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On the Role of Sign Order and Morphological Structure in Memory for American Sign Language Sentences

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Sentence processing in a visual–gestural language was investigated by testing signers' recognition for American Sign Language (ASL) sentences. Using a continuous recognition paradigm, sign order and structural changes that altered the meaning of a sentence were noticed at both immediate and delayed (45 seconds) test intervals. Sign order and structural changes that resulted in a paraphrase of an earlier-occurring sentence were noticed only with immediate testing. These results indicate that signers decompose a complex sign into its lexical and inflectional components during sentence comprehension and remember the meaning expressed by these components rather than remembering the exact sign structure.

In the past decade, it has become clear that there are primary gestural systems, passed down from one generation of deaf people to the next, that have taken their own course of development as autonomous languages. American Sign Language (ASL) is the common form of communication used by deaf native signers among themselves across the United States and parts of Canada. ASL is a primary visual–gestural system, not based on, nor derived from, any form of English, having its own lexicon and grammar (Klima & Bellugi, 1979). Because of the radical difference in the transmission medium for signed languages as opposed to spoken languages, ASL affords an opportunity to examine a question not easily investigated in other ways, namely: To what extent is language processing shaped by the production modality?

Research on American Sign Language shows that this visual–gestural system exhibits formal structuring at the same two levels as spoken languages: a sublexical level of structure internal to the sign (the phonological level in spoken languages) and a level of structure that specifies the ways signs are bound together into sentences (the grammatical level). ASL thus shares underlying principles of organization with spoken languages, but the formal devices that appear arise from the very different possibilities afforded by the visual–gestural modality. In spoken languages, the structuring of lexical items and morphological processes is essentially sequential. Words are composed of sequentially produced sounds; morphological processes commonly involve affixation of phonemic

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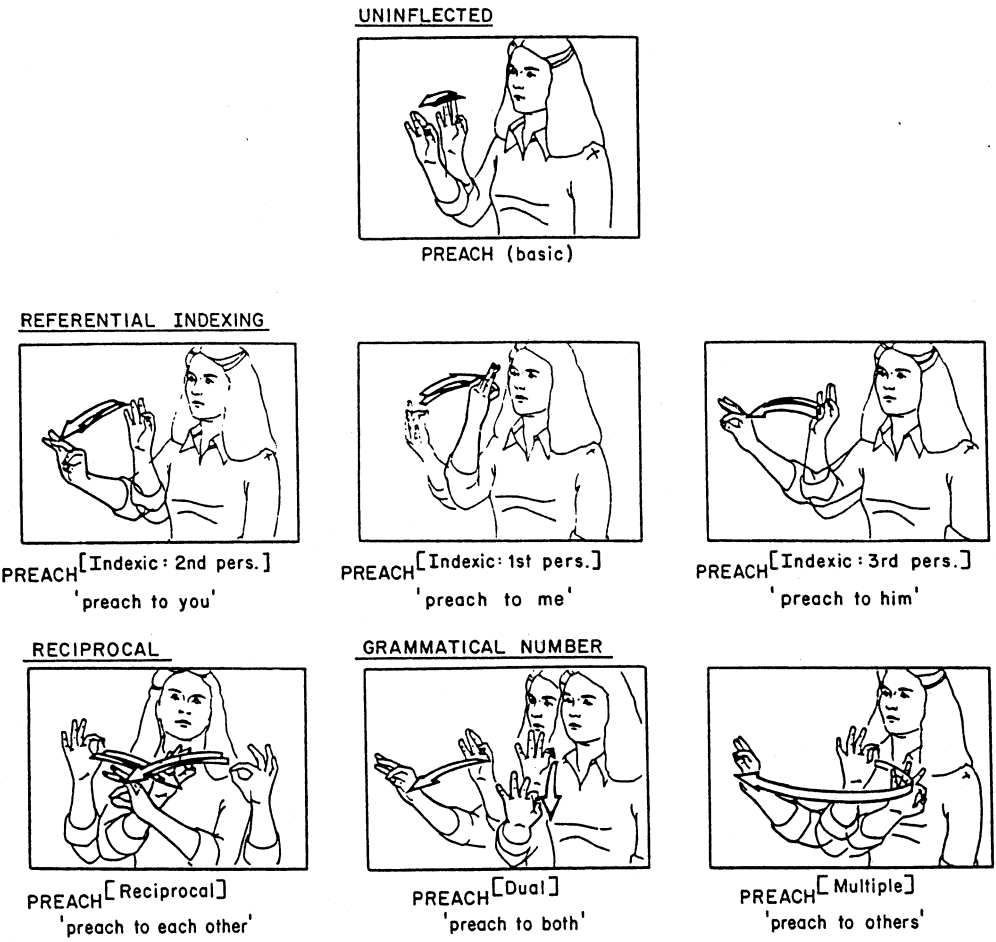

FIG. 1. The uninflected sign PREACH and its form under a variety of inflections.

segments sequentially ordered in the sound stream. In ASL, however, signs are composed of contrasting formational parameters, co-occurring throughout the sign, and the morphological processes of ASL involve embedding the sign stem in superimposed contours of movements. Sign and inflectional marker thus co-occur in time (Bellugi, 1980).

