3 Psychoinguistics of Sign Language[1]

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In this chapter we review a number of studies pertaining to the psycholinguistics of sign language. We begin by summarizing those studies whose goal was to determine if sign language is as effective as spoken language for communication. Having responded in the affirmative to this question, we present an account of the studies that have demonstrated the psychological reality of certain aspects of the structural organization of sign language as it is described by linguistics. Next we study the production of sign language—what it has in common with spoken language and in what ways it is different—as well as the perception of sign: psychophysics of rate, iconic memory, and on-line processing of signs presented individually and in sentential context. We end the chapter with a résumé of studies bearing on the role of memory in sign language communication.

Because our space is limited and because of a lack of systematic research, this chapter will not treat the following aspects of psycholinguistics of sign language: communication between signers of different sign languages, the role of the figurative aspect of sign language and its perception and memorization, perception and production of contrived signing systems (such as Sign English), spoken—sign language bilingualism, and the acquisition of sign language as a native language. The latter topic is reviewed by Hoffmeister and Wilbur elsewhere in this book. Two further preliminaries: Although most of the studies that we cite are concerned with American Sign Language (ASL), we believe that the processes of production, perception, and memorization that will be examined are for the most part descriptive of other sign languages

[1]Translated from French by Harlan Lane.

as well. Moreover, these processes should be compared to those for oral language and consequently we will attempt to clarify as far as possible the relations between the activities of the signer/observer and those of the speaker/listener. Psycholinguistics is addressed, after all, to the perception, understanding, and production of all languages, whether spoken or sign. No model of linguistic performance can be complete unless it describes those aspects of encoding and decoding that are specific to the modality of communication, oral or visual, and those that are common to all languages whatever their modality of perception and production.

THE LANGUAGE OF SIGNS AS AN INSTRUMENT OF COMMUNICATION

Several studies have been concerned with the question of whether sign language is as effective as oral language in everyday communication. The results of these studies have exerted considerable influence on a number of linguists and psycholinguists, some having concluded from these that sign language is not a symbolic system of communication at the same level as oral language. The general scheme of these studies is as follows: a sender transmits to a receiver various items of information concerning a scene (evoking, for example, the relations subject–verb–direct object–indirect object), or concerning an object (car, flower, fish, geometric figure, etc.) or the face of a person. The task of the receiver is to use this information to select the item that has been described from among an array of similar items. The correct or erroneous choice by the receiver thus becomes an index of the effectiveness of communication.

In a study of this type, Schlesinger (1970) wanted to study how certain grammatical relations are expressed in Israeli Sign Language (ISL); namely, subject, verb, direct object and indirect object. In one of the stimulus arrays, there was a man, a bear, and a monkey. The six drawings in this array represented the six possible permutations in the format "X gives Y to Z" (the man gives the monkey to the bear: the monkey gives the bear to the man, etc.). The experiment using this particular array is the one that Schlesinger describes in detail and hence we consider it at some length here. Thirty deaf subjects, divided into 15 sender-receiver couples, participated in the study. Schlesinger undertook a detailed examination of the structures used by the subjects in their communication. He noted that many different syntactic structures were used, that the verb was never placed at the start of the sentence, and that the adjective was always placed after the noun that it modified. Furthermore, among the 20 subjects who produced "complete sentences" (sentences, according to Schlesinger, that included a subject, a verb, a direct object and an indirect object) the signs arranged themselves as follows: subject (S), direct object (DO), indirect object (IO), but also as follows: IO, DO, S, and also S, IO, DO. Schlesinger concludes that Israeli Sign Language apparently has no systematic rules allowing a distinction between the functions of subject, direct object, and indirect object.

This conclusion was the object of a critical analysis appearing in a report of the New England Sign Language Society (1976). We note here simply that the syntactic analysis by Schlesinger is highly disputable: He eliminated utterances containing several sentences, he was uninformed about certain visual indices that would assist in identifying sentences (body movement, facial expressions, rhythm of production, use of the space by the signer, among others) and his analysis was based to a large extent on the erroneous premise that grammatical relations in Israeli Sign Language are expressed exclusively in a linear fashion and cannot be realized in parallel.

As concerns the effectiveness of communication, Schlesinger reports a 74% successful communication for couples that used "complete sentences"; 54% when only one member of the pair used such sentences; and 44% for the pairs who never produced such sentences. These percentages are well below those that we might expect from a similar experiment in oral language (however it should be noted that Schlesinger did not run a control group made up of hearing subjects, which would have aided in determining whether the results obtained from the deaf subjects were due to the inherent difficulty of the task or to the absence of good communication between senders and receivers).

A very similar experiment is reported by Hoemann (1972). His goals were to gain a better understanding of the development of communication among deaf children who acquire ASL and to compare their linguistic ability with that of hearing children of the same age. Two groups of hearing subjects, averaging 8 and 11 years of age, and two groups of deaf subjects with the same average age participated in the experiment in sender–receiver pairs. Here three different tasks were employed: description of pictures, description of symbols presented from various perspectives, and explanation of the rules of a game. The results obtained were quite similar to those reported by Schlesinger; we will restrict ourselves here to those from the first task. For the group of 8-year-olds, the percent effective communication, that is, the percent of correct selections by the receiver, was 36 for the deaf, 53 for the hearing; for the 11-year-olds the corresponding percentages were 59 and 84. Hoemann concludes that deafness constitutes a handicap in peer-to-peer communicating even with manual methods. To explain these results he proposes a general experiential deficit, which affected both the acquisition of a conventional linguistic system by the deaf children and their development of formal communication skills.

Several years later, Oléron (1978) undertook a similar study with users of French Sign language (FSL). He used the same general format as Schlesinger and Hoemann, but employed six different experimental settings. The first involved six groups of five pictures representing living things. Each group contained the picture to be described, a scene representing the relations subject–verb–direct object, and four pictures evoking the same relations but with variations concerning one or the other of the three syntactic terms. The second setting, constructed along the same lines as the first, presented relations of the type subject–verb–direct object–indirect object. Pictures presenting different views of an object and of its relative position, of geometric forms, of fishes, of flowers and a "maquette" including various objects broken into diverse groups along its surface, constituted the stimuli in the other situations.

