Semantic and formational clustering in deaf and hearing subjects' free recall of signs

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To investigate whether formational properties of sign language are used spontaneously to organize long-term memory, 16 deaf college students were given a free recall task with items that could be categorized either by shared semantic category or by shared sign language hand shape. Both presentation and response modes (signed or written) were varied between subjects. Analyses revealed no effects of mode on trials to criterion or number of items recalled at 1 week. The clustering that occurred was exclusively semantic, with significantly higher clustering scores during acquisition trials in subjects required to sign their responses. In Experiment 2, formational clustering was encouraged by including formational similarity as the only experimenter-defined basis of categorization, by increasing formational similarity within categories, and by testing only subjects with high signing skills. Input and output modes were again varied between subjects. Subjects were deaf college students with deaf parents ($n = 10$) or hearing parents ($n = 16$), and hearing adults with deaf parents ($n = 8$). Again, spontaneous clustering by formational similarity was extremely low. In only one case—deaf subjects with hearing parents given signed input—did formational clustering increase significantly across the eight acquisition trials. After the categorical nature of the list was explained to subjects at a 1-week retention session, all groups clustered output by formational categories. Apparently, fluent signers do have knowledge of the formational structure of signs, but do not spontaneously use this knowledge as a basis of mnemonic organization in long-term memory.

As part of a general interest in the modes that may be used in cognitive processing, investigators have designed studies to identify the processes and strategies used by deaf subjects in memory tasks, and to determine whether these differ qualitatively from those used by hearing subjects. Conrad and Rush (1965), for example, used consonants as stimuli in a short-term memory task to determine whether confusions made by deaf subjects would be based on acoustic similarities to the target letters, as they typically are in hearing subjects. The confusion matrices produced by the deaf subjects did show systematic patterns, but did not match the

acoustically based error matrices of the hearing subjects. In a later study, Locke and Locke (1971) examined the hypothesis that deaf subjects' short-term memory confusions are based on kinesthetic similarities of the letters' representations in the manual alphabet. Their results provided evidence that kinesthetic encoding does occur, particularly in deaf subjects who have relatively poor oral skills. Deaf subjects with good oral skills performed more like the hearing controls, who made errors based on phonetic similarity.

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In addition to the manual alphabet, in which individual letters are represented by individual hand shapes, American Sign Language (Ameslan) is also available to deaf subjects for cognitive tasks. In Ameslan, a single sign represents a concept, roughly equivalent to a word or phrase. Although the meaning is conveyed as a unit, each sign may be analyzed into components analogous to phonological features of spoken words. Three major components of signs were identified by Stokoe, Casterline, and Croneberg (1965) in their original linguistic analysis of Ameslan, specifically, (1) the hand shape or configuration used to make the sign, (2) the location on the body (place of articulation) where the sign is made, and (3) the movement of the hands in making the sign. More recently, a fourth

parameter, the position of the palms in relation to the body (orientation), has been noted as well (Friedman, 1977). For example, the sign that would be glossed by the English word "name" is made by placing each hand in a "U" position, bringing the active hand down onto the base hand (movement), palms toward the body (orientation), at about chest level (location), as illustrated in the first frame of Figure 1.

On the basis of data from short-term memory tasks with deaf people, Bellugi, Klima, and Siple (1975) and Bellugi and Siple (1974) have argued that these formational characteristics of sign have psychological reality for deaf subjects. Lists of three to seven items were presented as words (written on slides) to hearing subjects and as either words or signs (on videotape) to deaf subjects whose native language was Ameslan. Whereas the intrusion errors made by the hearing subjects on an immediate serial recall task were generally phonologically similar to the original list items, the intrusion errors of the deaf subjects were formationally similar to the original items, typically differing from the original list item on only one of the formational parameters discussed above. This description characterized intrusion errors regardless of presentation or response mode (written or signed). For example, when the original item presented was the word or sign for "vote," a common error for hearing subjects was the phonologically similar response "boat," whereas a common error for the deaf subjects was the formationally similar response "tea." In Ameslan the signs for "vote" and "tea" are made with the same handshape and in the same location, differing only in movement. Illustrations of these and similar errors may be found in Bellugi and Klima (1978).