In relation to the structure of the signs themselves, it has been determined that signs are not just holistic and iconic, but rather are composed of a limited number of arbitrary formational components that combine in regular and constrained ways in the signs of the language (Battison, 1974; Stokoe, Casterline, & Croneberg, 1965). These parameters (handshape, location, and movement) have been found not only to be formal linguistic descriptions of signs, but also to be psychologically real in the sense that signers rely on these parameters in sign processing. In studies of short-term memory for signs, signers characteristically make errors based on these formational parameters (Bellugi, Klima, & Siple, 1975; Frumkin & Anisfeld, 1977). Similarly, "slips of the hand" involve exchanges of these components (Newkirk, Klima, Pedersen, & Bellugi, 1980).

ASL differs dramatically from spoken languages in the form of its morphological processes. As a visual–gestural language, its morphological devices embed sign stems in superimposed changes of space and movement. Figure 1, for example, shows the sign PREACH under a variety of morphological operations [e.g., PREACH (basic

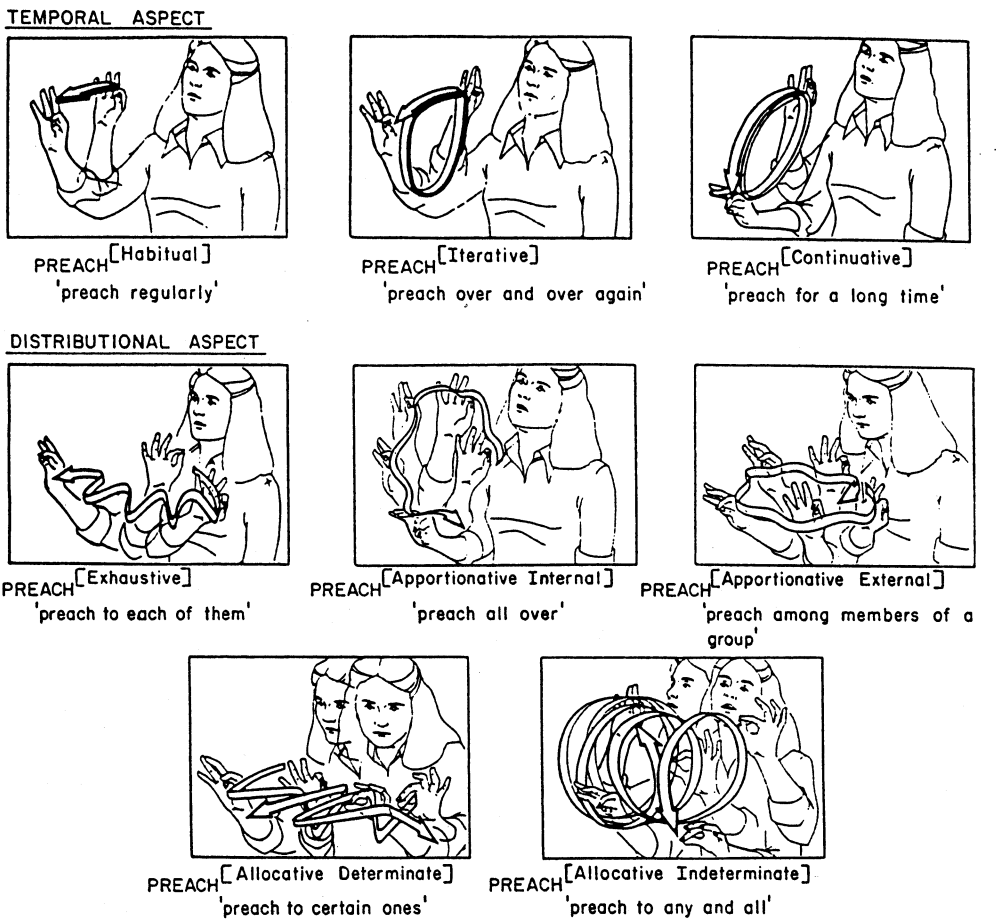

FIG. 1—*Continued*

sign), 'preach to them,' 'preach to each of them,' 'preach regularly,' etc.].[1]

