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Pauses and syntax in American Sign Language*

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Abstract

Research on spoken languages has shown that the durations of silent pauses in a sentence are strongly related to the syntactic structure of the sentence. A similar analysis of the pauses (holds) in a passage in American Sign Language reveals that sequences of signs are also interspersed with holds of different lengths: long holds appear to indicate the ends of sentences; shorter holds, the break between two conjoined sentences; and the shortest holds, breaks between internal constituents. Thus, pausal analysis is a guide to parsing sentences in ASL.

Several studies have shown that the durations of silent pauses in a spoken sentence are strongly related to the syntactic structure of the sentence. Grosjean and Deschamps (1975), for example, analyzed English and French interviews and found that pauses at the ends of sentences were longer and more frequent than those within sentences; about 70% of all pauses occurred at major constituent breaks. With a reading task, where such grammatical pauses are not confounded with hesitation pauses, Brown and Miron (1971) report that "up to 64% of the pause time variance in an extended oral reading performance can be predicted from syntactic analyses of the message".

If a person is asked to read or recite a known passage slowly, then it turns out that, with decreasing rate, pauses first appear between sentences, next

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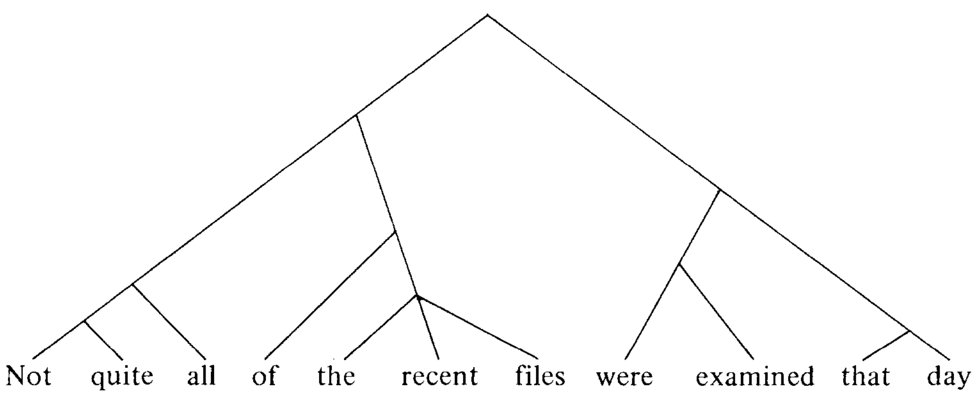
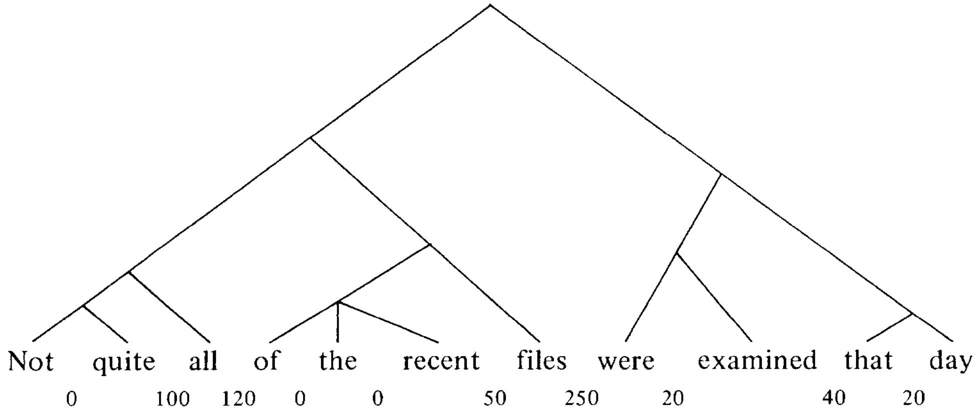
between major constituents (for example, NP and VP), and finally within these constituents. At any given rate, the pause durations are not equal; they reflect the importance of the syntactic breaks: for example, pauses within a major constituent are shorter than those between constituents (Grosjean, 1972; Lane and Grosjean, 1973). Indeed, L. Grosjean (1977) has shown that the surface structure tree of a sentence often can be reconstructed using only the record of pausing obtained from subjects reading the sentence at a reduced rate. To illustrate: one of the sentences in her study had the following surface structure tree:



Five readers read this sentence at five different rates including two rates above and three below normal; the average pause durations (in msec) are shown below, as is a hierarchical clustering of the words in the sentence based on these pause data:



The two structural descriptions are very similar; one measure of their correlation is the agreement between trees on the number of nodes dominating each successive pair of words. In this example, $r = 0.89$. In general, L. Grosjean found that there is substantial correspondence between the pause structure and surface structure of a sentence although deep structure and the length of the utterance may complicate the picture.

