SHORT-TERM MEMORY FOR PRINTED ENGLISH WORDS BY CONGENITALLY DEAF SIGNERS: EVIDENCE OF SIGN-BASED CODING RECONSIDERED

Vicki L. Hanson and Edward H. Lichtenstein†

Abstract. Shand (1982) found that deaf signers' recall of lists of printed English words was poorer when the American Sign Language translations of those words were structurally similar than when they were structurally unrelated. He presented these results as evidence of sign-based coding of printed words. This conclusion is challenged by the present finding that a group of hearing subjects, who were tested on Shand's stimuli and were unfamiliar with sign language, showed similar performance decrements on the lists of words having structurally similar signs. Alternative accounts of these findings for both hearing and deaf subjects are discussed.

The nature of short-term memory coding of printed words by deaf individuals is of considerable importance, both for theoretical and practical reasons. Theoretically, investigations in this area can provide insight into the role of speech coding in short-term ordered recall. Does the use of a speech code by hearing individuals derive from their experience with speech as a primary means of communication (Shand, 1982; Shand & Klima, 1981)? Or does speech coding provide an effective way of storing ordered information due to the highly sequential character of spoken language (Baddeley, 1979; Crowder, 1978; Healy, 1975)? If due to the primary use of a spoken language to communicate, then a language code rooted in another modality (e.g., a code based on visual/gestural sign language of deaf individuals) should be as effective a code for short-term ordered recall as a speech code. If, however, speech is an effective code for ordered recall due to its sequential properties, then deaf signers (who, in general, have received some speech instruction) may not be inclined to recode into signs, owing to the fact that signs involve simultaneous structuring of linguistic elements to a much greater extent than does speech (Klima & Bellugi, 1979).

In addition to these concerns, practical educational issues call for research on short-term memory coding by deaf individuals. In particular, research in this area addresses issues of coding in reading, such as whether deaf children can use speech coding in reading and whether sign coding can be used as an effective alternative to speech coding for deaf children in the

---

†National Technical Institute of the Deaf

Acknowledgment. This research was supported by Grant NS-18010 from the National Institute of Neurological and Communicative Disorders and Stroke and by Grant HD-01994 from the National Institute of Child Health and Human Development. We wish to thank Beth Schwenzfeier for her help in testing subjects, and Rena Krakow, John Richards, and Bruno Repp for their valuable comments on an earlier draft of this paper.

[HASKINS LABORATORIES: Status Report on Speech Research SR-85 (1986)]

acquisition of reading (see, for example, Conrad, 1979; Hanson, Liberman, & Shankweiler, 1984).

The presentation of American Sign Language (ASL) signs to deaf subjects for ordered recall has consistently provided evidence that information is coded in terms of the formational parameters (cheremes) of the signs; thus, presenting lists of formationally similar signs has lead to decrements in serial recall (Hanson, 1982; Poizner, Bellugi, & Tweney, 1981; Shand, 1980, 1982), and presenting lists of unrelated signs has lead to intrusion errors in which the incorrect items are formationally similar to the original signs (Bellugi, Klima, & Siple, 1975; Krakow & Hanson, 1985). In contrast, less consistent outcomes have been reported in experiments in which printed words have been presented to deaf subjects. Shand (1980, 1982) reported decrements in recall of printed words whose corresponding signs were formationally similar to other signs within the same list. However, the use of similar procedures by other researchers failed to obtain this same outcome, even when testing native signers of ASL (Hanson, 1982; Lichtenstein, in press). Furthermore, no evidence has been obtained of sign-based intrusions in deaf signers' recall of printed words (Krakow & Hanson, 1985). The failure to obtain evidence of sign-based coding with printed words cannot be attributed to insufficient power in the experimental design: Two of the studies that failed to find evidence of sign-based coding when printed words were presented found evidence of sign-based coding when signs were presented (Hanson, 1982; Krakow & Hanson, 1985).

The present paper focuses on the work of Shand (1980, 1982) in an attempt to resolve the discrepancy between his results and those reported by other investigators. A resolution of this issue is highly desirable given the importance of such findings for theories of short-term memory and their pedagogical implications.

