PROCESSING WORDS BY SIGN AND/OR SEMANTIC FACTORS BY DEAF SUBJECTS

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ABSTRACT

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By

Robert D. Moulton

This study tests the hypothesis that deaf subjects who consistently use sign language can use sign formation factors and/or semantic relationships as learning strategies during a paired-associate verbal learning task involving words. In addition, the study compares and contrasts the relative efficiency of coding by either a sign system, a semantic system, or a combination of the two.

Research dealing with verbal learning tasks suggests that language-related material is first perceived at the level of sensory impulses and is then converted into a code which facilitates rehearsal and recall. Such research has indicated that acoustic and/or speech-motor coding will be used by hearing subjects if they are required to recall lists of words or letters within seconds after presentation. Semantic processing of words has also been demonstrated in hearing subjects when the

temporal patterns of the verbal learning task have been long enough to permit such coding.

Because the acoustic and speech-motor coding models might not be readily applicable to deaf subjects, investigators have tried to discover the coding strategies used by the hearing impaired. It has been hypothesized that deaf subjects might encode language-related material in a form directly related to the type of communication used by individual subjects. This theory has been given support by recent research which has indicated that deaf subjects who have relatively good speech can code words and letters on a speech-motor basis. The suggestion of a relationship between communication systems and encoding modes leads to the prediction that deaf subjects who are dependent on sign language could code words and letters by some dactyl form. Evidence of manual coding of single letters has been found, but a relationship between word coding and sign language factors has not been clearly specified.

Twenty-six deaf teenage subjects who were proficient in the use of signs participated in a paired-associate learning task. The stimuli consisted of 5 lists of word pairs. The 5 lists were so constructed that they differed from each other on the basis of the sign and/or semantic relationship between the word pairs. List 1 contained word pairs which shared a similar meaning and a similar sign. List 2 contained word pairs which had different signs but similar meanings. List 3 contained word pairs which shared a similar sign but had different meanings. Lists 4 and 5 were control lists and the word pairs in these lists contained no obvious sign or semantic relationships. The subjects were randomly divided into thirteen groups of two individuals each and administered the paired-associate lists in a repeated measures design with random ordering of list order presentation. The presentation procedures used to examine subjects' performance on each of the 5 lists followed standard paired-associate study-test research techniques. The measured variable was the total number of word pairs learned during 6 learning trials for each of the 5 lists.

The results of this study indicate that during the initial phases of the paired-associate learning situation, deaf subjects who use sign language can code words on either a sign or a semantic basis. In addition, the findings indicate that for the paired-associate learning of words, semantic relationships offer a more efficient coding strategy than do sign formation factors.

The indication of coding by sign factors found in this study offers some support to the contention that

the physiological components of communication production will be reflected in the processing of language-related material. The findings showing that semantic coding occurs in a paired-associate task is consistent with learning models which predict a reciprocal relationship between the motoric component of short-term memory coding and the semantic aspects of long-term memory storage processes.

The findings of this study indicate that when given a choice between semantic and sign coding strategies, the deaf tend to select the semantic strategy rather than use the sign code or a combination of sign and semantic cues.

Based on the results of this study and related investigations, suggestions are offered for educational planning of deaf students. Some current methods of educating the deaf are discussed relative to possible relationships between educational practices, coding systems, speech, reading, language and speechreading.

PROCESSING WORDS BY SIGN AND/OR SEMANTIC FACTORS BY DEAF SUBJECTS

By

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Accepted by the faculty of the Department of Audiology and Speech Sciences, College of Communication Arts, Michigan State University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Verbal Learning in Deaf and in Hearing Subjects

Educators and researchers have long been dissatisfied with the ability of deaf subjects to learn language-related material. The deaf have been found to have a limited vocabulary (Vernon and Koh, 1970; and Stuckless and Birch, 1966), depressed reading ability (Wrightstone, Aronow and Moskowitz, 1962) and "abnormal" expressive language structure (Meadow, 1968; McClure, 1966; and Boatner, 1965). These language-related problems are thought by many to be related to the type of communication system used in teaching the deaf. Traditionally, the deaf in the United States have been taught in either oral or manual communication systems. The oral system has stressed speechreading, speech production, and auditory training; while the manual method has included the use of the fingerspelled manual alphabet and/or formally recognized signs from the American Sign Language or other sign systems. Research designed to specify the relative effects of the two communication systems has been equivocal. Critics of manualism have carried out investigations which seem to show that a reliance on signs and fingerspelling results in a myriad of language-related problems (Streng, 1960; Rupp and Mikulas, 1973; and Dale, D. M. C., 1967). However, other research seems to indicate that the oral method also results in deviant language patterns (Vernon and Koh, 1970; and Mindel and Vernon, 1971). While investigators agree that each system of communication has an effect on language skills, they are not in agreement as to the relative effects of the two systems. To date, it is not known what specific aspects of the language-learning problems of the deaf are peculiar to each communication system.

Recently, investigators have produced evidence dealing with coding during verbal learning tasks which may give some insight into language and learning processes used by deaf individuals. These investigators are asking if the type of communication system used will affect the way in which language-related material is coded during the language reception and production process. That is, it may be that the two communication systems used by the deaf can result in distinctively different coding processes. If this is the case, then the relative efficiency of different coding strategies used by

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used by the deaf might be directly related to such language-related skills as speech, reading, writing, and the learning of language-related material (Allen, 1970; Conrad, 1970; and Conrad and Rush, 1965).

Analysis of the errors made during verbal learning tasks using hearing subjects has shown that the errors committed are consistent rather than random. This consistency of errors is thought by many researchers to be a reflection of the type of coding used in the learning process. The errors made by hearing subjects when learning a list of letters have been shown to have an acoustic (Conrad, 1964; Conrad and Hull, 1964; and Wickelgren, 1965) or a speech-motor relationship (Hintzman, 1967). This acoustic or speech-motor coding is also evident when words are used instead of letters in the verbal learning task (Baddeley, 1966 and 1972). The use of words has also been shown to make semantic coding possible (Craik and Levy, 1970; Dale, 1967; Dale and Gregory, 1966; and Shulman, 1970 and 1971).

Because the acoustic and speech-motor coding models do not readily apply to deaf subjects, investigators have tried to specify the verbal learning coding systems used by the hearing impaired. It would appear that the type of coding used by the deaf depends on several factors such as the amount of hearing loss, age at onset of the loss, type of training received and the type and use of sound amplification. Conrad (1970) has shown that orally trained deaf subjects with relatively good speech appear to code letters on an articulatory basis during verbal learning tasks, while Locke and Locke (1971) have indicated that manual deaf subjects with poor speech code letters on the basis of kinesthetic cues from fingerspelling or from visual cues associated with the shape of the printed letter.

Research designed to distinguish between possible types of coding systems used by the deaf when performing verbal learning tasks involving words has been partially inconclusive. It is generally agreed that acoustic coding is not used by the profoundly deaf (Allen, 1970; and Blanton and Nunnally, 1967), and speech-motor coding is not used by deaf subjects with relatively poor speech (Blanton and Nunnally, 1967). Conrad (1970) has found that deaf subjects with relatively good speech code words on an articulatory basis. When researchers have investigated the possibility of deaf subjects coding for words by manual sign language cues, the findings have been inconsistent with established learning theories, as was the case with Putnam, Iscoe and Young (1962), or have had serious design problems, as exemplified in the research of Odom, Blanton and McIntyre (1970). It is evident that further research concerning the use of manual signs as a strategy for

coding words during verbal learning tasks is warrented.

Language, Thought and
Educational Methodologies

Speculation on the relationship between thought and language has colored the writings of philosophy and psychology since the very beginnings of these fields (Boring, 1950). Many of the early questions regarding thought and language are still providing researchers with topics for investigation. It is still cogent to ask: "Is thought possible without language? Is language possible without thought? Are language and thought the same thing?" Early philosophers concerned themselves with questions such as these and sought to grasp the nature of language, thinking, ideas, words and etc. through introspection, and later through semi-empirical research (Johnson, 1972). These "black box" investigations, as they have been called, led to the development of several schools of thought. Two of these schools, empiricism and behaviorism, were to have profound implications in education of the deaf.

The empirical school, founded by Locke in the 1600's, held that thinking took place in words which were merely an internal replication of speech. To Locke, language, thought, and the spoken word were simply different manifestations of the same thing (Garnett, 1967). This tenet was also held by Watson, founder of the

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American behaviorist movement. Watson saw a direct link between speech and thinking. He stated that "...according to my view, thought processes are really motor habits in the larynx." (Slobin, 1971, page 98).

Samuel Heinicke, founder of the oral method of teaching the deaf, was influenced by the notion that thinking was a form of inner speech (Garnett, 1967). Heinicke held that, since thinking was composed of speech patterns, deaf children must learn speech in order to think. He rejected any form of manual communication and held that only through spoken language patterns was abstract reasoning possible. The early proponents of the manual system countered these claims by stating that manual signs took the place of words in the thinking process. The Abbé Charles Michel de l'Épee, who founded the first school for the deaf using the language of signs in 1775, claimed that signs, not words, were the "mother tongue" of the deaf (Bender, 1960).

The concept of a link between thinking and speech and language processes is still providing ammunition for both sides in the oral vs. sign language controversy. Critics of manual systems of signs claim that the use of sign language will force a child into thinking processes which are not adequate for logical, abstract reasoning (Rupp and Mikulas, 1973; Hodgson, 1953; and

Morkovin, 1964). Proponents of sign language still hold that manual systems are the "mother tongue", "natural form of expression", "true language", and/or the "natural language" of the deaf (Furth, 1966; Giangreco and Giangreco, 1970; and Markowicz, 1972). Writers holding with this "mother tongue-natural language" concept contend, as did de l'Épee, that sign formations are used in place of spoken words in the thinking process of the deaf. Writers representing either of the two camps do not place strict boundaries around the critical concepts of thought and language. Each side claims that the effects on language and thinking which are peculiar to their system will be manifest in relatively better reading, written language, abstract reasoning, syntactic structure, increased vocabulary and other language-related tasks.

Researchers are now calling for objective evidence on the effects that various methodologies might have on the language, speech and thought processes of the deaf. Myklebust (1960) called for such action when he stated:

> Methods utilized for developing language in children with deafness are based on theory and experience rather than on scientific evidence... Many claims and counterclaims have been made regarding the effectiveness of a particular methodology. Only through objective study can such claims be evaluated. (page 240)

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An attempt to answer this need for objective investigation has led some researchers to look at the coding processes used by deaf subjects when learning verbal material in a short-term memory task. This search for coding strategies can be viewed as a method of objectively studying the issues raised by the early founders of oral and sign language systems. That is, can it be shown that deaf children who sign will code language-related material on the basis of signs and that deaf children who are taught orally will code in a manner related to spoken language? Investigators are also asking what effects these different coding strategies, if they can be shown to exist and to differ, might have on important educational objectives such as speechreading, speech, written language, reading, and etc. This research into verbal learning strategies has been carried out using both hearing and deaf subjects and attempts have been made to correlate the findings from the two populations.

Verbal Learning, Coding and Short-Term Memory

"Verbal learning" refers to a broad classification of behavior investigated by learning theorists, psychologists, philosophers, educators, speech scientists and others. In general, "verbal learning" is the term used to designate any learning situation in which

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which the task requires the learner to respond to verbal material, such as words or individual letters (Ellis, 1972). The task to be performed by the subjects might include the learning of lists of words or letters or the forming of associations between pairs of letters or words. The types of verbal learning tasks available have been limited only by the imagination of the investigator, and the literature concerning verbal learning constitutes one of the largest collections of systematic investigations in the behavioral sciences (Hall, 1971).

Verbal learning tasks usually involve several learning trials in which it is assumed that any change in behavior can be attributed to learning. Melton (1963) makes note of this in his definition of learning:

> Learning may be defined as the modification of behavior as a function of experience. Operationally, this is translated into the question of whether (and, if so, how much) there has been a change in behavior from trial n to trial n + 1. Any attribute of behavior that can be subjected to counting or measuring operations can be an index of change from trial n to trial n + 1, and therefore an index of learning. (page 3)

Even with a broad concept of learning such as is used by Melton (1963), it has sometimes been difficult to determine if the results of verbal learning tasks have not been confounded by perceptual or memorial factors rather than learning. For example, it

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might be possible to attribute the correct responses in a verbal learning task to the "remembering" of the stimulus items by a system which can only be defined as something less permanent than is usually found in true learning. Hall (1971) has acknowledged that it is often difficult to determine how permanent the learning aspect of the verbal learning procedure is but holds that the problem is probably largely semantic. Hall has reviewed the literature on the problem of distinguishing between learning and memory and concludes that clearly separating the two factors would not alter the concepts or conclusions reached from verbal learning research. Hall (1971) noted:

> It does not seem possible that we can resolve this problem of how permanent the behavioral change must be in order for the learning process to be inferred, since it appears that the nature of the controversy is primarily a semantic one. As we shall subsequently note, the distinction between a learning process and a retention or memorial one is arbitrary since the learning of new material obviously involves the remembering of that which has been previously learned. The placing of emphasis upon a memorial process, however, does emphasize the position that a continuum of behavior change exists in which at the one end we have changes that are extremely temporary and at the other end changes that are quite permanent. (pages 4-5)

In developing a verbal learning task, the investigator generally has not been too concerned with whether or not the results will be the product of "pure learning". Instead, the investigator has designed the task so that the performance on the verbal task can improve over trials and in turn this improvement has been operationally defined as learning. Hall (1971) has stated this aspect of verbal learning designs well:

> Generally, there is little concern on the part of the experimenter with looking at a given behavior pattern and attempting to decide whether or not it has come about as a result of learning or as a result of some other process, i.e., maturation, fatigue, etc. Rather, and this has been particularly true in the investigation of verbal learning, the general procedure has been to provide the subject with a task in which his change in behavior leads logically to what must be the operation of the learning process. Thus, when a subject is asked to learn a list of words, it is obvious he could not have produced these words before observing them; it is obvious that after a number of practice trials, he is capable of doing so. It is generally assumed, then, that the process that accounts for such a behavior change is learning. (pages 5-6)

Verbal learning tasks are closely allied to short-term memory (STM) processes. In fact, when the items used in a STM task involve words or letters, "STM" and "verbal learning" are simply two terms for the same process. Note, however that the two terms appear to foster the problem of distinguishing between memory and learning. Hall (1971) has attempted to lessen this problem somewhat by referring to STM as short-term retention. The point is, research into STM and verbal learning is very closely related, and when the items used in a STM task involve verbal material, little or no difference exists between the two constructs. This is an important point, since the research into coding strategies used in the processing of verbal material has usually been classified as STM.

The concept of short-term memory was introduced by Jacobs in 1887 (Hall, 1971) and given further attention by James in 1890 (Norman, 1969). These early writers noted that man has both a short-term memory and a long-term memory. James distinguished betweeen an immediate grasp of the past which he characterized as short-term memory, and "properly recollected objects" which he stated were peculiar to long-term memory (LTM). Norman (1969), in a more current discussion of STM and LTM, noted that short-term memory has a relatively small capacity of a few items or "chunks" of information, whereas LTM has a relatively large storage capacity. Norman also stated that items are held in STM in some form that facilitates rehearsal, and that items are retrieved from LTM through semantic associations. The time element associated with STM, according to Norman, is usually not considered to extend beyond several seconds, but items may remain in LTM for an indefinite period.

