When nonmanuals meet semantics and syntax: a practical guide for the segmentation of sign language discourse

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Abstract

This paper aims to contribute to the segmentation of sign language (SL) discourses by providing an operational synthesis of the criteria that signers use to segment a SL discourse. Such procedure was required when it came to analyse the role of buoys as discourse markers (DMs), which is part of a PhD on DMs in French Belgian SL (LSFB). All buoy markers found in the data had to be differentiated in terms of scope: some markers (like most list buoy markers) seemed to be long range markers, whereas others (like most fragment buoy markers) seemed to have a local scope only. Our practical guide results from a hierarchized and operationalized synthesis of the criteria, which explain the segmentation judgments of deaf (native and non-native) and hearing (non-native) signers of LSFB who were asked to segment a small-scale (1h) corpus. These criteria are a combination of non-manual, semantic and syntactic cues. Our contribution aims to be shared, tested on other SLs and hopefully improved to provide SL researchers who conduct discourse studies with some efficient and easy-to-use guidelines, and avoid them extensive (and time-consuming) annotation of the manual and non-manual cues that are related to the marking of boundaries in SLs.

Keywords: segmentation, discourse unit, head nod, eye blink, head movement, eye gaze, pause, sign hold, role shift, palm-up

1. Introduction

Several studies on different sign languages (SLs) have faced the necessary but tricky question of segmenting signed discourses (Crasborn, 2008; Ormel & Crasborn, 2012). When segmentation is tackled with the sentence as standard unit, the researcher faces the problems of the syntactic delimitation of predicates in SLs and the determination of the syntactic status of simultaneous constructions that are typical to SLs (Crasborn, 2008). Both problems are not solved to date. In a number of studies (Crasborn, 2007; Fenlon et al., 2007; Hansen & Heβmann, 2007; Herrmann, 2009; Hochgesang, 2009; Jantunen, 2007; Nicodemus, 2006; 2009), segmentation has been approached from a prosodic perspective, namely by considering that prosodic cues reflect the syntactic organisation to some extent. From these studies, we know that various manual (e.g. palm-up signs, sign holds) and non-manual cues (e.g. eye blinks, head nods) contribute to the marking of "intonational phrases" or, more generally, of "boundaries" (Fenlon, 2010) in SLs. None of these cues functions as dominant cue by itself; on the contrary, boundaries are frequently marked by a layering of several prosodic cues.

The emergence of large-scale SL corpora and the discourse studies they make possible imply a new (practical) perspective on SL discourse segmentation. In our case, the study of the role of buoys as discourse markers led us to compare the scope of the different buoys markers observed in our data. Some markers (like most list buoy markers) seemed to be long range markers, whereas others (like most fragment buoy markers) seemed to have a local scope only. We observed that such scope differences get a more enlightening interpretation when they are interpreted in terms of "discourse units" rather than in terms of number of signs. Nevertheless, our concern was how to delimit such discourse units in a consistent (and shared between researchers) way since we did not have any tool or guidelines, which allowed us to do so.

The purpose of this work is to solve the above mentioned lack of guidelines for discourse segmentation by extracting a synthesis of the criteria that seem to influence the segmentation of three deaf (two native and one non-native) and two hearing (non-native) LSFB signers. Such synthesis will be organized into a set of guidelines that describe a minimalist, hierarchical and operative set of criteria that allows the standardisation of discourse segmentation among researchers of different SLs, among different SL corpora and within the same SL corpus.

This contribution is divided into four parts: section 2 explains the methodology we used to carry out our study, section 3 gives an account of the quantitative results of this pilot study and tackles one specific cue (eye blinks layered with head nods), section 4 explains the principles that led us to the elaboration of the segmentation protocol and proposes a guideline composed of four steps in order to segment a SL discourse into units, and section 5 contains the summary and conclusions of our research.

2. Methodology

We used a one-hour corpus of one signer (Gabarró-López & Meurant, 2013) made up of two argumentative (A1 and A2), two explicative (E1 and E2), two metalinguistic (M1 and M2) and two narrative (N1 and N2) discourses. Each group was balanced in terms of time. We mixed spontaneous and prepared productions as well as monologues and dialogues, so that the sample contained very different data with the most possible speech contexts.