Shand's procedure (following Baddeley, 1966) involved the use of experimental sets of words chosen to be similar along a given dimension. For this purpose, Shand had a phonetically similar set of words (SHOE, THROUGH, NEW, SHOW, NO, SEE, THREE, SEW) and a cheremically (sign) similar set of words (CANDY, ONION, APPLE, JAPANESE, JEALOUS, CHINESE, SOUR, BORED). The signs corresponding to each of the words in the cheremically similar set are similarly formed. Accuracy on lists of words taken from the experimental sets is compared, in this procedure, with accuracy on lists of words taken from a control set. As controls, Shand used four words from the phonetically similar set and four words from the cheremically similar set. The resulting set of words (SHOE, THROUGH, APPLE, JAPANESE, NO, SEE, SOUR, BORED) allowed for a comparison of accuracy of specific words when they were presented in the experimental set vs. when they were presented in the control set. Thus, each of the words in the control set was matched with a word in one of the experimental sets.

The subjects in Shand's study were eight congenitally, profoundly deaf signers of ASL. Three were native signers of ASL; the other five had a minimum of seven years of signing experience. On each trial, the subjects saw five of the words from a word set and were asked for immediate written ordered recall of these words. Shand found, both with list scoring (percent lists recalled perfectly) and with item scoring (percent words correctly recalled in the correct position), that the deaf subjects had poorer recall of words with presentations from the cheremically similar set than from the control set.

This same finding was obtained when analyzing only those four words that were common to the cheremic and control sets; recall of these words was less accurate when they were presented in lists from the cheremically similar set than when presented in lists from the control set. In contrast, there was no significant difference in accuracy between performance on the phonetically similar lists and the control lists for either list or item scoring.

Shand concluded that these results provided evidence for sign-based coding of printed words. However, confounds within his stimulus sets lead us to question this conclusion. First, semantic associations occurred among the words in the cheremically similar set (e.g., CHINESE-JAPANESE, CANDY-APPLE-ONION), of the sort that have been found to produce decrements in short-term memory for hearing subjects (Baddeley, 1966). In addition, Lichtenstein (in press) noted that the cheremically similar words had more letters (21% more), more syllables (36% more), and less visual distinctiveness (in terms of the range of number of letters per word) than the control words.

Shand reported no data from hearing subjects on his task. However, he stated that pilot studies with hearing subjects revealed recall decrements for the phonetically similar lists relative to the control or cherological lists. He did not state whether or not the hearing pilot subjects demonstrated recall decrements for the cheremically similar lists relative to the control lists. In view of the potential stimulus confounds noted above and the implications of his results, such a control group is vital.

Reported here are the results of hearing subjects tested in the short-term memory task of Shand. We used the same stimuli and procedures, making only one modification in the experimental design: Due to the fact that hearing subjects, in most short-term memory tasks, are able to recall more items than deaf subjects, we increased the number of words presented on a trial from five to six in an attempt to keep our error percentages roughly comparable to those obtained with the deaf subjects tested by Shand.

Method

Stimuli. The stimuli were the three word sets used by Shand (1980, 1982), as given above.

Procedure. On each trial, subjects were presented with six words from one of the three sets. The words were serially presented, at a 1 s presentation rate, on a computer controlled CRT display. They were presented in uppercase letters. There were 16 trials of words from each set, with each word occurring an equal number of times in each serial position. Trials were blocked, such that subjects saw all 16 lists from one set of words before proceeding to a different set. The subjects were tested individually, and the order of set presentation was varied between subjects. During the testing on lists from a given set, the eight words of that set were displayed, on index cards, for the subjects. Each set was typed, in different orders, on two index cards; some of the subjects saw the first ordering of words, while other subjects saw the second.

The instructions, spoken by the experimenter, informed subjects that they were to watch each of the six words presented on a trial, and to write their responses when the signal (***) appeared at the end of the trial. They were told to write down the words in the serial position in which they occurred on

answer sheets that had the serial positions numbered 1-6 for each trial. The experiment was self-paced allowing subjects to initiate each trial by a key press on the computer keyboard.

Subjects. The subjects were eight normally-hearing college students in the New Haven area. They were paid for their participation in this 45-min experiment. None reported any familiarity with signs.