Shulman (1970) has pointed out that the boundaries between STM and LTM are not always distinct, and it is possible for these two memory systems to affect each other. Paivio (1971) has noted that, while theoretical definitions and distinctions regarding LTM and STM are possible, it is usually desirable to establish operational definitions based on temporal factors. Aaronson (1967) has reviewed the literature on this issue and designated the time factors relevant to studies of coding and learning during STM.

Recent research in STM has found evidence of the operation of two stages or systems (Sperling, 1960 and 1963; and Broadbent, 1957 and 1958). During the first stage, relatively large amounts of incoming perceptual information can be stored for a very brief period. Sperling (1960) noted that the visual impression during Stage 1 can decay in a matter of milliseconds, while Murdock and Walker (1969) and Craik (1970) suggested that precategorical auditory storage is longer than visual storage, perhaps up to 5 seconds. During this initial or "buffer" stage, very little mental processing of the information occurs --the information held in storage is more nearly a direct representation of the physical attributes of the stimulus and no categorization or encoding takes place. Stage 1 is relatively large in capacity and more than one item can enter the system simultaneously (Aaronson, 1967). Thus Stage 1 appears to be a brief store of sensory information that does not require attentional or coding mechanisms.

It is at Stage 2 of STM that individuals incorporate mental processes to select and code the sensory information found in Stage 1. In her description of

Stage 2, Aaronson (1967) has noted:

> Stage 2 differs from Stage 1 in several respects; (a) Processing at this stage is at a higher level than at Stage 1. Items are identified or encoded on the basis of meaning or a name of some sort. (b) Representations are more permanent after Stage 2 than during Stage 1. Their rate of decay has decreased even though some of the initial information was sacrificed in the abstraction of properties that occurred in identification. (c) At Stage 2, representations are handled by a limited-capacity system. This system can receive items only in series, that is, only one item can enter the system, additional items being delayed until the "single-channel" is free. (page 130)

Once material from Stage 1 has been encoded in Stage 2, it is repeated in its code as a form of rehearsal which will maintain the material in Stage 2 for a limited time (Brown, 1958; and Broadbent, 1958).

Figure 1 is a schematic representation of the relationship between Stage 1 (precategorical storage), Stage 2 (encoding), rehearsal and LTM.

While it is generally well accepted that this coding and rehearsal take place, the exact form of the code has been a much discussed theoretical subject. Paivio (1971) has reviewed the literature on the issue of coding and has noted that some controversy exists as to whether material is coded in a concrete fashion as a relatively direct representation of the original material, or if the material is transformed into a verbal code and then rehearsed in a verbal manner. Evidence suggesting the existence of a verbal coding

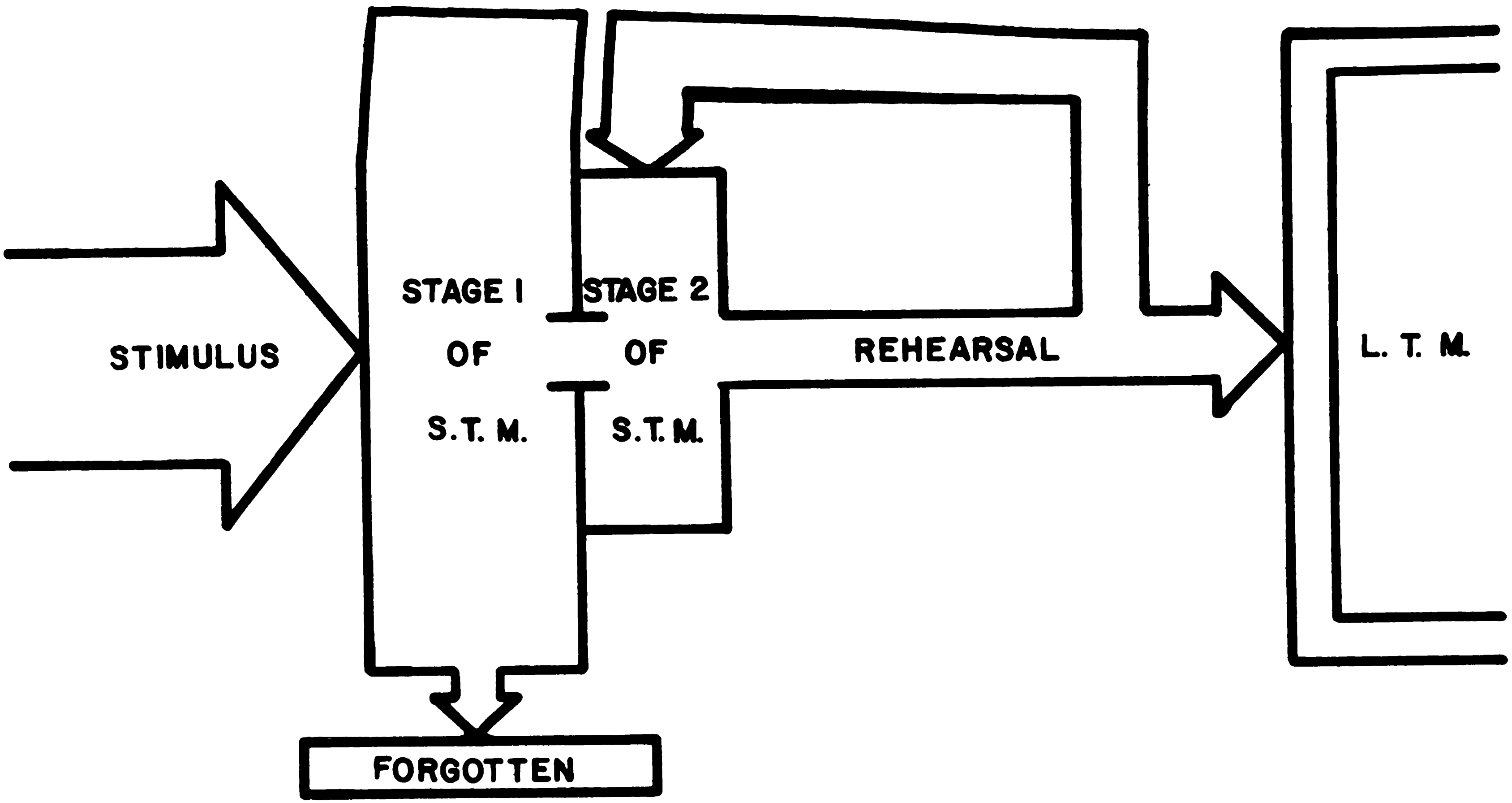

Figure I. Schematic representation of the relationship between Stage I (precategorical storage), Stage 2 (encoding), rehearsal, and L.T.M. Adapted from Waugh and Norman (1969; page 90).

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process has been supported by research into STM. Conrad (1964) suggested that if coded material in STM decayed gradually, errors made during recall should bear some resemblance to the original code. Conrad noted:

> Now the claims of the decay theory of immediate memory demand the existence of partially decayed memory traces. One would expect that such traces would sometimes yield memories which were not exactly correct, but which were not random with respect to the original stimuli -- i.e. not guesses. This becomes then a problem of showing that systematic errors occur after the likelihood has been removed that such errors are perceptual. (page 75)

Acoustic and/or Speech-Motor Coding

Investigators have not been in agreement as to whether the coding used in linguistic processes is acoustic or speech-motor. In testing STM, Conrad (1964) was able to demonstrate that items recalled incorrectly were acoustically related to the original items. This acoustic correlation was present even when the items were presented visually. Conrad concluded that in STM, coding for verbal material was an auditory process which could be vocal or subvocal. Norman (1969) reviewed the literature on this subject and concluded that rehearsal during verbal learning appeared to be silent, "inner speech", and that the material in a STM task was coded in an auditory form. This would imply that memory traces in the cortex were related to acoustic features, and subsequent incoming auditory impulses would be mediated or coded with these acoustic memory traces.

However, as Joos (1948) and Van Riper and Irwin (1958) have shown, different items which bear an acoustic relationship are also closely related on a motor or kinesthetic basis. Because of this relationship between production and product, it would be logical to assume that items in a verbal learning situation would be coded in a process related to motor aspects of speech production. Writers supporting this theory have designed studies which seem to have demonstrated that coding is related to motor impulses from the articulators. This does not imply that we actually repeat linguistic material before it is understood, but rather that neural impulses occur in a short-circuited manner within the neurological system without ever actually requiring movement of the articulators (Liberman, 1957; and Cooper, et al., 1952). Those supporting the acoustic model state that a particular item is recognized when its distinctive acoustic features are paired with its remembered standard or model. The proponents of a speech-motor theory, on the other hand, state that an item, such as a phoneme, is recognized when it is paired with the particular neural impulses rom the

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from the articulators which would have been used if the phoneme were actually produced (Hintzman, 1967). The issue of the exact nature of the encoding process during verbal learning is still open (Wickelgren, 1969; and Lane, 1963).

Coding for Letters in Hearing Subjects

An important factor in verbal learning tasks involving lists is the amount of similarity existing within the items of a list (Conrad, 1959). Underwood and Richardson (1956) and Underwood and Schulz (1958) have shown that it is more difficult to learn a serial order list of letters or numbers if there is a high degree of intra-list similarity defined as the repitition of common letters within the list. Investigators are not in agreement as to the probable cause of the decrease in performance which accompanies intra-list similarity. Some have contended that intra-list similarity causes confusion because of coding similarities, while others have suggested that the similarity leads to competition among coding strategies (Conrad, 1964; Wickelgren, 1965; Hintzman, 1967; and Shulman, 1970). Regardless of the cause, the factor of intra-list similarity has been used extensively in coding research.

Conrad (1964) used intra-list similarity based on

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acoustic relationships to study coding for letters in a verbal learning task with hearing subjects. Using the letters B C P T V F M N S X he generated a series of serial order STM tasks. Conrad was not concerned with the number of errors made, but rather with the types of confusion resulting from acoustic similarity between the letters. The lists of letters were presented in both a visual and an auditory mode. Table 1 shows the resulting confusion matrices used in the analysis of errors. Note that the errors were not random. The letters B C P T and V shared a common vowel between them and were consistently confused with each other. The analysis also revealed that the letters F M N X and S which bear an acoustic relationship to each other were consistently confused with each other. Note too that Conrad found these acoustically related confusions to occur even when the lists of letters were presented visually. The conclusion reached by Conrad was that coding for letters is acoustic in nature and this acoustic coding is reflected in the types of errors made. This conclusion was also reached in a study by Conrad and Hull (1964). However, Wickelgren (1965) has pointed out that the confusions noted by Conrad (1964) could also be accounted for on the basis of speech-motor similarities.

Wickelgren (1965) expanded the findings of Conrad

Table 1.

Response Letter

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Response Letter

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Table 1.—Confusion matrices used in the analysis of errors by Conrad (1964, page 78).

LISTENING CONFUSIONS

Response Letter	Stimulus Letter: B	C	P	T	V	F	M	N	S	X
B	.	171	75	84	168	2	11	10	2	2
C	32	.	35	42	20	4	4	5	2	5
P	162	350	.	505	91	11	31	23	5	5
T	143	232	281	.	50	14	12	11	8	5
V	122	61	34	22	.	1	8	11	1	0
F	6	4	2	4	3	.	13	8	336	238
M	10	14	2	3	4	22	.	334	21	9
N	13	21	6	9	20	32	512	.	38	11
S	2	18	2	7	3	488	23	11	.	391
X	1	6	2	2	1	245	2	1	184	.

VISUAL RECALL CONFUSIONS

Response Letter	Stimulus Letter: B	C	P	T	V	F	M	N	S	X
B	.	18	62	5	83	12	9	3	2	0
C	13	.	27	18	55	15	3	12	35	7
P	102	18	.	24	40	15	8	8	7	7
T	30	46	79	.	38	18	14	11	8	10
V	56	32	30	14	.	24	15	11	11	5
F	6	8	14	5	31	.	12	13	131	16
M	12	6	8	5	20	16	.	146	15	5
N	11	7	5	1	19	28	167	.	24	5
S	7	21	11	2	9	27	4	12	.	16
X	3	7	2	2	11	30	10	11	59	.

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(1964) by constructing a confusion matrix error analysis for all 26 letters and the digits 1 through 9. Wickelgren's findings were in agreement with Conrad's. Wickelgren concluded:

> (a) Short-term storage is auditory (or speech-motor. (b) Acoustically similar items are represented by similar traces (either overlapping sets of neurons or similar patterns of firing of neurons). (c) Partial forgetting of an item is possible, producing intrusion errors that share the unforgotten property common to both the original item and the intrusion. (page 108)

Hintzman (1967) has tried to distinguish between the acoustic and speech-motor aspects of coding for letters. He used the letters P T K B D and G as stimuli and constructed a confusion matrix error analysis. Hintzman found that two factors interplay in contributing to confusions among the consonants. Confusions were related to voicing as well as to place of articulation. The voicing factor could be attributed to acoustic or speech-motor confusions. However, according to Hintzman, the confusion caused by place of articulation can be attributed to speech-motor or kinesthetic similarity. Wickelgren (1969) reviewed the literature on the issue and concluded that confusion errors which occurred when letters were used as stimuli could be interpreted in either acoustic or speech-motor terms. Wickelgren stated that it would be very difficult to design empirical STM studies to separate the two factors. He noted:

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> Thus, it is impossible, at the present time, to make definite decisions regarding whether the feature dimensions underlying either recognition or STM confusions matrices represent auditory or articulatory feature dimensions. (page 234)

Coding for Words by Hearing Subjects

Utilizing many of the techniques used in STM for letters, investigators have studied STM coding for words presented serially. An independent variable frequently used to study STM for words has been intra-list similarity. However, with words the variables of semantic similarity, relative frequency of occurrence and similarity of letter structure have been considered in addition to similarities related to acoustic and speech-motor factors.

Baddeley (1966) contrasted performance on lists generated from acoustically similar words (e.g., mad, man, mat, cap, cad, can, cat, cab) with control lists from a group of acoustically different words (e.g., cow, day, bar, few, and etc.). Baddeley found that the lists with high intra-list similarity were significantly more difficult to learn. Because of the learning principle which states that, in general, intra-list similarity in coding during serial order lists will have an adverse effect on memory (Hall, 1966; Underwood and Richardson, 1956; Conrad, 1959; and Underwood and Schulz,

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1959), Baddeley concluded that coding for words during a verbal learning task was related to acoustic factors.