The data from these studies indicate that deaf people possess information about the formational parameters of signs, but the data do not indicate whether deaf subjects use this knowledge to organize their long-term memories. The extensive literature on organizational strategies used by hearing people with written or spoken English words as stimuli indicates that subjects typically organize materials on the basis of meaning, rather than on the basis of structural features of stimuli (e.g., Dolinsky, 1972; Lauer & Battig, 1972; Shuell, 1969; Wood, 1970, 1972). The studies described in the present paper were designed to investigate whether deaf subjects would show a comparable preference for semantic cate-

gorization and/or would make use of the formational properties of signs in organizing long-term memory.

EXPERIMENT 1

The purpose of the first investigation was to determine whether deaf subjects who were given a free recall task would choose to cluster according to semantic category or according to formational characteristics of sign language. The items for the memory task were, therefore, selected so that they could be categorized either by semantic category or by sign hand shape. In addition, the study was designed to determine whether signed vs. written presentation of items and/or of responses would be differentially conducive to sign language clustering. To investigate the latter question, half the subjects were given items in a written mode (English words presented on slides), while the other half were given items in a manual mode (signs shown on videotape). Each group was further divided according to whether written or signed responses were required. With respect to presentation and response mode, it was hypothesized that signed presentation and signed responses would lead to greater sign clustering than the written-written combination, and that sign clustering in the mixed modes (i.e., signed-written and written-signed) would fall between the two extremes.

Method

Subjects. Subjects were 16 deaf students in a postsecondary technical institute, the National Technical Institute for the Deaf (NTID), who volunteered to participate in the study. Included were students with varying degrees of hearing loss, ages of onset of deafness, and communication skills. All were able to communicate fluently in sign language, as determined informally by the examiner's conversations with them prior to testing.

Materials. The 16 list items were selected so that they could be grouped into either of two exhaustive sets of four-word groups. One system divided items into four semantic categories, and the other divided items into four groups according to sign language hand shape. Items are divided into both categorization systems in Table 1.

For the written presentation, slides were made of English words typed in black uppercase letters (IBM Presidential type) on a white background, and these were presented with a Kodak Carousel projector every 2 sec. For the signed presentation, the second author recorded signs on a Sony color cassette videotape recorder. These materials were then presented to subjects via a Sony color playback unit and monitor. As in the written mode, new items were presented every 2 sec.

Procedure. All testing was carried out by the second author, who is fluent in sign language. The examiner gave directions in Ameslan and/or a combination of signed and spoken English, as appropriate for the particular student being tested. Subjects were told to watch the projection/television screen carefully and to try to remember the 16 items that they would see. After all 16 items had been presented, subjects wrote/signed all of the items that they could remember. Written responses were made on plain white paper and signed responses were recorded on videotape. Additional study-test trials were given until the subject reached a criterion of one perfect trial. Items were presented in a new random order for each trial, with the condition that no two items from the same semantic or sign group occur consecutively.

Figure 1. Signs translated by English words "name," "train," "chair," and egg." Figure adapted from Bellugi and Klima (1978); used by permission.

Table 1
Materials Used in Free Recall Tasks (Experiments 1 and 2)

Hand Shape	Experiment 1				Experiment 2			
	Semantic Category				Formationally Similar Groups of Signs			
	Foods	Countries	Animals	Occupations	I	II	III	IV
F	Tea	France	Fox	Preacher	Name	School	Race	Machine
Open	Cheese	Germany	Lion	Fireman	Train	Cheese	Drama	War
U	Egg	United States	Horse	Nurse	Chair	Movie	Science	Football
A	Coffee	Canada	Turtle	Scientist	Egg	Paper	Game	America

Upon the completion of a perfect recall trial, each subject was thanked and asked to return the following week at the same time. At the 1-week retention trial, each subject was asked to try to remember the 16 items again (without additional study).

Results

Recall. To analyze recall, three separate 2 (signed vs. written input mode) by 2 (signed vs. written output mode) analyses of variance were performed using each of the following dependent variables: (1) the number of trials to criterion, (2) the mean number of items recalled on Trial 1, and (3) the mean number of items recalled at the 1-week retention session. Means for these measures are presented, by group, in Table 2. Analyses indicated no significant differences in any measure of recall as a function of input or output mode.