In the present study we are interested in the relationship, if any, between pauses and syntax in American Sign Language (ASL). It seems likely that sentence breaks in sign are correlated with semantic and syntactic information as well, perhaps, as facial expression, head tilt, body movement, raising of the eyebrows, decrease of signing speed, and pause duration (Fischer, 1975; Liddell, 1976; Baker, 1976). But can pause duration alone enable us to delimit ASL sentences, as Covington (1973) suggests? Further, can an examination of the pause durations separating signs within sentences produced at slow rate serve as a guide to obtaining the surface structure trees of the sentences? These are the questions we undertake to answer in the following paper.

Method

Subjects

The Ss were five adult native signers of ASL with deaf parents. Three Ss were congenitally deaf and two were hearing, ASL-English bilinguals. Each S signed a presented passage at five different rates, four times each, in a session lasting 30 minutes.

Materials

An English–ASL bilingual signer was asked to sign a story that she learned as a young child from her deaf parents, and a video recording was made (Sony AVC 3250S and VTR 3650). The first part of the story, Goldilocks, was transcribed literally into English, giving the following 52-sign passage*.

*Hyphenated glosses correspond to a single sign. It is important to recognize that the ASL passage reported here is not translated into English; in the absence of a writing system for ASL (but see Stokoe, Casterline and Croneberg, 1965), we have reported the passage by substituting an English gloss for each sign. The choice of English glosses is somewhat arbitrary; for example, the eighth sign might also be translated as GO-INTO. Our informants have also pointed out certain English influences on the sign passage, for example IT in REALLY DON'T LIKE IT.

LONG-TIME-AGO GIRL SMALL DECIDE WALK IN WOODS INTO WOODS SEE HOUSE INTO VERY HUNGRY THEN SIT-DOWN SEE BOWL BIG-BOWL EAT DON'T LIKE COLD MOVE-ON BOWL HOT REALLY DON'T LIKE IT MOVE-ON SMALLEST BOWL EAT-EAT PERFECT HUMM EAT ALL-GONE THEN SIT THREE DIFFERENT CHAIRS SAME THING HAPPEN ONE HARD ONE SOFT ONE PERFECT

The transcription was printed on a 70 × 55 cm panel; the letters were 12 mm high. The panel had a 9 × 9 cm hole at its center so it could be slipped over the lens of the video camera, located two meters from the subject.

Procedure

In order to avoid the variations in timing associated with spontaneous utterances (hesitation pauses, false starts and so on) and to obtain the identical passage at several rates of utterance, each S first practiced reading and signing the transcribed story. Once familiar with the story, S signed the passage at a normal rate. To the apparent rate of his signing E assigned the numerical value 10. A series of values (2.5, 5, 10, 20, 30) was then named in irregular order, four times each, and the signer responded to each value by signing the passage with a proportionate apparent rate. The signer was urged to use exactly the same signs at each rate. The 20 magnitude productions by each of the five Ss were recorded on videotape.

Data Analysis

With five signers producing the passage at five different rates, four times each, 100 recordings were made. We retained for analysis a representative sample of 25 by selecting for each signer, at each apparent rate, that recording whose signs per min (spm) was closest to the mean spm of the four replications of that apparent rate.

Two native signers of ASL, one congenitally deaf, the other a hearing ASL–English bilingual, independently measured the durations of the pauses in the five recordings selected for the first signer. Each of the judges separately viewed the recording at normal speed (Sony CVM 950 monitor) and noted the locations of the pauses. Then the passage was played back at 1/16 normal speed (Sony 3650 VTR) and the judge pressed a telegraph key for the duration of each pause. This response supplied a 1000-Hz coding tone to an audio tape-recorder (Tandberg 1600X). The recording was subsequently analyzed with a frequency counter: each pause duration in msec was equal to the number of cycles of the coding tone, divided by 16*.

Although the two judges worked independently and were not coached on their criteria for a pause, both delimited pauses in the same way. By their account, they detected a pause between two signs when either (a) a sign executed with continuous or repeated movement was extended by holding the hand(s) without movement in the terminal position; or (b) a sign executed with such a hold was extended by sustaining the hold. This type of pause corresponds to the "single-bar juncture, 'sustain' |I|" proposed by Covington (1973): "During the pause ... the hands are held in the position and often the configuration of the last sign". The judges also included as part of the pause the out-transition of the first sign, giving the following segmentation of the signing stream around each pause:

In transition	Sign	Hold	Out transition	Neutral	In trans...
Key up		Key down		Key up	

The intra-judge reliability was generally quite good (see Table 1) with a mean correlation of $r = 0.89$. The inter-judge reliability was slightly lower: the mean correlation between the durations reported by the two judges at each rate was $r = 0.80$ (they agreed on pause emplacements 88% of the time). Consequently, the recordings for the remaining four signers were analyzed by one judge, a congenitally deaf native signer of ASL.