In the same experiment, Baddeley contrasted semantically similar (e.g., big, long, broad, great, high, tall, large, wide) word lists with lists containing words of low semantic similarity. Here the semantic intra-list similarity caused a decrease in performance, but not as great a decrease as had been found with acoustic similarity. Baddeley also studied the effects of formal similarity which was defined by the shapes of the printed words. He found that the intra-list acoustic similarity had a greater adverse effect on performance than did either semantic or formal similarity. This relationship held whether the material to be learned was presented visually or auditorially. Baddeley concluded: "...subjects show remarkable consistency and uniformity in using an almost exclusively acoustic coding system for the short-term remembering of disconnected words." (page 304)

Craik and Levy (1970), Dale (1967) and Dale and Gregory (1966) have attempted to better isolate the effects of semantic coding in STM. The results of their studies were inconclusive and the problem of comparing acoustic and/or speech-motor factors with semantic factors remains a fertile area of research. Shulman (1970 and 1971) has argued that the temporal aspects of th

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of the verbal learning design were very important in determining what type of coding would be used by subjects when coding for words. Shulman noted that encoding of an item took place over time, and if the subject had to code rapidly, he used an acoustic and/or speech-motor code, since such codes would more closely resemble the form of the sensory input. Shulman has also shown that, given sufficient time, semantic coding may be utilized by subjects in a STM task. Baddeley (1972), on the other hand, concluded that while some retrieval rules in STM might have a semantic component, the acoustic and/or speech-motor factors are still the most important form of coding used.

Some writers have attempted to develop a learning model which could account for the occurrence of both semantic and phonetic (acoustic and/or speech-motor) coding. Norman (1969) noted that it was possible that the traditional discrete boundaries between STM and LTM may be an oversimplification. According to Norman, it may be that while phonetic coding is specific to STM and semantic coding is peculiar to LTM, the boundaries between these two learning modes might be "loose" enough to permit considerable interaction. Morton (1970) has used this concept of an interdependence between STM and LTM in his learning model. Morton described encoding and rehearsal as taking place in STM, but he noted that a syst

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a system of reciprocity between STM and LTM could permit the nature of the STM encoding to be affected by LTM semantic information. Morton's model, then, would allow for an interaction between the STM and LTM systems, especially in selecting an efficient coding system to be used in STM.

In addition to single words in serial order, lists of word pairs have been used as a verbal learning task in studying the relative effects of semantic and phonetic coding. The process of using word pairs instead of single words allows the investigator to study ways in which subjects form associations between words. This type of task has been termed paired-associate (PA) learning and the techniques used by researchers when using PA lists are fairly well standardized. The PA task consists of a number of word pairs in which the first word of each pair serves as the stimulus and the second word of the pair serves as the response. Several presentation methods have been used in PA studies, but the study-test procedure is probably the simplest and has been gaining increased popularity with investigators (Hall, 1971). In the study-test PA learning design, subjects are first exposed to all word pairs in a study session and then, in random order, the stimulus members of each pair is presented, and the subjects are asked to respond with the missing response words.

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words. Since the work of Shulman (1970) would predict that the temporal factors in the PA verbal learning task could affect performance, exposure times during the study session must be controlled. Calfee and Anderson (1971) and Hall (1971) report that exposures of 2-4 seconds per pair are considered to be optimal for discovering coding mechanisms.

Coding strategies are investigated by generating lists in which the relationship between word pairs is representative of possible coding strategies. For example, performance on a list of acoustically similar pairs (e.g., FLOWER-SHOWER) might be contrasted with a list of semantically similar word pairs (e.g., BIG-LARGE).

Intra-list similarity has unique effects when a PA list instead of a single item serial order list is used in a verbal learning study. Dallet (1966) and Jenkins, Foss and Greenberg (1968) found evidence suggesting that a consistent arrangement of the similarity between word pairs in a list can enhance learning; but if the same words are used with an inconsistent pairing, learning will be hindered. For example, the list DOOR-MORE, HIGH-CRY, STAMP-CRAMP, and BOX-FOX contain consistent word pairings of similarity and this consistency should make coding easier and improve performance on the PA task. However, when the consistence is rem

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is removed by rearranging the second member of each pair to form DOOR-FOX, HIGH-CRAMP, STAMP-MORE, and BOX-CRY, learning should decrease because of confusions due to inconsistency of the intra-list similarity. By carefully arranging the similarity between and within pairs, researchers have been able to use the PA procedure to examine coding systems for words.

Results of PA studies have been consistent with the findings of single item serial order word tasks. That is, coding for words takes place in acoustic and/or speech-motor modes but semantic factors can also be indicated when semantic coding is relatively efficient and/or when the temporal patterns make semantic coding possible.

In conclusion, analysis of the consistent errors made by hearing subjects in STM tasks for letters has shown coding to be related to acoustic and/or speech-motor factors. By manipulating the intra-list similarity, investigators have found that hearing subjects code single words or word pairs on the basis of shape, acoustic characteristics, stored speech-motor patterns, and/or semantic strategies.

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Verbal Learning by Deaf Subjects

Furth (1964 and 1971) reviewed the literature which compared performance of deaf and hearing subjects on verbal learning tasks. He arrived at the general conclusion that deaf subjects are consistently inferior to hearing subjects in their performance on verbal learning tasks. While investigators have attributed this relatively poor performance by the deaf to a lack of auditory or speech-motor coding, or even to a language deficit (Pintner and Paterson, 1917; and Blair, 1957), Furth was of the opinion that the poor performance was due to a lack of experience with formal language-related material. Blank (1965) has reviewed Furth's arguments and concluded that both the experience and the coding factors were interrelated.

An early study by Pintner and Paterson (1917) contrasted the STM performance of deaf and hearing subjects. The task was designed to test memory span for visually presented numbers. The deaf subjects were found to have a relatively small memory span for digits. Pintner and Patterson attributed this deficiency to the inability of the deaf to use an auditory coding strategy. Blair (1957) was able to confirm the findings of Pintner and Paterson. Blair studied both forward and backward memory spans for digits and found that the backward span in the deaf did not differ from the forward span. This finding was in direct contrast to hearing subjects, who had forward memory spans which appeared to be superior to their backward memory span. Blair concluded that the backward and forward memory spans of the deaf did not differ because the deaf subjects were using a visual coding system rather than the acoustic or speech-motor system used by the hearing subjects.

Olsson and Furth (1966) compared deaf and hearing subjects on a verbal learning task. The task had three different sets of stimuli: digits, nonsense forms of high linguistic association value, and nonsense forms of low linguistic association value. As expected, results showed the deaf subjects to consistently perform poorly in memory for digits. However, the deaf subjects' performance on STM for nonsense forms of low linguistic association value did not differ from the performance of the hearing subjects. High linguistic association seemed to aid the deaf as much as it did the hearing subjects. The important point to note here is that when the material in a STM task was less language-oriented, the deaf did not differ from the hearing subjects. MacDougal and Rabinovich (1971), Olsson (1963) and Furth (1961) have shown that if the items to be learned in a verbal learning situation consisted of digits, colors, names, letters, words

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words or sentences, the linguistic content of the material would lead to poor performance by deaf subjects.

Coding for Letters by Deaf Subjects

Several investigators have noted that neither the acoustic nor the motor models of coding can be readily applied to the deaf, and attempts have been made to discover more appropriate alternative models of such coding. Most writers have tried to find an acceptable amendment to the motor theory which would fit the deaf. An early observation by Max (1935 and 1937) and a more recent electromyography (EMG) study by Novikova (1961) have shown that finger movements in deaf children increased during various thought processes. This observation led some investigators to suggest that the mediating or coding mechanism for deaf subjects who are dependent on signing and fingerspelling might be neural impulses from the hands and fingers (Locke, 1970). However, Stoyva (1965) was not able to replicate the findings of Max and Novikova. At present, the results of EMG studies have been inconclusive relative to the connection between dactylo-kinesthetic factors and coding with deaf subjects who are dependent on manual forms of communication.

Most of the information concerning coding in deaf subjects has come from verbal learning tasks. Conrad

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and Rush (1965) reported the results of a pilot study wherein the STM errors of deaf subjects were analyzed with a confusion matrix. Conrad and Rush followed the same procedures used by Conrad (1964) in looking for consistent confusions among groups of letters which shared a similar feature. Conrad and Rush reported that though the deaf subjects seemed to make consistent errors, it was not possible for the researchers to interpret the coding strategy which led to the confusions. They were able to state that the deaf do not code on an acoustic basis, but the effects of other factors such as speech-motor and shape cues could not be established. Conrad and Rush noted that the establishment of the existence of shape confusions in coding for letters would be very difficult, and could only conclude that the coding strategy of deaf subjects differs markedly from that used by the hearing population. No studies have attempted to specify the relative confusability of printed letters, though Tinker (1928) did compare the relative legibility of the letters of the alphabet. At present, it would seem to be difficult to acquire data on visual confusions for letters without confounding the results with acoustic or speech-motor factors.

Conrad (1970) followed up on the work of Conrad and Rush (1965) and attempted to more clearly specify the coding process used by the deaf when learning lists of letters. Using a population of deaf subjects trained in an oral system which stressed speechreading, speech and auditory training, Conrad constructed a confusion matrix for the errors made in STM serial order letter tasks generated from the letters B C H K L T X Y and Z. Again Conrad was trying to determine whether the confusions would be associated with coding strategies of articulation or shape. From the results of the error analysis, Conrad was able to separate his subjects into two groups. The first group consistently made errors related to articulatory similarity, while the second group of subjects made errors which seemed to be consistent but which could not be interpreted by Conrad. Interestingly, Conrad also found that the deaf subjects who coded on an articulatory basis had relatively better speech when compared to the group who did not code with articulatory cues. Thus, Conrad concluded that the type of coding strategy used in learning verbal material can be shown to be associated with the motor skills used in speaking. This conclusion was again reached in a similar study by Conrad (1973).

Locke (1970) has tried to expand the Conrad (1970) findings. Locke attempted to interpret the systematic errors made by Conrad's group which did not code on an articulatory basis. A group of deaf subjects conversant with fingerspelling used an ABX procedure to compare the letter

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letters used by Conrad for dactylo-kinesthetic similarity. Using the results of the ABX comparisons, Locke tried to analyze the confusions of Conrad's non-articulatory group. However, Locke was not able to show a correlation between his findings and those of Conrad (1970) and concluded that "...deaf subjects do not encode orthographic stimuli with a dactylo-kinesthetic system exclusively, if at all." (page 233)

Locke and Locke (1971), in turn, have provided evidence that does not agree with the findings of the earlier Locke investigations. Locke and Locke prepared three lists of paired consonant letters. One list was designed to contain high intra-list acoustic and/or speech-motor similarity, a second list was designed to reflect dactylic relationships among the letters, and the third list was intended to represent letters similar in shape. The letter pairs for this PA learning task were arranged in an inconsistent manner to increase the likelihood of confusions when the intra-list similarity correlated with the coding strategy used by the subjects. Three groups of subjects were used: hearing controls, deaf subjects with relatively intelligible speech and deaf subjects with relatively unintelligible speech. As expected, the hearing control group performed significantly worse when attempting to learn the list containing high intra-list acoustic and/or speech-motor similarity. Of particular interest, though,

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though, are the findings regarding the performance of the two deaf groups. The deaf subjects with intelligible speech were found to have more acoustic and/or speech-motor errors than the group with unintelligible speech. Further, the unintelligible group made more errors related to dactyl and visual relationships than did either the hearing controls or the intelligible deaf subjects. Thus, the conclusion that deaf subjects with relatively good speech code letters on an articulatory basis agreed with the findings of Conrad (1970). The findings suggesting that deaf subjects with relatively poor speech code letters on a manual or visual basis, while deaf subjects with relatively good speech code letters on an acoustic and/or speech-motor basis was a step forward in specifying the coding mechanisms used by the deaf.

Coding for Words by Deaf Subjects

When words are used as stimuli in verbal learning tasks with hearing subjects, the number of coding possibilities increases because of the addition of semantic features. This increase in variables is even more dramatic with deaf subjects. With the deaf, the possible means of coding for words might include: (a) shape of the printed word, (b) fingerspelling, (c) semantic, (d) sign formations, (e) speechreading, and (f) acoustic cues from res

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from residual hearing. The findings of research designed to distinguish between these factors have been equivocal.

Allen (1970) conducted a paired-associate study based on the technique and findings of Dallett (1966). Dallet had constructed two lists of words. One of the lists contained rhyming words paired consistently (e.g., DOOR-MORE, HIGH-CRY, and BOX-FOX). The other list contained the same words paired in a non-rhyming, inconsistent manner (e.g., DOOR-FOX, BOX-CRY, and HIGH-MORE). Dallet found that hearing subjects performed poorly on the inconsistent list and concluded that this was due to acoustic coding confusions. Allen used this same procedure on deaf subjects and found no difference in performance between the consistent and inconsistent PA lists. Since the consistency of acoustic and/or speech-motor pairings did not affect learning difficulty, Allen concluded that her deaf subjects did not code words on an acoustic and/or speech-motor basis. In attempting to explain the type of coding actually used by her deaf subjects, Allen noted that a visual mode dependent on the shape of the letters of the words must have been used. However, no empirical evidence for this conclusion was given.

Conrad (1970) studied coding for words with his two groups of deaf subjects. He had already found that the deaf subjects with relatively good speech coded letters on an articulatory basis while the subjects with poor speech coded letters in a manner which could not be identified. Conrad wanted to determine if this difference in coding would also be found in coding for words. Two lists of words were designed which differed in intra-list visual and articulatory similarity. The words in the first list were spelled differently but were pronounced in a similar manner (e.g., PAST-PASSED, and WAY-WEIGH). The word pairs in the second list were intuitively designed to have similar shapes (e.g., SEEM-SCAN, and DEN-HAM). The intra-list similarity in both lists was arranged in an inconsistent manner to increase the possibility of confusions due to coding correlations. Procedural and statistical constraints prevented Conrad from comparing the performance of the two groups of deaf subjects with each other. Conrad found that the deaf group which coded on an articulatory basis had difficulty with the list of words which were spelled differently but sounded the same. This was an indication of acoustic and/or speech-motor coding and was consistent with Conrad's findings with letters and with Allen's (1970) findings with words. However, the deaf subjects who coded on a non-articulatory basis performed equally well on both of Corad's lists, and Conrad was not able to specify the type of coding used by these subjects. Since Conrad was not able to show visual coding by the non-articulatory or the articulatory groups, the conclusion reached by Allen (1970) that coding for words by the deaf was a visual process needs further attention.

When the semantic aspects of coding for words in deaf subjects have been investigated, the fingerspelling and signing variables have posed special problems. Fingerspelling consists of separate finger configurations which represent the alphabetical symbols. A direct link between "standard" American English and fingerspelling can be established and some writers have compared fingerspelling with reading and writing printed letters (Zakia and Haber, 1971; Quigley, 1967; and Schlesinger and Meadow, 1972). Signing differs from fingerspelling in several ways. Schlesinger and Meadow (1972) have stated:

> In American Sign Language a message consists of intricate visual patterns, produced by gestures and received by the eye. Each gesture is made by one or both hands, held in a specific configuration and at a particular portion of the message-sender's body; the hand or hands are either still or traverse a certain motion for a particular meaning. The configuration of the hand, its placement in front of the body, or the motion itself may be varied in such a way as to produce signs that are related in meaning. For example, male signs are characteristically made on or near the forehead, female signs on or near the lower cheek. (page 31)

A simplistic view of sign language would be that it is a system whereby an English word is replaced by a single formally recognized manual gesture. A deeper analysis of sign language reveals that it is much more complicated. Recent research has shown that sign language has a structure which is unique from that used by the hearing population (Stokoe, 1965 and 1970). Perhaps the major problem in dealing with the semantic aspects of signs in verbal learning research occurs when words from the English language are used to interpret signs. Bornstein (1973) noted that English and the sign language used in America have both developed from different language bases, and an accurate translation from one language into the other is often difficult. While fingerspelling can be used to produce an unlimited number of words, the American Sign Language is limited to a few thousand words or gestures (Stokoe, Casterline, and Croneberg, 1965; Alterman, 1970; and Bergman, 1972). This limited number of gestures in the sign vocabulary often makes it necessary for several words to be represented by a single sign (Putnam, Iscoe and Young, 1962).