Clustering. The data were also examined for evidence of two types of clustering: clustering by semantic category and clustering by sign hand shape. The clustering measure used was the adjusted ratio of clustering developed by Roenker, Thompson, and Brown (1971), which measures how often items from the same category (here, semantic or hand shape) are recalled in consecutive order, adjusted for the number of categories recalled and the total number of items recalled, and transformed to provide fixed lower and upper bounds (Friendly, Note 1). A score of +1.00 indicates a perfectly clustered recall protocol, a score of 0.00 indicates chance clustering, and a score of less than 1.00 indicates that items from the same category were recalled consecutively even less often than would be expected by chance.

A 2 (input mode) by 2 (output mode) analysis of variance was performed for each of the following four dependent measures: (1) semantic clustering, averaged

over acquisition trials, (2) semantic clustering at the 1-week retention session, (3) sign clustering averaged over acquisition trials, and (4) sign clustering at the 1-week retention session. Again, means for each group are shown in Table 2.

Mean semantic clustering scores during acquisition were found to differ significantly as a function of output mode [$F(1,12) = 4.94, p < .05$]. Specifically, significantly greater semantic clustering occurred across acquisition trials when signed output was required (mean = .59) than when written output was required (mean = .29). By the 1-week retention session, however, there were no significant differences in semantic clustering as a function of mode.

The results from the comparable analysis of sign clustering show the inverse of the effects discussed above, simply reflecting the fact that the sign categories and the semantic categories did not overlap, so that consistent use of one is necessarily linked with below-chance use of the other. Thus, the only significant effect was that mean sign clustering scores differed as a function of output mode [$F(1,12) = 6.94, p < .05$], with those using signed output having significantly lower sign clustering (mean = -.21) than those using written output (mean = .07). As in the semantic clustering analysis, there were no differences among groups in the extent of sign clustering by the 1-week session.

Discussion

The data from Experiment 1 indicate that deaf subjects do cluster spontaneously in free recall tasks. Importantly, the clustering that did occur was based exclusively on semantic categories, rather than on sign

Table 2
Mean Recall and Clustering Scores by Group (Experiment 1)

Input-Output Mode	Recall Measures				Clustering Measures**			
	Trials to Criterion	Number Correct*		Acquisition†	Semantic		Sign	
		Trial 1	1 Week		1 Week	Acquisition†	1 Week	
Sign-Sign	3.7	10.6	12.5	.44	.51	-.14	-.27	
Sign-Write	3.0	9.7	10.3	.32	.49	-.12	-.19	
Write-Sign	4.5	10.5	11.5	.70	.89	-.25	-.26	
Write-Write	4.0	8.6	12.0	.26	.59	-.03	-.20	

*Maximum score = 16.

**A score of +1.00 indicates a perfectly clustered response.

†Averaged across acquisition trials.

hand shape. Although this preference for semantic categorization occurred across all groups, regardless of input or output mode, there was significantly greater semantic clustering when the output mode was signed rather than written. If deaf subjects process (represent in memory) the stimulus materials in signs, then when signed output is required, no translation is needed between the processing mode to the response mode. In contrast to the written output mode, then, the use of signed output may give deaf subjects the opportunity to pay greater attention to the meaning of the stimuli, and/or to the selection and use of an appropriate memory strategy (here, semantic clustering). It is important to remember, however, that any conclusions concerning the apparent advantages of signed over written output (e.g., for educational purposes) must be tempered by the fact that no significant differences among groups occurred on the recall measures.

The failure to find evidence for clustering based on formational properties of sign language in Experiment 1 may be attributed to one or more factors. One possible explanation of the lack of sign language clustering in the present study could lie in the characteristics of the subject sample. Several of the 16 subjects had good oral skills and may, therefore, not have been dependent on sign language as a major communication or processing mode. Conrad (1970) has shown that individual deaf subjects do appear to differ significantly in their optimal processing modes in relation to their own oral-aural skills. It should be noted, however, that if sign were not a readily available, meaningful system for the present subjects, it is unlikely that there would have been greater semantic clustering with signed output.