A college student unfamiliar with ASL was also asked to analyze one passage (30 spm) to determine if a knowledge of ASL is required to identify and measure pauses. It turns out that it is not. Like the ASL judges, he viewed the passage first at normal speed to note pause emplacements, then at 1/16 speed to key in a coding tone concurrent with each pause. Our naive observer agreed on pause emplacements 86% of the time with judge 1 and

*The reduction in the speed of the video playback was calibrated as follows: a running chronoscope, graduated in centiseconds (Standard Timer S1), was videotaped at normal speed. The tape recording was played back at reduced speed and the same chronoscope was used to measure the time it took for the recording to show an elapsed time of one sec. There was an undershoot of about 5% early in the 0.5 inch reel and an overshoot of about 5% late in the reel. Consequently only the first 40% of the reels were recorded in the experiment and the mean reduction was computed to be $1/16 \pm 2\%$. The frequency of the recorded coding tone was calibrated with a frequency counter (Hewlett-Packard, 204A) and a correction was applied to the pause durations measured by counting cycles of that tone so that the readings were expressed in msec.

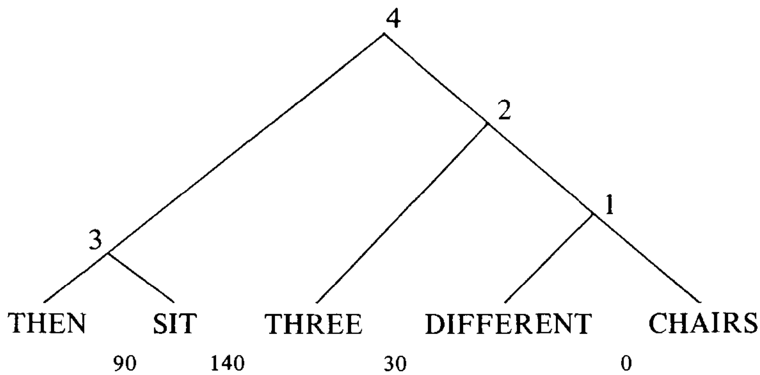
Table 1. *Intra-judge reliability in reporting pause duration in ASL. A passage signed at five different rates was analyzed twice by each of two judges. Shown are the rate of the passage, the average hold between every pair of signs on the first and second measurement, and the correlation between these two sets of measurements for each of the judges. (There were no pauses reported at the highest signing rate).*

Rate (signs/min)	Judge 1			Judge 2		
	Evaluation 1	Evaluation 2	r	Evaluation 1	Evaluation 2	r
30	0.79	0.73	0.95	0.72	0.71	0.91
52	0.51	0.52	0.86	0.47	0.52	0.80
80	0.31	0.32	0.91	0.32	0.33	0.91
147	0.15	0.15	0.83	0.14	0.12	0.93
193	0.00	0.00	1.00	0.00	0.00	1.00

80% of the time with judge 2 (the two judges agreed with each other 86% of the time on this passage). He agreed on durations r = 0.85 with judge 1 and r = 0.70 with judge 2 (the judges' duration measures correlated r = 0.76). Although he knew no sign language, his duration measures yielded slightly higher test–retest reliability than those of the native judges (r = 0.97 *vs.* 0.95 and 0.91).

The durations of the measured pauses were pooled over the five rates by each signer and over the five signers to give a grand mean duration, based on N = 25, for each of the possible pause locations in the text. These pause data were used to partition the paragraph into sentences and then to make hierarchical clusters of the signs within the sentences, according to the following iterative procedure: First, find the shortest pause in the sentence. Second, cluster the two elements (signs or clusters) separated by that pause by linking them to a node situated above the pause, and delete the pause. (If three or more adjacent signs are separated from each other by the same pause duration, make one cluster of these signs: trinary, quaternary, etc.). Finally, repeat the process until all pauses have been deleted. The following tree illustrates the process for a sentence from the Goldilocks story by labelling each node for the iterative cycle in which it was derived (grand mean pause durations in msec are shown at the bottom of the tree).

An examination of the pause frequencies at the 51 possible pause emplacements in the text showed them almost perfectly correlated with the mean pause durations at those emplacements (r = 0.97). Since the two judges showed high agreement on the presence or absence of pauses in the



five signed passages used for the reliability check and since this measure is much more readily obtained than pause duration, future studies of ASL syntax may prefer it to the temporal measure used in the following analyses.

Results and Discussion

Demarcating sentences

Figure 1 presents the grand mean pause durations for the Goldilocks text, averaged over signers and rates. The distribution of pauses in the signed text is not random; the holds appear to cluster the signs together in an orderly manner: long holds appear to mark the end of sentences, whereas shorter holds tend to occur within these sentences.