It might be expected that subjects who code on the basis of signs would be confused by intra-list similarity defined by word pairs which shared the same sign. Putnam, Iscoe and Young (1962) investigated this question using two lists which differed in intra-list similarity. One list consisted of word pairs which had identical signs for each pair (e.g., PRETTY-BEAUTIFUL), while the other list contained words which had distinctively different signs (e.g., ANGRY-COLD). The word pairs in each list were arranged in an inconsistent manner to increase the possibility of confusions resulting from coding correlations. Deaf subjects were found to perform equally well on both lists and the predicted confusions from the identical sign word pairs was not found. This finding was intriguing since words which share a sign are often related semantically (e.g., PRETTY-BEAUTIFUL), and this semantic similarity coupled with the similarity related to the signs should have made the material relatively difficult to learn.

Another attempt to study manual coding for words in deaf subjects has been made by Odom, Blanton and McIntyre (1970). In this case, subjects were selected from a population of deaf elementary school students who used both fingerspelling and sign language as their major means of communication. Two different word lists were developed. The first list was composed of words for which single manual signs were available in the American Sign Language. The second list contained words for which deaf people have not yet developed a sign. Since the deaf usually fingerspell words that do not have a sign (Alterman, 1970; Moores, 1970; and Cicourel and Boese, 1972), the second list was considered a list of fingerspelled or unsignable words. The results of the STM learning task seemed to indicate that coding with signs was more efficient than codin

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coding with unsignable or fingerspelled words. That is, fewer errors were made in remembering the list of words for which deaf people have a sign. In the majority of the studies concerning words discussed previously, the lists which contained the greater amount of intra-list similarity corresponding to the coding system of the subjects could be expected to be the most difficult to learn. However, a different interpretation must be placed on the Odom, et al. findings since the lists differed on the basis of communication mode and no attempt was made to introduce inconsistent intra-list similarity. The finding that the signable words were easier to learn does not indicate that deaf subjects who depend on manual modes of communication code exclusively on a sign basis. The results simply indicate that in this instance signing appeared to be a more efficient coding strategy than fingerspelling for unpaired serial learning tasks. The authors concluded: "Deaf subjects presumably asses the visual image of the word in memory more readily with one motor-encoding (a sign) response than with a series of fingerspelling responses..." (page 57)

Odom, et al. attempted to explain their findings by stating that a word from the unsignable list was more difficult to learn because it had to be coded by using the individual fingerspelled letters which were contained within the word. A signed word, they noted, was easier to ode beca

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code because it consisted of just one motor-encoding unit. This explanation was not consistent with the findings of Zakia and Haber (1971) who have shown that deaf subjects perceived a fingerspelled word as a single unit rather than a chain of separate fingerspelled letters. Fisher and Husa (1973) have enlarged upon this single unit concept by pointing out that much of the findings of coarticulation during speech can also apply to fingerspelled words. Fisher and Husa stated that for fingerspelling:

> ...the letters are more like phonemes in an oral utterance than letters in a printed communication. At normal conversational speed the exact configuration is not reached before movement toward the next letter begins. (page 510)

If it is true that a fingerspelled word is coded as a unit rather than individual letters, a different justification for the findings of Odom, et al. (1970) seems necessary.

A critical review of the Odom, et al. study reveals a glaring problem in the selection of words for the two lists. The authors stated that the two lists of words were matched for frequency of occurrence by means of the Thorndike-Lorge "G-count". Matching the lists on the basis of frequency counts is one established method of controlling for list familiarity and meaningfulness. Hall (1966) wrote:

> A second variable which has been considered as a dimension of meaningfulness is frequency, conceptualized as the number of times that a subject has

> experienced a given item of verbal material. It often has been assumed that such experience is related to the frequency with which such material appears in print, and the frequency values for common English words can be found in the Thorndike-Lorge (1944) frequency count. This count was obtained by examining a wide range of printed materials and tabulating the frequency with which the various words occurred. Although Thorndike and Lorge have provided different word counts depending upon the source examined, the most frequently used one is the general word count (G), which reflects all of the sources of material which the researchers perused and which categorizes words on the basis of occurrences per million words examined. (page 297)

In STM serial learning tasks, frequency counts are a crucial variable because of the influence of word familiarity on learning. Lists of words occurring frequently are relatively easy to learn when compared to lists of words which occur infrequently (Hall, 1954; Jacobs, 1955; Bousfield and Cohen, 1955; and Bousfield, Cohen, and Whitmarsh, 1958).

The selection of the Thorndike-Lorge "G-count" to establish word frequency in the Odom, et al. study must be questioned for several reasons: (a) The "G-count" was made in 1944 and may not be representative of word frequency in the U.S. today (Hall, 1966). (b) The "G-count" represents the written representation of the language of hearing people. The Language of Signs does not parallel "Standard American English" and there is little reason to suppose that words frequently used by the hearing population in 1944 will be frequently used or encountered by deaf children in elementary school in 1970 (Bergman, 1972;

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1972; and Bornstein, 1973). (c) Wrightstone, Aronow and Moskowitz (1963) found the average reading level of 16 year-old deaf children to be grade level 3.4. Since the deaf children in the Odom, et al. study were in elementary school, it is probable that the reading level of even the best readers in the study was not better than grade 3. If this is the case, then the frequency count obtained from the Thorndike-Lorge "G-count" is taken from a population of reading materials beyond the reading ability of the deaf subjects.

Although Odom, et al. claim that the words used in the two lists occurred with equal frequency according to the "G-count", an examination of the Thorndike-Lorge (1944) tables shows that this is not the case. Table 2, column "G" indicates that the signable word list is composed of words occurring more than 100 times per million. Note, however, that the words in the unsignable list of Odom, et al. occur less frequently. Because of the previously noted objection that the "G-count" was taken from a population of reading materials that the deaf children of the study potentially could not read, the Thorndike word frequency count taken from 120 juvenile books (Thorndike and Lorge, 1944) might have been more appropriate. Reference to column "J", Table 2, reveals that again the signable words occurred more frequently.

Carroll, Davies and Richman (1971) have compiled a

Table 2.--Comparison of the word frequency counts of the signable and unsignable word lists used by Odom, et al. (1971).

Signable Words	G	J	F	C
earth	AA	?	2,690	95
travel	AA	700	814	162
people	AA	M	7,989	1,704
future	AA	380	354	10
control	AA	260	556	36
success	AA	513	242	13
mountain	AA	?	834	158
important	AA	700	2,588	278
(Mean)	> 100	> 592	2,008	307
Unsignable Words				
steam	A	341	340	73
harvest	48	217	112	27
modern	AA	250	731	40
energy	41	116	1,190	194
material	AA	376	651	32
special	AA	360	1,192	167
engineer	40	126	167	28
condition	AA	700	193	9
(Mean)	> 72	311	572	71

Where:
- G = Thorndike-Lorge (1944) "G-count" based on word occurrence per one million words.
- J = Thorndike-Lorge count from 120 juvenile books based on word occurrence per $4\frac{1}{2}$ million words.
- F = Total word frequency, Carroll, et al. (1971) based on word occurrence per 5 million words from text-books from grades 3 through 9.
- C = Total word frequency from Carroll, et al., grade 3.

And Where:
- AA = Word occurs more than 100 times per million words.
- A = Word occurs more than 50 times per million words.
- M = Word occurred 1,000 times or more in the count of 120 juvenile books checked by Thorndike and Lorge (1944).

word frequency count which would seem to be more applicable to the subjects in the Odom, et al. (1970) study. The Carroll, et al. frequency count is the result of a computerized analysis of the words contained in texts used in public schools for grades 3 through 9. Since the majority of the books used in schools for the deaf were designed for use with hearing students, the Carroll, et al. frequency count should give some indication of how often a deaf child is meaningfully exposed to particular words in their printed form. While it would be best to take frequency counts from direct translations of the sign language, Bornstein (1973) has shown that theoretical and practical problems have so far precluded this possibility. Further, although Stokoe, Casterline, and Croneberg (1965) have developed a notation system to represent sign language, the system has not been used enough to make word frequency counts feasible. It would appear that until an accurate frequency count can be made of words used in the American Sign Language, the Carroll, et al. (1971) compilation will have to suffice. Column "F", Table 2, represents the word frequencies found in the texts used in grades 3 through 9 according to Carroll, et al. Column "C", Table 2, is a listing of word frequencies taken from grade 3 reading level only. Grade 3 was chosen to match the low reading ability of deaf children. In column "F" and in column "C", the signable words are shown to occur more frequently than the unsignable.

The results of the Odom, et al. (1970) study can be explained in terms of list familiarity rather than a difference in coding efficiency between signing and fingerspelling. Neither Putnam, et al. (1962) nor Odom, et al. have adequately explained the effects of signing on coding for words in deaf subjects who depend on manual forms of communication. Even if the theoretical and methodological problems of the two studies are disregarded, the question of coding systems used by the deaf remains unsolved since the results of the two studies indicate both the existence of a sign code (Odom, et al., 1971) and the absence of a sign code (Putnam, et al, 1962). A review of the literature has revealed no further studies on this issue and the question remains a fertile topic for research.

Summary and Statement of Problem

The performance of deaf subjects on language-related material used in verbal learning tasks has been shown to be significantly different from the performance of hearing subjects. One possible explanation for this difference in performance is that different communication systems used by the deaf could produce distinctively different coding strategies which affect learning. These coding systems have been examined with verbal learning techniques.

A review of the literature revealed that language-related material in a verbal learning situation is converted into a code which facilitates rehearsal and recall (Paivio, 1971). This coding process is affected by temporal factors (Aaronson, 1967). It appears that acoustic or speech-motor coding will be used by hearing subjects if they are required to recall serial order material within seconds after presentation (Shulman, 1970 and 1971). Acoustic and/or speech-motor coding has been found to occur in both letters and words during STM tasks with hearing subjects (Conrad, 1964; and Hintzman, 1967) and some indication of semantic coding for words has also been found (Shulman, 1970).

The loss of the auditory channel in the deaf essentially precludes the use of the acoustic coding mode (Conrad, 1970). Speech-motor coding has been found in learning lists of letters and also in learning word lists for deaf subjects with relatively good speech (Conrad, 1970), but not in subjects with poor speech skills (Blanton and Nunnally, 1967). The search for coding processes other than that of a speech-motor nature in deaf subjects has been successful with letters but not with words. Locke and Locke (1971) have shown that subjects who depend on signing and fingerspelling code letters on the basis of kinesthetic cues from the fingers as well as on the basis of visual cues related to the shape of the printed letter. Only two studies have been found dealing with coding for words on a manual basis and they have produced equivocal results. A study by Putnam et al. (1962) failed to find evidence of coding based on sign language, whereas a study by Odom, et al. (1970) found that coding by signs did occur and was an efficient coding strategy. The results of both the Odom, et al. and the Putnam, et al. studies must be questioned, however, because: (a) the results of the two studies are contradictory, (b) the results of the Putnam, et al. study do not conform to established learning and coding theory, (c) Putnam, et al. failed to distinguish between sign and semantic similarity between the word pairs used, (d) the Odom, et al. study did not properly control for word frequency differences between the two lists used, and (e) the Putnam, et al. study has reported no attempt to control for word frequency.

Currently, there appears to be a paucity of empirical information concerning the effects of manual forms of communication on coding of words during verbal learning tasks with deaf subjects. The purpose of the present investigation, then, is to further delineate the verbal learning coding strategies used by deaf subjects. Specifically, the following questions will be investigated:

1. Does coding by sign and/or semantic factors occur during a PA learning task using words as stimuli?
2. Do semantic and sign cues interact during the

3.

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coding process?

3. If semantic and sign coding can be shown to occur, how will these two coding systems compare in relative efficiency?
4. If deaf subjects are given a choice between two coding systems, will the subjects use one code, both codes simultaneously, or will a switching process be used between the two codes?
5. If the PA task involves several trials, how will the learning curves for the different coding modes compare?

EXPERIMENTAL PROCEDURES

For this study, 26 deaf teenagers participated in a paired-associate learning task. Each subject attempted to learn five lists of word pairs over a period of six learning trials per list. The five lists represented several possible combinations of sign and/or semantic coding factors.

Subjects

The 26 deaf subjects used in this study were students from the Total Communication Department of the Utah School for the Deaf. The Total Communication Department uses, teaches and encourages sign language and fingerspelling as possible modes of communication. All subjects were required to meet the following criteria: (a) Be not younger than 12 nor older than 20, (b) have a hearing loss of at least 70 dB (re ANSI, 1969) in the better ear for the frequencies 500, 1,000, and 2,000 Hz (AAOO, 1970), (c) have a hearing loss which was discovered before the child's first birthday, and (d) have satisfied the visual screening criterion of 20/20 acuity in both eyes (with or without correction). The mean age of the subjects selected was 18 years. To satisfy the hearing and visual criteria, reference was made to the school records for each subject. The school employs a full-time Ph.D. Audiologist (CCC-A) who keeps the hearing evaluations current. Yearly visual screenings and necessary referrals are performed by the school's Registered Nurse.

Stimuli

The stimuli for the study consisted of five lists of 14 word pairs. The five lists differed in the sign and/or semantic relationship of the word pairs. The sign-semantic relationship was arranged as follows:

List 1 - The two words making up each word pair were similar to each other on both a sign and a semantic basis. That is, the words within a pair shared a common sign formation as well as a close semantic association (e. g., PRETTY-BEAUTIFUL is a word pair with close semantic association and the sign formation is the same for each word). This list was designated as "similar sign, similar meaning".

List 2 - For this list the two words within each pair were related to each other on a semantic basis only. The words making up a pair shared a common semantic association but had distinctively different sign formations (e.g., LAUGH-SMILE is a word pair which has a close semantic association but does not share a similar sign). This list was designated "similar meaning, different sign".

List 3 - For this list, the two words within each pair were related to each other on the basis of a similar or common sign. The words making up a pair shared a similar sign but were not closely related semantically (e.g., HAMBURGER-MARRY is a pair of words which have a similar sign but do not share a similar meaning). This list was designated as "similar sign, different meaning".

Lists 4 and 5 - These two lists served as control lists in the testing situation. The two words making up each pair in these lists were not related to each other by any obvious sign or semantic relationship (e.g., TOMORROW-KEY is a word pair with no close semantic or sign associations). These lists were designated as "different meaning, different sign".

The word pairs for Lists 1, 2, and 3 were developed with the cooperation of a panel of six teachers of the deaf subjects. Four of the panel members were deaf and two had normal hearing. All of the panel participants were proficient in the use of manual communication. The characteristics of the three lists were explained to each panel member and the members were then asked to generate as many word pairs as possible for each list, with the restriction that all words selected should, in the teacher's opinion, be part of the general vocabulary of the students in question. If a word could be represented by more than one sign, the panel was instructed to use the sign which was more commonly used by the teachers and students at the Utah School for the Deaf.

