The Production of Sign Language: Psycholinguistic Perspectives

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Sign Language Studies, Volume 25, Winter 1979, pp. 317-329 (Article)

Published by Gallaudet University Press
DOI: *https://doi.org/10.1353/sls.1979.0011*

SLS (1979), 317-329

THE PRODUCTION OF SIGN LANGUAGE: PSYCHOLINGUISTIC PERSPECTIVES[1]

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The production of language. The questions underlying the production of language are not only numerous but also highly complex, and current psycholinguistic research has only just begun to specify and order the cognitive and linguistic processes that underly the production of an utterance from the moment a signer or a speaker has something to express (a thought, a wish, a question, etc.) to the moment it is expressed in sign or speech (see Clark & Clark 1977, Foss & Hakes 1978). A model of language production will have to specify, among other things, which cognitive operations intervene to encode an idea into an utterance; how the semantic, syntactic, and phonological systems of the language interact to create an utterance and how we go about executing the utterance; which motor commands are given; which muscles are contracted; which articulators are moved—the list can easily be extended.

The numerous studies that have examined the articulation and formational characteristics of sign languages (e.g. Stokoe 1960, Battison 1978, Klima & Bellugi 1979) have only too clearly underlined the many differences that exist between production in speech and in signing: the modality of production

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[1] Originally presented at the NATO Advanced Study Institute "Recent Developments in Language and Cognition: Sign Language Research" held in Copenhagen, August 1979. Support by NSF grant 768 253 and DHEW grant RR 07143 is gratefully acknowledged.

(vocal and gestural, respectively), the different organs of articulation (pharynx, tongue, lips, teeth in one case, arms, hands, upper body, head and face in the other), the interaction of breathing and speech but the relative independence of breathing and gesturing). Based on these and other differences, we might conclude that speech and signing are the result of very different mechanisms of production. And yet both sign and speech are modalities of human language and so controlled by human cognitive processes. Production of language in the two modalities is based on complex motor behaviors governed by the brain. Production in sign and in speech takes place in a social environment with similar social needs, and the languages in the two modalities of sense perception share many formal traits and linguistic similarities.

Production compared. In what follows we will compare speech and sign production from the psycholinguistic viewpoint. We will consider approaches that have been used in the study of language production—mainly that of speech—with the hope that similar approaches when adapted to the signing modality will be adopted by researchers interested in sign language production. We will then outline a number of stages in the production of utterances that are probably common to speaking and signing. We will end by examining one aspect of production, the timing of language output, that has been studied in detail in the two modalities and show that speech and sign probably share (among other things) a common language timing mechanism. Throughout a recurring theme will appear: psycholinguistic study of the production of language cannot concentrate on one modality, ignoring others, without weakening the resultant performance model. No model of linguistic performance can be complete until it describes those aspects of encoding and decoding that are specific to the modality of communication—vocal or gestural, auditory and visual—as well as those that are common to all languages whatever their modality of perception and production. We will discuss below three main approaches that have been used in the study of spoken language production at the planning stage and mention comparable studies in signed language production when they apply.

Production experiments. The experimenter who studies production may manipulate the output of the speaker or signer by presenting a stimulus (or a series of stimuli) and asking the subject to produce an utterance, making sure that the output falls only into the required response category. In such experiments the subject is not free to speak or sign spontaneously but is restricted to a response or set of responses. Osgood (1971), for example, studied the use of articles, pronouns, auxiliaries, negatives, and active vs. passive sentences, by performing a series of brief and very simple vignettes before an audience instructed to write descriptions of the scenes that they had just observed. Although this is a promising approach to the study of language production, it has not been used very extensively, and to our knowledge has not been carried over to the study of sign production. [Research in progress at Gallaudet College by Mary Hockersmith is using precisely this technique with native signers and others, Ed.] The analysis of indexing, use of space, modulation, and inflection in sign language could certainly benefit from such a highly controlled experimental approach.