Oléron used two groups of subjects, one deaf and the other hearing. There were 10 boys and 10 girls in each group with practically identical ranges in age (15 years, four months to 19 years, eleven months for the deaf and 15 years, 0 months to 17 years, eight months for the hearing). Ten pairs of subjects of the same sex were constituted in each of the samples. The experimental procedure was practically identical to that of Schlesinger and Hoemann: Communication was conducted in one direction only and the experimenter provided no information at the time of picture selection. Furthermore, the messages from the sender were videotaped (which Schlesinger had failed to do).

The results obtained by Oléron are very similar to those reported by the first two authors. The rate of effectiveness of communication of the deaf was well below that of the hearing: 71.7% for the deaf receivers and 91.7% for hearing receivers as regards correct choices in the first situation; in the second setting, the scores were 58% and 82%, a difference that was reproduced approximately in the other settings. We do not discuss here the very detailed study of syntax and lexis that Oléron undertook on the utterances that were produced by the deaf subjects. Let us note however that this author, like Schlesinger, had difficulties in demarcating sentences and that his transcription of the utterances did not sufficiently take into account the information provided by sign inflection and by nonmanual channels of sign communication. We know, for example, that movements of the eyes, the head, and the body are often used to demarcate simple sentences and clauses in complex sentences such as relatives, subordinates, conditionals, etc. (see Baker, 1976, 1977; Baker & Padden, 1978). Oléron does not report using these cues in his syntactic analysis of the sign utterances. The conclusions put forth by Oléron concerning the effectiveness of the deaf in communication are rather revealing. He writes that the transmission of information is certainly less effective in the gestural language of the deaf than in spoken language. He hastens to add however that the finding depends nonetheless on the conditions in which research was accomplished. Oléron then invokes several factors that may partially explain the results he obtained: the level of language mastery of the subjects, the conditions under which they learned and used sign language, possible areas of lack of correspondence between the experimental conditions for the deaf and those for the hearing, the possible difficulty for the deaf sender to put himself in the place of the receiver, etc. He adds, however, that it is nonetheless difficult to account for the results solely by pointing to these factors and proposes that the detailed examination of gestural productions brings to light various characteristics which in all likelihood bear the major responsibility for these difficulties in communication.

On the basis of these three studies we might conclude that manual language does not allow as effective communication as oral language. Indeed, three different sign languages were used (Israeli, American, and French) in three different experiments and roughly the same result was obtained in each: a level of communication among the deaf of 74% or below and much higher scores for the hearing communicators.

Such a conclusion would be quite wrong, however. In what follows we report two experiments in which deaf and hearing subjects give very similar results and we undertake to show that Schlesinger, Hoemann, and Oléron did not sufficiently control the sign language proficiency of their subjects nor the particular system of manual communication that they used (all three investigators report this problem in their studies but none gives it the importance that it merits). Bode (1974) replicated as best she could the conditions of Schlesinger's experiment. She added a group of hearing subjects and very carefully controlled for the level of mastery of sign language of her deaf subjects (13 of her 16 subjects had learned ASL before the age of six). The percentage of descriptions correctly interpreted by the receivers was 95 for the hearing group and 86 for the deaf group, a difference of 9% that was not statistically significant. Bode concludes that ASL indeed contains mechanisms for communicating information concerning agent–object–indirect object relationships, which are comparable in effectiveness to those in oral language. She also casts doubt on the results obtained by Schlesinger concerning the effectiveness of communication in Israeli Sign Language and the purported absence of a system that allows the expression of the grammatical mechanisms cited earlier. According to Bode, a hearing control group, such as that used by Oléron, and a homogeneous set of deaf subjects chosen with respect to their dialect and their level of mastery of manual language should have been included in the design of Schlesinger's experiment.

Jordan (1975) asked a group of hearing subjects and a group of deaf subjects who used ASL to describe pictures of faces. The receiver was to select the picture described among 23 others. The results showed that the users of ASL communicated as well as the hearing subjects (4.83 errors in 24 presentations for the deaf, 3.96 for the hearing, a nonsignificant difference). Moreover, Jordan revealed that the deaf used fewer cues than the hearing to describe the pictures and that their productions were shorter than those of the hearing subjects; however the two groups used the same visual cues in their descriptions.

It seems, then, that when the homogeneity of dialect used by the subjects is controlled and when their perfect mastery of the dialect is assured, communication in sign language is as effective as that in oral language. Schlesinger himself was partly aware of this and Oléron commented that his 20 deaf subjects knew and used the gestural language of the deaf but that the experimenter did not test their proficiency in this respect. It would be interesting to know what type of manual communication was in fact used by the subjects in the experiments of Schlesinger, Hoemann, and Oléron and how proficient they were in that system. Certain subjects probably had a good knowledge of the oral language of their country and may well have utilized some form of sign language that was influenced by the oral language; others, perhaps less competent in oral language, may have used a form of the national sign language that was more authentic. (This situation is more complex in Israel where the population has a variety of linguistic backgrounds.) It is thus possible to advance the hypothesis that some of the sender–receiver pairs did not use exactly the same sign language or dialect, which would of course hinder effective communication. For example, many ASL signers can understand users of Sign English, but the inverse is seldom true. Not only were some of the pairs of subjects used by Schlesinger, Hoemann, and Oléron probably mismatched in this regard, but also the experimenters did not confirm that their subjects were truly fluent in the relevant manual languages. It seems probable that a certain number of subjects were not fluent signers, especially if they had learned to sign relatively late (deaf children of hearing parents often begin the acquisition of sign language when they attend a specialized school for the deaf and encounter children of deaf parents). Three additional questions ought to be asked: What dialect of sign language is learned in these schools? How long does it take to achieve mastery of a sign language? Do the deaf children of hearing parents ever succeed in achieving the same level of mastery as that attained by the deaf children of deaf parents, who learn the language quite early and in a familial environment? These questions were probably not asked by the experimenters when they selected their subjects. Moreover, and what is perhaps more serious, the results were used to form conclusions on the effectiveness of sign language in general whereas they merely reflected the varying competence in sign language of the samples of subjects employed. As Bode (1974) and Jordan (1975) have shown, when subjects are chosen for their knowledge of sign language and with proper consideration of the dialect they are using, then communication in sign language is as effective as in oral language.

LINGUISTIC DESCRIPTION AND PSYCHOLOGICAL REALITY OF SIGN LANGUAGE

Although the linguistic analysis of sign language is still in its early stages, as is clear from Chapter 2 by Wilbur, some experimental studies have begun nonetheless to describe the psychological reality of certain aspects of the structural organization of sign language as it is characterized by linguists.