From the pool of word pairs submitted by the panel, the three test lists were produced. The three lists were matched on word length by considering the total number of letters making up each list. The lists were also matched on word frequency counts for third grade reading material compiled by Carroll, et al. (1971). This was accomplished by keeping the sum of the word frequencies equivalent between lists. Lists 4 and 5, the two control lists, were generated from a pool of words selected from the third grade reading vocabulary of Carroll, et al. Referrence was made to Watson (1964) to make certain that the words in the control lists were part of the American Sign Language. The two control lists were so constructed as to make them equivalent with the other three lists on word length and word frequency. Finally, the two control lists were referred back to the panel of six teachers who were ask

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asked to delete any words which were not within the students' semantic and sign vocabulary. The five lists of word pairs and their respective word lengths and frequency counts can be found in Appendix A.

A 35mm slide was made for each word pair and for each stimulus word. To produce these slides, a word pair or a stimulus word was typed on a white 3" by 5" index card with a Royal Model 470 typewriter with bulletin type style. A picture of each card was then taken with a Mamiya/sekor 1,000TL camera with a 1:1.8 lens fitted with a Spiralite Proxivar 52mm close-up lens (No. 665222). The camera was mounted on a Honeywell Copy Stand Model 7101 fitted with photographic tungston lamps.

Presentation Procedures

13 groups of 2 subjects each were randomly assigned to individual testing sessions. Each group of 2 subjects participated in one training session and 5 testing sessions over a three week period. In each testing session, subjects were allowed a maximum of six trials to learn one list of paired-associate words. Subjects were tested on one list per session and sessions were separated from each other by a minimum of two days and a maximum of four. Testing sessions varied in length from 25 to 45 minutes depending on how soon both subjects reached the required performance criteria. The performance criteria was set as two

consecutive errorless trials or a maximum of 6 trials per list.

The training and testing sessions occurred within the same classroom at the School for the Deaf. The slides used in the PA task were projected on a 4 x 4 foot Da-Lite screen by a Kodak Carosel 750 projector. A distance of ten feet separated the front of the viewing screen from the two chair-desks provided for the subjects. The subjects' chair-desks were separated from each other by 5 feet to help insure individual work. The projector and the testor were located at a table behind the subjects. A distance of 15 feet separated the projector from the screen.

Blackout drapes were used over all windows during the testing. A General Electric Model 8DW58Y4 Exposure Meter calibrated at 0 foot-candles in the darkened room was used to measure the reflected light from the screen. The reflected light readings were made with and without slides in the projector. Reflected light 6 inches in front of the screen reached 30 foot-candles without a slide and 18 foot-candles when a slide was used. At the subjects' chair-desks, the readings were 5 foot-candles without a slide and 3 foot-candles with a slide.

The study-test paired-associate task procedure as described by Hall (1971) was used in the training and test sessions. By this procedure, the subjects were first given a study session which exposed them to all of the word

pairs of a particular list. Following this study segment, the first word (stimulus) of each pair was presented alone and the subjects attempted to supply the missing second word (response) on an answer sheet (see Appendix B). The study-test procedure was repeated after the subjects had attempted to respond to all 14 stimulus words. Each cycle of the 14 stimulus-response pair study session followed by the test segment of the 14 stimulus components was considered one trial. Subjects were allowed a maximum of 6 of these study-test trials for each list but the process was terminated for a subject if the criterion of 2 errorless trials was reached.

The temporal patterns in the presentation of the slides during the study and test sessions were controlled by a Tiffen Show/Corder Model 7100 which automatically advanced the Kodak projector. During the study session of each trial, subjects viewed each pair of words for 3 seconds. A one second period was used by the Kodak projector to change each slide. The entire study session of each trial consisted of 56 seconds (4 seconds for each of the 14 pairs). Fifteen seconds elapsed between the last word pair in the study sequence and the first stimulus word in the test sequence. Each test sequence slide exposed a stimulus word for 9 seconds and one additional second was used to change slides. This allowed the subjects 10 seconds in which to insert their response on the answer sheet. The entire test sequence lasted for 140 seconds. Following the last test word, a new trial was begun after the lapse of one minute. These presentation times follow the suggestions of Hall (1971) and Calfee and Anderson (1971).

In order to control for a possible learning effect as well as a possible fatigue factor, both list presentation order between sessions and the serial order of the word pairs and stimulus words between trials were randomized. This meant that no two groups received the lists, the stimulus-response pairs, or the stimulus words in the same order. This randomization also meant that no single group ever recieved the same word pair or stimulus word order between trials in the same session.

If the serial order of the stimulus words corresponds to the serial order of the stimulus-response pairs (e.g., a PA task with HOUSE-BLUE, MONKEY-BLACK, TREE-YELLOW, and CHAIR-GREEN followed by HOUSE ___?___, MONKEY ___?___, TREE ___?___, and CHAIR ___?___), the subjects could conceivably simplify the PA task by learning only the serial order of the response words and disregarding the stimulus words (McGeoch and Underwood, 1943). In this study, subjects were forced to attend to the stimulus words because the serial order of the stimulus words was independent of the serial order of the stimulus-response pairs. This independent reordering of both the

study (stimulus-response pairs) and the test (stimulus only) lists occurred between each of the 6 trials in each session.

During the training session, the nature of the test was explained to the subjects. The instructions for the test were given in a combination of signs, fingerspelling, speech and writing by a trained, experienced teacher of the deaf (see Appendix C for the complete set of instructions). Following the instructions, the subjects participated in a training session in which they performed a PA task which paralleled the task which would later be used in the test situation. The training task differed from the test situation in that the list of words used did not contain any of the test words found in the five test lists. In addition, the training list did not contain any obvious or systematic sign-semantic associations. Each subject was given repeated trials during the training session until the criterion of the two errorless trials was reached.

Analysis

The data was hand-scored by the experimenter. The number of correct responses per trial for each list was recorded for each subject. If a subject had reached the criterion of 2 errorless trials before being tested on all 6 trials, he was given full credit (14 points) for each trial for which he was exempt. Since the two control lists

(Lists 4 and 5) were developed from the same parent pool of words equated on reading level and word frequency counts, the results from these two lists were averaged and considered as one list. During the analysis and discussion stages of the study, the list which resulted from the averaging of the two control lists (Lists 4 and 5) was referred to simply as "List 4".

Following the suggestions of Kirk (1968), the data was placed into a two factor (6 x 4) analysis of variance with repeated measures design, and suitable F-tests were performed (computerized). Two computerized post hoc procedures were also employed. A simple effects ANOVA was used to test for AB (trials by list) interactions occurring within the 6 trials. Where appropriate, Scheffé post hoc comparisons were then used to locate differences between the lists within trials.

RESULTS

The findings of this study support the thesis that profoundly deaf subjects who communicate manually code words on a semantic basis. Performance on the two lists devised according to semantic criteria (Lists 1 and 2) was superior to the performance on the other two lists during the early stages of learning. Further, the results give qualified support to the thesis that these deaf subjects can also code words by sign formation. Coding by signs was indicated by the higher scores on List 3 (similar sign, different meaning) relative to the scores obtained on List 4 (different sign, different meaning). However, coding by sign formation was found to be less efficient that semantic coding during the first trial. The results also indicate that, given a choice between coding by sign and/or coding by semantic factors, the semantic coding will take precedence over coding by signs. This preference for semantic coding was indicated by the fact that the learning curve for List 1 (similar meaning, similar sign) followed the learning curve for List 2 (similar

meaning, different sign) rather than the learning curve for List 3 (similar sign, different meaning).

Main Effect of Trials

Table 3 depicts the results of the two factor (6 x 4) analysis of variance with repeated measures on all factors for each subject which was performed on the data.

Table 3.--Summary of an analysis of variance performed on individual scores for all subjects (N = 26) at six levels of factor A (trials) and four levels of factor B (lists).

Source	SS	df	MS	F
A	2,588.12	5	517.62	223.58*
B	603.33	3	201.11	28.28*
AB	328.97	15	21.93	13.67*

* Significant at a level greater than .001.

Table 3 reveals that the main effect of trials was significant at an alpha level of 0.001. Thus the over-all means of all lists for each of the six trials (7.35, 10.63, 11.90, 12.61, 13.07 and 13.25, respectively) contain significant differences. Figure 2 shows these differences were most pronounced during the first three learning trials.

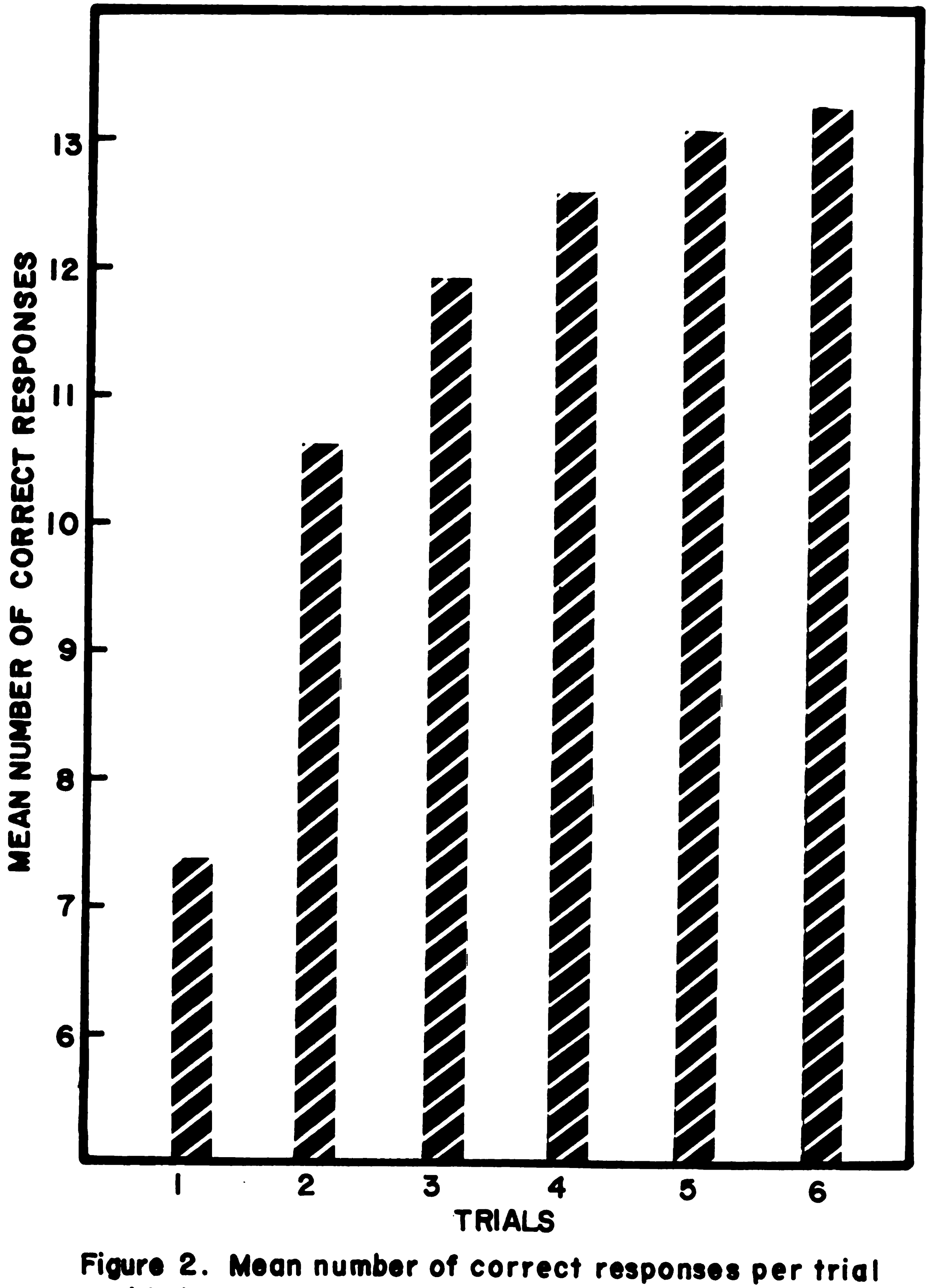

Figure 2. Mean number of correct responses per trial with lists averaged.

Main Effect of Lists

A significant main effect of lists ($p < 0.001$) is shown in Table 3. This indicates that significant differences can be found in the means for the 4 lists (12.45, 12.22, 11.26 and 9.95, respectively) when the mean performance for all trials within each list is considered. Figure 3 shows that over-all performance on the 4 lists can be considered to be on three levels. The greatest number of correct responses occurred in Lists 1 (similar meaning, similar sign) and 2 (similar meaning, different sign). Performance on List 3 (similar sign, different meaning), while not as high as Lists 1 and 2, was above that of List 4 (different meaning, different sign). Finally, overall performance on the three codable lists (Lists 1, 2, and 3) was greater than the performance on List 4 (control list, coding association between pairs unknown).

List by Trial Interaction

Table 3 also shows the significant interaction effect which was found between lists and trials ($p < 0.001$). That is, there was a greater increase in scores between Trials 1, 2, and 3 than between Trials 4, 5, and 6 (see Figure 4). Figure 4 indicates that List 1 (similar meaning, similar sign) and List 2 (similar meaning, different sign) differed minimally from each other between trials. Figure 4 also suggests that the differences between List 3 (similar sign,

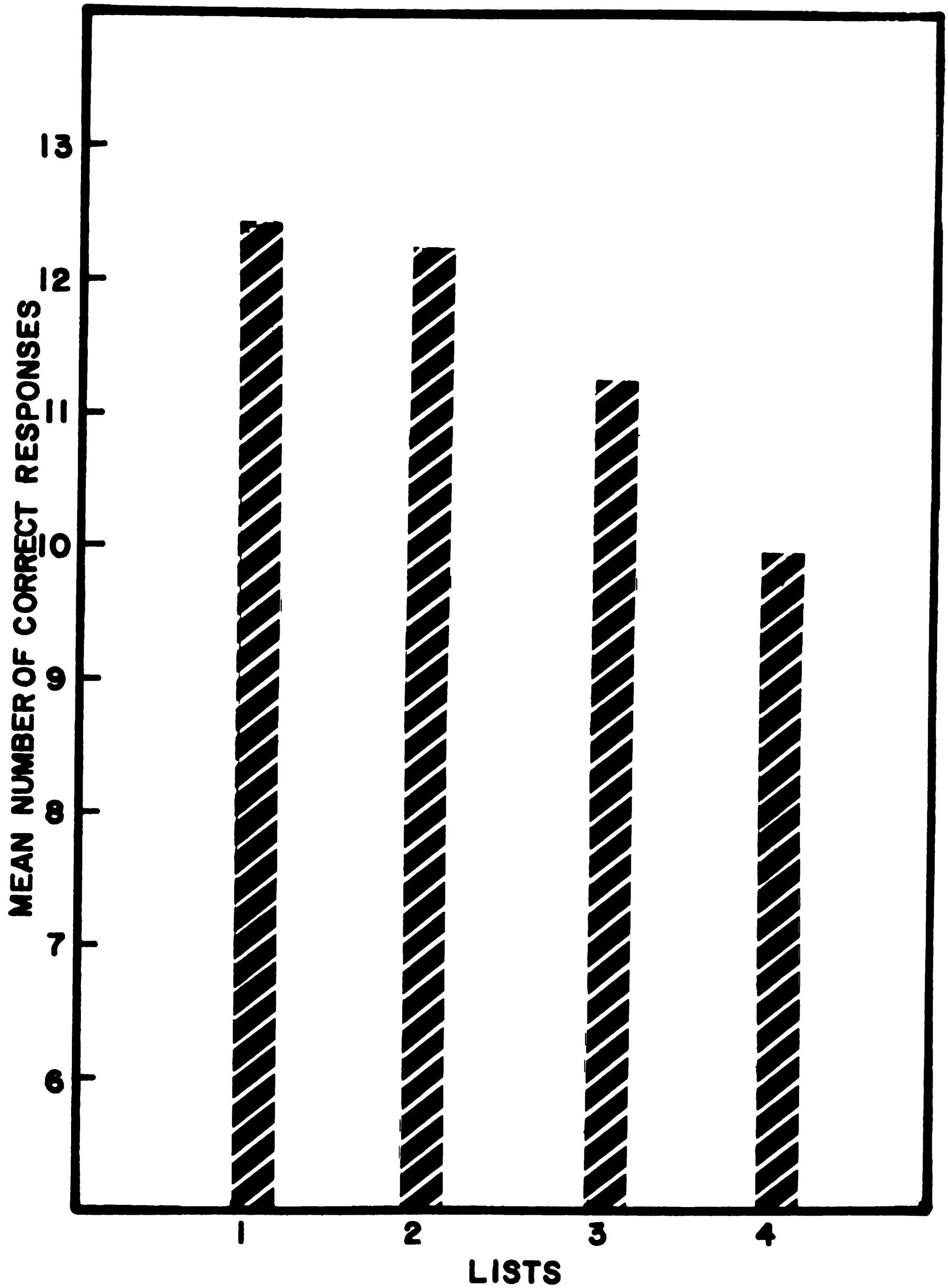

Figure 3. Mean number of correct responses per list with trials averaged.

