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# Deaf signers and serial recall in the visual modality: Memory for signs, fingerspelling, and print

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This study investigated serial recall by congenitally, profoundly deaf signers for visually specified linguistic information presented in their primary language, American Sign Language (ASL), and in printed or fingerspelled English. There were three main findings. First, differences in the serial-position curves across these conditions distinguished the changing-state stimuli from the static stimuli. These differences were a recency advantage and a primacy disadvantage for the ASL signs and fingerspelled English words, relative to the printed English words. Second, the deaf subjects, who were college students and graduates, used a sign-based code to recall ASL signs, but not to recall English words; this result suggests that well-educated deaf signers do not translate into their primary language when the information to be recalled is in English. Finally, mean recall of the deaf subjects for ordered lists of ASL signs and fingerspelled and printed English words was significantly less than that of hearing control subjects for the printed words; this difference may be explained by the particular efficacy of a speech-based code used by hearing individuals for retention of ordered linguistic information and by the relatively limited speech experience of congenitally, profoundly deaf individuals.

Hearing individuals have been shown to use a speech-based code in the short-term recall of linguistic information, whether spoken or printed (Conrad, 1964; Wickelgren, 1965). Their recall performance is similar in the two cases except for a recency advantage favoring spoken over printed items in the last serial positions (Corballis, 1966; Murray, 1966). Because the orthography of English is a secondary representation derived from the primary or basic spoken language (Mattingly, 1972), it is not surprising that orthographic representations are recoded into a speech-based code. In addition, a speech-based code may be especially useful when the memory task calls for recall of ordered information (Baddeley, 1979; Crowder, 1978; Hanson, 1982; Healy, 1975).

The relations among primary language, coding strategy, and recall performance become more difficult to unravel when we consider bilingual deaf individuals who use American Sign Language (ASL) as a primary language and English as a secondary language. The term "primary language" refers to a natural language in the form in which it functions as a principal means of communication among members of a speech community. Writing systems and other invented representations that are based upon natural languages are viewed as nonprimary derived systems.

ASL is the primary visual-gestural language of the deaf community in the United States and Canada, and is acquired as a native language by children of deaf parents. Structural differences between signed and spoken languages reflect differences between auditory-vocal and visual-gestural channels of communication. For example, spoken languages are characterized by sequential forms of structuring at the abstract phonological and morphological levels. Words are composed of sequentially arranged phonemes, and morphological processes typically add one or more prefixes and/or suffixes (each composed of one or a series of phonemes) to a stem. In contrast,

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ASL is strikingly different from spoken languages in the extent to which it utilizes simultaneously structured units in lexical and morphological composition (Bellugi, 1980; Klima & Bellugi, 1979). Signs, the lexical items of ASL, are composed of several co-occurring formational parameters (Stokoe, Casterline, & Croneberg, 1965), and morphological relations are expressed by spatial and temporal modifications of the basic form of a sign (Bellugi, 1980).[1]

Those who use ASL as a primary means of communication also use fingerspelling for concepts that lack a sign. Fingerspelling is a manual form of English orthography that assigns a unique hand configuration to every letter of the English alphabet; as such, it is a changing-state representation of the graphic form of a spoken language. Fingerspelling is not used as a primary means of communication by members of the deaf community (Battison, 1978). Although fingerspelled words may often occur within signed sentences, their letter-by-letter sequential representation of English words differs considerably from the co-occurring formational parameters of ASL signs.

No writing system in use is based upon ASL, and educated deaf American signers read and write in English. But the use of ASL and of written or fingerspelled English by deaf bilinguals is quite different from the use of two spoken languages by hearing bilinguals. For a deaf person, learning the orthography (whether through writing or fingerspelling) of English means learning an orthographic visual system derived from a primary form to which he or she does not have normal access. In contrast, hearing bilinguals do have normal access to the primary forms of both languages that they use. Moreover, the significant structural differences between ASL and English at both the lexical and grammatical levels require the ASL-English bilingual to know two radically different forms of linguistic structuring. The bilingual who uses two spoken languages is required to know one form of linguistic structuring, that characterizing spoken languages.