How do these studies differ from those undertaken with oral languages in the 1960s? The first difference concerns the mere number. They are not numerous, as the research in sign language is recent and many psycholinguists are more aware now of the problems associated with this type of research. But a second difference concerns the linguistic models themselves. These are often incomplete or even nonexistent when it comes to sign language. The traditional order of investigation—model first and psychological reality of the model second—has thus sometimes been inverted. Beginning with experimental findings, various investigators have proposed structural descriptions of some aspects of sign language; see, for example, the study of Lane, Boyes-Braem, and Bellugi (1976) concerning distinctive features for handshape, and the study by Grosjean and Lane (1977) on the surface structure of ASL sentences. In what follows we summarize briefly the main results obtained in this domain and then proceed to other aspects of psycholinguistics of sign language such as perception, production, and memory.

Stokoe (1960, 1966) proposes that a sign is made up of three parameters: handshape, location, and movement. To these Battison (1974) adds a fourth: the orientation of the hand(s). Thus, one question that has had a lively interest for investigators is the following: Are signs in fact decomposed into these parameters by signers and sign observers, or are they solely a product of linguistic analysis and thus without any psychological reality? As it turned out, the reality of these parameters was shown by several studies. In an experiment on the short-term memory for lists of signs (described in greater detail in the last section of this chapter), Bellugi, Klima, and Siple (1975) showed that errors of recall were not related to the meaning of the original sign but rather to the values of its formational parameters. The signs erroneously recalled differed from the stimulus sign in one or more formational parameters, thus indicating the psychological reality of the description provided by Stokoe.

An examination of errors made during the production of ASL—slips of the hand—likewise confirms the psychological reality of the formational parameters of signs. Comparable spoken language studies not only have confirmed the psychological reality of certain descriptive units such as words, phonemes, and distinctive features (see Fromkin, 1971, 1973; Garrett, 1975) but they have also given clear evidence for the formational rules that are used in the construction of syllables and words. Newkirk, Klima, Pedersen, and Bellugi (1979), in an analysis of 131 errors of production in ASL, wished to demonstrate the validity of the parametric analysis of sign and to evaluate certain rules for the formation of signs (for example, the symmetry constraint on handshape in two-handed signs). The authors noticed from the outset that very few errors (7%) were a result of entire sign substitutions; the greater part concerned rather the substitution of one parameter value for another, thus supporting the hypothesis that signs are organized in terms of these parameters. Among the parametric errors, 50% concerned handshape, 10% location, and 8% movement. These errors broke down into three categories: errors of substitution, where the values of parameter X in signs A and B are exchanged (when, for example, the handshape of SICK and that of BORING are switched); errors of anticipation, where the value of parameter X in sign B is used by anticipation in sign A (for example, in the phrase SIGN BASIS O–F POEM, SIGN was articulated with the K handshape of POEM instead of the index finger G shape required); perseveration errors, where the value of parameter X in sign A is maintained in Sign B. We should note that these types of errors were observed not only for the three major parameters, handshape, location, and movement, but also for the minor parameters, orientation of one or both hands, place of contact of the sign, and hand arrangement in two-handed signs.

The errors detected by Newkirk et al. (1979) not only provided evidence for the independence of formational parameters in the construction of signs but also for rules of sign formation. Although certain errors yielded signs that already exist in ASL, the majority were possible but nonexisting signs (only 4% of the errors proved to be impossible in ASL). These errors were constructed from precise combinatorial rules that the authors illustrated in their study. These rules apply, for example, to the constraints governing the use of contacting regions for particular handshapes in particular locations or again to the symmetry of two-handed signs. The latter rule stipulates that two-handed signs with both hands active require the same movement to be executed by each of the two hands (Battison, 1974, 1978). This rule was used in 21 of 22 errors, thus revealing its role in the production of sign language. Newkirk et al. (1979) conclude their study by stating that production errors provide striking evidence for the psychological reality and the independence of individual parameters of ASL and that they bring supplementary evidence that signs are organized sublexically according to a set of formational rules.

Research on the psychological reality of structures and rules in sign language took a further step in a study by Lane, Boyes-Braem, and Bellugi (1976), which was concerned with the organization of hand configuration at the level of distinctive features. Several studies on spoken language have shown that the phoneme is not the smallest unit of linguistic analysis; rather the distinctive feature seems to lay claim to this title (Chomsky & Halle, 1968; Miller & Nicely, 1955; Wickelgren, 1965, 1966). Lane et al. (1976) undertook to determine if handshapes are composed of distinctive features and if a model of these feature assignments would predict errors of perception in an experiment on the identification of signs in visual noise. If a description in terms of distinctive features is justified in sign language, we may conclude that the analysis of phonemes in terms of features is not unique to spoken language but rather that it is rooted more profoundly in the properties of language processing. These authors used a procedure similar to that of Miller and

Nicely (1955) but adapted to the visual modality. A series of 20 signs without meaning, representing the 20 hand configurations widely used in ASL, was videotaped and mixed with visual noise so as to induce subjects into error during the identification of the signs. The confusion matrices were analyzed by means of computer programs for hierarchical clustering (D'Andrade, 1978) and multidimensional scaling (Shepard, 1962, 1972). This analysis revealed a specific organization of handshapes with the degree of finger extension being the most important organizational factor. Lane et al. (1976) used their results to arrive at a model of hand configuration in terms of distinctive features. The model predicts identification errors at a level of r = .6 and is also compatible with findings on errors for sign memory and in sign production. Although the model was revised and extended by Stungis (1978), the earlier study was the first to show that the formational parameters of signs, and in particular, handshape, are decomposable into distinctive features, and the first to propose a linguistic model of these features based on experimental findings. In studies of spoken language, as we mentioned previously, linguistic models have almost always preceded the psychological investigations by several years.