The wide variety of semantic distinctions that are obligatorily marked morphologically in ASL sentences are often indicated in English either lexically or phrasally. ASL verb signs, for example, undergo obligatory inflections for *referential indexing,* indicating subject and/or object of the verb; for *reciprocity;* for *grammatical number,* marking distinctions such as dual and multiple; for *temporal aspect,* indicating distinctions such as 'regularly,' 'over and over again,' 'for a long time,' 'gradually'; for *distributional aspect* 'to each,' 'to any,' 'all over,' 'to certain ones.' There are also a large number of derivational processes such as those that derive nouns from verbs, that derive predicates from nouns, and that signal figurative or extended meanings. The elaborate system of formal inflectional devices, their widespread use to vary the form of signs, and the variety of fine distinctions they systematically convey suggest that ASL, like Latin

[1] Words in capital letters represent English glosses for ASL signs. The gloss represents the meaning of the basic uninflected form of a sign. A bracketed symbol following a sign gloss indicates the grammatical process the sign has undergone (X: for referential indexing; M: for modulation for temporal aspect or focus; N: for numerosity inflection; D: for derivational process; iD: for idiomatic derivative). The symbol may be followed by a specification of the inflectional process or by the meaning of the inflected form. For example, GIVE [N:Exhaustive] and GIVE [N:'to each'] are alternative ways of representing the same inflectional process. The solid bar above specific parts of a sentence indicates sentence topicalization.

and Navajo, is one of the inflective languages of the world (Klima & Bellugi, 1979).

The present research examines for the first time whether these formal linguistic descriptions of ASL morphological structure correspond to psychological representations that signers use in the interpretation and retention of sentences.

Several experiments with English have been conducted to test whether linguistic descriptions of the language can be applied to describe the way in which readers/listeners process sentences. These experiments, taken as a whole, provide evidence that while descriptions of grammatical structure are psychologically real in the sense that they are used in sentence comprehension, these structures are not used as a basis for sentence representation in memory.

In a seminal study, Sachs (1967) presented data strongly supporting the hypothesis that after the meaning of a sentence is comprehended, the exact wording and the syntactic structure are forgotten. Sachs had passages of text read to normally-hearing college students and, after various intervals of interpolated material, tested the students' recognition memory for sentences of the text. The test sentences could be different from an earlier-occurring sentence in one of the following three ways: (1) different by a semantic change; (2) different by an active/passive change; or (3) different by a formal change (e.g., "He called up Mary" vs "He called Mary up"). For immediate testing, performance was quite accurate for all sentence change conditions. But after the presentation of as little as 27 seconds of interpolated material following the target sentence, only the semantic changes were noticed. These results have been replicated in later studies using both spoken and printed sentences and text with adults (Anderson, 1974; Begg, 1971; Begg & Wickelgren, 1974; Brewer, 1975; Fillenbaum, 1966; Johnson-Laird & Stevenson, 1970; Sachs, 1974; Wanner, 1974) and with children (Trembath, 1972).

An experiment by Bransford and Franks (1971) clearly demonstrates the tendency of subjects to recall the meaning rather than the form of sentences. Subjects in that study were presented semantically-related study sentences that contained one, two, or three propositions. In a recognition test, subjects tended to falsely recognize four-proposition sentences that they had never seen before, but which were semantically consistent with the integration of propositions across the study sentences.

The present research is concerned with whether signers similarly abstract the meaning of ASL sentences and then retain this meaning independent of the sentence structure. At one level this experiment tests retention of sign order. The work with English readers/listeners has indicated that there is little retention of the exact word order of sentences for anything but immediate testing. It is similarly expected here that signers will not retain information about the sign order of ASL sentences in long-term memory. Work with English sentences has also shown that following sentence comprehension, readers/listeners do not retain information about the exact lexical composition of sentences. The morphological processes of ASL afford the opportunity to provide a more stringent test than is possible with English of the tendency of language users to remember the meaning of sentences independent of the lexical composition. The morphological processes of ASL, by superimposing movement patterns on basic lexical signs, strikingly alter the dynamic visual form of the sign. Of interest here is whether signers will remember the global form of a sign or whether they will decompose the complex sign into its lexical and inflectional components and remember only the meaning expressed by these components.

The paradigm to be used is one adapted from work on memory for sentences in both written and spoken English (Begg, 1971; Begg & Wickelgren, 1974). In these paradigms, subjects are presented with several sentences. After various intervals, a test sentence is presented. Subjects are asked if that sentence is identical to an

earlier-occurring one. In the present experiment, a test sentence can be changed from the target in one of four ways: Two of these changes (*Formal* and *Lexical* changes) will be paraphrases of the target sentence, preserving meaning. The other two changes (*Inflection* and *Semantic* changes) will have different meanings than the target.