The present research examined serial-order recall by deaf signers and addressed the question of how coding strategies and recall performance are affected by the requirement to remember ASL in contrast to English. Differences in performance that may stem from the presentation of English words by fingerspelling and print were also examined. The hypotheses underlying this work are discussed in the following sections on serial-position effects, coding, and accuracy of recall.

## Serial-Position Effects

Although hearing subjects use a speech-based code for recall of both spoken and printed word lists, auditory presentation results in a recency advantage over visual presentation (for a review of this research, see Penney, 1975). This advantage for the more recently presented items occurs whether the experimenter or the subject reads the stimuli aloud. On the basis of such findings, the critical variable appears to be hearing the items. The "modality effect" was originally attributed to the fact that information in precategorical acoustic storage (PAS) has greater durability than information in an iconic sensory representation (Crowder & Morton, 1969).

However, further research provided evidence for similar effects in the visual modality in the absence of acoustic information, thus casting doubt on the PAS explanation for the recency advantage. Findings of recency advantages for ASL signs (Shand, 1980), moving hand shapes (Campbell, Dodd, & Brasher, 1983), lipread items (Campbell & Dodd, 1980; cf. Crowder, 1983), mouthed items (Nairne & Walters, 1983), and items vocalized "aloud" by deaf subjects (Engle, Spraggins, & Rush, 1982) are all incompatible with an explanation based on acoustic advantage.

Two alternatives to the PAS explanation have been proposed. First, the difference in recency favoring, for example, spoken, lipread, and signed information over orthographic information may reflect an advantage in recall of primary-language input over nonprimary (printed) input (Campbell & Dodd, 1980; Campbell et al., 1983; Nairne & Walters, 1983; Shand, 1980; Shand & Klima, 1981). Second, this effect may be attributed to an advantage in remembering changing-state information over remembering static information (Campbell & Dodd, 1980; Campbell et al., 1983; Nairne & Walters, 1983). Hereafter, the term "dynamic" will be used to mean "changing-state."

It is important to note that recall differences between lists of words that are heard and lists that are silently read are restricted to the recency portion of the curve, with a recency advantage for the words that are heard. Thus, there is an overall advantage for the heard lists. However, the recency advantage for lipread and for mouthed lists does not yield an overall advantage over printed (silently read) lists. This is because recall of lipread and mouthed lists is poorer than recall of printed lists at earlier serial positions. Researchers have tended to focus on the similarity in recency effects among mouthed, lipread, and spoken input conditions, without giving adequate attention to the fact that spoken input results in the best recall overall. The dynamic-presentation hypothesis and the primary-language hypothesis must therefore be examined with respect to effects that span the entire serial-position curve.

The present study was designed to separate serial-position effects attributable to primary language from those attributable to dynamic presentation. Serial-position functions that distinguished fingerspelled and printed English lists from lists of ASL signs would provide support for the primary-language hypothesis. On the other hand, serial-position functions that distinguished the signed and fingerspelled lists from the printed lists would provide support for the dynamic-presentation hypothesis.

## Coding

Research with deaf signers can also provide insight into the question of whether a code based on one's primary language is useful when the recall task involves informa-

tion whose linguistic structure is quite different from that of the primary language. Shand (1982; Shand & Klima, 1981) suggested that the primary code is the natural and most efficient code for short-term recall of linguistic information. Recoding by hearing individuals from print into a speech-based code takes advantage of the systematic relation between the spoken form and its orthography (Mattingly, 1972). However, there is no such systematic relation between ASL signs and English orthography.