At the level of the sentence, studies on the psychological reality of linguistic structure in sign language have also been undertaken with some success, but there are rather few to report. This is in part attributable to the lack of a partial, not to say complete, grammar of ASL on which these studies could base themselves. (See, however, Fischer, 1973, 1975; Kegl & Wilbur, 1976; McCall, 1965; Stokoe, 1960, 1966.) The few studies that have been undertaken all show that sign language syntax plays an important role in the processing of language by the signer/observer and that sign sentence constituents are functional units. In a molar demonstration of this fact, Hoemann and Florian (1976) showed that anomalous sentences in ASL are judged less meaningful than grammatical sentences and that immediate recall is better when the signs are in the expected grammatical order. In another study, Tweney and Heiman (1977) presented signs to deaf subjects in grammatical sentences and ungrammatical strings, each containing one nonsense sign. They found that the recall of the nonsense signs and indeed the recall of the meaningful signs were both better when they were positioned in sentences rather than sign strings, thus highlighting the importance of grammatical structure in decoding sign language. Tweney, Heiman, and Hoemann (1977) undertook a series of experiments using visual disruption as the paradigm: Signed messages were subjected to varying amounts of disruption using repetitive temporal interruption. Subjects were asked to look at the sign strings and then to repeat in ASL exactly what they had seen. The first experiment showed that nongrammatical lists of ASL signs proved to be quite resistant to disruption compared to equivalent lists of English words, and in the second experiment, ASL sentences proved more resistant to disruption than lists of semantically anomalous signs or unstructured lists. The authors concluded from this that ASL intersign structure has psychological reality.

Other studies have examined more closely the functional units in sign language sentences. Baker and Padden (1978), for example, find that the eye blinks of the signer and of the sign observer respect the boundaries of constituents. Eye blinks have been found regularly between subject and predicate, between the verb and the direct object, and between a temporal indicator and the rest of the sentence. Tweney, Liddell, and Bellugi (1978) have demonstrated the psychological reality of relative clauses in ASL. They used seven types of sentences from simple sentences (subject, verb, direct object) to sentences with complements, and relative clauses. All the sentences were recorded on videotape with superimposed visual noise. The task of their subjects was to report each of the sentences as accurately as possible and a transitional error probability was calculated at each sign boundary. The results showed that in general there was a greater probability of making an identification error at the boundary between clauses than within clauses. The authors conclude that the structure of relative clauses as proposed by Liddell (1977) on linguistic grounds and more generally, embedding in sign, have psychological reality.

Other techniques have also been used to get a firmer grasp on the importance of syntax in sign language. Grosjean and Lane (1977), for example, wanted to determine if the duration of pauses in ASL (these are revealed in continuous signing by a hold in the movement of the hands between two signs) could serve to delimit sentences and immediate constituents within them, and if the durations of the pauses between signs could serve as a guide to the assignment of surface structures to the ASL sentences. We should note that this approach, like that of Lane et al. (1976), sought to use experimental results as an aid in suggesting a linguistic model. Five deaf subjects, all native users of ASL, signed a text containing 52 signs at five different rates. The analysis of their productions furnished, among other things, the locations and the durations of their pauses. Grosjean and Lane found, first of all, that the distribution of pauses in the text was not arbitrary, that longer pauses seemed to mark the ends of sentences whereas shorter pauses were to be found within those sentences. At the slower rates, the investigators obtained pause values between every pair of signs which allowed them then to construct a hierarchical structure for each sentence. These were very similar to the provisional surface structures assigned by linguists. The durations of the pauses indicated not only the breaks between simple sentences and coordinate sentences, but equally the boundaries of constituents inside these sentences. The average durations of the pauses, expressed as a percent of the total pause time between and within sentences, were as follows: between sentences, 47%; between conjoined sentences, 28%; between the noun phrase and the verb phrase, 22%; within the noun phrase, 1%; within the verb phrase 2%. Grosjean and Lane conclude that the average pause value between two signs corresponds to the order of the syntactic break between those signs.

This line of investigation has shown therefore that certain aspects of sign language grammar, which is still being elaborated, have psychological reality: units at the phonological level (distinctive features, and parameters of sign formation), and at the syntactic level (constituents, clauses, sentences) are truly functional in the encoding and decoding of sign language. In what follows we summarize studies that have analyzed the production, the perception, and the recall of utterances in sign language.

THE PRODUCTION OF SIGN LANGUAGE

In one of the very first studies from the Salk Institute for Biological Studies, Bellugi and Fischer (1972) compared the rate of production in English and in ASL. They asked three bilingual English/ASL speakers to tell a story in ASL, in English, and also in the two languages simultaneously. (The signing in this latter task probably resembled manual English more than ASL but this does not invalidate the conclusions.) The authors separated the articulation time from the pause time in English and ASL and calculated the rate of articulation in the two languages. The results showed that the rate of articulation in spoken language is almost double that in sign language (4.7 words per second and 2.37 signs per second). As regards the bilingual production, in which signing and speaking took place concurrently, they found an increase in pause time in both English and ASL as compared to the monolingual rendition, an increase that may be explained by the greater cognitive effort required for the simultaneous production in two languages. But again the rate of articulation was clearly less in sign language than spoken language. This difference can be explained by the fact that the articulation of a word requires less displacement of the articulators than that of a sign, where the arms and the hands move over a distance that can range from the top of the head to the waist of the signer.

Bellugi and Fischer (1972) next undertook the analysis of rate in terms of underlying propositions and discovered a fact of major importance: The two languages were characterized by comparable speeds—1.27 seconds per proposition in English and 1.47 seconds in sign in the monolingual productions (the range was from 1 to 2 seconds in both languages.) The communication of a message given in sign language and in oral language thus takes about the same time although the rates in terms of words and signs per second are different. The authors reconciled this result with that preceding by observing that sign language is heavily inflected and hence a sign sentence has fewer "words" than its English counterpart. Moreover, concurrent movements of the body and facial expressions provide additional channels of communication utilized by signers (see Baker, 1976, 1977; Baker & Padden, 1978). From these results we can conclude that sign language is not transmitted more slowly than oral language, as one might have thought from a superficial analysis of rate of utterance in the two languages, and we can further postulate that every language whether oral or visual, will probably have an information rate of approximately the same value.

Grosjean (1977, 1979) likewise compared the production of English and ASL. He summarizes these results in a 1978 article where he proposes that the two languages share, at least in part, a common production mechanism that is influenced by the rate of output, the semantic novelty of the message, the syntactic structure of the sentence, and the necessity of producing groups of words or signs of approximately equal length. Grosjean (1977) showed that speakers and signers produce a range of rates that is almost identical when they go from a slow to a fast production rate (a range of 2.6:1 for the signers and 2.7:1 for the speakers). This suggests that despite the different articulators that come into play in oral language and in sign language (tongue, lips, jaw in oral language, and hands and arms in sign language), there exists a common central system that determines the strategies used in increasing and decreasing rate.