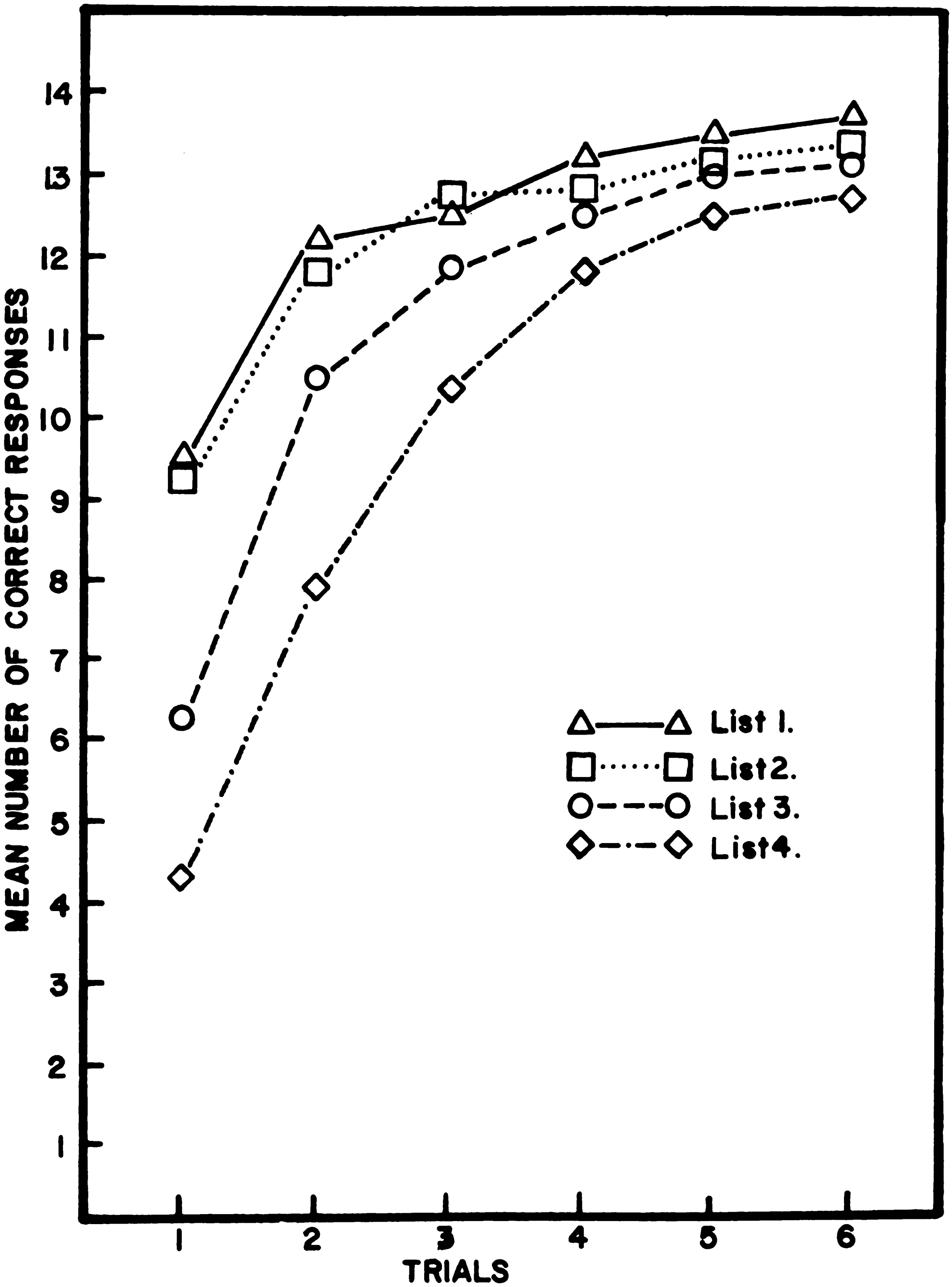

Figure 4. Mean number of correct responces per list for each trial.

different meaning) and Lists 1 and 2 considered together, were most evident in the earlier learning trials. The learning curve for List 4 (different meaning, different sign) shows that the lag in performance found in the earlier trials may have been overcome during the last few trials (see Figure 4).

The significant interaction effect between lists and trials was further investigated using post hoc statistical procedures. The first of these post hoc tests consisted of an analysis of variance of the four list means found in each trial. This was done with a simple effects ANOVA (see Table 4). Table 4 shows that significant differences between the means of the four lists may only be found within the first three trials. As can be seen in Figures 2 and 4, the differences between list means during the last three trials tended to become smaller relative to the differences found during the first three trials.

A Scheffé post hoc procedure was used to further locate the differences indicated by the simple effects ANOVA. The Scheffé technique was used to make simple and complex contrasts between the 4 list means within trials. Only the list means of the first three trials were considered since the simple effects ANOVA had indicated that significant differences between list means did not occur within any of the last three trials. The results of the comparisons made by the Scheffé procedure can be found in Table 5.

Table 4.--Summary of the simple effects ANOVA performed on the individual means of the 4 lists found within each trial.

Source	SS	df	MS	F
A	497.85	3	165.95	65.80*
B	294.18	3	98.06	38.88*
C	88.35	3	29.45	11.68*
D	27.26	3	9.09	3.60
E	12.55	3	4.18	1.66
F	12.11	3	4.04	1.60
G	1,135.01	450	2.52	

Where:
A = List means within Trial 1
B = List means within Trial 2
C = List means within Trial 3
D = List means within Trial 4
E = List means within Trial 5
F = List means within Trial 6
G = Pooled error term
* = $p < 0.001$

Table 5.—Confidence intervals around the differences between list mean contrasts found using the Scheffé post hoc procedure.

Trial	Contrasts	99.2% Confidence Interval
1.	List 1 vs. List 2	(-1.36 to 1.67)
	List 1 vs. List 3	(1.71 to 4.75)*
	List 1 vs. List 4	(3.69 to 6.73)*
	List 2 vs. List 3	(1.56 to 4.60)*
	List 2 vs. List 4	(3.54 to 6.58)*
	List 3 vs. List 4	(0.46 to 3.50)*
	½(List 1 + List 2) vs. List 3	(1.84 to 4.47)*
	½(List 1 + List 2) vs. List 4	(3.82 to 6.45)*
	1/3(List 1 + List 2 + List 3) vs. List 4	(2.82 to 5.30)*
2.	List 1 vs. List 2	(-1.06 to 1.98)
	List 1 vs. List 3	(0.25 to 3.29)*
	List 1 vs. List 4	(2.81 to 8.85)*
	List 2 vs. List 3	(-0.21 to 2.83)
	List 2 vs. List 4	(2.35 to 5.38)*
	List 3 vs. List 4	(1.04 to 4.08)*
	½(List 1 + List 2) vs. List 3	(0.22 to 2.85)*
	½(List 1 + List 2) vs. List 4	(2.78 to 5.41)*
	1/3(List 1 + List 2 + List 3) vs. List 4	(2.33 to 4.81)*
3.	List 1 vs. List 2	(-1.71 to 1.33)
	List 1 vs. List 3	(-0.94 to 2.09)
	List 1 vs. List 4	(0.63 to 3.67)*
	List 2 vs. List 3	(-0.75 to 2.29)
	List 2 vs. List 4	(0.83 to 3.86)*
	List 3 vs. List 4	(0.06 to 3.10)*
	½(List 1 + List 2) vs. List 3	(-0.64 to 1.99)
	½(List 1 + List 2) vs. List 4	(0.93 to 3.56)*
	1/3(List 1 + List 2 + List 3) vs. List 4	(0.78 to 3.26)*

* Significant at $p < 0.008$

In general, the findings from the Scheffé give credence to the trends noted in the original two way (6 x 4) analysis of variance. That is, Lists 1 (similar sign, similar meaning) and 2 (similar meaning, different sign) did not differ from each other and together exhibited higher mean scores than the other lists during the initial stages of the learning curve. Mean performance on List 1 was better than the mean performance on List 3 (similar sign, different meaning) during Trials 1 and 2 only. Mean scores for List 2 were higher than the mean scores for List 3 during the first trial but no significant differences between these two lists were found during later trials. Lists 1 and 2, considered together, had a higher mean score than List 3 during Trials 1 and 2 but significant differences were not found during the later trials. Performance on List 4 (different meaning, different sign) was lower than on any other list or combination of lists during the first three trials.

Summary

The results of this study revealed that, in the first three learning trials, significant differences exist between the relative efficiency of the paired-associate coding strategies investigated. As evidenced by the relatively high mean scores achieved on Lists 1 and 2, the deaf subjects performed best when the word pairs within a list shared a similar meaning or a similar meaning as well as a similar sign. The results also indicate that associations between signs may also be used as a coding strategy. However, coding by sign formation was not found to be as efficient as was coding by meaning during the first and second learning trial as indicated by the depressed scores obtained on List 3 relative to Lists 1 and 2. Performance on the control list (List 4), where no consistent coding strategy was readily available, was lower than the performance on the other three lists.

DISCUSSION

The findings of this study are in general agreement with the direction of previous research into coding strategies for verbal learning tasks. Studies dealing with hearing subjects had indicated that coding strategies could be expected to be related to speech-motor and/or acoustic factors of speech as well as semantic factors when the learning task involved words. Corollaries to this process had been sought in deaf subjects and some evidence had been found which indicated that no one coding strategy was used by all deaf subjects. Research indicated that when coding for letters in a STM task, deaf subjects would usually code by speech-motor or manual alphabet configuration factors. However, when the complexity of the learning task was increased by using words instead of letters, investigators were not able to completely specify the possible coding strategies. Research had indicated that subjects with good speech coded words by speech-motor and/or semantic factors, and several writers had speculated that deaf subjects who communicated with the language of signs would probably code words on the basis of sign formation and/or semantic factors. The findings of this study give support to this assumption and also give some indication of the relative efficiency of coding by sign or semantic factors. In addition, the results of this study provide significant insight into theories and models applied to learning and language processing.

Coding by Sign Formation Factors

The results of this study indicating a coding strategy related to signs in deaf subjects who use the sign language are consistent with predictions which can be made from parallel studies on hearning subjects and on deaf subjects who have relatively good speech. This can be seen in Table 6.

Table 6 shows that hearing subjects as well as deaf subjects with relatively good speech can encode words in a manner related to the coding strategy used for letters. That is, when acoustic and/or speech-motor processing has been evidenced in research using letters, similar processing systems have also been found in investigations using words. This relationship between the coding of letters and the coding of words would lead to the prediction that the dactyl processing for letters found by Locke and Locke (1971) would be followed by some form of manual coding for words in deaf subjects who sign. Indication of this predicted manual coding for words has been found by Odom, et al. (1970) and by the present study.

Table 6.--Summary of research into coding systems for words and for letters in hearing subjects, deaf subjects with relatively good speech, and deaf subjects who sign.

	Hearing	Deaf-Good Speech	Deaf Signers
Letters	Acoustic and/or speech-motor (Conrad, 1964)	Speech-motor, (Conrad, 1970)	Dactyl, (Locke and Locke, 1971)
Words	Acoustic and/or speech-motor, semantic, (Shulman, 1970)	Speech-motor, (Conrad, 1970) semantic, (probable but not specified)	sign formation, (Odom, et al., 1971) semantic, (specified by the present study)

Semantic coding has been found to occur in coding for words by hearing hearing subjects. It is probable that semantic coding can be shown to be used by deaf subjects with relatively good speech but this has not yet been reported in the literature. Table 6 shows that coding by sign formation factors and coding by semantic relationship on the part of deaf subjects who sign is consistent with existing research findings. It should not be considered that the processing strategies indicated in Figure 6 are mutually exclusive. For instance, it may be possible for a hearing subject to code words on a sign basis if he is well versed in signs and if the verbal learning task permits efficient coding by signs. As will be seen later, it does not necessarily follow that evidence of the existence of a particular coding system automatically rules out the use of other systems.

The findings of this study are an extension of the findings of Conrad(1970). That is, while Conrad was not able to specify the nature of the coding system used by his deaf subjects who did not code on an articulatory basis, Conrad did speculate on possible coding mechanisms for such subjects. Conrad considered that it might be possible for deaf subjects to code words by storing visual images of printed words but he was not able to find empirical evidence of this process. Conrad (1972) also speculated on the possibility of coding by signs when he stated that "There is no reason at all why a deaf person should not mentally plan an activity by means of imaged signs-again they might be visualized or experienced in imagination kinesthetically" (page 149). The results of this study are in accord with Conrad's prediction that coding can occur on the basis of signs. The present findings, however, can not be used to determine the exact nature of this coding. Like Conrad (1972), the present writer can only state that the coding was probably related to either visual or kinesthetic factors or possibly to a combination of the two.