Simultaneously occurring parameters of movement, place of articulation within the signing space, and hand configuration are the sublexical components of ASL signs (Stokoe et al., 1965). These formational parameters (cheremes or primes) evidently support recall of signs by deaf signers much as phonetic parameters of speech support recall of spoken information by hearing individuals (Bellugi, Klima, & Siple, 1975; Hanson, 1982; Poizner, Bellugi, & Tweney, 1981; Shand, 1982). Thus, Bellugi et al. found intrusion errors suggesting sign-based coding of ASL signs by deaf signers on a serial-recall task. The majority of the intrusion errors were signs that differed from a correct response by one formational parameter. For example, some of the subjects reported JEALOUS for CANDY. The signs for JEALOUS and CANDY are a minimal pair in that they have the same place of articulation and movement; they differ only in the hand configuration. Likewise, some subjects reported NEWSPAPER for BIRD; these two signs share movement and hand configuration and differ only in place of articulation.

Evidence for both sign-based and speech-based recoding of printed words by deaf subjects has been obtained in serial-order recall tasks (Hanson, 1982; Lichtenstein, in press; Shand, 1982). Subject characteristics associated with coding preferences suggest that speech-based recoding is typically used by those prelingually, profoundly deaf adults who are better readers and who have better speech production skills (Lichtenstein, in press). A shortcoming of previous studies was that they compared the performance of different groups of subjects on the different stimulus types. Furthermore, they never included fingerspelled English. Presenting ASL signs, printed English words, and fingerspelled English words to the same group of deaf signers in the present study made it possible to ascertain whether individuals changed strategies as the stimuli changed or maintained a preferred strategy, such as sign-based or speech-based coding. In order to provide English words that were compatible with a sign-based code, half of the fingerspelled and printed words were chosen because they had readily available sign translations ("high-signability" words); the other half, because they did not ("low-signability" words). If deaf subjects recode into signs and recoding into one's primary language is the most natural and efficient strategy (Shand, 1982), then two outcomes might be expected. First, high-signability words should be recalled more accurately than low-signability words. Second, recall performance on high-signability words should provide evidence of sign-intrusion errors.

### Accuracy of Recall

In general, when congenitally, profoundly deaf individuals perform a task that calls for ordered recall of English words or letters, they do not perform as well as hearing subjects (Belmont & Karchmer, 1978; Belmont, Karchmer, & Pilkonis, 1976; Hanson, 1982; MacDougall, 1979; Wallace & Corballis, 1973). Belmont and Karchmer argued that the generally poorer performance of deaf individuals reflects a "mismatch" between the native language (ASL) and the language of the information to be recalled (English). However, even on serial-recall tasks involving ASL signs, deaf signers do not remember as many items as hearing subjects tested on the signs' printed (Hanson, 1982) or spoken (Bellugi et al., 1975) English equivalents. Moreover, Hanson found that deaf subjects did perform as well as hearing subjects on tasks that called for free recall of printed English words. The nature of the ordered-recall task, rather than characteristics of the input, may actually favor hearing individuals.

Recent studies indicate that the speech code is particularly useful for retaining order information (Baddeley, 1979; Crowder, 1978; Hanson, 1982; Healy, 1975). For deaf subjects, accuracy of recall has been found to correlate with the use of a speech-based code; those who use this code efficiently recall more than those who use it inefficiently or not at all (Conrad, 1979; Hanson, 1982; Lichtenstein, in press). Therefore, it seems that the speech-based code may facilitate serial-order recall in a way that alternative coding mechanisms, including sign-based coding of ASL signs, do not. Furthermore, it is likely that the use of the speech-based code by deaf individuals is not as effective as it is for hearing people. The present study examined the recall performance of deaf subjects who were highly proficient in English as well as in ASL, and asked whether accuracy of recall differs as a function of the type of linguistic input (dynamic vs. static; primary vs. nonprimary) or whether serial recall is, regardless of input characteristics, a particularly difficult task for individuals who do not have normal access to speech.

