by predicting a verb's complexity as an auxiliary task in a neural network (see, e.g., Plank et al. (2016) and Bjerva et al. (2016)).

2 Data and Methodology

2.1 Data and Annotations

The data consisted of video recorded descriptions of 17 transitive events (see Table 2) by five Deaf signers of SSL (4 male; aged 18–44), all using SSL as their first language. The signers were individually recorded describing the stimuli events to another signer, who was instructed to correctly identify the described event from three different options. Descriptions were annotated in the ELAN software (Wittenburg et al., 2006). In total, 145 individual transitive verbs were annotated for the categories in Table 1.

Handshape and Directionality involve morphological complexity dependent on the Object: Object classifier handshapes are selected on the basis of the Object's physical properties; Directionality involves the incorporation of referential locations in signing space, such that the verb moves between – or *agrees* with – locations established for various discourse referents (here, the Object(s)). Both of these categories entail the verb form being altered according to its Object, in a sense making the verb form *dependent* on physical and spatial properties of the Object. This has been suggested to influence the order of `O` and `V`, such that an Object-dependent Verb *follows* its Object, i.e., `OV` (Napoli and Sutton-Spence, 2014).

The latter two categories also involve morphological complexity, but rather independent from the Object: Reduplication involves phonological repetition, for signed language often associated with aspectual and/or pluractional morphology (Fischer and Janis, 1990; Bergman and Dahl, 1994); Non-manual concerns the addition of non-manual markers (e.g., facial expression, or so-called oral adverbs[2]) accompanying a verb. These are associated with both phonological and morphological weight, and are also found to be associated with a post-Object position (Napoli and Sutton-Spence, 2014).

Each individual verb in the data set was coded for these four categories by one of the authors of this paper. If a verb occurred with two objects (i.e., a direct and an indirect object), the verb token was counted as two items: once for each object. The annotations were binary features (`yes` vs. `no`), but for the Object-dependent categories (i.e., Handshape and Directionality) also matched to the relevant object. That is, the Handshape value `yes` would only be assigned for the object indexed by the handshape. Each item in the data set was also annotated for whether its Object was `human` or `inanimate`.[3] Thus, we could differentiate the four complexity features' effect on word order on the basis of the animacy of the Object in question.

Each Object was also annotated as Overt or Elliptical: that is, if the Object occurred within the same clause as its Verb, it was coded as Overt; if the Object was present in an adjoining clause, it was coded

[2] Adding adverbial meaning by use of grammaticalised mouth gestures.

[3] In the elicitation stimuli, no referents were `[-human,+animate]`.

Table 2: Video clips for the clause elicitation task

Valency	Event
Monotransitive	A girl tearing a paper A man placing a book on a bookshelf A girl pulling a cart through a living room A man tapping a watermelon on a table A woman lifting a box onto a table A girl pulling a man by the hand A woman looking at a man A girl feeding a woman A woman rolling a ball on the floor A woman pushing a girl A man tapping a girl by the shoulder A girl brushing a woman's hair A man washing a plate
Ditransitive	A woman giving a shirt to a man A man throwing a ball to a girl A man showing a woman a picture A woman taking a pair of scissors from a girl

Table 3: Comparison between `OV` and `VO` orders per condition. Numbers indicate p-values as obtained by the bootstrap test, with p-values indicating the probability that the `OV` condition is not significantly more complex than the `VO` condition. `n/a` indicates a too small sample size to examine the difference in question.

Object type	All	Overt	Overt-hum	Overt-inanim
DO + IO	< 0.0005	< 0.01	< 0.05	< 0.001
DO	< 0.0005	< 0.01	> 0.05	< 0.001
IO	> 0.05	n/a	n/a	n/a

as Elliptical.[4] For the latter, the order of `V` and `O` was determined by linear order on the utterance level.

2.2 Statistical Analysis

In order to avoid making unwarranted assumptions about the distribution of the variable we investigate (verb complexity), we chose to use a non-parametric bootstrapping test (Efron and Tibshirani, 1990; Efron and Tibshirani, 1994). Instead of fitting the parameters of a distribution specified a priori to our data, we repeatedly resample from our original sample (the data) to estimate the amount of variation and thus the significance of our results. For a high-level introduction to this statistical method, we refer the reader to Calmettes et al. (2012).

In the data set used in this paper, we compare annotations of 145 verbs. We calculate the complexity of each verb as being the number of features present, divided by the maximum number of features (see Table 1). We then use bootstrap resampling to estimate the populations as divided into two groups, comparing the complexity between `OV` and `VO` items.[5] We subdivide our data into groups depending on whether or not the argument is `overt`, and if so whether or not this argument is `[+human]` or `[+inanimate]`. Additionally, we investigate whether the Object in question is direct (`DO`) or indirect (`IO`). This leads to a total of 12 possible comparisons between the `OV` and `VO` orders.