Grosjean (1979) then studied the ways in which the signer and the speaker change their rate. He found that both modify their articulation time and their pause time but that the signer introduces greater changes in articulation time whereas the speaker prefers to modify pause time. Moreover, the slight change that pause time undergoes when the rate is modified in ASL is due to comparable changes in the number and length of the pauses and not, as in English, to a much greater change in the number of pauses than in the average length. The explanation put forward for these differences was connected to the differing respiratory behaviors in speech and sign; sign production takes place independently of breathing whereas speech output is highly dependent on the intake of air. A slower production rate in sign simply implies a slowing down of the articulators whereas in speech it means shorter runs of speech (the air reserve after intake is used up on fewer words) and hence more pauses.

Grosjean pursued his study by examining the factors that influence the durations of signs and of words and those that affect the frequency, duration, and location of pausing in the two languages. Klatt (1976) lists the following factors that influence the durational structure of syllables and words: the psychological and physical state of the speaker, the speaking rate, the position of the element within the paragraph, emphasis, semantic novelty, the lengthening at the end of the word and of the sentence, the inherent duration of segments, effect of linguistic stress, etc. Grosjean showed that four of these factors are also influential in determining the durations of signs. In the first place, each sign has its inherent duration. The distribution of the sign durations at normal speed turned out to be skewed to the right—the average duration of signs was .36 sec (median .33) and the range was from .18 sec to .68 sec. An analysis of sign duration in relation to hand configuration, place of articulation, and number of hands used in the execution of the sign, revealed that these factors do not play a major role in accounting for the inherent duration of signs. The movement involved in a sign, however, is a major contributor: Signs that are made with a movement involving the hands and the arms are twice as long (.6 sec) as those in which only the hands are involved (these signs last only an average of .3 sec). Further, signs in which the hands alternate and where the movement is repeated will have a duration that is longer than those in which there is more direct movement.

In the second place, rate of utterance affects the sign duration: The greater the rate the shorter the sign and vice versa. In the third place, the duration of a sign (like the duration of a word) is affected by semantic novelty. When a sign is presented for the second time in the course of signing a text, its duration is reduced by approximately 10%. And finally, we find that the signs at the end of sentences are about 12% longer than within the sentence.

These findings support the general hypothesis that oral and sign languages share, at least in part, a common underlying production mechanism. This view is strengthened when we examine the pause distribution in English and in ASL. As we noted in the preceding section, Grosjean and Lane (1977) found that the duration of pauses in ASL—as in French and English—signals the importance of the syntactic breaks. Some differences were found, however, between the performance structures of the sentences (that is to say the structures deduced from experimental findings, here pausing) and the formal linguistic structures. Grosjean, Grosjean, and Lane (1979) had previously shown this mismatch in spoken English, and they were led to recognize that performance structures respond to at least two major, but sometimes conflicting, constraints: the need to respect the linguistic structure of the sentence and the need to balance the length of constituents during speech production. They proposed therefore a predictive model for these performance structures that took into account both demands; this model accounted for 72% of total pause time variance whereas the linguistic structures alone accounted only for 56%.

The question that arose naturally for sign language was the following: Can a formal model of the linguistic structure of a sign sentence alone explain the results obtained during the production of a text in ASL (the durations of the pauses found by Grosjean and Lane, 1977, for example) or does the signer, like the speaker, need to make a compromise between respecting the linguistic structure and balancing the length of the constituents? Grosjean, Grosjean, and Lane (1979) reanalyzed the pause distributions obtained by Grosjean and Lane (1977) and found that the model of performance structure better predicted the durations of pauses in ASL than the syntactic structure of the sign utterance alone. (The model accounted for 72% of total variance in pause time whereas the linguistic structure accounted for 61%.) A subsequent study by

Grosjean, Battison, Teuber, and Lane (1979a) invoked four different experimental tasks in order to study performance structure in ASL; parsing of sentences, reading at reduced speed (in order to encourage pausing), relatedness judgments for pairs of signs, and sign recall. These four different approaches produced very similar performance structures—structures that reflect at one and the same time the linguistic structure of the sentence and the need to produce constituents of approximately equal length. The authors conclude that performance structures have their roots in the organization of language in general and not in some property specific to the production modality whether oral or visual.

Grosjean (1978) concludes his synthesis, therefore, by proposing that despite the numerous differences that exist between sign language and oral language (production modality, role of breathing in production, etc.) these languages share, at least in part, a common underlying production mechanism, which is influenced by such factors as the rate of output of the utterance, the semantic novelty of the message, the syntactic structure of the sentence, and the necessity to produce groups of words or signs of approximately equal length. Further study of this common mechanism may lead to its integration into a general model of language production, clearly revealing those apsects that are common to the two modalities and those that are unique to each.

THE PERCEPTION OF SIGN LANGUAGE

Although a number of perceptual tasks have been used by sign language investigators (Bellugi et al., 1975; Lane et al., 1976; Stungis, 1978) their aim was more to demonstrate the psychological reality of the structural organization of the language or to study the memorization of the language than to clarify the processing of the visual signal from the moment it is detected by the retina to the moment the word or utterance is understood by the observer.

The few studies that do exist have only touched upon the scope of this vast domain of research. Grosjean (1977), for example, studied the perception of rate among English listeners and ASL observers. He showed that the function that relates physical rate to apparent rate for the listener and the observer is linear in log–log coordinates. But the two power functions, determined for a comparable range of stimulus rates (about 3 to 1) have different exponents: 1.9 for English and 1.6 for ASL. This means that when a speaker and a signer double their rate, a listener will perceive a fourfold increase in the speaking rate whereas an observer will perceive a threefold increase in the signing rate. These results, confirmed with subjects who know neither the oral language nor the sign language in question, may be explained by the modality difference between the two languages but this remains to be demonstrated experimentally.

Reef, Lane, and Battison (1978) were interested in another aspect of the perception of sign language, the visual persistence of signs. Erwin and Hershenson (1974) and Erwin (1976a, 1976b) showed that when one asks a subject to react as quickly as possible to the onset of a stimulus and then to react to the end of the same stimulus, the difference in the reaction times is in general greater than the duration of the stimulus. This difference is called the visual persistence of the stimulus. When the stimulus can be encoded linguistically, visual persistence is shorter than when the stimulus is not readily codified in linguistic terms. Erwin (1976a, 1976b) attributes the duration of the visual persistence to an iconic short-term memory that persists while visual information is being encoded and disappears only when that encoding is finished. The hypothesis advanced by Reef et al. (1978) was therefore the following: For users of ASL the visual persistence of signs should be shorter than that of handshapes impossible in ASL, because the latter are not codable linguistically, but this difference should not appear for subjects who are unacquainted with ASL. Their results confirm the hypothesis. On the average, the visual persistences of real signs and of nonsigns were identical for naive subjects but significantly different for the users of ASL. Deaf signers gave shorter visual persistences for the signs than for the nonsigns, thus suggesting that the first were encoded more rapidly than the second. The authors conclude that visual persistence reflects stimulus encoding and can be used to study the cognitive processes involved in the perception of sign language.