## EXPERIMENT

This experiment compared the performance of congenitally, profoundly deaf signers when presented with English words and ASL signs for serial-order recall. The presentation mode of the English words was varied so that some were printed and others were fingerspelled. All the deaf subjects used ASL as their primary means of communication. The recall performance of two groups of deaf subjects was compared in order to find out whether there were performance differences between native and nonnative signers on these tasks. Members of one group acquired ASL as a native language from deaf parents, and

members of the other group learned ASL outside the home in the early school years. A normal-hearing control group was tested on the printed stimuli.

## METHOD

### Subjects

All subjects were tested individually and were paid for their participation.

**Deaf subjects.** Twenty congenitally, profoundly deaf subjects participated in the short-term memory experiment; two were eliminated because their hearing loss was less than the criterion for profound deafness (85 dB, better-ear average). Background information gathered from the subjects indicated that they all used ASL as their primary means of communication, supplemented by fingerspelling. Eight of the subjects were born to deaf parents and had acquired ASL as a native language (native signers), while 10 of the subjects had hearing parents and learned ASL outside the home in the early school years (nonnative signers). All subjects were currently attending or were recent graduates of Gallaudet College, a liberal arts college for deaf students.

Twenty congenitally deaf adults served as control subjects on a perceptual task, described below. Nine of these subjects had participated in the memory experiment several months before. Each had a hearing loss of at least 70 dB in the better ear. They were all students or graduates of Gallaudet College and reported using ASL as a primary means of communication.

**Hearing subjects.** Ten hearing subjects were recruited from among Yale University students and affiliates. They were native speakers of English who reported no history of hearing impairment. Because the hearing subjects were tested on both sets of printed stimuli, 10 subjects provided sufficient data for comparison with the deaf subjects.

### Stimuli

Stimulus lists were constructed from 141 high-signability (HS) English nouns and 94 low-signability (LS) English nouns. All were words considered to be commonly known by college-age adults, and were selected with the assistance of a deaf native signer. HS words were matched with LS words for frequency of occurrence in printed English (Kučera & Francis, 1967). HS words were randomly assigned to each of three presentation conditions: signs, fingerspelling, and print. LS words were randomly assigned to fingerspelling or print conditions. These assignments produced one set of stimuli. A second set of stimuli was constructed by reassigning printed items to fingerspelling or signs, reassigning fingerspelled items to signs or print, and reassigning signed items to print or fingerspelling, in order to partially counterbalance the assignment of words to presentation conditions. Thus, the following five conditions were obtained for both sets of stimuli: (1) American Sign Language signs; (2) HS fingerspelled English words; (3) LS fingerspelled English words; (4) HS printed English words; and (5) LS printed English words. Each condition contained 42 nouns, in seven lists of 6 nouns each. Previous work with deaf subjects indicated that a list containing 6 nouns could be expected to produce both primacy and recency serial position effects (Bellugi et al., 1975). An additional five lists of 5 nouns each provided practice blocks.

### Procedure

All stimulus lists were videotaped at a rate of 2 sec per trial. A native signer recorded the signed and fingerspelled lists on videotape; for maximal visibility, she was framed from forehead to waist. The signer maintained a neutral expression throughout the taping session. Printed words were videotaped directly from an Atari 400 computer and were displayed for 1.5 sec with a .5-sec interstimulus interval. Stimuli in each condition were recorded in seven continuous lists of six nouns each. One practice list preceded each of the five conditions.

The order in which stimulus conditions were presented was partially balanced across subjects as follows: There were five orders of presentation for each stimulus set and no condition ever occurred in the same ordinal position twice. Four subjects were tested on each of the orders. Order 1 was based on differences in mode of presentation: (a) *Signs*; (b) HS *Fingerspelling*; (c) LS *Fingerspelling*; (d) HS *Print*; (e) LS *Print*. Order 2 was also based on mode differences but it involved a rearrangement of the ordering of signs, fingerspelling, and print modes: (a) HS *Print*; (b) LS *Print*; (c) HS *Fingerspelling*; (d) LS *Fingerspelling*; (e) *Signs*. Order 3 mixed modes and signability in a random fashion: (a) *LS Fingerspelling*; (b) *Signs*; (c) *LS Print*; (d) *HS Fingerspelling*; (e) *HS Print*. Order 4 arranged lists by signability differences: (a) *LS* Print; (b) *LS* Fingerspelling; (c) *HS* Print; (d) *Signs*; (e) *HS* Fingerspelling. Order 5 arranged lists by signability but in a different order than that of Order 4: (a) *HS* Fingerspelling; (b) *HS* Print; (c) *Signs*; (d) *LS* Print; (e) *LS* Fingerspelling.