In order to practically define discourse units, we designed a two-stage process that we named “copy test” and “cut test”. The first stage (“copy test”) consisted in taking a three-minute sample of each genre and asking the three deaf people to repeat the content and the signs of the clips to an experimenter who did not see the video. To do so, they first watched the three minutes of one video and afterwards they had to watch it again and stop the video whenever they thought it would be convenient for them. They repeated each segment to the experimenter who was sitting beside them and who was in charge of coding their fragments in ELAN. This procedure was repeated for the other three videos. It aimed to bring the segmenters to cut the discourses into semantically coherent units. The second stage (“cut test”) consisted in cutting the whole corpus into discourse units. The instructions given to both hearing and deaf annotators were that they had to watch the video and segment whenever they thought it was possible to cut the discourse. Each video was segmented using ELAN by a minimum of two people and by a maximum of four. Moreover, among these four people, three participated in the “copy test” as well.

Once both tests were finished, the tier “Common_units” and “Common_cues” were created. The first aimed at showing the number of annotators who had segmented in a particular place in the “copy test”, whereas the second aimed at gathering all the boundaries where at least two segmenters had coincided in the “cut text” so that we could create the list of cues appearing at that particular boundary.

3. Results

For the sake of clarity, our results are divided into three subsections: the first and the second one contain quantitative data and are related to the “copy test” and the “cut test” respectively, and the third contains qualitative data that tackles the case of a particular cue, i.e. the eye blinks layered with head nods.

3.1 The “copy test”

In this subsection, we will present three different sets of data, which concern the “copy test”: (i) the inter-segmenter agreement, (ii) the frequency of appearance of manual and non-manual cues at common boundaries, and (iii) the distribution and weight of boundary cues.

3.1.1. Inter-segmenter agreement

For the “copy test”, we found a total of 190 boundaries spotted by the participants of the “copy test” being 95 at the beginning (b) of a segment and 95 at the end (e). Both letters (b and e) are followed by the number of segmenters who had agreed on a particular boundary. The following table shows a summary of the data.

Common beginnings or ends	Number of boundaries	Percentage
e1 (idem for b3)	55	57.89%
e3 (idem for b1)	31	32.63%
e2 (idem for b2)	9	9.47%
total (including b)	95 (190)	100%

Table 1: Annotator agreement on the (begin and end) boundaries in the “copy test”

These data show that one boundary is commonly noticed by three segmenters out of three, so a third of the boundaries are undeniable. Most of the boundaries (more than one out of two) were only spotted by an annotator (not always the same one), which means that beyond undeniable boundaries (32.63%) and shared boundaries (9.47%), there is a high number of possible boundaries that varies from one segmenter to the other. Such divergence may probably be related to the capacity of memorising.

Moreover, the comparison between the “copy test” and the “cut test” allows us to refine the analysis of the "e1" boundaries of the "copy test". Indeed, 60% of the "e1" boundaries (33 out of 55) correspond to a boundary, which was at least noticed by two segmenters in the "cut test". This refines the picture of the inter-segmenter agreement in the "copy test". These figures confirm that these boundaries had to be considered as coherent from a discourse perspective and linguistically founded.

3.1.2. Manual and non-manual cues at discourse units’ boundaries

Once the “copy test” had taken place in the twelve-minute sample of the corpus, we crossed the results of the boundaries that had been spotted by any of the three deaf segmenters with the manual and non-manual cues appearing at every boundary that we had coded in the “Common_cues” tier. Table 2 shows every cue that was boundary marking, the number of times that it occurred and the percentage that it represents. The sum of percentages is higher than 100% because the cues of the list are sometimes layered since one boundary is often marked by several combined cues.

The criteria highlighted in grey made up the top seven cues noticed for segmentation and their percentage of appearance is over 10%. Pauses are by far the cue, which coincides more often with the segmentation resulting from the “copy test” (64 occurrences, i.e. at 67% of the boundaries spotted). This is not surprising, since pauses are organised in a systematic way that reliably indicates intonational phrase boundaries (Fenlon, 2010). Our definition of pause for this work coincides with this author: they are periods of no signing at all that can be divided into weak pauses (hands still raised but relaxed) and strong pauses (hands are dropped to the signer’s lap or clasped together).