Results

Shown in Table 1 are the mean percentages of correct recall for both list scoring and item scoring. For comparison purposes, the results of the deaf subjects tested by Shand are also given in Table 1. As can be seen from the Table, the magnitude of the difference in accuracy between the cheremically similar set and the control set for these hearing subjects is comparable to that of Shand's deaf subjects. With list scoring, the accuracy was 23% less for the hearing subjects and 18% less for the deaf subjects. With item scoring, the accuracy was 8% less for the hearing subjects and 9% less for the deaf subjects. Analyses on the percentage correctly recalled by the hearing subjects confirmed that this performance difference between the cheremically similar lists and the control lists was significant. Analyses of variance indicated significant main effects of condition for both list scoring $F(2,14) = 11.79$, $p < .01$, $MSe = 204.93$, and item scoring, $F(2,14) = 13.57$, $p < .01$, $MSe = 34.13$. Post hoc tests revealed a significant difference in accuracy between the cheremically similar and control lists for both scoring procedures (Newman-Keuls, $p < .05$).

Table 1

Percentage Accuracy in Recall of Lists of Printed English Words.

	Lists recalled perfectly (%)		Items recalled correctly in the correct position (%)	
Stimulus Set	Hearing	Deaf[a]	Hearing	Deaf[a]
Control	77	62	91	86
Cheremically similar	54*	44*	83*	77*
Phonetically similar	43*	59	76*	84

Note: [a]from Shand (1982); * significantly different from control

The data of the hearing subjects differed from those of the deaf subjects in terms of the relative accuracy on the phonetically similar set. Consistent with Shand's statement regarding his hearing pilot subjects, the hearing subjects in the present study had difficulty in the recall of words from the

phonetically similar sets. Post hoc tests revealed a significant difference in accuracy between the phonetically similar and control lists with both list scoring and item scoring (Newman-Keuls, $p < .05$). These hearing subjects, also consistent with Shand's observation regarding his hearing pilot subjects, were less accurate on the lists from the phonetically similar set than on lists from the cheremically similar set. This difference was statistically significant with item scoring (Newman-Keuls, $p < .05$), but not with list scoring (Newman-Keuls, $p > .05$).

Shand reasoned that using four words each from the phonetically and cheremically similar sets as the words in the control set would allow these matched items to serve as their own control; the ability to recall these matched items could be compared when they occurred in lists from the experimental set vs. when they occurred in lists from the control set, allowing for a determination as to the relative ability to recall particular words as a function of list type. The percentages of items correctly recalled on the four matched words in the control and experimental sets are given in Table 2. The error pattern on these matched words indicated recall decrements on both the cheremically similar lists, $t(7) = 4.25$, $p < .01$, and the phonetically similar lists, $t(7) = 2.72$, $p < .03$ (both tests two-tailed). Thus, for these subsets of the stimuli, as for the full set of stimuli, recall was less accurate when words occurred in experimental lists than when they occurred in control lists.

Table 2

Percentage Accuracy in Recall of Items that Appeared in Both the Control Set and an Experiment Set.

	Experimental Set			
	Phonetically similar (%)		Cheremically similar (%)	
Stimulus Set	Hearing	Deaf[a]	Hearing	Deaf[a]
Control	90	86	92	86
Experimental	77*	85	84*	78*

Note: [a]from Shand (1982); * significantly different from control

Discussion

The results reported here call into question Shand's (1982) conclusion that the deaf subjects' recall decrement on his cheremically similar lists of printed words can be taken as evidence of sign-based coding. When the same word lists were presented here to non-signing hearing subjects, their performance showed a decrement as well; a finding that, in this case, clearly cannot be attributed to sign-based coding. Rather, the greater semantic

relatedness, word length, visual similarity, or number of syllables of the words in Shand's cheremically similar than control sets are likely to have led to the decrement for the hearing subjects. The same factor(s) may also have been responsible for the recall decrement for the deaf subjects.