Deaf subjects were tested on all five conditions by a native signer who provided both printed and signed instructions; nine of the subjects were tested on one set of stimuli and nine on the other. The subjects were told that they would see lists of nouns presented by various modes: ASL signs, printed English, and fingerspelled English. A message printed on the screen indicated the termination of each list. The subjects were instructed to watch the screen and to write the words they had just seen, in serial order, on the answer sheet provided. The answer sheet included the numbers 1 through 6 for each list with blank spaces for responses. The subjects were not prevented from recording words in any order. It was, however, required that words appear in their correct serial positions. Bellugi and Siple (1974) reported that deaf signers' recall performance with written report of signs was as good as their recall performance with signed report.

To control for possible dialectal variations on the interpretations of the signs and to ensure a fair scoring procedure, a control group of deaf subjects was tested in a perceptual task. These subjects were asked to watch the signed portions of the videotapes and to simply write down the English translation of each sign.

The hearing subjects were tested by a hearing experimenter who provided both printed and spoken directions. Stimuli for the hearing subjects, who served as partial controls in this experiment, consisted of the printed conditions only. Each hearing subject saw both sets of printed stimuli.

### Scoring

All subjects' responses in the memory task were scored as follows: Items were marked correct if they appeared in the proper serial position in the current list. Dialectal differences were taken into account when scoring the answer sheets from signed trials; a response on the memory task that matched a response in the correct serial position on the perceptual task was scored as correct. Because there were seven lists in each condition, seven was the maximum score possible at each serial position for each condition.

## RESULTS

A three-way ANOVA examined the within-subjects effects of presentation condition (ASL signs, printed English, fingerspelled English) and serial position (one through six) and the between-subjects effect of group (native or nonnative signers) on the number of words the deaf subjects recalled accurately. For the purpose of this analysis, performance on high- and low-signability lists was

averaged. The analysis revealed a significant main effect of serial position [$F(5,80) = 30.01$, $p < .0001$], and no significant effect of either group or condition (both $Fs < 1$). These latter results indicated that native and nonnative signers could not be differentiated on the basis of their performance on these serial-recall tasks and that their recall accuracy was similar for the three presentation conditions. There was, however, a significant condition × position interaction [$F(10,160) = 3.33$, $p < .001$], indicating differential effects on the serial-position curve as a function of condition. This interaction is shown in Figure 1, in which mean recall is plotted at each serial position for the three conditions: ASL signs, fingerspelled English words, and printed English words. In this figure, we have pooled the high- and low-signability trials and averaged across the two groups of deaf subjects.

Additional analyses were undertaken in order to understand the nature of the interaction. The competing hypotheses regarding the effects of primary language versus those of dynamic presentation prompted examination of the differences in serial-position effects as a function of condition. To test the primary language hypothesis, one ANOVA compared performance on the print condition to that on the fingerspelling condition. This was a three-way analysis, as above, with the exclusion of the sign condition. In this comparison, the condition × position interaction was also highly significant [$F(5,80) = 6.84$, $p < .0001$]. Thus, the serial-position curves for the print and fingerspelling conditions differed. Performance on the signed and fingerspelled trials was compared in the same way. In this ANOVA, the condition × position interaction disappeared [$F(5,80) = 1.69$, $p > .05$]. This lack of a significant interaction indicates no difference in the serial-position curves for the signed and fingerspelled trials. To complete the comparison of dynamic and static conditions, an ANOVA was performed on the printed and signed trials; the results showed a significant condition × position interaction [$F(5,80) = 3.66$, $p < .01$]. As is evident in the figure, the deaf subjects were never at ceiling in their recall performance.