Eye blinks co-occurring with head nods seem to be the most common and recurrent non-manual boundary marker that segmenters look at with 38 occurrences (40%)[1]. Sign holds (the final handshape of a sign is held in final position for a longer duration) are also an easy-to-notice cue that comes right afterwards with 23 occurrences (24%). Changes in head position layered with eye gaze also appeared as cues in 19 boundaries (20%), whereas eye blinks occurred at 17 boundaries (18%).

Cue	Number of appearances	Percentage
Pause (1)[2]	64	67%
Eye blink layered with head nod (3)	38	40%
Sign hold (2)	23	24%
Change in head position layered with a change in eye gaze (4)	19	20%
Eye blink (8)	17	18%
Role shift (5)	14	15%
Palm-up (9)	11	12%
Head nod (10)	5	5%
Bracketing repetition (6)	4	4%
Head movement (11)	4	4%
Change in eyebrow position (13)	3	3%
Buoy (14)	3	3%
Rhetorical question (7)	2	2%
Change in eye gaze (12)	1	1%

Table 2: Frequency of appearance of the different cues at the 95 common boundaries of the "copy test"

Even if role shift is in the sixth position with 14 occurrences (15%), it is commonplace in narratives and very often the boundary of a discourse unit was found there. On the contrary, palm-ups could be found in all discourses (monologue and dialogue, prepared and spontaneous) but their presence at a boundary is not that common (11 occurrences, i.e. 12%).

3.1.3. Distribution and weight of boundary cues

The data in the previous sub-subsection illustrates the cues used in the "copy test" that coincide with a discourse unit boundary, regardless of whether it was one segmenter, two or the three of them who spotted that boundary. The aim here is to give an account of the cues noticed by the three segmenters at the same time, by the two and by only one.

The three segmenters (e3) coincided in 31 boundaries, 30 were featured by the pause and one was featured by a sign hold. Therefore, the pause is a key cue to mark discourse units' boundaries (not very surprising as we said in 3.1.2) and the sign hold may have the same effect (we have sometimes found cases of 5-seconds holds). In very few cases we had boundaries marked by only two segmenters (e2). Once again the pause was par excellence the most common cue appearing at 8 boundaries out of 9, whereas the role shift was present in the remaining one.

As regards the boundaries noticed by only one segmenter (e1), we observed that 33 boundaries out of a total of 55 in the "copy test" (i.e. 60%) are also boundaries spotted by at least two segmenters in the "cut test". The pause is still the dominant cue with 18 occurrences, whereas the role shift accounts for 12. In conclusion, 28 boundaries out of 33 contain one of these two cues, whereas the remaining 5 are a combination of cues (3+9, 8+4, 8+8+2, 8+4), which means that a blinking has always occurred.

3.2 The "cut test"

In this subsection, we will present two different sets of data that relate to the "cut test": the inter-segmenter agreement and the frequency of appearance of the different manual and non-manual cues. The "cut test" was conducted on a one-hour corpus (including the 12 minutes of the "copy test") and contains four different situations whose discourses were at least segmented by two people each.