However, the comparable decrement on the cheremically similar lists for both deaf and hearing subjects does not rule out the possibility of different underlying causes for these two subject groups. For example, it seems that Shand's deaf subjects would have been less likely than the present hearing subjects to have been influenced by the number of syllables in words. Although some deaf individuals, even native signers, have been found to use speech-based coding in short-term ordered recall (Conrad, 1979; Hanson, 1982; Lichtenstein, in press; Shand, 1980), these same studies have found that certainly not all deaf individuals do. The use of a speech code by prelingually, profoundly deaf persons appears to be related to a number of variables, including English proficiency and speech skill (Conrad, 1979; Hanson et al., 1984; Lichtenstein, in press). Shand's (1982) deaf subjects, as a group, showed no significant effect due to phonetic similarity; the present hearing subjects, however, did.

Although the possibility remains that the recall decrement for Shand's deaf subjects on the formationally (cheremically) similar lists was due to sign coding, the comparable results obtained here with hearing subjects clearly undercut Shand's argument. His conclusion must also be considered in light of the fact that his results are inconsistent with other studies in the literature in which deaf college students have served as subjects: Other studies using similar procedures (but different word sets) have shown performance decrements by deaf signers in the serial recall of formationally similar signs (Hanson, 1982; Poizner et al., 1981), but not in the serial recall of printed words having formationally similar signs (Hanson, 1982; Lichtenstein, in press). Moreover, although sign-based intrusion errors have been found in the serial recall of unrelated lists of signs (Bellugi et al., 1975; Krakow & Hanson, 1985), sign-based intrusions have not been found in the recall of lists of printed words (Krakow & Hanson, 1985). Taken together, these facts argue against Shand's conclusion that his results can be taken as evidence of sign-based coding of printed words.

References

Baddeley, A. D. (1966). Short-term memory for word sequences as a function of acoustic, semantic and formal similarity. Quarterly Journal of Experimental Psychology, 18, 362-365.

Baddeley, A. D. (1979). Working memory and reading. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds.), Processing of visible language (Vol. 1). New York: Plenum.

Bellugi, U., Klima, E. S., & Siple, P. (1975). Remembering in signs. Cognition, 3, 93-125.

Conrad, R. (1979). The deaf school child. London: Harper & Row.

Crowder, R. G. (1978). Language and memory. In J. F. Kavanagh & W. Strange (Eds.), Speech and language in the laboratory, school, and clinic (pp. 331-376). Cambridge, MA: MIT Press.

Hanson, V. L. (1982). Short-term recall by deaf signers of American Sign Language: Implications of encoding strategy for order recall. Journal of Experimental Psychology: Learning, Memory and Cognition, 8, 572-583.

Hanson, V. L., Liberman, I. Y, & Shankweiler, D. (1984). Linguistic coding by deaf children in relation to beginning reading success. Journal of Experimental Child Psychology, 37, 378-393.

Healy, A. F. (1975). Coding of temporal-spatial patterns in short-term memory. Journal of Verbal Learning and Verbal Behavior, 14, 481-495.

Klima, E., & Bellugi, U. (1979). The signs of language. Cambridge, MA: Harvard University Press.

Krakow, R. A., & Hanson, V. L. (1985). Deaf signers and serial recall in the visual modality: Memory for signs, fingerspelling, and print. Memory & Cognition, 13, 265-272.

Lichtenstein, E. (in press). The relationships between reading processes and English skills of deaf college students: Part I. Applied Psycholinguistics.

Poizner, H., Bellugi, U., & Tweney, R. D. (1981). Processing of formational, semantic, and iconic information in American Sign Language. Journal of Experimental Psychology: Human Perception and Performance, 7, 1146-1159.

Shand, M. A. (1980). Short-term coding processes of congenitally deaf signers of ASL: Natural language considerations. (Doctoral dissertation, University of California, San Diego, 1980) Dissertation Abstracts International, 41.4, 1572A-1573A.

Shand, M. A. (1982). Sign-based short-term coding of American Sign Language signs and printed English words by congenitally deaf signers. Cognitive Psychology, 14, 1-12.

Shand, M. A., & Klima, E. S. (1981). Nonauditory suffix effects in congenitally deaf signers of American Sign Language. Journal of Experimental Psychology: Human Learning and Memory, 7, 464-474.