Hesitation phenomena. A second approach to the study of language production has been to examine the hesitation phenomena in spontaneous utterances. By studying such hesitations as unfilled pauses, filled pauses, false starts, repeats, filler words, and drawls, a number of researchers have been able to show that planning of utterances takes place at various processing levels. The study of unfilled pauses, for example, has shown that these tend to occur before unpredictable lexical items (Goldman-Eisler 1968), at the beginning of phonemic clauses (Boomer 1965), and in association with "idea" boundaries in utterances (Butterworth 1975). It has been concluded from such studies that unfilled pauses are used for lexical selection, planning of phonemic clauses, and planning at the discourse level. To our knowledge, no systematic examination of the signing equivalents of hesitation phenomena in speech has been conducted. It has been reported that gaze aversion, body shift, raising of the eyebrows, and wiggling of the fingers are marks of hesitancy (Bellugi & Fischer 1972); and sign informants report that repeats and false starts do seem to occur in sign; still a comprehensive analysis of such phenomena in sign needs to be undertaken.

Errors in production. A third approach to the study of language production has been to examine errors in production—slips of the tongue in speech and slips of the hand in sign. Fromkin (1971, 1973) and Garrett (1975) have used errors in speech production to confirm the psychological reality of language units such as the distinctive feature, the phoneme, the syllable, the word, the phrase, etc. to give evidence for the formational rules used in the construction of these units and to propose models of language production. In sign language production, Newkirk, Klima, Pedersen, and Bellugi (1979) analyzed 131 errors of production in American Sign Language (ASL) and showed that these provide evidence for the independence of formational parameters or aspects in the construction of signs. Most of these signing errors consisted of the substitution of one aspect (i.e. handshape, action, or location) for another and so support the hypothesis that signs are organized as combinations of these aspects (Stokoe 1960). The errors also provide evidence for posited rules of sign formation; e.g. that errors followed the symmetry rule (Battison 1974, 1978), which stipulates that two-handed signs with both hands active require the same action to be executed by each of the two hands. Unfortunately, Newkirk et al. did not go one step further (the step that Fromkin took in her 1971 paper) and use their data to propose a model of sign language production. One possible reason for this may be that the data base of 131 errors was too limited. Like the hesitation phenomena, the production errors of signing should be the subject of more research in the study of sign language production.

Common stages in the production of signing and speech. Based in large part on the data obtained from the three approaches just considered, models of speech production have been proposed (Fromkin 1971, Garrett 1975, Foss & Hakes 1978, Butterworth 1979, Cooper et al. 1979). From these diverse models we have extracted a number of stages in the production of utterances; these may also apply to production of utterances in sign. Although for the sake of clarity we present these stages of production in a specific order, we need to be aware that many of them doubtless occur in parallel. In addition, each stage is linked to other stages by a series of feedback and feed-forward loops, which will not be discussed here. What follows is a summary of various stages research has found in language production as these apply to signing. To

illustrate each stage, we will follow the steps taken by a particular signer from the moment she decides to ask a friend if she is going to a party that night to the actual sign utterance YOU GO PARTY?

A. Basic message formulation. Here the message is formulated in a non-linguistic code (an idea, a thought, a wish,...). In our example, the signer has decided to ask a question and has a basic idea of what she will ask. This basic question is first formulated in a non-linguistic "code" of some kind.

B. Pragmatic factors involved. At a very early level in the planning of an utterance the signer considers a number of pragmatic factors, which influence not only the content but also the form of the message. The signer takes into account the existing knowledge of the utterance receiver, the social context of the interaction, what the focus of the utterance will be, etc. S/he also obeys a number of conversational maxims that have been outlined by Grice (1975): we are expected to be "appropriately" informative (i.e. neither too precise nor too general), to speak the truth, to be relevant, and to be perspicuous. Thus, in our example, it is at this stage that the signer of YOU GO PARTY? centers on the appropriate content of the question. She knows that her friend has been thinking about that particular party for some time, and therefore she does not have to specify which party or that the party is being held that evening (Grice's informative maxim); but she does have to mention the concept 'party' because the topic of conversation just before was local politics or some other matter.

C. Grammatical structure assignment. Quite early in the planning of the utterance the structure of the utterance has to be determined. Here the semantic representation is structured syntactically and the grammatical morphemes are provided. The utterance now takes form something like this:

Pronoun Verb + directionality Noun

D. Prosodic features chosen. Such prosodic features as sentence stress and intonation in a spoken utterance are chosen early and are based on the syntactic, semantic, and pragmatic

factors decided upon. For the message in our example, what corresponds with the prosodic component of the production system will call for a raising of the eyebrows, a tilting of the head, and movement of various other parts of the body that mark a Yes/No question in ASL (Baker 1976, Baker & Padden 1978).