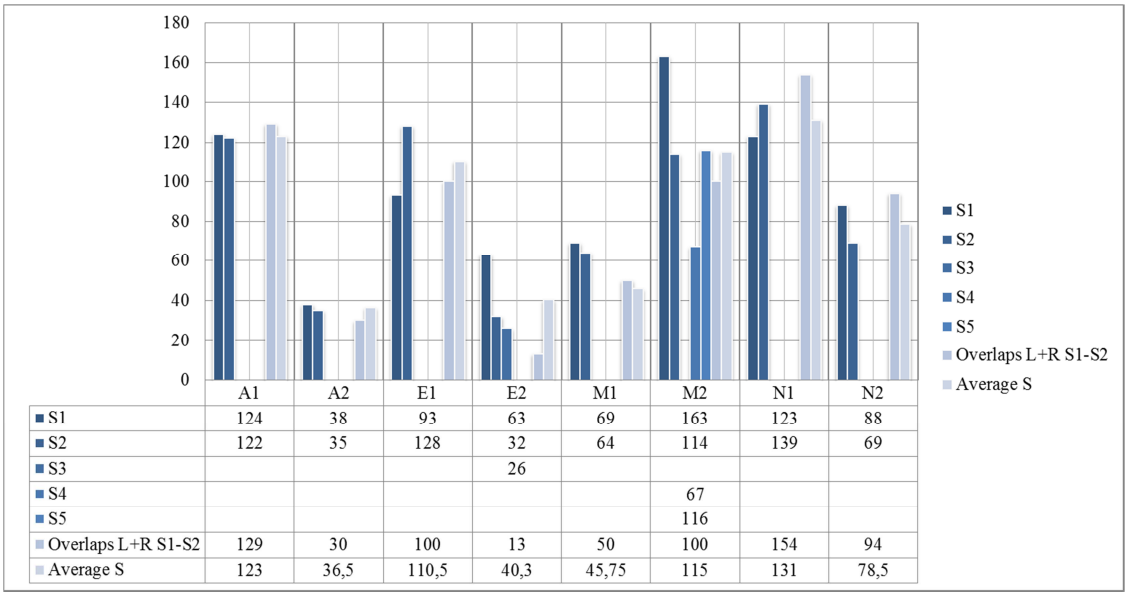
3.2.1. Inter-segmenter agreement

To begin with, we can see that the number of segments in a particular video varies sometimes greatly from one discourse to another due to the different length of each video and to the different situation in which the signer is found, i.e. monologue and dialogue. The agreement between segmenters tends to be high, at least between two segmenters participating in the same annotation file. Figure 1 illustrates the number of segments per segmenter (S) in each discourse, the right and left overlaps taking place within S1 and S2 segments (Overlaps L+R) and the average number of segments resulting from S1 and S2 segmentations.

The segmentations of six discourses out of a total of eight show a high degree of similarity from one segmenter to another. Numbers are very similar in A1, A2 and M1. E1, N1 and N2 show a slightly lower rate of agreement compared to the previous discourses but which, in any case, remains high.

[1] This statement about the semantically-guided boundaries the segmenters spotted is in line with the conlcusions of Herrmann (2010) about the consistency and the frequency of use of eye blinks to mark prosodic boundaries.

[2] The numbers following each cue are the codes that we used in order to annotate them in the "Common_cues" tier. This list of codes and cues comes from our first hypotheses on what cues (be them manual, non-manual, phonologic, syntactic or semantic) seemed to have more influence to spot a boundary.



	A1	A2	E1	E2	M1	M2	N1	N2
S1	124	38	93	63	69	163	123	88
S2	122	35	128	32	64	114	139	69
S3				26				
S4						67		
S5						116		
Overlaps L+R S1-S2	129	30	100	13	50	100	154	94
Average S	123	36,5	110,5	40,3	45,75	115	131	78,5

Figure 1: Inter-segmenter comparison in the "cut test"

E2 and M2 were segmented by more than two people. In M2, we can see that the numbers vary but at least two segmenters, S2 and S5, have very similar figures, and they are very close in the overlaps' sum as well as in the average. In E2, the results we got are weaker than those for the other videos because S1 segments almost double the number of S2 segments. S2 segments embrace most of S1 segments (there are 53 surrounding). Nevertheless, if we compare the segmentation performed by S2 with that of S3, we get more consistent results since S3 had 26 segments with 17 left overlap and 16 right overlap (i.e. 33 L+R) and the average of segments is 29.

3.2.2. Manual and non-manual cues at common boundaries

The "cut test" gave as a result 591 segments where at least two segmenters had coincided. Table 3 illustrates the name and the code of each cue, the number of appearances of each one and the percentage. As in Table 2, the sum of percentages is higher than 100% because the cues of the list are often layered in a single boundary.

If we compare this table with the previous one, we can see that results are not divergent. On the one hand, the same seven cues are found at the top of both lists with two almost anecdotal inversions: the change in head position layered with a change in eye gaze is in the third position and the sign hold in the fourth in the "cut test" list whereas it was the other way round for the "copy test", and the same happens with role shift which is now in the fifth position and the eye blinks in the eighth for the "cut test". On the other hand, the percentages are similar from one experience to the other, which means that regardless of the instruction that is given and how it is carried out, the same cues appear to be influent when it comes to segment the discourse into units.

In addition, Table 3 has a supplementary cue: the repetition of a sign (AA or AAA) that we only found in M2. We think that it is due to the nature of the video: it is a non-prepared dialogue on metalinguistic issues. Even if the number of boundaries where it occurs is not representative, the sample we took for the "copy test" does not include repetitions of a sign so we do not know whether a segmenter would have spontaneously marked a boundary there or not.