Figure 2 is a frequency distribution of the 51 ASL holds while Fig. 3 is the comparable distribution for the English version of the same text (6 speakers, 5 rates; Grosjean and Collins, 1977). Both distributions are approximately hyperbolic but contain significant peaks. In the case of English, we know from prior research on pausing in reading (see Grosjean, 1972) that the righthand peak is the mode of a distribution of long pauses occurring at the ends of sentences, whereas the first maximum reflects within-sentence pausing. In this particular English passage, all the pauses with duration ⩾ 445 msec were found at sentence breaks whereas pauses whose durations ranged from 245 to 445 msec were associated with breaks between conjoined sentences, between NP and VP, or between a complement and the following NP. Pauses with average durations less than 245 msec corresponded to breaks within constituents. Turning to the distribution for

Figure 1. *English glosses for the Goldilocks passage in American Sign Language with the pause durations (holds) obtained after each of the 51 signs. Each pause is the grand mean of 25 signing productions: each of five Ss signed the passage at five different rates.*

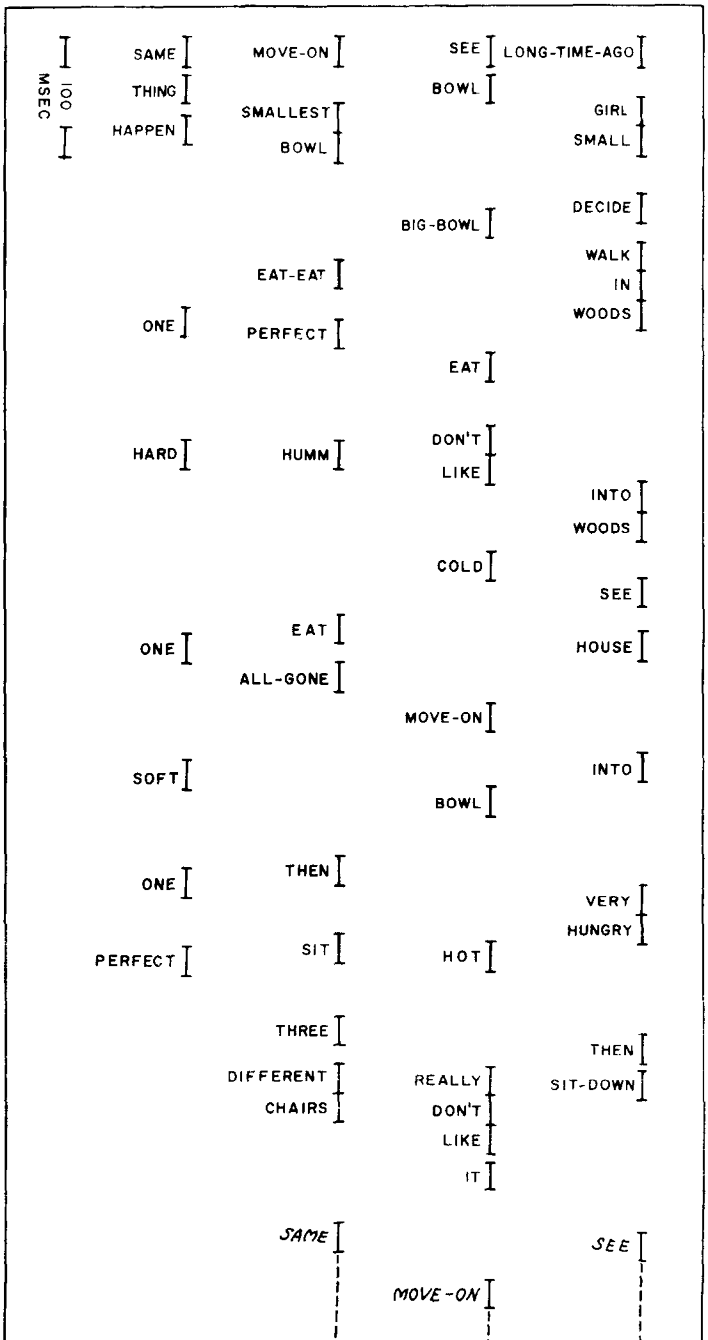


Figure 2. *Frequency distribution of the grand mean durations of 51 holds in the 25 signing productions of the Goldilocks text.*