Since the hypothesis that deaf subjects who use sign language as their form of communication will code language by sign factors is a logical extension of existing research, it is not surprising that attempts have been made to identify such coding. Putnam, Iscoe and Young (1962) used a paired-associate design similar to that used in the present study. However, the findings of the present investigation and the Putnam et al. study are not in accord with each other. Putnam, et al. were not able to find indication of coding by sign formation, while the findings of the present study do indicate such coding. The differences between the results of the two studies might be explained by the different temporal patterns used. Also, Putnam, et al. failed to control for the confounding effects of semantic associations between their word pairs which shared a similar sign. In addition, no attempt was made in the Putnam, et al. study to control for word frequency differences between the word lists used.

Another attempt to identify coding by signs was made by Odom, Blanton and McIntyre (1970). The Odom, et al. investigation was designed to examine the hypothesis that coding by a single sign would be more efficient than coding by multiple fingerspelling codes. The findings of the Odom, et al. study appear to indicate that a sign coding system was used by some deaf subjects and that such coding was relatively efficient. Such a finding was consistent with and predictable from previous research of such coding systems. However, further research such as the present study was deemed necessary because of the failure of Odom, et al. to properly control for frequency count differences between the word lists used in the experiment. As will be seen later, an imbalance in frequency counts can be an indication of a serious confounding of word lists by semantic factor differences.

Coding by Semantic Factors

Table 6 shows that the evidence of semantic coding found in this study is consistent with the findings of related studies conducted on hearing subjects. The findings of the present study, however, differ from previous studies in that the performance of deaf subjects on the semantically related lists (Lists 1 and 2) was better than would have been expected. Parallel research has shown that when semantic coding occurs in hearing subjects during a PA learning task, its efficiency will be equal to or less than the efficiency of coding by acoustic and/or speech-motor cues (Shulman, 1970). In this study, performance on the semantically related lists was equal to or better than the performance on the other lists. This difference in performance between deaf and hearing subjects may have been caused by differences in vocabulary size between the two populations. For hearing subjects, semantic associations in the PA task may be weakened by the fact that semantic relationships between words are made practically limitless by the size of the hearing person's vocabulary. The smaller vocabulary of the deaf, however, would make semantic coding relatively efficient because the field of possible words which could be used in each association is limited, and the opportunity for confusion is minimized. For example, consider the case where the word pair "PRETTY-BEAUTIFUL" is used. Assume that a hearing subject had noted the semantic relationship of the similar meaning during the study session of a study-test PA task. Then, if, during the test session, the hearing subject forgot the correct response but remembered the semantic cue, the possibility of a correct response by chance selection from all words which have the same meaning as the word "PRETTY" would not be high. The smaller vocabulary of a deaf subject placed in the same situation could narrow the field of possible words from which to select, and therefore the mathematical probability of selecting the correct response would be greater with deaf than with hearing subjects. While this explanation is a plausible cause of the relatively high performance on the semantically codable lists, it could also be suggested that semantic coding is a more efficient means of coding for the deaf subjects in question. Due to the derth of research in this area, it can not be assumed that coding by the deaf will parallel coding by the hearing in all areas. That is, it does not necessarily follow that the coding efficiency hierarchy found in the hearing population will be mirrored in all research designed to investigate coding strategies used by the deaf.

The importance of this semantic aspect can be seen when the implications of semantic coding found in the present study are used to interpret the Odom, et al. (1970) and the Putnam, et al. (1962) studies which were designed to investigate coding by sign formations by deaf subjects. In these studies, the frequency of occurrence of the words within lists were either not controlled at all or were not properly controlled. Hall (1971) has found that word frequency counts are closely correlated with measures of meaningfulness. Since the present study has shown that deaf subjects can use meaning as a relatively efficient coding factor, it can be seen that failure to adequately control for word frequency could have affected the results of the Odom, et. and the Putnam, et al. studies.

The indication that the performance on List 1 (similar meaning, similar sign) more closely resembled the performance on List 2 (similar meaning, different sign) more than List 3 (similar sign, different meaning) has several implications. In List 1, the subjects could have elected to code by signs, by meaning, or by a combination of the two factors. The relationship between Lists 1 and 2 indicates that wh

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that when given such a choice, the semantic component rather than the sign component will be used as the coding association strategy. This gives added emphasis to the implication that semantic factors were relatively important coding elements for the deaf subjects in this study.

The indication that the deaf subjects' performance did not differ between List 1 (similar meaning, similar sign) and List 2 (similar meaning, different sign) is interesting in light of some conclusions reached by Schlesinger and Meadow (1972). These writers state that one of the unique properties of the American Sign Language is the way in which words sharing similar meanings are formed. These authors stated that words with similar meanings often shared similar signs. As examples, Schlesinger and Meadow noted that male signs are characteristically made on or near the forehead, while female signs are made on or near the lower cheek. This characteristic of the sign language could be considered to be represented by List 1. It would seem plausible that the similar sign-similar meaning phenomenon which, according to Schlesinger and Meadow, occurs in the sign language should have made List 1 relatively easy to learn because deaf subjects would be very familiar with the consistency of the sign-meaning relationship. By the same reasoning, List 2 would have been predicted to be relatively difficult to learn because the signs were distinctly different. The fact that performance between these two lists (Lists 1 and 2) did not differ indicates that the deaf subjects were capable of discriminating between sign and semantic factors of each word pair without dependence on the similar sign-similar meaning relationship reported by Schlesinger and Meadow. List 3 (similar sign, different meaning) would represent a relationship opposite to that described by Schlesinger and Meadow and it may be that the similar sign-different meaning relationship occurs often enought to discourage the deaf from depending on the similar meaning-similar sign associations as a coding strategy.

Learning Theories and Models

The results of this study indicated that coding by semantic factors occurred in deaf subjects and was more efficient, at least during the very early stages of the PA learning task, than was coding by sign formations. These findings can not be explained by learning models which make a definite separation between short-term memory (STM) and long-term memory (LTM). Such models usually assume that acoustic and/or speech-motor coding is restricted to STM and that semantic coding takes place only in LTM (Norman, 1969). Such models can be used to explain the results of experiments which produce a clearly definable coding strategy using either semantic or acoustic and/or speech-motor factors, but not both. For example, when

Baddeley (1966) found acoustic coding evidence in his verbal learning task using acoustically similar words, he was able to state that his results were a reflection of acoustic coding which is traditionally restricted to STM. Also, when Baddeley and Levy (1971) extended their presentation time periods in a PA task, they began to see the effects of semantic coding, and therefore concluded that their time intervals were long enough to allow their subjects to use semantic rules and associations previously stored in LTM.

In the present study, however, the results would seem to imply that coding originated in both STM and LTM. Coding in STM was evidenced by the higher performance on List 3 (similar sign, different meaning) relative to the control list, and coding from LTM was indicated by the high performance on the two lists containing semantically related words (Lists 1 and 2) relative to the other lists. To make this statement, it should be observed that the assumption was made that a correlation exists between speech-motor coding in STM by the hearing and sign formation coding in STM by the deaf. Such an assumption is justified by the widely held tenet that coding in STM takes a form which is closely related to sensory input (Shulman, 1971).

A learning model, then, which would best fit the results of the present study must be able to explain the existence of coding strategies from both STM and LTM.

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Norman (1969) noted that many researchers are becoming disenchanted with the traditional separation of STM and LTM, and many writers are postulating that the boundaries between the two memory systems are not distinct. Norman also found that some researchers are finding it increasingly useful to alter their learning models to include a means of reciprocity between STM and LTM. A good example of such a system is given by Morton (1970), (see Figure 5).

To apply Morton's model to the findings of the present study, a few modifications in labeling would be necessary. The Cognitive system in Morton's model corresponds to the semantic coding factors of LTM. The Logogen system and The Acoustic analysis are related to the reception of a word and its subsequent coding in some form related to sensory input (speech-motor and/or acoustic factors in hearing subjects, and sign factors in the deaf subjects used in this study). Note that this model is uniquely suited to application to the deaf due to the inclusion of a visual input system.

The Morton model can be used to explain the occurrence of coding by semantic factors in the present study. The model depicts a give-and-take between the Cognitive (LTM with its stored semantic rules and associations) and the Logogen system (which will be identified as encoded words in STM, neglecting serious problems of detailed definition).

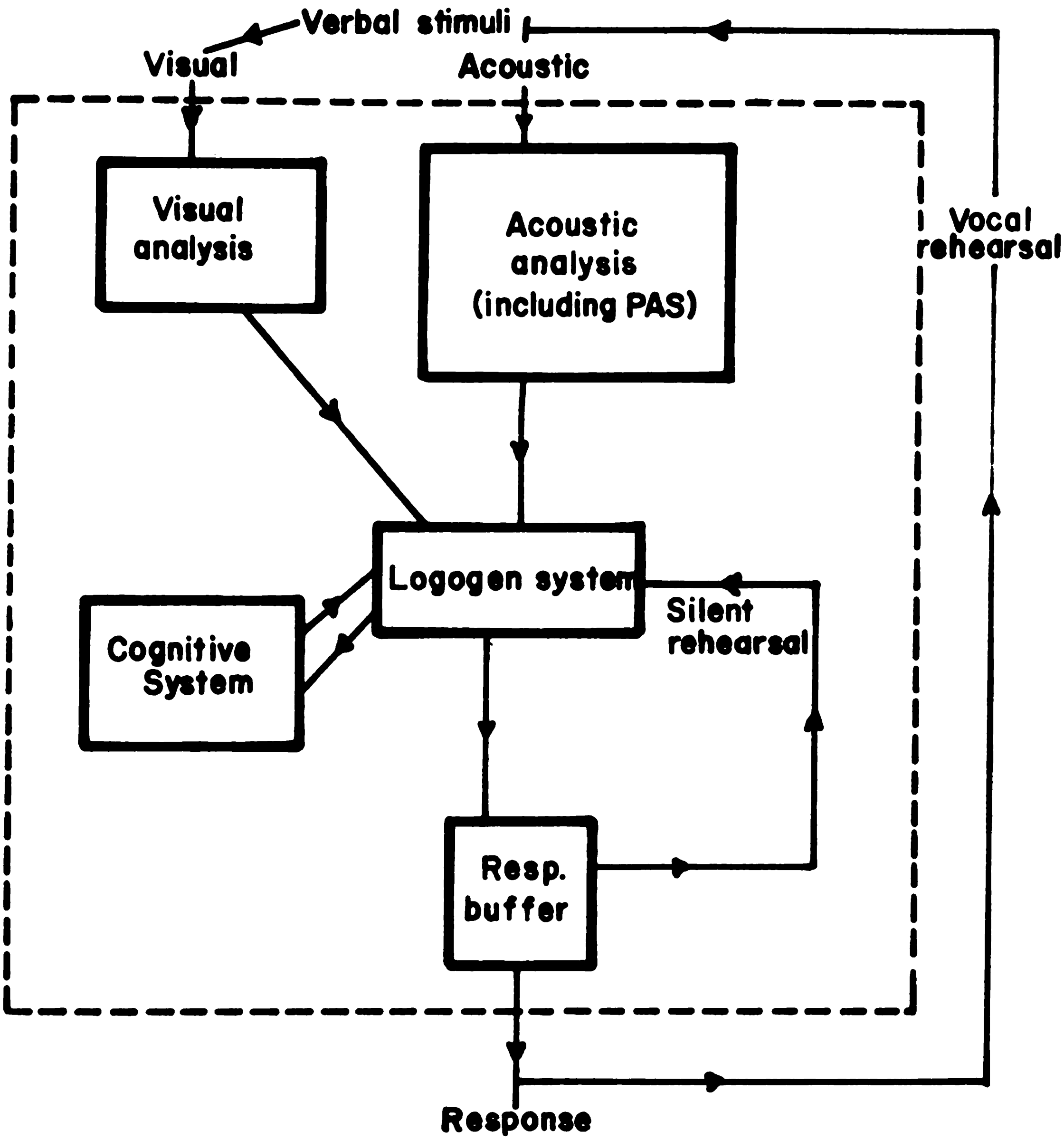

Figure 5. A flow-diagram of information in the Logogen System Model. The dotted line indicates the boundaries of man. Adapted from Morton (1970; page 205).

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This interaction between the Cognitive and Logogen systems would allow a subject to discover the semantic coding strategy available in Lists 1 (same meaning, same sign) and 2 (same meaning, different sign). This application of semantic associations found in LTM to material held and rehearsed in STM is consistent with the model and predictions of Baddeley (1971). Baddeley has noted that as a subject searches for a possible coding strategy in a PA learning task involving words, he may be able to discover a semantic retrieval rule which is usually stored in LTM. This semantic retrieval rule is then used to simplify the task called for in STM. The high scores obtained on Lists 1 and 2 are an indication that the semantic associations between the word pairs of these lists were recognized through reference to semantic rules obtained from the Cognitive system.

This does not mean that the words entered the Logogen system as visual impressions and were then coded directly into a semantic code with no mediating strategy. The necessity of using a mediating system such as speech-motor and/or acoustic factors for increased efficiency and rehearsal is well documented (Conrad, 1970; Norman, 1969; Hall, 1971; and Frijda, 1972). Ervin-Tripp (1973) has stated that mediation systems are necessary for the processing of language-related material. She has noted:

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> information is retained, language learning could not occur. There must be some storage of the phonological markers and semantic features inferred from the milieu of a new item for it to become part of the dictionary. (page 280)

Though it is probable that the deaf subjects in this study used some form of encoding as a mediating system between the printed form of the words and their semantic aspects, the exact nature of this encoding can not be ascertained from the data at hand. All that can be stated at this point is that the semantic associations between the word pairs of List 1 and 2 were used by the subjects as a relatively efficient learning strategy.

Morton's model can also be used to describe the occurrence of coding by sign formation. Such coding is indicated by the high level of performance on List 3 (similar sign, different meaning) relative to the performance on List 4 (different sign, different meaning). According to the model, the word pairs entered the Logogen system via the Visual Analysis component. In the Logogen system, the words were encoded and an attempt was made to find an association between the encoded words. Here again the Cognitive system was brought into play. At some point, rules of association which were stored in the Cognitive system were used to discover the associative link between the encoded pairs. The nature of this encoding can be deduced from the structure of the word pairs and the subsequent performance of the subjects on List 3.

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Given that the word pairs in this list shared a common sign, it follows that the subjects could not have discovered this sign association without first encoding the visual image of the printed words into their sign equivalents.

The specification of coding by sign factors might be interpreted as complimenting a motor theory of speech production/perception (Liberman, Shankweiler, and Studdert-Kennedy, 1967). The motor theory would predict that the mediating system used in processing language-related material would be directly related to the muscular processes used in the production of speech, or at least the stored neurological patterns associated with such processes. In the hearing population, this implies that a linguistic unit such as a word or phoneme is recognized when it is paired with the particular neural impulses from the articulators which would have been used if the phoneme or word were actually produced. This does not imply that hearing subjects actually repeat linguistic material before it is understood, but rather that neural impulses occur in a short-circuited manner within the brain without ever actually moving the articulators.

One obvious problem with the motor theory is the fact that the motor aspects of speech production are closely associated with the acoustic factors of the speech product. In trying to specify the motor components of speech perception, researchers have had difficulty in separating the motoric and the acoustic aspect (Delattre, 1941) resulting in a great deal of controversy (Wickelgren, 1969). It might appear that using a deaf population could be one way to eliminate the acoustic factor and objectively test the motor theory. However, as will be seen, using deaf subjects might eliminate the acoustic variable, but the new variable of visual images of the sign formations is introduced and no real progress in solving the motor theory controversy has been made.