Cue	Number of appearances	Percentage
Pause (1)	304	51.4%
Eye blink layered with head nod (3)	266	45%
Change in head position layered with a change in eye gaze (4)	187	31.6%
Sign hold (2)	142	24%
Role shift (5)	137	23.2%
Eye blink (8)	81	13.7%
Palm-up (9)	77	13%
Head movement (11)	43	7.3%
Head nod (10)	27	4.6%
Change in eyebrow position (13)	21	3.6%
Bracketing repetition (6)	18	3%
Rhetorical question (7)	17	2.9%
Change in eye gaze (12)	13	2.2%
Buoy (14)	12	2%
Repetition of a sign (AA or AAA) (15)	2	0.3%

Table 3: Frequency of appearance of the different cues within 591 segments arising from the "cut test"

3.3 Eye blinks layered with head nods

Eye blinks layered with head nods (cue 3) is one of the most commonly spotted cues at discourse unit boundaries

being present in 45% of the boundaries. However, it is a special and sometimes tricky cue that deserves a specific subsection.

Unlike all the other six cues that could be found at the top of Table 2 and Table 3 (pause, change in head position layered with a change in eye gaze, sign hold, role shift, eye blink and palm-up), eye blinks combined with head nods can also act as linkers between two syntactic components; the first component is dependent on the second one, and thus do not correspond to a discourse unit. This means that while we can say that some other cues are conclusive to mark the end of a segment, we have to be careful with cue 3 (c3) because if we always segment there, we can lose the true syntactic construction of the discourse unit as well as its meaning. The three examples below illustrate this phenomenon of eye blinks combined with head nods.

(1) COMMUNICATION-SUPPORT-WORKERS
ce-up c3
SIGN-WRONG OUT PEOPLE SEE GOOD IT GOOD
"Even if communication support workers do not sign well, outside people see it and think they do well"

(2) DATE MEETING DATE CONFERENCE DATE
ce-up c3
TRAINING SEMINAR INTERPRETER THERE-IS-NOT NOT FIND PALM-UP REPLACE COMMUNICATION-SUPPORT-WORKER TAKE SAY NO
"When there is a meeting, a conference or a seminar and there is no interpreter there because none was found, and it is replaced by a communication support worker, say no!"

(3) YEAR UP-TO-NOW DEAF GROWING-GROUP
c3
COLLEAGUES STRUGGLE WANT INTERPRETER HIGH-LEVEL
"For years now, we (a growing group of deaf colleagues) have struggled to get high-level interpreters"

In the first two examples, the eye blink layered with a head nod that occurs in the middle of the utterances is the link between the two parts of a temporal syntactic structure, so no segmentation must be made there. Nevertheless, these cases where c3 is not a boundary can be easily isolated because (i) they come close after a boundary, (ii) there is no other associated cue, and (iii) the chin and the eyebrows go up (ce-up) in the first part of the segment before the eye blink layered with a head nod takes place.

The third example is different from the other three in articulatory and semantic terms. Here c3 marks the end of a kind of parenthetical comment that makes explicit the agent of the utterance, i.e. "*we (a growing group of deaf colleagues)*". Once again, the two first criteria that we mentioned above (cue 3 is near a boundary and not combined with another cue) are valid to distinguish whether it is a discourse unit boundary or not.

Anyhow, when an eye blink layered with a head nod is not associated with other cues, the segmenter will have to verify the possible role of cue 3 as a syntactic linker, especially if such cue is close to a discourse unit boundary.

4. A proposal for SL discourse segmentation

As we said at the beginning of this contribution, our purpose is to create a set of guidelines, which allow the standardisation of discourse segmentation among researchers of different SLs, among different SL corpora and within the same SL corpus. The tool that we are proposing aims to facilitate inter and intra corpus/ora comparisons in the field of discourse analysis and thus to facilitate the elaboration of studies on the position of an element as regards segment boundaries and the development of automatic language processing tools, to name a few of its potential usages.

4.1 The principles of the guidelines

To conceive these guidelines for discourse segmentation, we decided to base our research on the spontaneous segmentation carried out by three deaf signers (two natives and one non-native) and two hearing non-native signers (see previous sections). Such procedure was systematized, the criteria taken into account for the segmentation was minimized and the criteria that could be easily spottable when watching a video were favoured, so priority was given to phonological criteria, i.e. to the "visible markers" (Fenlon, 2010). Since our goal was to avoid the time-consuming annotation of manuals and non-manuals as well as long lists of cues to look at, we limited as much as possible the number of elements to take into account for the segmentation. Last but not least, we wanted to propose a tool that avoided wrong segmentations or, in other words, we did not want to create a too powerful and rigid procedure that would allow the segmentation in the right places but also in the wrong ones.