E. Lexical look-up. At this stage, the signer enters her lexicon and chooses the appropriate lexical items that correspond to the semantic, syntactic, and pragmatic factors already specified. The output of this stage is the actual lexical items, which are specified phonologically. In our example the signs YOU, GO, and PARTY would be chosen by the signer.

F. Assembly in short-term buffer. The syntactic, lexical, and prosodic components obtained in previous stages are now assembled in some sort of short-term buffer (often thought to be the size of a phrase or clause) and are transformed into serially organized units (this may be serial and parallel organization for sign language utterances; in our example manual and facial, head, and body actions are in parallel).

G. Commands to motor control of the brain. At this stage, about which we know very little, commands are given to the motor control centers of the brain, which in turn activate the appropriate articulators. The utterance YOU GO PARTY? is then signed by the hands, arms, face, head, etc.

As can be seen from the foregoing, we have concentrated on those stages of production that clearly appear to be common to both sign and speech production. The last stage at which the actual utterance occurs will of course be the point at which the spoken output and the gestured output each go their own way. Additional studies are needed now to confirm and especially to refine our knowledge of the various stages outlined, but also to add any necessary new stages to the model, and to spell out in greater detail those aspects of sign production and speech production that are common and those that are peculiar to each.

Timing of speech and sign production. In this section we will concentrate on one aspect of production, which has been studied quite extensively both in spoken and in signed production—the timing of language production; and we will show that both modalities probably share an underlying production mechanism that controls the timing of language output. Our approach will be to state four main findings concerning the temporal variables of sign and speech that on the surface reinforce the differences between the two modalities, and then to show that a deeper level of processing a common mechanism is at work for both.

A. Production rate in sign and speech. Bellugi and Fischer (1972) report a mean production rate of 4.7 words/second in English speech as opposed to a mean of 2.37 signs/second in ASL for the same producer in a story-telling task, and Grosjean (1979) has shown that a speaker produces 2.77 words in the time it takes the signer to produce one sign in a reading task. This difference in production rate may be explained by the fact that the articulation of a word requires less displacement of the articulators of speech than of the articulators of signing. The arms and hands are not only of considerably greater mass than the tongue and vocal folds but also may move over distances as great as that from the top of the head to the waist.

Fortunately Bellugi and Fischer had the insight to measure production rate in terms of underlying propositions and so discovered a fact of major importance: the two languages, English and ASL, are produced at very comparable rates when propositions are timed; English at one proposition in 1.27 seconds and ASL at one (the same) proposition in 1.47 seconds. The communication of an utterance in signing and speaking takes nearly the same amount of time, although the phonetic rates are quite different. Signers appear to compensate for the slower phonetic rate (if manual activity is considered) by using additional channels of expression, body shift, facial expression, eye gaze and blinking (Baker 1976, Baker & Padden 1978), as well as by inflecting and modulating the manual signs (Klima & Bellugi 1979).

This close similarity in proposition output rate suggests that some underlying mechanism is controlling the temporal processing of both speaking and signing. Klima and

Bellugi propose that

> ...the tendency toward compacting linguistic information in signs may be a response to temporal pressure on language production. Cognitive processes underlying language might well create an optimal production rate for propositions, regardless of the language mode. Under such temporal pressure, a relatively slowly articulated language of signs might well exploit the possibilities of simultaneous elaboration of meaning which exist in the visual-spatial mode. (1979: 194)