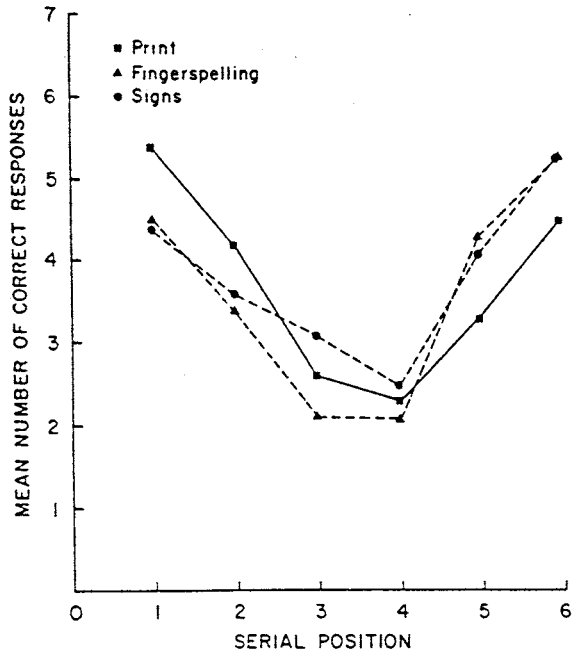


Figure 1. Mean number of printed, fingerspelled, and signed items correctly recalled by deaf subjects at each serial position.

Taken together, these analyses indicate that the condition × position interaction in the original analysis was due to differences between the print condition on the one hand and the fingerspelling and sign conditions on the other. This is consistent with the hypothesis that recall of dynamic and static forms of linguistic information produces different serial-position curves. In order to localize the effects of dynamic versus static input on the serial-position curve, planned comparisons (using the method of contrasts) were done at each serial position, going back to the original analysis, by contrasting recall performance in the static condition (print) with that in the dynamic conditions (fingerspelling and signs). The contrast was significant at Position 1 [$F(1,34) = 10.49$, $p < .01$] and Position 2 [$F(1,34) = 4.99$, $p < .05$], with accuracy greater in the print condition than in the other two conditions. The contrast was also significant at Position 5 [$F(1,34) = 10.05$, $p < .01$] and Position 6 [$F(1,34) = 8.67$, $p < .01$], with accuracy greater in the sign and fingerspelling conditions than in the print condition. The contrast was not significant at Position 3 or Position 4 (both $Fs < 1$). These results indicate that there is a recency advantage for the dynamic information (signed and fingerspelled) but a primacy advantage for the static information (print). The existence of some recency gains in all conditions probably reflects the relatively short list length and the freedom of subjects to record the items they remembered in any order they wished.

To test specifically for the effects of signability on recall, a three-way ANOVA was performed on the recall accuracy for the within-subjects factors of signability (HS, LS) × mode (fingerspelling, print) × serial position (1-6). Because the group factor never entered into any significant main effects or interactions, native and nonnative subjects were pooled in this and subsequent analyses. The main effect of signability was nonsignificant ($F < 1$); thus, the availability of a direct sign translation for an English word did not enhance its recall. Mean recall of all deaf subjects on the six-item blocks was 3.16 for the HS stimuli and 3.12 for the LS stimuli. The main effect of mode was also nonsignificant ($F < 1$), and the ANOVA revealed a significant mode × position interaction [$F(5,85) = 7.42$, $p < .0001$], reflecting the differences in serial-position effects between static printed input and dynamic fingerspelled input. As in the previous analysis, the main effect of serial position was highly significant [$F(5,85) = 30.91$, $p < .0001$].