3 Results and Analysis

Running a bootstrap resampling test with resampling, using 10,000 iterations estimating the mean of the populations, yields differences at the p-levels reported in Table 3, with $p < 0.05$ indicating that the mean complexity of `OV` is significantly higher than that of `VO`.

[4] Cases of covert, implicit (i.e., semantic) Objects were excluded from the data set.

[5] We use the implementation found at `http://gcalmettes.github.io/bootstrap-tools/`.

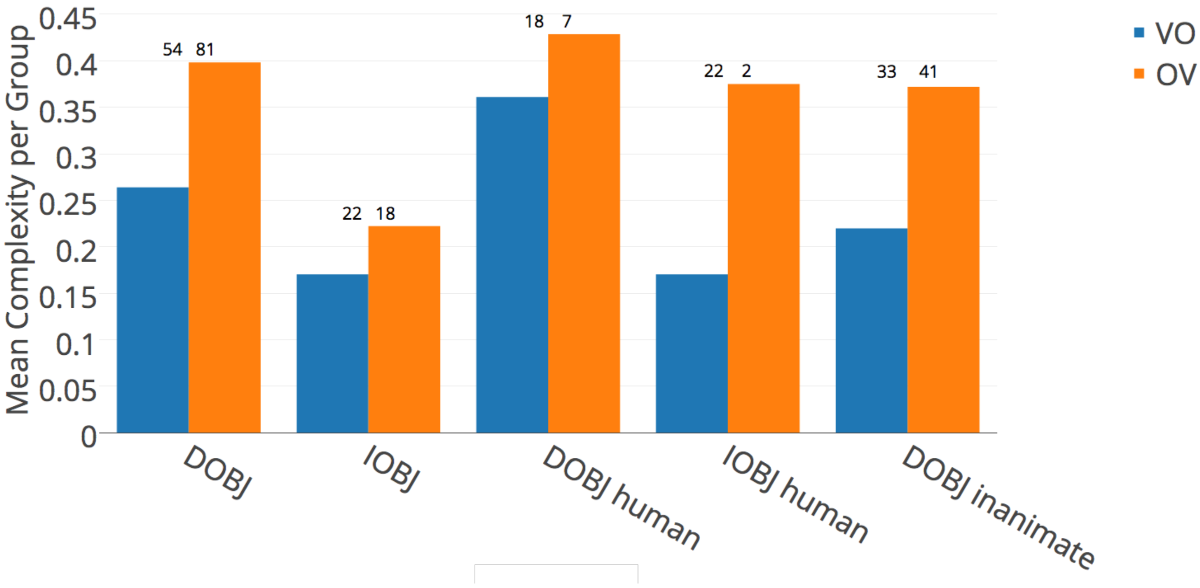

Figure 1: Mean complexity (y-axis) and number of samples (numbers above each bar) per condition. IOBJ inanimate is not plotted as the condition contains no data.

We see a division here on the basis of animacy. For all tokens (`DO` + `IO`), we see that the mean complexity in `OV` is significantly higher than that of `VO` across conditions. For the `DO` tokens, the same is true for all conditions but the `overt-human`. For the `IO` tokens, there is no significant difference between `OV` and `VO` based on complexity. Instead, an important aspect here is that the `IO` row contains several `n/a` cells. This is due to that fact that for the `IO` tokens (of which all are `[+human]`), the distribution of `VO` vs. `OV` is so skewed that practically all items fall into the former category, making statistical testing impossible (see Figure 1).[6] This should be taken as an indication that humanness is, in fact, associated with the `VO` order to a high degree, which corroborates the findings by Meir et al. (in press). Thus, while morphologically complex verbs prefer the `OV` order, humanness pushes towards `VO`.

4 Discussion and Conclusions

We have shown that morphological complexity is a relevant factor when investigating word order patterns in SSL. From a computational perspective, this suggests that machine learning approaches to SSL could benefit from using morphological complexity and animacy as features. As claimed for other sign languages (Napoli and Sutton-Spence, 2014), the incorporation of Object features (Handshape classifiers and Directionality) together with other morphological features (Reduplication and Non-manual marking) influence the ordering of `V` and `O` in SSL. Furthermore, animacy features of the Object also affect the ordering of `V` and `O`, such that `[+human]` Objects push towards the order `VO`. As argued by, e.g., Meir et al. (in press), this would be explained by disambiguation strategies in reversible sentences, observable in several emerging sign languages. That is, for sentences in which both `S` and `O` are possible Agents, the roles are disambiguated by separating `S` from `O` by putting `V` in between the two. In the case of non-reversible sentences, this strategy is not needed, and other preferences may play a larger role. For general linguistic theory, this relates to the notion of Differential Object Marking (Bossong, 1985; Aissen, 2003), and the preference of explicitly marking Objects that are high in the prominence hierarchy (e.g., animacy).

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[6]The data is elicited based on video stimuli, which makes it quite challenging to elicit data for the `IO -human` condition.

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