Another possible explanation of the failure to find formational clustering may lie in the materials used: The semantic categories were extremely elementary and obvious, while the sign language categories might be considered relatively subtle. Alternatively, it is possible that while formational properties of sign are coded in short-term memory (Bellugi et al., 1975; Bellugi & Siple, 1974), they are not used for long-term memory. A second investigation was designed to evaluate the possibilities discussed above.

EXPERIMENT 2

In the first study, the list for the free recall task allowed clustering either by semantic category or by formational similarity of signs. In the second investigation, competition from semantic categorization was reduced by having sign formational similarity as the sole experimenter-defined basis for categorization. In addition, the formational similarity was strengthened. Whereas in Experiment 1, formational similarity was defined by shared hand shape only, in Experiment 2, similarity was defined both by shared hand shape and shared location. An additional modification was the

use of stringent criteria for subject selection, thereby insuring that the deaf students tested were people who normally rely upon manual communication. As in Experiment 1, input and output modes were varied between subjects. Again, the signed mode was expected to be more conducive to clustering on the basis of formational similarities of sign than was the written mode.

To provide additional information about factors affecting the spontaneous use of formational clustering, three different groups of subjects were tested. One contained deaf students with deaf parents, the second contained deaf students with hearing parents, and the third contained hearing adults with deaf parents. The various input and output mode conditions might be expected to affect performance in the two groups of deaf subjects differently, as a result of the different contexts in which sign language was initially acquired, that is, early and within the family for those with deaf parents, but later and outside the family for those with hearing parents. Since only in the former group is sign language truly a native language, these subjects' processing might more naturally take place in sign language, hence leading to greater use of sign language clustering. The direction of difference between formational clustering by deaf subjects with deaf parents vs. hearing subjects with deaf parents was not predicted. Deaf subjects might show more sign language clustering because of more exclusive reliance on sign, while hearing subjects might show more sign language clustering because of a generally greater tendency to employ active strategies in memory tasks.

Method

Subjects. As described above, three groups of subjects were tested. All deaf subjects were enrolled at NTID. One group of deaf subjects contained 10 NTID students whose parents were deaf (deaf/deaf), while the second contained 16 NTID students whose parents had normal hearing (deaf/hearing). All subjects in both these groups were prelingually deaf and, in addition, were highly dependent upon sign language for communication. Operationally, the latter characteristic was determined by performance on a communication test administered by NTID; to be included, the student must have obtained a high score (4 or 5 on a 5-point scale) on a test of skill in receiving signed English and a low score (1-3) on a test of skill in receiving oral communication (Johnson, 1975). The third group of subjects contained eight hearing staff members of NTID whose parents were deaf (hearing/deaf), and who had thus been exposed to both signed and spoken language from childhood. All subjects in this group had already completed Bachelor's or Master's level programs.

Materials. The 16 list items used in the free recall tasks were composed of four groups of four items each. Each group contained signs (or their English-word equivalents) that are made with the same hand shape and at the same location of the body. The items used are given in Table 1, with an illustration of one set of signs presented in Figure 1. Pilot testing was done with these signs to insure that there was general agreement on the way in which the signs were made. Even with this precaution, regional signs for two items (cheese and movie) were given by several students during subsequent memory testing.

As in Experiment 1, half the subjects were given items in signs, while half saw English words. The signed presentation and responses were again on videotape, while the English words were again presented on slides. The equipment used for the videotaped presentation was identical to the earlier study. The slides differed from the earlier study only in that words were presented in blue letters on a black background to reduce glare. As before, new items appeared every 2 sec.

Procedure. The general instructions, procedures, and methods for presentation and response were like those used in Experiment 1, with the following exceptions. First, rather than using a trials-to-criterion procedure, all subjects were given eight study-test trials for the acquisition phase of the experiment. Second, subjects assigned to the written response mode were asked to record their responses in spiral-bound booklets, one word to a page, rather than to list all items recalled on a single sheet of paper. This modification was made so that the written response mode would be more comparable to the signed response mode, in which earlier responses were unavailable for review during recall.