The analysis of signability indicated that if deaf subjects were using a sign-based code to recall English words, it was not to their advantage. However, no evidence of sign-based coding of fingerspelled or printed English words was obtained in an analysis of the intrusion errors. Two deaf native signers of ASL examined each error on the sign trials and on the HS fingerspelling and print trials and judged whether or not each was formationally similar to the target item (i.e., a sign intrusion). Disagreements between the two signers were rare (occurring on only 4 of the 63 errors that did not include misorderings or blanks) and when they occurred they were resolved by consulting a vocabulary book on ASL signs (O'Rourke, 1978). Error analysis of the sign trials showed that of the 63 errors, 30 were sign intrusions. The results of the perceptual task indicated that these sign intrusions were not due to perceptual confusions. (Many of the remaining errors consisted of words that were formationally similar to a word in another position in the same list.) Table 1 lists examples of sign intrusion errors and the corresponding target signs for the same serial positions in the recorded list of signs. In contrast, errors made on the fingerspelled and printed English conditions did not tend to be sign intrusions. The 79 errors on the HS trials (not counting misorderings and blanks) included only a single response that had a sign similar to that of the target item. This was the intrusion of "caution" for "warning", which is also semantically related. The other 78 errors could not be differentiated in kind from errors on corresponding LS printed and LS fingerspelled lists. Errors made on fingerspelled and on printed lists appeared to be of the same general type, as indicated by the examples of errors on HS lists provided in Table 2. Patterns of visual resemblance of item and error pairs are obvious. Such errors could reflect either visual or phonological confusions; the present experiment was not designed to distinguish between these two possibilities. Taken together, these results suggest that well-educated deaf signers employ sign-based coding in retention of ASL signs but not in retention of English words, whether printed or fingerspelled.

Finally, recall accuracy of the deaf subjects on the printed trials was compared with that of the hearing subjects. Collapsing the data across all deaf subjects, mean recall on the six-item printed blocks was 3.14. (It should be remembered that for the deaf subjects, mean recall did not differ significantly as a function of condition: average recall on the fingerspelling and sign conditions was 3.10 and 3.17, respectively.) Mean recall of the hearing subjects on the printed blocks was 4.87, and many of the subjects were at ceiling. An analysis comparing mean recall of the deaf subjects with that of the hearing subjects indicated that there was a significant difference in the accuracy of subjects as a function of group (deaf or hearing) [$t(26) = 6.85$, $p < .0001$]. No valid tests of parallel serial-position differences could be used because so many hearing subjects performed at ceiling.

**Table 1**
**Item and Error Pairs in Recall of ASL Signs**

| Target Item | Intrusion Error | Parameter(s) of Difference |
|---|---|---|
| danger | algebra | movement |
| zero | photograph | handshape |
| telegram | declination | handshape |
| secret | patience | movement |
| debt | this | movement |
| instructions | iceskating | handshape |
| pope | princess | movement, location |
| fence | screen | handshape, location |
| rosary | interpreter | movement, location |
| sandwich | school | movement, location |

**Table 2**
**Item and Error Pairs in Recall of Fingerspelled and Printed English Words**

| Fingerspelling | | Print | |
|---|---|---|---|
| Target | Error | Target | Error |
| diamond | almond | heart | horse |
| wrestling | recycling | concept | corn |
| ceremony | cemetery | leaf | leather |
| pipe | pope | interference | inference |
| bomb | bubble | rosary | rosemary |
| noon | noun | digit | dignity |
| temptation | temperature | outlaw | outline |
| vinegar | vineyard | cure | burn |
| cure | sure | antique | unique |

## DISCUSSION

In the present experiment, there was no significant difference in performance between the native and nonnative signers tested. This suggests that native signers and nonnative signers who learned ASL at an early age form a homogeneous subject group; as far as these tasks are concerned, ASL functions as a primary language in the same way for both.

Serial-position effects were examined in order to test the dynamic-presentation hypothesis against the primary-language hypothesis by comparing deaf signers' recall of English print, fingerspelling, and ASL signs. The results revealed that the serial-position curves were similar for the two types of dynamic stimuli (fingerspelling and signs) and that these curves differed from those obtained for the static stimuli (print).Recall was better for dynamic stimuli in the last two serial positions but worse in the first two serial positions.