4.2 The guidelines for discourse segmentation

The intuitions we had after the first segmentations of video were that we would compulsory need a combination of at least four cues – a pause, a sign hold, an eye blink layered with a head nod or a change in head position layered with a change in eye gaze – in order to segment without mistakes. Surprisingly, the results of both tests showed that we only need a set of two cues to process an almost complete segmentation that is consistent with the linguistic intuitions of the signers: cue 1 (pauses) and cue 3 (eye blinks layered with head nods). Then, three additional cues (5, 8 and 4) allow the segmentation to be refined.

To get optimal results from our segmentation protocol, the segmenter needs to watch the video thrice, if it is the first time that he is confronted with the discourse. The first

time he will only watch the video, the second he will segment it into discourse units (steps I, II and III) and the third he will verify that the segmentations are situated in the right places (step IV). However, the last two viewings will suffice if the segmenter already knows the video or has already worked with it.

The four steps for the segmentation into discourse units are the following:

I. As a general rule and for all kinds of discourse, segment at every pause (i.e. periods of no signing no matter whether hands are still raised, dropped to the signer's lap or clasped together) and at every sign hold.
II. For narrative discourses, which usually involve characters and dialogues, segment at the end of every constructed dialogue and role shift.
III. Segment systematically at every eye blink layered with a head nod (cue 3) (or at every combination of a blink (cue 8) in the close context of a change in eye gaze and head position (cue 4)).
IV. Remove all the eye blinks layered with head nods acting as discourse unit linkers (see for example the three criteria given in section 3.3).

The identification of manual and non-manual cues meets the tracking of semantic units of role taking and some syntactic relationships.

5. Summary and conclusions

This paper has contributed to the topic of segmentation of sign language (SL) discourses by creating a practical and easy-to-use layout for discourse segmentation which avoids time-consuming annotation of every nonmanual. To do so, we have tried to (i) understand the hierarchy of criteria that lead native and non-native signers towards the identification of segment within a discourse, and (ii) see how we could organise in an operational and minimalist way the intuitions of signers. Our objective was not to predict where a signer would segment spontaneously, but to standardize the segmentation among researchers working in the field of discourse analysis and providing them with a systematization of the linguistic intuitions of signers.

We designed two tests in order to elicit the spontaneous segmentations. The first one ("copy test") involved the three deaf segmenters, who were asked to watch four video samples of a one hour corpus and stop them whenever they found it necessary in order to repeat in detail the same signs with the same meaning to another researcher who was copying their segments into an ELAN file. The second one ("cut test") consisted in having the five segmenters (at least two per file) viewing and segmenting the whole corpus containing different discourses directly in ELAN.

The results show a high consistency between both tests. Seven manual and non-manual cues are the most commonly used by segmenters to spot segment boundaries: pauses, eye blinks layered with head nods, changes in head position layered with changes in eye gaze, sign holds, role shifts, eye blinks and palm-ups. The results also show a high rate of inter-segmenter agreement. We could then consider the spotted boundaries as coherent from a discourse perspective and linguistically founded. The comparison between the "copy test" and the "cut test" proved that more than half of the boundaries spotted in the "copy test" corresponded to a boundary which was at least noticed by two segmenters in the "cut test", which means that these boundaries had to be considered linguistically coherent.

We have also tackled the particular case of the eye blinks layered with head nods, which sometimes may have a linker role rather than a boundary marking cue role. As a final point, we have presented the principles, which guided us towards the creation of this segmentation protocol and the steps which compose it.

Since this is a pilot study, we are well aware of its shortcomings, the first one being that the videos are featured by one signer only, hence we want to test our protocol with a larger sample of the LSFB Corpus which contains a wider sample of discourses and different signers. Such testing would allow us to get even more solid results and would also prove whether these guidelines are suitable for segmenting the discourse of any signer. Finally, we would also like other SL researchers to test these guidelines with their data on other SLs and give us feedback on their experience and the possible issues to implement.

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