The process of recognition for signs presented individually also interested Grosjean, Teuber, and Lane (1979c). In a prior study (Grosjean, 1979), ASL users had been asked to measure the durations of a certain number of signs. This task created no particular problem, but they always placed the onset of the sign (that is to say, the moment at which they started timing) at a point when the location had hardly been reached, the handshape was not fully formed, and the movement had hardly begun. What visual cues were the observers relying on to decide that a sign had actually begun? This was the question that Grosjean et al. (1979c) sought to answer. The approach they used was to present a sign repeatedly, increasing its duration with each presentation, measured from the beginning of the sign, from 28 msec to 744 msec. The subjects were to accomplish three tasks after each presentation: copy what they had just seen, guess the sign that had been presented, and give an estimate of their confidence in that guess (along a scale of 1 to 5).

This experiment showed, first, that the formational parameters of a sign are not all copied correctly at the same instant. The orientation of the hand, its configuration, and the location of the sign are copied correctly much sooner than the movement of the sign. This finding is explained by the fact that movement is distributed over time and is associated with the inherent duration of the sign; it is therefore normal that it should be the last parameter to be copied correctly.

When we examine the moment at which a parameter is used correctly in a guess, similar results are obtained. Movement is again the last parameter to be guessed correctly and it is movement, as a result, that triggers the correct identification of the sign. The authors conclude that the on-line processing of a sign does not consist of an all-or-none operation but rather that observers narrow in on the sign parameter by parameter.

An analysis of the errors made by the subjects when they were guessing the signs leads to the same conclusion. Sixty percent of all the errors involved only one parameter (usually movement); 28% of the errors concerned two parameters (movement once again played the major role), and as might be expected, very few errors involved three or four parameters (these results closely resemble those obtained by Crittenden, 1974, in his study of identification of signs by subjects learning ASL). The error data confirm that observers narrow in on the sign by using the information given by the different parameters, and as movement is the last parameter to be identified, it is involved in the greatest number of erroneous guesses.

Grosjean, Teuber, and Lane (1979) then studied the factors that account for the identification time of signs. They noticed at the outset that only the first half of the sign proved critical for its identification. This finding illustrates very clearly the temporal redundancy of sign language at the lexical level. Further, the time necessary to identify a sign was not constant across signs: On the average, a sign was identified in 400 msec and the range was from 200 msec (for the sign LIKE) to 600 msec (COW). How can we explain this range of some 400 msec? Two factors, the duration of the sign and the number of alternative signs with the same place of articulation, did not account for the variation. However, place of articulation, the number of hands used in the sign, frequency of occurrence of the sign, the use of visual and bodily indices in articulation of the sign and the existence of other signs that differ from the stimulus sign in only one parameter—which is to say, minimal pairs—all played a role in sign identification. Research is now underway to compare lexical access and lexical storage in English and American Sign Language with words and signs occurring in the context of sentences.

The on-line processing of sign can be approached in quite a different way: with a shadowing task, such as that used in oral language studies undertaken by Miller and Isard (1963), Rosenberg and Jarvella (1970), and Marslen-Wilson (1975). Marslen-Wilson proposes, for example, that the on-line processing of spoken language is not serial, as Bever and Hurtig (1975) would contend, but rather that it is interactive and parallel. The phonetic analysis of the linguistic signal, its lexical analysis, and the construction of syntactic and semantic representations all take place concurrently. Information at any given level is accessible to all levels and modifications of internal representations at each level are on-going in a parallel and interactive fashion. This perspective of on-line processing of the signal is sharply opposed to that of other psycholinguists who maintain that signal processing is conducted principally in an additive and serial fashion. An extreme interpretation of the latter position would be as follows: Lexical units remain in short-term memory until the end of the clause and are then integrated in order to construct a semantic representation of the clause. By using a shadowing task with selectively disrupted stimuli, Marslen-Wilson (1975) was able to show that restoration errors produced by subjects were not only phonetic but also syntactic and semantic, thus indicating an interactive and parallel analysis at several levels.

McIntire and Yamada (1976) undertook a similar study with ASL in order to find out whether such interactive and parallel processing was modality invariant. They asked two sign language users to tell several stories, which were videotaped and then presented to deaf subjects who attempted to shadow the stories as closely as possible. The shadowing performances were recorded and the shadowing lag between the stimulus and the response tapes was calculated. Marslen-Wilson had found a latency varying from 200 to 800 msec for an oral language (English) and McIntire and Yamada report a similar range for a sign language (ASL). But what is even more interesting are the types of errors that were made by the subjects, errors that tend to support the hypothesis of parallel interactive processing of linguistic information. First, no error yielded an ungrammatical sequence in ASL, which led the investigators to conclude that syntactic and semantic processing was ongoing throughout the task. For example, many personal pronouns were omitted during shadowing but only in those cases where the linguistic structure allowed it (the referent having already been established). There were also numerous additions, but once again their presence did not lead to lack of grammaticality. And what is perhaps even more important is that numerous errors of semantic substitution occurred, such as to leave the meaning of the sentence in which one sign was substituted for another largely unchanged (e.g., the sign OK was replaced by the sign FINE). This type of substitution would be impossible if the observer merely copied the stimulus sentence: It suggests that decoding is proceeding at all linguistic levels (phonetic, semantic, syntactic) during on-line processing.

We should note also that errors of elaboration were also found—that is the addition of several signs that add information to the base message. These errors suggest that the signer/observer again is not limiting himself to a simple copying of the signal but that he has understood the meaning of the incoming stimuli and can embellish the story in a logical manner. McIntire and Yamada (1976) conclude therefore that, whatever the modality of the language, oral or visual, the message is processed simultaneously and interactively at all levels of analysis. Mayberry (1977) also used a shadowing task to determine the importance of facial expression in the processing of sign. Although the data concerning this question were not clear-cut—native ASL subjects shadowed equally well under the face-in and face-out conditions (in the latter condition fleshtones were Chromakeyed out), less well under the face-out with poor signal-to-noise ratio, and least well under the face-in with poor signal-to-noise ratio—Mayberry reports that the errors subjects made were semantically correct and that they made frequent dialectal and synonym substitutions, thus confirming the results reported by McIntire and Yamada.