Finally, the 1-week retention session was expanded. As in Experiment 1, subjects returned 1 week after the initial session and were asked to recall as many of the 16 items as possible. In addition, however, subjects were then given an explanation of the categorical nature of the list and were again asked to recall as many items as possible. Upon completion of this second "cued" recall trial, subjects were thanked for their help and paid \$2 for their participation.

Results

Recall. For each group of subjects, the number of items recalled during acquisition was analyzed by a 2 (input mode) by 2 (output mode) by 8 (acquisition trial) analysis of variance, in which the trials factor was a within-subjects variable. Separate analyses for each subject group were performed, since unequal sample and population sizes make comparisons within the same analysis of variance difficult to interpret meaningfully.

Neither input nor output modes, nor their interaction, showed a significant effect for any of the subject groups. The only significant effect was a main effect for trial, with performance increasing across the eight trials in all three subject groups with significant linear and quadratic trends [deaf/deaf: $F(7,56) = 24.98$, $p < .001$, $F_{LIN}(1,56) = 121.25$, $F_{QUAD}(1,56) = 41.25$, $ps < .001$; deaf/hearing: $F(7,84) = 23.44$, $p < .001$, $F_{LIN}(1,84) = 128.81$, $F_{QUAD}(1,84) = 31.93$, $ps < .001$; hearing/deaf: $F(7,28) = 12.30$, $p < .001$, $F_{LIN}(1,28) = 72.27$, $F_{QUAD}(1,28) = 21.37$, $ps < .001$]. Overall means for each group are shown in Table 3.

Additional analyses were made to compare the number of words recalled on the last acquisition trial, the first 1-week retention trial, and the "cued" trial (the trial following an explanation of the categorical nature of the list). Specifically, a 2 (input) by 2 (output) by 3 (final acquisition trial vs. first 1-week retention trial vs. cued trial) analysis of variance was calculated for each subject group. Means are shown in Table 3. In each group of deaf subjects, the only significant effect was a main effect for trial [deaf/deaf: $F(2,4) = 22.91$, $p < .01$; deaf/hearing: $F(2,24) = 14.68$, $p < .001$]. In both cases, Newman-Keuls post hoc tests showed that

Table 3
Number Recalled by Subject Group (Experiment 2)

Group	Trial			
	Mean Acquisition	8	1 Week	Cued
Deaf/Deaf	10.6	12.6	8.6	10.2
Deaf/Hearing	11.1	12.7	8.5	9.8
Hearing/Deaf	12.7	15.0	12.8	13.8

Note—Maximum score per cell is 16.

recall on the final acquisition trial was significantly better than on either the 1-week or cued retention trials, and that the increase following explanation (i.e., 1-week trial to cued trial) was not significant. The same pattern was evident in the hearing subjects, but here the trial factor did not reach the .05 level of significance [$F(2,16) = 3.68$, $p < .08$].

Clustering. The clustering measure described in Experiment 1 was used to assess the extent to which recall was clustered by sign similarity. Mean clustering scores across acquisition trials and for the 1-week and cued trials are given, by group, in Table 4. Acquisition clustering was analyzed for each subject group with a 2 (input) by 2 (output) by 8 (trials) analysis of variance, with repeated measures on the last factor.

As may be seen in Table 4, absolute values of clustering scores were extremely low in all groups of subjects. The only subject group showing significant effects of mode were deaf subjects with hearing parents. In this group, a significant Input by Trial interaction effect was evident [$F(7,84) = 2.95$, $p < .01$], such that clustering increased across trials with signed input, but not with written input. As implied by this significant interaction, the main effect of trial was also significant [$F(7,84) = 4.73$, $p < .001$], although the main effect of input was not [$F(1,12) = 2.13$, $p < .20$].