The recency advantages found for fingerspelled English words and ASL signs add to a growing body of results indicating that "modality effects" can be obtained even in the absence of acoustic input (Campbell & Dodd, 1980; Campbell et al., 1983; Engle et al., 1982; Nairne & Walters, 1983; Shand, 1980). However, the present results are inconsistent with the primary-language hypothesis, according to which differences would have been expected between the serial-position curves for the primary-language items (ASL signs) and those for the nonprimary language items (fingerspelling and print). Rather,

the present findings provide support for the hypothesis that the modality effect is a reflection of a recency advantage that accrues to dynamically presented information, regardless of input modality. The primacy advantage found for printed stimuli over fingerspelled and signed stimuli resembled the primacy advantage for printed over lipread and mouthed stimuli reported in previous studies (Campbell & Dodd, 1980; Nairne & Walters, 1983). As mentioned earlier, the comparison between hearing subjects' recall of spoken and of printed words reveals only a recency difference between the two conditions, and consequently, an overall advantage for the spoken words. But it appears that in spite of the recency advantage for nonacoustic dynamic stimuli (e.g., signs and lipread, mouthed, and fingerspelled words), such stimuli show no overall advantage over static stimuli (printed words). What is important to note in all of these studies is that dynamic information (whether spoken, signed, fingerspelled, etc.) and static information (printed) yield different serial-position curves.

As in previous research (Bellugi et al., 1975), analysis of the deaf subjects' intrusion errors revealed sign-based coding of the ASL signs. However, the lack of sign intrusion errors on both printed and fingerspelled English lists suggests that well-educated deaf persons do not recode English words into signs. In addition, there was no recall advantage for those English words that have direct sign translations. These results are especially noteworthy because they suggest that deaf bilinguals can change their recall strategies depending upon whether they are presented with information in English or in ASL.

The number of items recalled by deaf signers did not differ as a function of language, signability, or dynamic-static differences. But their mean recall was significantly less than that of hearing subjects when the performance of both groups on printed trials was compared. These results are not consistent with the view that the generally poorer performance on serial-recall tasks by deaf subjects than by hearing subjects stems from the requirement to remember English. In conjunction with earlier findings that deaf signers perform as well as hearing individuals on free-recall tasks involving English stimuli (Hanson, 1982), the present study indicates a specific difficulty on the part of the deaf signers with serial-order recall.

It is important to realize that difficulties deaf individuals may have with serial-recall tasks need not interfere with their primary-language abilities in ASL because of ASL's emphasis on simultaneous production of linguistic units. But serial-recall performance may become a problem when deaf individuals learn a spoken language. English, even more than some other spoken languages, relies heavily on word order in syntactic structuring. Not surprisingly, deaf children have difficulty in learning to read and write the complex syntactic structures of English which place a heavy load on memory for ordered units (Russell, Quigley, & Power, 1976), and deaf individuals usually do not read as well as their hearing peers (Bornstein & Roy, 1973; Karchmer, Milone, & Wolk, 1979). If we are to improve our methods for teaching deaf persons to read and write, it is crucial that we gain more insight into the strategies that deaf individuals bring to bear when remembering English letters, words, and sentences, and the ways in which deafness affects the perception of and memory for sequential flow of linguistic information.

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## NOTE

1. Sequential structuring does, of course, play a role in ASL, much as simultaneous structuring does in speech. The essential difference is in the extent to which sequential structure or parallel structure is part of the abstract organization of the language. Studdert-Kennedy and Lane (1980) suggest that speech draws on parallel organization (coarticulation, for example) to implement an abstract sequential linguistic structure, while ASL draws on sequential organization of its gestures to implement an abstract parallel linguistic structure. For example, in ASL the formation of a sign's handshape may precede the start of its movement. Clearly, there is also a sequential component in ASL syntax.

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