METHOD

Stimulus Materials and Design

Stimuli were ASL sentences. The sentences were independent of each other in terms of grammatical structure and content. They were not related in a story context. There were three different kinds of sentences: original, test, and filler sentences. Original sentences were the first presentation of an experimental sentence. Test sentences were the second presentation of an experimental sentence.

Fifty experimental sentence pairs were used in five testing conditions. In one condition, the original and test sentences were identical. Eighteen pairs of experimental sentences were included in this condition. The other 32 sentence pairs were equally divided among four conditions in which the test sentence was changed from the original sentence. There were eight sentence pairs in each of the following four change conditions:

(*a*) *Formal.* Formal changes involved a change in sign order with no resultant change in meaning. An example of a formal change is given below. Both the ASL gloss and the English translation are presented.

(1)
Original:

DOCTOR NO[X: 'to me'] EAT CHEESE MILK ETC. THAT.

English translation:
The doctor told me not to eat dairy products.

Test:

CHEESE MILK ETC. THAT DOCTOR NO [X: 'to me'] EAT.

English translation:
Dairy products are the food the doctor told me not to eat.

(*b*) *Lexical.* Lexical changes involved pairs of sentences that had the same meaning expressed in two different ways. Thus in one sentence a particular meaning was carried by two lexical signs while in the other the same meaning was conveyed by a single inflected sign. An example of such a sentence pair is the following:

(2)
Original:

SUPPOSE WINTER (MY) FRIEND[ID: 'chum']S-U-R-E OFTEN SICK PITY[X: 'him'].

English translation:
If it's winter my chum will surely get sick often, poor thing.

Test:

SUPPOSE WINTER (MY) FRIEND[ID: 'chum'] S-U-R-E SICK[M:Frequentative] PITY[X: 'him'].

English translation:
If it's winter my chum will surely get sick often, poor thing.

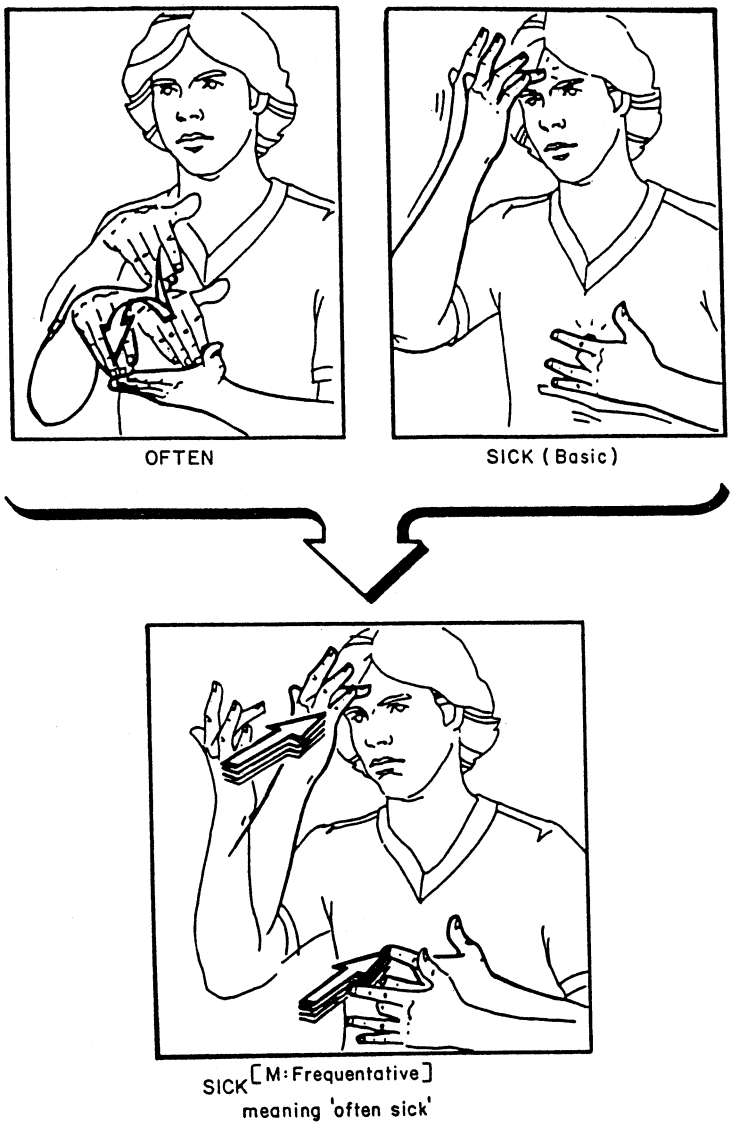

FIG. 2. An example of a Lexical change. In the top panel, the meaning "often sick" is expressed by two lexical signs: OFTEN and SICK. In the lower panel, the same meaning is expressed by the inflected sign SICK[M:Frequentative].