Clustering on the retention trials was analyzed in each subject group with a 2 (input) by 2 (output) by 2 (1-week vs. cued retention trial) analysis, again with the last factor being within subjects. Means for these analyses are also presented in Table 4. The trials factor was significant in each subject group [deaf/deaf: $F(1,8) = 127.42$, $p < .001$; deaf/hearing: $F(1,12) = 5.71$, $p < .05$; hearing/deaf: $F(1,4) = 67.72$, $p < .01$]. Thus, in all cases, clustering showed a significant increase following explanation of the categorical nature of the list, with absolute clustering scores being high in all cases. In addition, the deaf subjects with deaf parents were also affected by mode. Specifically, a significant Input by Output by Trial interaction was found [$F(1,8) = 10.66$, $p < .01$], such that while clustering was virtually identical across modes on the first retention trial, clustering was significantly higher in groups with matched input-output modes (i.e., signed-signed and written-written) than in groups with unmatched presentation and response modes (i.e., signed-written and written-signed).

Table 4
Clustering Scores by Subject Group Across Acquisition and Retention Trials (Experiment 2)

Input-Output Mode	Trial									
	Acquisition								Retention	
	1	2	3	4	5	6	7	8	1 Week	Cued
Deaf/Deaf Group										
Sign-Sign	-.11	-.12	-.07	-.08	-.09	-.08	-.08	-.04	-.08	1.00
Sign-Write	-.12	-.06	-.05	-.06	-.05	-.05	-.05	-.05	-.03	.65
Write-Sign	-.12	-.09	-.05	-.09	-.10	-.06	-.04	-.07	-.08	.67
Write-Write	-.13	-.09	-.13	-.08	-.11	-.10	-.13	-.10	-.13	.92
Deaf/Hearing Group										
Sign-Sign	-.03	-.01	-.14	.18	.45	.42	.06	.40	.41	.67
Sign-Write	-.01	.00	-.01	.31	.25	.40	.17	.39	.15	.78
Write-Sign	-.03	.00	.03	-.01	.10	.06	.08	.02	.34	.44
Write-Write	-.01	.14	-.02	.04	-.02	-.01	-.02	-.01	.08	.62
Hearing/Deaf Group										
Sign-Sign	-.10	-.06	-.07	-.06	-.10	-.08	-.07	-.06	-.03	.89
Sign-Write	-.05	-.05	-.05	-.03	-.02	-.03	-.02	-.01	.00	1.00
Write-Sign	-.09	-.08	-.09	-.10	-.10	-.10	-.10	-.03	-.05	.94
Write-Write	-.12	-.03	-.11	-.13	-.12	-.08	-.11	-.10	-.07	.71

Discussion

The strongest and most important finding of Experiment 2 was the almost complete absence of spontaneous clustering by formational similarity. This finding is particularly compelling for several reasons. First, subjects were selected for having strong sign language skills, with two subgroups of subjects (deaf/deaf and hearing/deaf) having learned Ameslan as a native language. Second, no competing semantic organizational system was provided (as it had been in Experiment 1). Third, the experimenter-defined sign clusters contained signs that were alike in place of articulation as well as in hand shape. Fourth, subjects possessed the necessary knowledge to categorize signs into the intended four groups, as demonstrated by their high clustering scores on the cued trial. Fifth, there is considerable evidence that deaf subjects are perfectly able to use clustering as a mnemonic aid in general, as indicated by the high degree of semantic clustering found in Experiment 1, and by the high degree of spontaneous clustering found in other investigations using semantically categorizable material (Koh, Vernon, & Bailey, 1971; Liben, in press). In view of these factors, the failure to find significant clustering here suggests that although people who are fluent in sign language may store analyzed features of signs at some level (as shown by intrusion errors made in memory experiments and by "slips of the hand" made in everyday conversation; see Bellugi & Klima, 1978), they do not appear to use such properties of sign in a purposefully selected mnemonic strategy in long-term memory tasks. It should be noted that the task was difficult enough to have prompted strategy use: The deaf subjects recalled only about 75% of the 16 items on the last (eighth) acquisition trial, a notable contrast to performance in Experiment 1, in which perfect recall of 16 items was reached after an average of about four trials.