B. Inherent duration of signs and words. For the many reasons mentioned above, signs are inherently longer than words. Grosjean (1979) reports that for the same reading task, words lasted on the average 0.20 seconds but signs almost twice as long, 0.36 seconds; and yet a number of common factors account for the difference in duration. The first is production rate. As the rate of reading in the experimental task is increased, signs and words decrease in duration and vice versa. Thus, Grosjean found in the same experiment that at a very fast signing rate (176 signs/minute), the mean duration of signs was 0.16 seconds, while at a slow signing rate (35 signs/minute) the mean duration had risen to 0.79 seconds. (Similar changes in the duration of words as a function of production rate have been reported by Lane & Grosjean, 1973, and Grosjean, 1979.) Although signers and speakers use different approaches to changes required in production rate (signers increase or decrease the articulation rate or duration of signs, while speakers mainly add or take away pauses), it is interesting to note that both signers and speakers cover the same range of rate when asked to go from a slow to a fast production rate (i.e. from one-fourth their normal rate to three times their normal rate. Grosjean (1977) reported a 2.6:1 range of rates for signers and a 2.7:1 range for speakers. This suggests again that despite the different articulators that come into play in spoken language and in signed language production (which determine the average production rate for the two) there exists a common central system that determines the relative change of rate in the two modalities.

A second factor that accounts for the change in duration of both signs and words is the semantic novelty of the lexical items in the utterance. Grosjean (1979) reports that signs, like words, that occur twice in the same syntactic position are on the average 10% shorter on the second occurrence. A third factor is phrase structure lengthening. Again both words and signs at the end of sentences are about 12% longer than the same words and signs within sentences. These results strengthen the premise that some underlying production mechanism mediates the timing of both signed and spoken language production.

C. Breathing and pausing in speech and sign. Grosjean (1979) reports that the signer's respiratory cycle is very regular during signing production and resembles a "quiet breathing" pattern, in which about 40% of the breathing cycle is spent inhaling and 60% exhaling. For speech, however, the respiratory cycle is reorganized completely for language production. The speaker inhales rapidly at the beginning of the sentence, adjusts expiration to serve the needs of speech production, and inhales again rapidly during the pause at the end of the sentence.

Despite these differences, both the signing and the speaking streams are composed of articulation time and pause time. At normal rate speakers spend about 16% of the speaking time in silence, and signers about 10% of the production time in holds (see Grosjean & Lane 1977, Grosjean 1979). This would seem to indicate that the production mechanism—with no regard for the difference in output modality—requires cognitive processing time to plan and execute the utterance. This time is obtained by inserting fluent pauses in speaking and by inserting holds in signing as well as by use of the hesitation phenomena that can be found in production of language in both modalities.

D. The distribution of pauses in sign and speech. Fluent pauses in speech and sign are superficially very different (silence in speech, holding the hand or hands in sign); also pauses in sign are much shorter than pauses in speech (a mean of 0.20 seconds in sign as opposed to about 0.46 seconds in speech; see Grosjean 1979). Nevertheless, the distribution of pauses in the two modalities can it seems be

explained by similar factors. Grosjean and Lane (1977) found that in sign, as in speech, a hierarchical organization of pause frequency and duration corresponds closely or exactly to a hierarchical organization of constituents. More pauses and longer pauses are found at major syntactic breaks (for example, at the end of complex sentences or between conjoined sentences) than at minor constituent breaks. In other words, the higher the syntactic order of the juncture, the more likely there will be a pause and the longer that pause will be.

Thus the syntactic structure of both spoken and signed utterances is an important factor in accounting for the distribution of pauses in the utterances. Recently, however, we have uncovered other factors that play a role in the distribution of fluent pauses. We found in speech production that when constituents are of unequal length (e.g. a sentence with a very short NP and a long VP), subjects in a reading task will attempt to displace the pause to a point midway between the beginning of the first constituent and the end of the second constituent, if at that point there occurs a syntactic boundary important enough to warrant a pause (Grosjean, Grosjean, & Lane 1979). Thus the speaker needs to respect the linguistic structure of the sentence against the perhaps physiological need to balance the length of the constituents during speech production. Having found this for speech, we wondered if the signer also needs to compromise between these two sometimes conflicting demands. Grosjean, Battison, Teuber, & Lane (1979) invoked four different experimental tasks in order to study the subjective chunking (or utterer parsing) of ASL sentences and showed that the structures obtained reflect at the same time the linguistic structure of the sentence and the need to produce constituents (between major pauses) of approximately the same length. (The structures obtained are called "performance structures," because they are based on the actual production of signing subjects and not on theoretical models of linguistic structure.) We can conclude from this experiment that performance structures have their roots in the organization of language itself and not in some property specific to spoken languages or to signed languages.