The difference in form between the phrase OFTEN SICK and the modulated SICK[M:Frequentative], both of which have the same meaning, is shown in Figure 2.

(*c*) *Inflection.* Inflection changes involved pairs of sentences that were different in meaning. The original sentence included inflected signs; in the test sentence, the inflections were transposed, but the order of the sign stems was maintained, resulting in a different meaning. The following sentence pair is an example in which the inflections on GIVE and INFORM are exchanged. Figure 3 illustrates this change.

(3)

Original:
MARY, JANE PAPER GIVE[R:Reciprocal], BUT NEVER INFORM[N:Multiple] THEIR WORK.

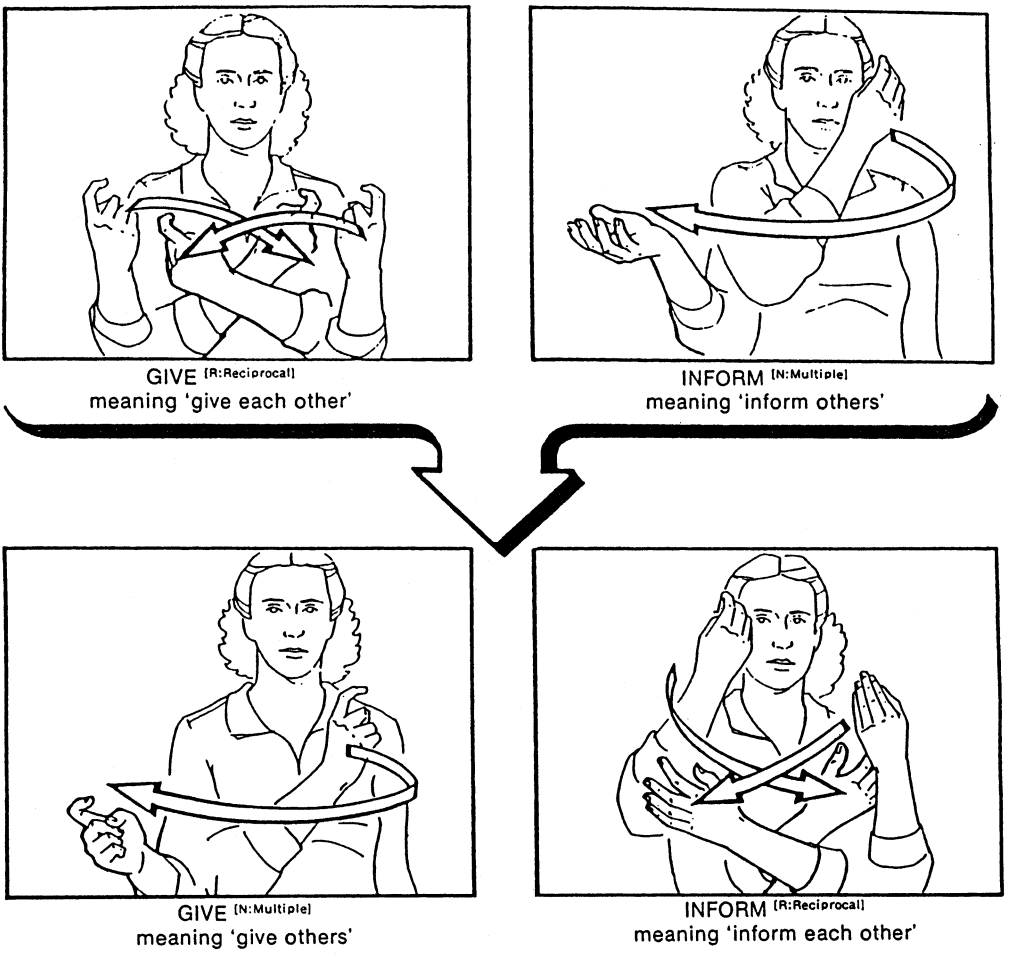

FIG. 3. An example of an Inflection change. In the top panel, the signs GIVE and INFORM are inflected with the reciprocal and multiple inflections respectively. In the bottom panel, the same signs occur but with transposed inflections, resulting in different meaning.

English translation:
Mary and Jane give each other papers, but never inform others about their work.

Test:
MARY, JANE PAPER GIVE[N:Multiple] BUT NEVER INFORM[R:Reciprocal] THEIR WORK.

English translation:
Mary and Jane give others papers, but never inform each other about their work.

(*d*) *Semantic*. For semantic changes, the meaning of the test and original sentences was altered by a change in sign order in which two signs exchanged positions, often across clauses. An example of such a semantic change is given here, where MATH and MUSIC are interchanged.

(4)

Original:
MY WIFE TEACH[M:Continuative] MATH ALL-MORNING, AFTERNOONS TEACH[M:Habitual] MUSIC.