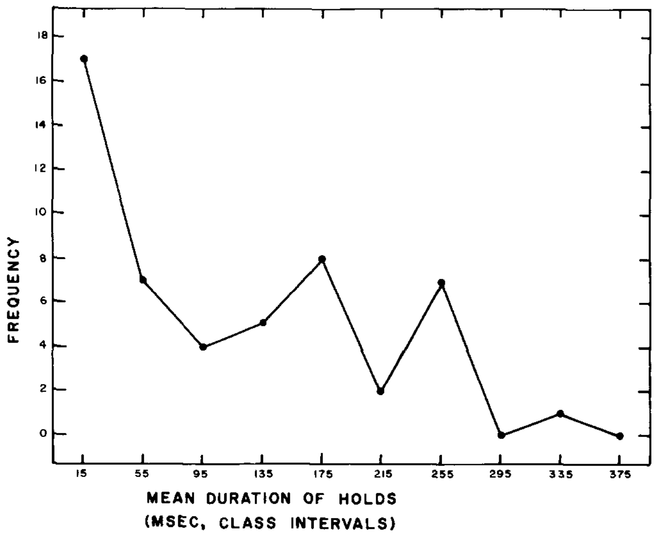
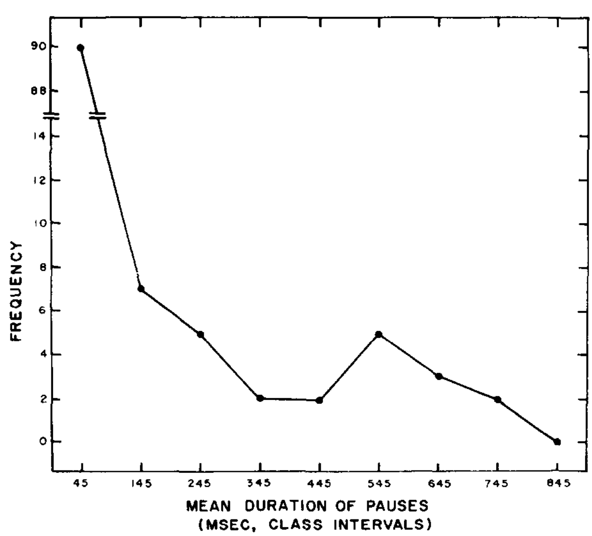


Figure 3. *Frequency distribution of the grand mean duration of 116 pauses in 60 readings of the English translation of the Goldilocks text (6 Ss, 2 readings at each of 5 rates).*



ASL (Fig. 2), we find that if we select once more all the pauses associated with the righthand distribution ($\geqslant$ 215 msec), we obtain the following segmentation of the passage.

1. LONG-TIME-AGO GIRL SMALL DECIDE WALK IN WOODS
2. INTO WOODS SEE HOUSE INTO VERY HUNGRY THEN SIT-DOWN
3. SEE BOWL BIG-BOWL EAT DON'T LIKE COLD
4. MOVE-ON BOWL
5. HOT REALLY DON'T LIKE IT
6. MOVE-ON SMALLEST BOWL EAT-EAT PERFECT HUMM
7. EAT ALL-GONE
8. THEN SIT THREE DIFFERENT CHAIRS
9. SAME THING HAPPEN
10. ONE HARD
11. ONE SOFT ONE PERFECT

It appears that longer hold durations correspond to the ends of simple and complex sentences. The adjacent mode in Fig. 2, at somewhat shorter hold durations (160 - 190 msec), reflects three different phenomena: first, holds following stressed signs: e.g., ONE_HARD, ONE_SOFT; second, holds where conjuctions might otherwise be expected: e.g., HOT_REALLY DON'T LIKE IT; third, holds of intermediate duration corresponding to pause emplacements where some signers put a sentence break (and hence a long hold) and some did not (hence a short or zero hold). Sentences 2, 3 and 6 enter into this last category. The differences in segmentation strategies followed by Ss are illustrated below (the locations of the sentence breaks and the number of Ss who chose the particular segmentation are shown). In

2. INTO WOODS SEE HOUSE $^{2}\underbrace{\text{INTO}}_{2}{}^{1}$ VERY HUNGRY THEN SIT-DOWN

3. SEE BOWL $^{1}\underbrace{\text{BIG-BOWL}}_{2}{}^{2}$ EAT DON'T LIKE COLD

6. MOVE-ON SMALLEST BOWL $^{3}\underbrace{\text{EAT-EAT PERFECT}}_{1}{}^{1}$ HUMM

sentence 2, for example, two Ss chose to segment the utterance after HOUSE; one S chose to do so after INTO; and two Ss chose two segmentations, after HOUSE and after INTO, thus producing three sentences: INTO WOODS SEE HOUSE, INTO, and VERY HUNGRY THEN SIT-DOWN.

For the following analysis of within-sentence structure, then, sixteen sentences were demarcated; a sign was considered to terminate a sentence if the following hold duration fell into the righthand mode of the pause distribution of at least two Ss (Fig. 2). This criterion demarcated sentences 1, 4, 5, 7, 8, 9, 10, 11 and the following other sentences:

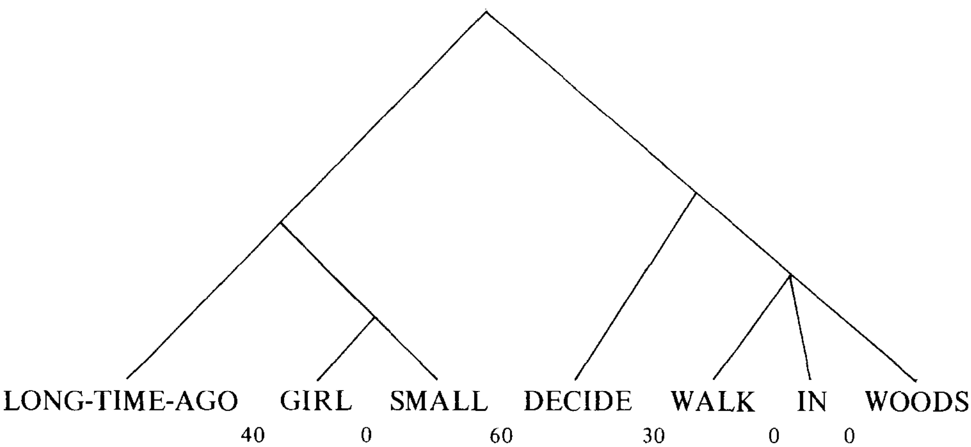
2a. INTO WOODS SEE HOUSE
2b. INTO VERY HUNGRY THEN SIT-DOWN
2c. INTO
2d. VERY HUNGRY THEN SIT-DOWN
3a. SEE BOWL BIG-BOWL
3b. EAT DON'T LIKE COLD
3c. SEE BOWL
3d. BIG-BOWL
6a. MOVE-ON SMALLEST BOWL
6b. EAT-EAT PERFECT HUMM

The mean sentence length was 3.25 signs; only one sentence is over 6 signs long (sentence 1) and two sentences are one sign long (sentences 2c and 3d). As will be seen below, several of the sentences in the passage are conjoined sentences (e.g., 2d). If we consider only the simple sentences, the average length is 2.82 signs, 0.43 signs less than the mean for the passage.

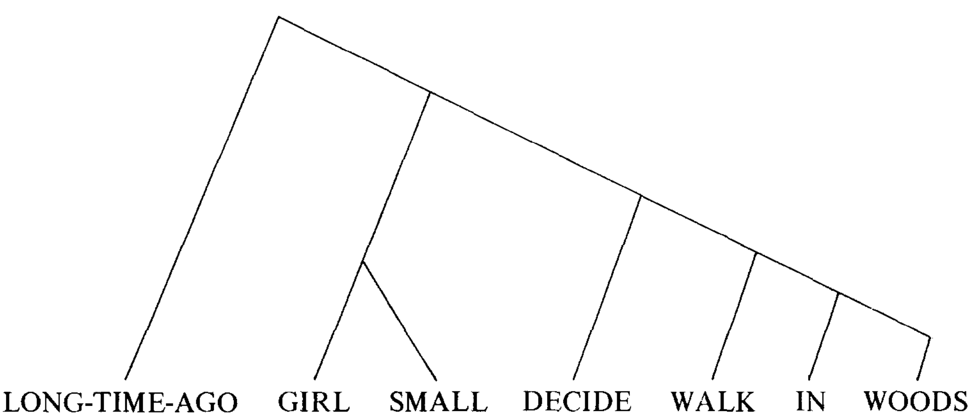
The structure of sentences in ASL

Although the end-of-sentence pauses appeared quite clearly at normal signing rate, the within-sentence pauses had to be provoked by asking the signers to sign at a rate slower than normal (more precisely, at half and at one quarter their normal rate). As can be seen from Fig. 1, this tactic was on the whole quite successful and almost every sign is separated from the next by a pause. Figure 4 represents sentences 7, 8, 9 as they were signed at each of the five rates. At the highest rate (173 spm), no holds occur between these sentences. At the next two rates (130 and 82 spm), the between-sentence breaks appear. Then, as the Ss sign the text at rates slower than normal, breaks start emerging between and within major constituents. At 59 spm, sentence 8 is already divided up into Conj–Vb–VP2 and at the slowest rate (39 spm) the other two sentences are also partitioned by holds. The question now is: Can these pauses be used as a guide in parsing the sentences just demarcated? The answer seems to be yes.

With the clustering procedure explained earlier applied to the grand mean pause durations, the following tree diagram was obtained for sentence 1:

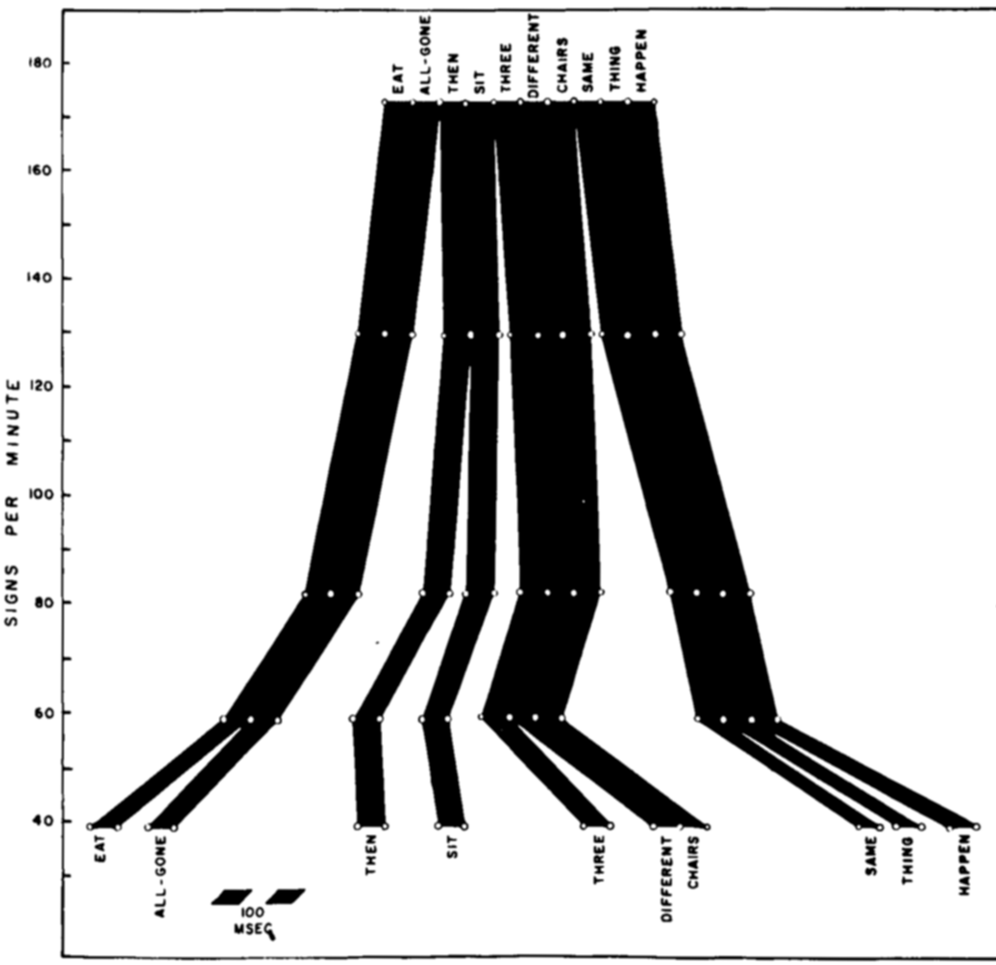


From this clustering solution, the breaks occur, by order of importance, between NP and VP (60 msec), between the Adv and NP (40) and between Vb and S (30). These terms imply a structural analysis such as the following:



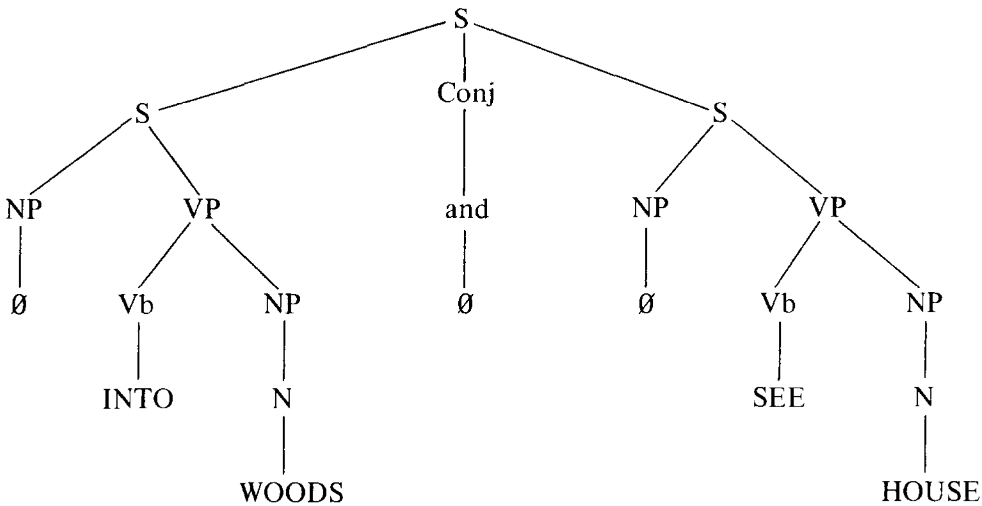
This immediate constituent analysis differs from the clustering of the signs in two ways. First, the verb phrase WALK IN WOODS remains as a single cluster in the performance tree, whereas it has structure in the linguistic tree. This is not a serious problem: the inclusion of more subjects, more replications, or lower rates of magnitude production would in all likelihood introduce pause structure where it is lacking. Second, the main break in the analysis is between NP and VP whereas in the structural analysis it is between ADV and S. This discrepancy may reflect narrative style in ASL

Figure 4. *The relation between hold durations and overall rate in an excerpt from a passage in ASL. As overall rate decreases, the syntactic structure of the sentences emerges in the pattern of hold durations (white spaces). Each hold is the mean of five productions, one by each of five Ss.*