Although studies of sign language perception are still few in number, they tend to show that after a peripheral analysis differing from that of oral language the processing of the message in the two modalities follows a similar route, which takes the form of interactive and parallel analysis.

MEMORY FOR SIGN LANGUAGE

Although only a few studies of memory in sign language have been conducted, they all show that the strategies adopted by deaf subjects are very similar to those used by hearing subjects in oral language. Bellugi and her collaborators (Bellugi et al., 1975; Bellugi & Siple, 1974) have studied the short-term memory of lists of signs of varying length (three to seven signs) with ASL users. Conrad (1962, 1970) and Sperling and Speelman (1970), among others, had shown that when words and letters are presented visually to hearing subjects for memorization and later recall, the errors of recall that are made are phonetic in nature, not visual or semantic. Thus, among the erroneous responses obtained for the stimulus written C, there were more responses of Z than O (which is visually close to C), and for the word *bee* more errors were found that were due to phonetic resemblance with the word (e.g., *pea*) than semantic resemblance (e.g., *wasp*). How does all this work out in sign language? How do users of ASL store signs in short-term memory? Are they encoded in terms of parameters of sign formation or in terms of some other system (a global visual representation of the signs, a coding of their meaning, a translation of the signs into oral language and memorization in terms of the latter, etc.)?

The study by Bellugi et al. (1975) undertook to answer these questions. They asked two groups of eight subjects each, one composed of hearing students, the other of deaf students (all of the latter had learned ASL as a native language) to participate in a memory experiment with word lists (for the hearing) and sign lists (for the deaf). The lists, with three to seven items, were presented aurally and visually at the rate of one word or sign per second. The recall task after each list required the subjects to recall the words or signs in the order presented (in English). The authors found curves of serially ordered recall that were similar for the two groups; both groups showed recency and primacy effects but the memory span for the deaf in signs (4.9 items) was one item shorter than for the hearing subjects in words (5.9 items). The authors explained this difference by the smaller primacy effect found among the deaf; the rehearsal of the signs at the start of the list takes more time than that of words and this reduces the number of items that can be memorized at the start of the list. (Bellugi & Fischer, 1972, and Grosjean, 1979, indeed showed that the rate of sign production is less than that of spoken words.)

The recall errors of the hearing subjects turned out, as expected, to be largely phonetic. For example, the word *vote* was replaced by *boat, peas* by *knees*, etc. In the same way, the errors of the deaf subjects almost all showed visual similarity with the sign stimuli. For a stimulus sign articulated with two hands, the substitution in recall had the same number of hands involved. Further, the majority of the errors preserved the parameter values of the sign stimuli save one, thus creating minimal pairs. For example, a frequent error of the sign HOME was the sign YESTERDAY. In ASL these two signs share the same place of articulation, hand-orientation, and movement but differ in handshape. Other errors distinguished the sign stimulus from its recall along other formational parameters; for example, SOCKS became STAR, an error primarily of orientation; and BIRD became NEWSPAPER, an error in place of articulation. An evaluation of the errors made by the hearing subjects in English and the deaf subjects in ASL confirm that these errors were indeed acoustic in the former case and visual in the latter. Bellugi et al. (1975) conclude that short-term memory errors in sign language provide further evidence of the existence of formational parameters in the structure of signs (see the earlier section on linguistic description and psychological reality).

Poizner, Bellugi, and Tweney (1979) pursued the work on the recall of signs by running three experiments that examined short-term encoding processes for different aspects of signs. Experiment 1 compared short-term memory for lists of formationally similar signs with memory for matched lists of random signs, (for example, TAPE, CHAIR, NAME, EGG, etc. which all share the same place of articulation and which are made with two hands in contact as opposed to random lists of the type RUSSIA, APPLE, PRESIDENT, SENTENCE, which differ from each other on most parameters.) Just as the acoustic similarity of words interferes with short-term memory for word sequences, the formational similarity of signs had a marked, debilitating effect on the recall of sequences of signs. In a second experiment, the authors evaluated the effects of the semantic similarity of signs on short-term memory: semantic similarity (e.g., AMERICA, RUSSIA, ENGLAND, SCOTLAND or CHERRY, LEMON, CABBAGE, TOMATO) produced a weak, adverse effect on the short-term recall of sequences of signs. And in the third experiment, they studied the role that the iconic value of signs played in short-term recall. The results showed that greater iconicity has no reliable effect on recall, but there was no testing of iconically homogeneous lists. The authors conclude that further support is provided for the conclusion that deaf signers code signs in short-term memory in terms of linguistically significant formational parameters. The semantic and iconic information of signs, however, seem to have little effect on short-term memory.

In a recent study, Poizner, Newkirk, Bellugi, and Klima (in press) leave aside the recall of basic sign forms and investigate the coding and remembering of morphologically complex signs. They wanted to find out whether inflected verbs are remembered as holistic units or in terms of a base and an inflection. Ten basic ASL verbs and eight inflected forms of each verb were used. Forms were inflected for referential indexing, numerosity, and temporal aspect. Several types of lists (all four signs long) containing a varying number of inflected forms and basic signs were presented. Subjects viewed each list and immediately afterwards tried to recall, in sign, each item in the correct serial position. An analysis of the error patterns suggests that signers do indeed remember signs in terms of base and inflection. For example, in their recall, subjects deleted inflections, recalling only basic signs, and added inflections to basic signs presented alone. Also, subjects transposed inflections across basic signs, recalling the basic signs in the correct serial position. And in addition, recombinations occurred in which the recalled inflection maintained the meaning, but differed in form from the presented inflection. This last result clearly indicates that the errors of recombining morphological elements within lists were not due simply to subjects misremembering movements similar in form but rather implies a more abstract encoding of inflections. Poizner et al. (in press) conclude that subjects were indeed encoding inflections and basic signs as independent units that constitute the building blocks for a morphological system of a combinatorial nature.

How are signs stored in long-term memory? Are they stored according to their formational parameters (as in short-term memory) or rather according to semantic traits (as for words)? In order to answer this question, Siple, Fischer, and Bellugi (1977) undertook a recognition study with signs and words using deaf subjects.