English translation:
My wife works hard teaching math all morning, and in the afternoons she generally teaches music.

Test:
MY WIFE TEACH[M:Continuative] MUSIC ALL-MORNING, AFTERNOONS TEACH[M:Habitual] MATH.

English translation:
My wife works hard teaching music all morning, and in the afternoons she generally teaches math.

There were thus five different experimental conditions as defined by the different relationships between original and test sentence pairs. In addition, there were two different time intervals tested: an immediate test and a 45-second delayed test. Sentences in the five experimental conditions were tested half the time at each interval.

Stimulus Tape

Stimulus sentences were signed by a native signer of ASL and were recorded on videotape for use during testing. Natural facial expression was included in all sentences. The hands of the signer were restored to a neutral position between sentences to indicate the end of one sentence and the beginning of another. The first three sentences presented were filler sentences.

Test sentences were indicated by a star that appeared in the upper left-hand corner of the screen at the onset of each such sentence. Following each test sentence, a blank interval lasting approximately five seconds was included to be used as a response interval.

For the immediate test, the test sentence followed the original sentence. For the delayed test, four sentences always intervened between original and test sentences. These four intervening sentences included original and test sentences as well as filler sentences. In many cases, there was also one response interval between original and test sentences. This difference in events between original and test sentences was caused by the variance in length of sentences used in the experiment. The number of intervening sentences was held constant, however, and the time of the delay interval was held constant at 45 seconds.

Instructions, signed in ASL, were recorded on the beginning of the videotape.

Procedure

Subjects were instructed that they would see several ASL sentences and that they were to pay careful attention to each. At various times test sentences would be presented and would be indicated by a star in the upper left-hand corner of the screen. For each, subjects were to decide if the test sentence was exactly the same as a sentence that had been presented previously. They were to circle YES on their answer sheet if the test sentence was the same as an earlier-occurring sentence and to circle NO if the test sentence was not exactly the same as an earlier one. Subjects were instructed that "exactly the same" meant the same signs and same sign order as well as the same meaning.

In addition, subjects were asked to make a confidence judgment about each sen-

tence. They were to circle whether they were "VERY SURE," "SORT OF SURE," or "GUESSING" about their decision as to whether the original and test sentences were the same.

The stimulus sentences were preceded by a practice session that included four practice test sentences. All sentences included in the practice phase were simple sentences designed to illustrate clearly the nature of the procedure and to indicate that the structure as well as the meaning of the sentences would be important in the experiment. During this practice, subjects' answers were checked after each response. If a subject had answered incorrectly, the original and test sentences were shown to the subject again.

Subjects

Subjects were ten deaf volunteers recruited through the Center on Deafness at California State University, Northridge. Nine of the subjects had deaf parents and had learned ASL as a first language. The other person had grown up signing and was considered by native signers to be a skilled ASL user. There were five women and five men, mean age 24.2 years.

Results

The percentage of trials on which the subjects responded that the test sentence was "different" from the original sentence is given in Table 1. For all but the Identical sentences this percentage indicates percentage correct responses. For Identical sentences there was no difference in subjects' accuracy at the two response intervals, $t(9) = 1.48, p > .05$.

The percentage of "different" responses for the Identical sentences may be taken as an index of subjects' bias to respond that a test sentence is not the same as the original. Following Sachs (1974), "chance" is therefore defined here as the percentage of "different" responses for Identical sentences. The results are graphed in Figure 4 as the percentage of "different" responses greater than "chance."

Analyzing the percentage of "different" responses for the four change conditions, with immediate testing it was found that subjects were equally likely to respond that the test sentence was different from the original for all four sentence types, $F(3,27) = 1.00, MS_e = 125.00, p > .05$. Subjects were therefore able to notice all four types of sentence changes equally well with immediate testing. They did not, however, notice the different types of sentence changes equally well with delayed testing. An analysis of variance on the four types of change conditions by intervals indicated main effects of both condition, $F(3,27) = 4.22, MS_e = 195.30, p < .025$, and interval, $F(1,9) = 16.35, MS_e = 339.56, p < .01$, that were qualified by an interaction of interval

TABLE 1
MEAN PERCENTAGE RESPONSES IN WHICH SUBJECTS RESPONDED THAT THE TEST SENTENCE WAS DIFFERENT FROM THE ORIGINAL SENTENCE

	Immediate test	Delayed test	Difference
Formal	97.5%	59.2%	38.3%*
Lexical	92.5%	67.5%	25.0%*
Inflection	90.0%	81.7%	8.3%
Semantic	90.0%	95.0%	−5.0%
Identical	28.4%	37.3%	−8.9%

Note. Also shown is the difference in such responses at the two time intervals. (A negative number as the difference indicates that there was more tendency to respond that the test sentence was different for delayed than for immediate testing.)