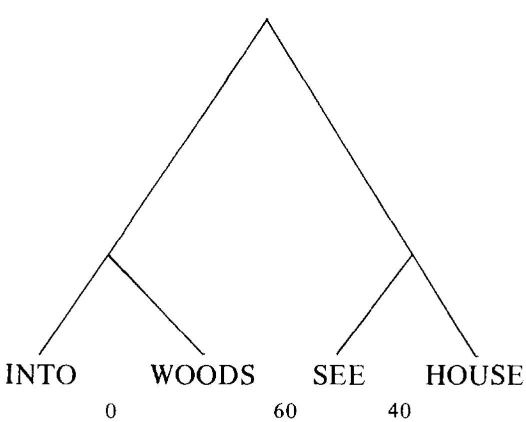


or a more general tendency to delimit units of equal length which interacts with the tendency to delimit constituents, often of unequal length. We have found a similar tendency in our analysis of recitation pausing in English.

Despite these complications, the pause data do prove to be a useful guide to parsing the ASL sentences previously identified. In the first place, they clearly reveal breaks between major constituents. The second sentence is an example of the many conjoined sentences in this passage:



The measures of pausing gave the following clustering:



Here we have a case of conjoining sentences where the conjunction has been deleted, as opposed to sentences 2b and 2d, for example, where it is maintained. The deleted conjunction is replaced by a pause, shorter than the end-of-S pause but longer than within-constituent pauses.

The frequency of conjunction deletion (it is also found in sentences 5 and 11) may be related to signing economy; it takes less time and effort to replace a conjunction by a hold of set length than to sign it. Perhaps signing economy also motivates the NP-deletion observed in this text; the subject has been identified at the beginning of the story and is therefore not reiterated in each sentence.

The durations of pauses indicate not only the breaks between simple sentences and between conjoined sentences, but also the boundaries between and within the major constituents of these sentences. For example, in sentence 9 (Fig. 4), a pause separates NP (THING) and the following VP (HAPPEN) and in sentence 5, the Adv and Vb (REALLY DON'T LIKE) are separated by a short pause from the following NP (IT). Within major constituents, the average pause duration drops to very short values, or zero, over the range of rates employed in this study. Examples in NP include sentence 1: GIRL_0 SMALL; 6a: SMALLEST_0 BOWL; 8: DIFFERENT_0 CHAIRS; and 9: SAME_{10} THING; and in VP, sentence 5: DON'T_0 LIKE; 1: WALK_0 IN_0 WOODS. In general, long pauses mark breaks between sentences; somewhat shorter pauses, those between conjoined sentences; shorter pauses still, those between major constituents. The grand mean duration of pauses between sentences was 229 msec; between conjoined sentences, 134 msec; between NP and VP, 106 msec; within NP, 6 and within VP 11 msec. The higher the syntactic order of the break, the longer the hold that occurs at the break.

One reason for studying the relation between pause structure and sentence structure, whether in speech or in sign, is to discover units of sentence processing. But this study is highly motivated in ASL for two additional reasons. First, if the same relation applies to sign as to speech, then we may make a general statement about language processing that is founded in man's cognitive processes and not in any particular sensory modality. Second, there is as yet no reasonably comprehensive grammar of ASL (or any other sign language) that would assign structural descriptions to sentences (but see steps in that direction by McCall, 1965; Fischer, 1973, 1975; Kegl & Wilbur, 1976). Yet such descriptions are needed for many purposes, among them psycholinguistic studies of sign-language processing. To the extent that sentence processing units correspond to structural units, the analysis of sign-language pause structure can serve as a guide in assigning structural descriptions to sign sentences.

In taking this approach – from language function to language structure – we are, from a traditional point of view, driving the wrong way on a one way street. Our research on the sublexical structure of signs provides another example. By examining sign confusions in production, perception and memory, we are led to group the combining elements of signs into classes and to describe the shared features that determine class membership. It remains to be seen whether the constituents identified by analyzing pausing or the features identified by analyzing perceptual confusions provide convenient units when formulating a grammar of ASL. The point is that psycholinguistics has often been the handmaiden of linguistics, and all too subject to her mistress's whims. We think that an exchange of roles might be therapeutic all the way around.

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Résumé

Les recherches sur les langues parlées ont montré que la durée des pauses silencieuses d'une phrase est fortement liée à la structure syntaxique de cette phrase. Une analyse du même type sur un passage de la Langue des Signes Américaine permet de voir que les suites de signes sont également entrecoupées par des pauses (arrêts entre les signes) de longueurs variables: les pauses longues semblent indiquer la fin des phrases, les pauses courtes marquent la frontière entre des phrases coordonnées et les pauses très courtes indiquent les frontières de constituants internes. L'analyse des pauses est un guide pour la segmentation des phrases dans la Langue des Signes Américaine.