The experimenters asked their subjects to observe a list of 160 lexical items composed of signs and written words and presented on a television screen. At the end of the presentation, the subjects were to wait a half hour before seeing a second list of items (the recognition list); this list differed from the first in the following way: Half of the words and signs were new, and among these some differed from the original signs in one parameter only (for example, BIRD and NEWSPAPER) whereas others were entirely different. Furthermore, the items that had been presented previously were presented either in their original language (whether ASL or English) or in the other of the two languages. The subjects were asked to indicate if the items were present in the original list and, if so, in which language they had originally appeared, ASL or English.

The results showed that the ASL items were stored in long-term memory in the same way as the lexical items from English, specifically according to their semantic traits. Although the formational parameters of a sign play an important role in short-term memory these parameters are not utilized in the organization of long-term memory. The subjects in the present experiment were rarely misled when the new signs resembled the old in every formational respect but one. (Similar findings are reported by Liben, Nowell, & Posnansky, 1978.)

Battison, Lane, and Grosjean (1978) were equally interested in memory for signs but in the context of sentences. The psycholinguistics of oral languages is rich in studies that show the importance of syntax in the recall of isolated sentences. For example, Johnson (1965, 1968) found a strong correlation between the importance of a syntactic break (for example, the break between the noun phrase and the verb phrase) and the transitional probability of an error in recalling the word following the break given correct recall of the word preceding the break. A different approach (Suci, Ammon, & Gamlin, 1967) consisted in presenting a sentence followed immediately by one of the words of the sentence. The subject was to state as rapidly as possible the words in the sentence that followed the probe word given by the experimenter. The results demonstrated once again the role of syntactic structure in the recall of sentences. Response latency was always longer when the probe word and the response word lay on either side of an important syntactic break and shorter when they surrounded a minor break within a major constituent.

The study by Battison et al. (1978) asked whether comparable results would be obtained for sentences in ASL, that is, whether the syntactic structure of the signed sentence would play a role in its memorization. Moreover, they were interested in the possibility of replicating the following finding for spoken language (Grosjean et al., 1979b; see the earlier section on production of sign language): When the major constituents of a sentence, the noun phrase or the verb phrase, are unequal in length, processing measures are better predicted by a performance model that embraces linguistic structure and a tendency to balance the constituents than they are by linguistic structure alone. Balanced sentences, wherein the noun phrase was as long as the verb phrase, and unbalanced sentences where the noun phrase was much shorter, were presented to deaf native users of ASL, and each syntactic break in the sentence was probed in the method of Suci et al. (1967). The results obtained were in the expected direction. For the balanced sentences, the correlation between order of the syntactic break and reaction time was $r = .86$, indicating the importance of syntax in the recall of sentences of ASL. But when the noun phrase and the verb phrase differed in length, the syntactic structure of the sentence was no longer able to predict reaction time ($r = .14$). Instead accurate prediction required the model of performance structure that took into account the surface structure of the sentence and the balancing tendency mentioned earlier; the performance model predicted the results with a correlation of $r = .88$ for the balanced sentences and $r = .70$ for the unbalanced sentences. These results are entirely comparable to those obtained in spoken language. Dommergues and Grosjean (1979) replicated the study by Johnson (1965) using balanced sentences and unbalanced sentences. They found that errors of recall were better predicted by the duplex model of Grosjean et al. (1979b) than by the syntactic structure alone.

Our account of studies of memory in sign language must end here. In view of the results reported previously, it is likely that forthcoming studies will provide further evidence of parallel processes in the two language modes, visual and oral. How far does this parallelism extend? When a signed sentence is understood, is its meaning stored in long-term memory without any trace of the original syntactic structure (see the results of Sachs for English, 1967)? Are elements of meaning integrated with one another? Brewer, Caccamise, and Siple (1979) adapted the Bransford and Franks (1971) paradigm and showed that subjects receiving manually coded English integrated semantic information from the linguistic stimuli. Although the experiment still needs to be run with native users of ASL, one would expect similar results. Is inferred meaning added to this core meaning (Bransford, Barclay, & Franks, 1972)? And is the message thus enriched, integrated in turn with already existing knowledge (Bransford & Johnson, 1972)? In view of the initial results obtained by Bellugi and others, it would seem likely that future research will reveal that all these operations apply equally to sign language memory.

CONCLUSIONS

We would like to recapitulate here the aspects of encoding and decoding that are specific to the language modality on the one hand and common to all languages, oral or visual, on the other. Although this conclusion can be rooted in only a small number of studies which are, furthermore, concerned primarily with ASL and English, we believe that it will prove useful insofar as these results may ultimately be extrapolated to other oral and sign languages.

Differences in modality seem to be most apparent in the first steps of decoding—receptor systems, feature detectors, preperceptual storage, primary and secondary recognition systems (see the model of speech decoding in Massaro, 1978), and in the last steps of encoding—morphophonemic rules, phonetic and phonological rules, motor commands to muscles, articulation of utterance, (see the model of speech production in Fromkin, 1971).

But at a deeper level of language processing, oral and visual languages seem to be processed in much the same way. Production rate in sign language and in oral language can serve as an example. The phonetic rate of English and of ASL (measured in signs and words per minute) is quite different but speakers of the two languages produce an identical number of propositions per minute thus yielding a similar information rate in a given time. Another example concerns the change of rate in the two languages: signers and speakers adopt different strategies in modifying rate but in the end cover comparable ranges when they speed up and slow down. Thus, because of the different modalities—visual and auditory—signed and spoken languages are necessarily characterized by different peripheral traits but at a deeper level of analysis the two languages have numerous points in common. We will mention only a few. First, communication in sign language is as rapid and as effective as in oral language. Next, the two types of languages are organized in hierarchical units that play a role in encoding and decoding. Distinctive features at the phonological level, morphological units at the morphological and lexical levels, constituents, propositions, sentences at the syntactic level—all these units are truly functional in the production and perception of language. In addition, it would appear that speakers and signers have in common an underlying production mechanism influenced by such factors such as the rate of production, the semantic novelty of the message, the syntactic structure of the sentence and the need to output segments of approximately equal length. Also the processing of the message in the two modalities takes the form of an interactive and parallel analysis. Finally, signs and words are stored in short-term memory according to their formational or phonetic parameters, whereas in long-term memory they are stored according to their meaning.

Although still in its infancy, the psycholinguistics of sign language has not only made headway in uncovering the processes invoved in the production, perception, and memorization of manual languages, but it has also begun to isolate those aspects of encoding and decoding that are specific to the modality of communication (oral or visual) and those that are common to all languages, whatever their modality of perception and production. In this it is helping to frame a general model of linguistic performance.

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