* $p < .05$.

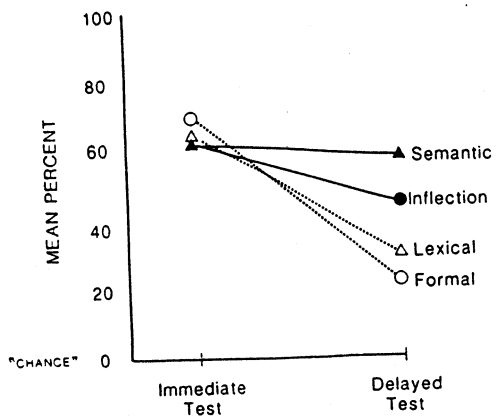

FIG. 4. Percentage of "different" responses greater than "chance" for the four change conditions.

by condition, $F(3,27) = 10.20$, $MS_e = 176.02$, $p < .001$. Thus, while performance was generally better with the immediate test than with the delayed test, the degree to which the time interval adversely affected performance was dependent upon the condition being tested. Results of a Tukey (hsd) post hoc analysis indicated that there were significant differences between the immediate and delayed testing only for Formal and Lexical changes (those that preserved meaning), $p < .05$. Inflection and Semantic changes, both of which changed meaning, were noticed as well with the delayed as with the immediate test, $p > .05$.

A one-way analysis of variance was performed on accuracy in the five delayed test conditions. The main effect of condition was significant, $F(4,36) = 19.49$, $MS_e = 248.47$, $p < .01$. Post hoc analyses were undertaken to determine the basis for this effect. Results of these tests indicated that the percentage of "different" responses was greater than "chance" for all four change conditions (Dunnett's t statistic, $p < .05$). Additional analyses indicated a distinction between meaning-preserving and meaning-changing sentence pairs: For both the Inflection and Semantic changes, subjects were more likely to respond that the test sentence was "different" than they were to respond "different" for the Formal and Lexical changes (Newman-Keuls, $p < .05$). There was no difference in the percentage of "different" responses between Semantic and Inflection changes (Newman-Keuls, $p > .05$) nor between Formal and Lexical changes (Newman-Keuls, $p > .05$). These results indicate that while subjects responded more accurately than would be expected by chance for all four types of sentence changes, their ability to notice the sentence changes was dependent on the type of change: changes of meaning (Inflectional and Semantic changes) were noticed more consistently than were meaning-preserving changes (Formal and Lexical changes).

To obtain a score for the confidence rating, subjects' responses were assigned the following numerical values: VERY SURE = 3, SORT OF SURE = 2, GUESSING = 1. If the subject responded that the test and original sentences were identical, their confidence rating was multiplied by -1. If the subject responded that the test and original were not the same, their response was given a score equal to the confidence rating. Subjects' scores on this confidence rating were then analyzed. Mean confidence ratings are shown in Table 2.

A t-test was performed on subjects' confidence in responding that the Identical test sentences were the same as an earlier-occurring sentence at the two response intervals. The nonsignificant results, $t(9) = 1.69$, $p > .05$, indicated that for Identical sentences there was no difference in subjects' confidence of their responses at the two time intervals.

Scores for immediate test in the four change conditions showed no difference in confidence for the different conditions, $F(3,27) = 1.71$, $MS_e = .372$, $p > .05$. Scores were then subjected to an analysis of variance on condition by interval. Results indicated main effects of both condition, $F(3,27) = 5.25$, $MS_e = .533$, $p < .01$, and interval, $F(1,9) = 25.02$, $MS_e = .871$, $p < .01$, that were qualified by an interaction of the two variables, $F(3,27) = 11.16$, $MS_e =$

TABLE 2
MEAN CONFIDENCE RATINGS AT BOTH IMMEDIATE AND DELAYED TESTING

	Immediate test	Delayed test	Difference
Formal	2.88	.56	2.32*
Lexical	2.57	.97	1.60*
Inflection	2.30	1.77	.53
Semantic	2.40	2.67	−.27
Identical	−1.24	−.73	−.51

Note. A positive number indicates a tendency to respond that the original and test sentences were different. A negative number indicates a tendency to respond that the original and test sentences were identical. The scoring procedure is explained in the text.
* $p < .05$.

.587, $p < .001$. Again, a post hoc Tukey (hsd) analysis indicated the difference in performance at the two intervals was apparent only for the Formal and the Lexical changes, $p < .05$. This pattern of results reflected the fact that with delayed testing subjects were not confident of responding that the test sentences were different from the original sentences for the Formal and Lexical changes although they *were* confident of responding that the test sentences were different from the original sentences for the Inflection and Semantic changes.