From the above discussion we propose therefore that speech and sign production share some underlying timing mechanism that controls the utterance rate of propositions

in the two modalities, the durational pattern of words and signs, and the distribution of pauses in the two modes.

Conclusion. The research reviewed clearly indicates the need for more systematic research in sign language production. It is our hope that by studying the breakdowns in sign production (hesitation phenomena, slips of the hand, etc.) and by using other approaches such as controlled experimentation and analysis of a spontaneously produced corpus, researchers will continue to isolate those aspects of language production that are common to signed and spoken languages and those that are specific to each. In this they will help construct a valid general model of linguistic performance.

REFERENCES

Baker, Charlotte
1976 What's not on the Other Hand in American Sign Language, Papers from the 19th Regional Meeting of the Chicago Linguistic Society.

- - - - -, & Carol Padden
1978 Eye Blinking Behavior in a Visually Monitored Language, in Understanding Language through Sign Language Research, Siple ed. (NY, Academic Press).

Battison, Robbin M.
1974 Phonological Deletion in American Sign Language, Sign Language Studies 5, 1-19.
1978 Lexical Borrowing in American Sign Language (Silver Spring, MD, Linstok Press).

Bellugi, Ursula, & Susan Fischer
1972 A Comparison of Sign Language and Spoken Language, Cognition 1, 173-200.

Boomer, D.
1965 Hesitation and Grammatical Encoding, Language & Speech 8, 148-158.

Butterworth, B.
1975 Hesitation and Semantic Planning in Speech, Journal of Psycholinguistic Research 1, 75-78.
1979 Constraints on Models of Language Production, in Language Production, Vol 1, Butterworth ed. (London, Academic Press).

Clark, Herbert, & Eve Clark
1977 Psychology and Language (New York, Harcourt Brace Jovanovich).
Cooper, W., & J. Paccia-Cooper
1979 Syntax and Speech Coding (In preparation).
Foss, D., & D. Hakes
1978 Psycholinguistics (Englewood Cliffs, NJ, Prentice-Hall).
Fromkin, Victoria
1971 The Non-Anomalous Nature of Anomalous Utterance, Language 47, 25-52.
1973 Slips of the Tongue, Scientific American 229, 109-117.
Garrett, M.
1975 The Analysis of Speech Production, Psychology of Learning & Motivation 9, 133-177.
Goldman-Eisler, F.
1968 Psycholinguistics: Experiments in Spontaneous Speech (New York, Academic Press).
Grice, Herbert
1975 Logic and Conversation, in Syntax & Semantics, Vol 3: Speech Acts, Cole & Morgan eds. (New York, Seminar Press).
Grosjean, François
1977 The Perception of Rate in Spoken and Sign Languages, Perception & Psychophysics 22, 408-413.
1979 A Study of Timing in a Manual and a Spoken Language: American Sign Language and English, Journal of Psycholinguistic Research 8, 379-405.
- - - -, R. Battison, H. Teuber, & H. Lane
1979 Performance Structures in ASL. Working paper, Northeastern University, Boston.
- - - -, L. Grosjean, & H. Lane
1979 The Patterns of Silence: Performance Structure in Sentence Production, Cognitive Psychology 11, 58-81.
- - - - -, & H. Lane
1977 Pauses and Syntax in American Sign Language, Cognition 5, 101-117.
Klima, Edward, & Ursula Bellugi
1979 The Signs of Language (Cambridge, MA, Harvard University Press).
Lane, Harlan, & F. Grosjean
1973 Perception of Reading Rate by Speakers and Listeners, Journal of Experimental Psychology 97, 141-147.

Newkirk, Donald, E. Klima, C. Pedersen, & U. Bellugi
1979 Linguistic Evidence from Slips of the Hand, in Slips of the Tounge and Hand, Fromkin ed. Proceedings of the 12th International Congress of Linguistics, Vienna.

Osgood, Charles
1971 Where Do Sentences Come From? in Semantics Steinberg & Jakobovits eds. (London, Cambridge University Press).

Stokoe, William C.
1960 Sign Language Structure (Occasional Paper: 8, Studies in Linguistics, o.o.p.; revised edition, 1978, Silver Spring, MD, Linstok Press).

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