The general conclusion discussed above is tempered somewhat by differences as a function of subject group and mode. The analysis of clustering on acquisition trials indicated that mode did have an effect on clustering by deaf subjects with hearing parents in interaction with mode. Specifically, with signed input, but not with written input, there was a significant increase in clustering across trials. Indeed, as is evident in Table 4, spontaneous clustering scores of any meaningful size (i.e., greater than .40) were confined to the subjects under the signed input condition in later trials. The finding that the signed mode enhances sign clustering is, of course, consistent with the original hypothesis. What is less obvious, though, is why this effect should have been confined to deaf subjects with hearing parents. Perhaps learning sign language later in life (rather than learning it as a native language) is more conducive to the type of reflective thinking about the language that is necessary for using it in mnemonics. If this is the case, still greater formational clustering with signed input would be expected with subjects who learn sign language late in life and who do not rely upon it as a primary language, for example, among interpreters or educators of the deaf who did not have early exposure to sign language.

The contrasts between the two retention trials given at 1 week are also interesting. After the categorical nature of the list was explained to subjects, clustering scores rose dramatically. However, although there was a slight improvement in recall scores, in no subject group was the improvement significant. As described in the results section, mode affected performance on retention trials in only the deaf subjects with deaf parents, with higher postexplanation clustering in the unmixed presentation-response modes (signed-signed, written-written) than in the mixed modes (signed-written, written-signed). This finding might suggest

that consistency in presentation and response facilitates the use of clustering. However, since the particular clustering system here is related to a signed mode, it is difficult to explain why consistent use of writing (written-written) could be beneficial. Although the meaning of the findings concerning mode unfortunately remains obscure, the present findings are important in demonstrating that mode is an important variable to investigate in future studies of long-term memory and should not be ignored simply because Bellugi and Siple (1975) found no effects of presentation or response mode in their investigations of short-term memory.

CONCLUSIONS

The results of the two experiments described here add to previous evidence that deaf subjects are able to use appropriate mnemonic strategies for recall (Koh et al., 1971; Liben, in press; Liben & Drury, 1977). Data from the acquisition trials of Experiment 1 provided strong evidence of spontaneous semantic clustering, while data from the cued trial of Experiment 2 indicated that subjects were able to use similarities of the surface features of signs to organize recall when told specifically that the list could be categorized in this manner.

There was, however, very little spontaneous clustering on the basis of formational similarity among signs. When an alternative, semantic clustering system was provided (Experiment 1), no formational clustering at all was evident. Even when no competing system was provided (Experiment 2), formational clustering remained extremely low. These data parallel results from studies in which hearing subjects are tested with spoken or written English stimuli. Although surface features of stimuli have been shown to be important in hearing subjects' short-term memory, these features are not typically used in long-term memory (e.g., Baddeley, 1966; Kintsch & Buschke, 1969). Subjects have been shown to have strong preferences for organization based on taxonomic rather than on structural attributes of stimuli. For example, Dolinsky (1972) found little acoustic clustering (clustering of words that rhyme) in free recall when both associative and acoustic bases for clustering were available in the list. Lauer and Battig (1972) and Mondani, Pellegrino, and Battig (1973) found that subjects preferred taxonomic organization over orthographic (initial letter) organization. More recently, Ozier (1978) has provided evidence that semantic information, but not orthographic (initial letter) information, is encoded automatically in memory.

Under some conditions, however, hearing subjects can make use of the surface features of linguistic material in organizing long-term memory. For example, Freund and Underwood (1969) found that subjects clustered alphabetically if they were given prior instruction in the utility of such clustering. Bruce and Crowley

(1970) showed that subjects recalled acoustically related words better than control words if the acoustically related items were presented contiguously (rather than distributed) during acquisition. Wood (1972) found that subjects clustered acoustically during recall if they had been asked earlier to sort items into categories of words that rhyme. And Ozier (1978) showed that initial letters can serve as effective retrieval cues if subjects are required to use these during acquisition. Additional research is needed to determine whether conditions such as these (e.g., blocked presentation, sorting instructions) would lead deaf subjects to cluster on the basis of formational similarity of signs in free recall. On the basis of the evidence currently available, it seems most reasonable to propose that deaf subjects process Ameslan in memory tasks much the way that hearing people process English. That is, although they have knowledge of the surface features of list items, they show strong preference for processing items on the deeper level of meaning.

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