In this experiment, therefore, subjects were both accurate and confident in noticing Inflection and Semantic changes even with 45 seconds intervening between original and test sentences. In contrast, sentence changes that preserved meaning (the Formal and Lexical changes) were accurately and confidently noticed only with immediate testing.

DISCUSSION

This experiment represents one of the first attempts to study ASL sentence processing. It was found that signers use syntactic structure to comprehend sentences but represent the meaning of ASL sentences in long-term memory independently of the sign order and the holistic sign structure.

As in studies with English, paraphrases were not noticed well with anything but immediate testing. This does not mean that *only* sentence meaning was retained. Sachs (1967) also noted this fact, stating that subjects "did have some ability to recognize the form of the sentence but that it was quite low and contrasted greatly with their memory for the semantic content of the sentence" (p. 441). The present finding that all four types of sentence changes are recognized better than "chance" is consistent with this conclusion. In particular, research has shown that when subjects know in advance that their memory for sentences is being tested (as in the case of the present study), additional information about the surface form of sentences is retained (Anderson, 1974; Begg & Wickelgren, 1974; Johnson-Laird & Stevenson, 1970). This is similar to work showing that people can remember such "trivia" as the typography of words when reading (Kolers & Ostry, 1974). Thus, it is apparently the case that people can remember many types of information about the sentences they process: however, there is strong evidence that the primary information remembered about sentences is the semantic interpretation for written and spoken sentences and, as shown here, for signed ASL sentences.

It is clearly the case here that after a brief delay signers remembered the meaning, not the form, of the signed sentences. With delayed testing, changes that preserved the meaning of earlier-occurring sentences were not noticed as well as changes that

resulted in a meaning different from the original.

One type of paraphrase in the present study involved a change in word order. These Formal changes were not noticed with delayed testing even though, as shown in sentence pair (1), the sign order changes generally involved a topicalization change. Sentences in ASL often follow what has been referred to as a topic-comment structure. This means that the topic of the sentence, marked by a specific facial expression, occurs first, and is followed by a comment on that topic. For example, in the test sentence of sentence pair (1), the topic is "dairy products." The comment is that "the doctor told me not to eat [them]." In the original sentence for that pair, the topic of the sentence was that "the doctor told me not to (do something)" and the comment explains that the prohibited activity is eating dairy products. Sentence topicalization in ASL is marked by an eyebrow raise and an upward head tilt (Liddell, 1977). The beginning of the comment is signaled by a relaxation of head and eyebrow position. A topicalization change was present for three of the four test sentences at each delay. The fact is that subjects did not notice even these Formal changes.

Semantic changes in this experiment, as well as Formal changes, were caused by changes in sign order. But when the sign order change also caused a meaning change, the change was noticed. Thus, it is not the sign order, per se, that was remembered, but rather it was the semantic content that was remembered.

One important aspect of the present results is that signers were shown to be representing the meaning of a signed sentence independently of its morphological composition. This was shown strikingly by the results of the Lexical change condition. Subjects remembered the meaning of the sentence but after a brief delay did not remember the form in which the meaning was conveyed. Thus, for example, subjects remembered the meaning "frequently sick" but did not remember if the actual sentence contained a two-sign phrase OFTEN SICK or a single inflected sign, SICK[M:Frequentative].

This finding agrees nicely with work by Poizner, Newkirk, Bellugi, and Klima (1981) on short-term memory for lists of inflected signs. In that study, subjects saw short lists of inflected signs and were asked to recall the list by signing the items immediately after each list. Recall errors revealed that subjects recalled the base sign and its inflection independently. Thus, signers decomposed the sign into its meaning components and did not retain the exact form of the sign.

Notice, however, a striking difference in this work on sentence memory and the results from the short-term memory paradigm of Poizner et al., (1981). For the lists of inflected signs in their study, subjects confused which inflections were superimposed on which basic signs. But this was not true when the inflected signs were put in the meaningful sentence context of the present experiment. The high recognition accuracy for Inflection changes, even at longer intervals, indicates that people did not make this confusion. Results from the Lexical change condition further show that this lack of confusion was not a result of signers remembering the exact form of the sign presented. Rather, this accurate performance in the Inflection change condition can be attributed to the fact that switching the inflections changed the meaning of the test sentence. Thus, signers were able to reject the test sentences for Inflection changes, not because they noticed that the sign forms were changed but because they noticed that the meanings of the test sentences were changed.

In recent years a picture has been emerging in which basic cognitive processes constrain the structure of signed and spoken languages so that underlying structure for languages in both modalities exhibit many similarities (Bellugi, 1980). The present work on sentence memory suggests that in signed language as in spoken languages,

the meaning of a sentence is abstracted and the structural mechanism by which this meaning is conveyed is not retained in the long-term memory representation of the sentence.

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