If the production of signs could be equated with the production of speech, and if the neural impulses from the hands could be considered to be the equivalent of the neural impulses from the articulators, evidence of coding by signs might be considered to be supportive of the motor theory of speech perception. It is not difficult to see a correlation between speech and signing since both are used as a means of communication (Bornstein, 1973). It might be a little more difficult to equate the neural impulses of the hands with the neural impulses from the articulators. However, a close anatomical relationship between the motor area for speech and motor area for the hand has been noted by Penfield and Roberts (1959), and Ranson and Clark (1959). With but few qualifications, the results of the present study could be considered to be in support of the motor theory.

However, such a conclusion is not without an inherent problem. Just as the acoustic aspects of speech closely follow production, the visual aspects of the sign formation are closely related to the kinesthetic factors in sign production. The present study has found indication of encoding words by signs, but it is not known at this point in what form these signs are encoded. That is, a subject might use the visual form of the sign or he could use the kinesthetic or movement patterns of the sign for coding. Coding by signs, then, could be considered to be supportive of the motor theory of perception only if it could be shown that kinesthetic factors, rather than visual images, were in fact used in the coding strategy.

Thought, Language and Coding

The indication of coding by sign formation found in this study has some implications regarding theories of thought and language. Evidence of coding by sign is not consistent with the empirical and behavioral schools' stand on the importance of coding by speech-motor factors. Historically, these schools held that thinking was language dependent and that language could only occur through the use of speech. The present findings would indicate that coding can take place in forms other than speech-motor. This finding is in direct contrast with the opinions of early writers who shared Sapir's (1921) view that ". . .

auditory imagery and the correlated motor imagery leading to articulation, are, to whatever devious ways we follow the process, the historic fountain-head of all speech and of all thinking." (Markowicz, 1972, pages 33-34).

It should not be considered that the indication of coding by signs found in this study gives support to the "mother tongue-natural language" concept proposed by Furth (1966), Giangreco and Giangreco (1970) and Markowicz (1972). These authors have stated that the sign language is the "natural" form of language processing used by the deaf. Though their references are vague and unsubstantiated by research, the proponents of this theory hold that deafness somehow alters the human language processing system so that only manual forms of communication will correspond to the "natural language" of the deaf. For example, Furth (1966) has written that "The true 'language' of the deaf is the sign language, as one can readily observe" (page 15), and Markowicz (1972) has stated that "The deaf turn to sign language as their 'natural' language in the same way that a hearing individual acquires and uses the language of the community in which he grows up." (page 23). Statements such as these must be questioned in light of the results of Conrad's (1970) study and the present investigation. Conrad has shown that some deaf subjects code on a speech-motor basis and do not show any evidence of Furth's and

Markowicz's "natural" coding by signs. The present study indicates that even when coding by sign is evidenced, such coding is less efficient than semantic coding during initial learning trials and is never more efficient than is coding by semantic factors. In addition, neither Conrad's study nor any other investigation has been designed to contrast coding by signs with coding by speech-motor factors. Until this is done, speculation as to whether the sign cue or the speech-motor factor is the "most natural" or most efficient coding mechanism for the deaf will remain tenuous.

Educational Implications and Suggestions for Further Research

The present study has been limited in scope as well as highly theoretical. Nevertheless, there are several implications for educational applications and future research which have become apparent. One might hypothesize, for example, that a deaf child will make optimal educational progress when the manner in which he codes language "matches" the system in which he is taught. This would suggest that a deaf child might process linguistic material at an optimal level only when input and processing coincide. Both White (1972) and Conrad (1972) have discussed such a possibility but neither have provided objective evidence to support this concept. Such evidence could result from research which first specified the coding strategies used by the deaf subjects. This specification could be achieved through a simple verbal learning task such as that described in the present study or by Conrad (1970). Following this, research could be conducted to investigate the relationship between coding efficiency relative to different modes of information input.

It is tempting to assume direct relationships between educational methodology, coding systems and speaking ability in the deaf. Such an assumption might seem warrented because Conrad (1970) has indicated that deaf subjects with relatively good speech code words on an articulatory basis, and the present study has shown that deaf subjects who consistently use signs can code words on a sign basis. These findings could conceivably lead to the conclusion that deaf children who are taught orally will develop articulatory coding and good speech, while deaf children who are taught in a system allowing the use of a sign language system will develop sign coding strategies which, in turn, will be reflected in relatively poor speech skills. Such conclusions, however, are not justified by the data currently available. The subjects in Conrad's study were selected from an oral school but not all of the subjects exhibited articulatory coding. Conrad (1973) reported that he tried unsuccessfully to determine why some deaf children code on an articulatory basis while others do not. Related to this, Conrad noted that while it is probable that relatively good speech in the deaf and articulatory coding are highly correlated, variables leading to or discouraging such coding have not yet been specified. The results of the present study must not be interpreted as an indication that coding by sign formation precludes coding on an articulatory basis. This study was designed to investigate evidence of coding by sign and/or semantic factors, and no attempt was made to correlate these coding strategies with speaking ability. Further research is therefore needed to delineate the effects which different coding systems have on speech and to indicate what variables contribute to the development of a particular coding method.

A frequent criticism of the sign language is that it is such an efficient communication tool that its use tends to discourage the use of other perhaps more "desirable" methods of communication, such as speechreading, speech and residual hearing (Dale, 1967 and Ewing and Ewing, 1961). The results of this study should not be considered as proof of such a contention. This study indicates only that coding by sign or semantic factors can be used by the deaf subjects in question. The data gives no indication that coding by these two systems occurs exclusively. It is possible that deaf subjects may be capable of switching codes and that an efficient coding system could be sought for different situations. The present study does indicate that at least two systems may be used (sign or semantic), but the semantic coding, not the sign coding appears to be the more efficient method in the initial stages of learning. Here, too, further research is needed. It would be very useful in educational planning, for example, to determine how the three coding systems identified by this study and by Conrad (1970 and 1973) compare in relative efficiency in different learning and communication situations.

The findings of this study indicate that when given a choice between semantic and sign coding strategies, the subjects tended to select the semantic strategy rather than use the sign code or a combination of sign and semantic cues. This finding is consistent with the findings of Gaeth (1966). Gaeth reported that the deaf subjects in his verbal learning study, when presented with two modes of information input (visual and auditory), tended to disregard the less meaningful auditory channel and attend to the visual channel. Further, Gaeth found no evidence of additivity of cues. That is, performance on a verbal task containing cues from both channels was not superior to the performance on tasks using a single channel. He also found that the hard-of-hearing subjects did not consistently attend to one information transfer mode, but instead shifted back and forth between modes. This shifting strategy used by the hard-of-hearing subjects might mean that they are capable of coding by either of the systems investigated by Gaeth. This could indicate that the hard-of-hearing may code using any of several systems, depending on which system is carrying the most information at any given time. At this point, such a conclusion is merely speculation. The present study used no hard-of-hearing subjects and no data is currently available on the coding systems used by subjects whose hearing loss is less than the 70 dB criteria used in the present study.

Conrad (1973) has noted that a correlation exists between articulatory coding and hearing loss. He noted that articulatory coding is more likely in subjects with relatively better hearing. Conrad's study was designed to find evidence of articulatory coding and he was not concerned with coding by sign formations or with a possible relationship between hearing levels and coding by signs. It would seem important to ask what effects different levels of hearing loss might have on coding systems of deaf children who are in an educational setting which permits and/or encourages signing. Will all children in a school system which uses signs develop sign and semantic codes or will other codes be possible? Conrad's findings could lead to the hypothesis that children with relatively

better hearing might develop an articulatory code instead of, or in additon to, sign and semantic codes; but again, further research is needed to determine this.

Recently an educational methodology which claims to promote all forms of communication in deaf children has been receiving wide interest in the United States. This educational philosophy has been termed "total communication" and has been defined by Denton (1971) as:

> By total communication is meant the right of a deaf child to learn to use all forms of communication available to develop language competence at the earliest possible age. This implies introduction to a reliable receptive-expressive symbol system in the preschool years between the ages of one and five. Total communication includes the full spectrum of language modes: child devised gestures, formal sign language, speech, speech-reading, fingerspelling, reading and writing. (page 3)

Proponents of total communication have not couched their theories in the terminology of the learning theorists. However, it is apparent that the philosophy behind total communication is directly related to coding theory. As can be seen in Denton's (1971) definition, total communication attempts to incorporate both speech and sign systems in preschool age children. This would imply that the total communication methodology somehow fosters, or at least allows, the development of multiple encoding and decoding systems in young deaf children.

The concept of total communication could provide several areas of research. For example, the concept of multiple encoding and decoding systems, on which the total communication philosophy is partly based, has no empirical backing to date. No research has been devised to investigate the possibility of coding by both articulatory and sign formation systems. Also, no research has directly considered the coding systems of preschool age deaf children, and it is not known what affects multiple coding systems will have on deaf children during their very early years when language systems are being formulated.

The relationship between age, educational planning, and coding systems may provide new areas of research in deaf education. Traditionally, deaf children in an oral program begin their oral training during their preschool years. Many of these children remain in the oral educational system throught their elementary and secondary schooling. However, a child may be transferred into an educational system using sign language if it is determined that he will not succeed orally. Knauf (1972) has written that "For those deaf children who were identified late and show no aptitude for oral language and for those, who after reasonable exposure in a totally committed oral program still can not understand and use oral language, manual communication is recommended." (page 752). Educators of the deaf in oral systems, then, are frequently faced with the question of the optimal placement for a child who does not appear to be developing adequate verbal language, speech, and speechreading skills. In such a situation, these educators must decide: (a) if the child has had a "reasonable exposure" to verbal language; (b) will the student benefit from continued oral education; or (c) would the student be better placed in a system using signs. It may be that research into coding systems used by the deaf could aid in answering such questions. It is a plausible assumption that a deaf child who is failing in an oral system might be processing linguistic information in some code other than articulation. If this is the case, educators could use data concerning a child's coding system or systems in decisions regarding the placement of deaf children. It would also be well to ask at what age or developmental level decisions concerning coding systems can or should be made. Is it ever "too late" for a child to develop coding systems which will benefit speech, speechreading, and verbal language? Can a child who remains for a given length of time in an educational system to which he is not suited ever "catch up" when he is eventually placed into a system which must first teach the child a new language coding system before moving on to academics? If a child has relatively good speech and speechreading skills, will these skills be detrimentally affected by the introduction of sign coding? Can a deaf child function in an educational system on a "bilingual" basis using both sign and verbal language processing systems? Educational questions such as these all relate to coding systems, and all await further research.

LIST OF REFERENCES

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American Academy of Ophthalmology and Otolaryngology, Subcommittee on Noise in Industry. Guide for Conservation of Hearing in Noise. Dallas, Texas: Callier Speech and Hearing Center, 1970.

Aaronson, D. Temporal factors in perception and short-term memory. Psychological Bulletin, 1967, 67, 130-144.

Allen, D. V. Acoustic interference of paired-associate learning as a function of hearing ability. Psychonomic Science, 1970, 18, 231-233.

Alterman, A. I. Language and the education of children with early profound deafness. American Annals of the Deaf, 1970, 115, 514-521.

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

Baddeley, A. D. Retrieval rules and semantic coding in short-term memory. Psychological Bulletin, 1972, 78, 379-385.

Baddeley, A. D., and Levy, B. A. Semantic coding and short-term memory. Journal of Experimental Psychology, 1971, 89, 132-136.

Bender, R. The Conquest of Deafness. Cleveland: Western Reserve, 1960.

Bergman, E. Autonomous and unique features of American Sign Language. American Annals of the Deaf, 1972, 117, 20-24.

Blair, F. X. A study of the visual memory of deaf and hearing children. American Annals of the Deaf, 1957, 102, 138-149.

Blanton, R. L., and Nunnally, J. C. Retention of trigrams by deaf and hearing subjects as a function of pronunciability. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 428-431.

Blank, M. Use of the deaf in language studies: a reply to Furth. Psychological Bulletin, 1965, 63, 442-444.

Boatner, E. B. The need of a realistic approach to the education of the deaf. Paper presented at the joint convention, California Association of the Deaf. November 6, 1965.

Boring, E. G. A History of Experimental Psychology. New York: Appleton-Century-Crofts, 1950.

Bornstein, H. A description of some current systems designed to represent English. American Annals of the Deaf, 1973, 118, 454-463.

Bousfield, W. A., and Cohen, G. H. The occurrence of clustering in the recall of randomly arranged words of different frequencies of usage. Journal of General Psychology, 1955, 52, 83-95.

Bousfield, W. A., Cohen, G. H., and Whitmarsh, G. A.. Associative clustering in the recall of words of different taxonomic frequencies of occurrence. Psychological Reports, 1958, 4, 39-44.

Broadbent, D. E. Immediate memory and simultaneous stimuli. Quarterly Journal of Experimental Psychology, 1957, 9, 1-11.

Broadbent, D. E. Perception and Communication. New York: Pergamon Press, 1958.

Brown, J. Some tests of the decay theory of immediate memory. Quarterly Journal of Experimental Psychology, 1958, 10, 12-21.

Calfee, R. C., and Anderson, R. Presentation rate effects in paired-associate learning. Journal of Experimental Psychology, 1971, 88, 239-245.

Carroll, J. B., Davies, Pl, and Richman, B. Word Frequency Book. New York: American Heritage Publishing Co., Inc. 1971.

Cicourel, A., and Boese, R. J. Sign language acquisition and the teaching of deaf children, part 1. American Annals of the Deaf, 1972, 117, 27-33.

Conrad, R. Errors of immediate memory. British Journal of Psychology, 1959, 50, 349-359.

Conrad, R. An association between memory errors and errors due to acoustic masking of speech. Nature, 1962, 193, 1314-1315.

Conrad, R. Acoustic confusions and memory span for words. Nature, 1963, 197, 1029-1030.

Conrad, R. Acoustic confusions in immediate memory. British Journal of Psychology, 1964, 55, 75-84

Conrad, R. Short-term memory processes in the deaf. British Journal of Psychology, 1970, 61, 179-195.

Conrad, R. Some correlates of speech coding in the short-term memory of the deaf. Journal of Speech and Hearing Research, 1973, 16, 375-383.

Conrad, R., and Hull, A. J. Information, acoustic confusion and memory span. British Journal of Psychology, 1964, 55, 429-432.

Conrad, R., and Rush, M. L. On the nature of short-term memory encoding by the deaf. Journal of Speech and Hearing Disorders, 1965, 30, 336-343.

Cooper, F. S., Delattre, P.C., Liberman, A. M., Borst, J. M., and Gerstmen, L. Some experiments on the perception of synthetic speech sounds. Journal of the Acoustical Society of America, 1952, 24, 597-617.

Craik, F. I. M. The fate of primary memory items in free recall. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 143-148.

Craik, F. I. M., and Levy, B. A., Semantic and acoustic information in primary memory. Journal of Experimental Psychology, 1970, 86, 77-82.

Dale, D. M. C. Deaf Children at Home and at School. London, England: University of London Press, L.T.D., 1967.

Dale, H. C. A., Semantic similarity and the A-B, C-D paradigm in STM. Psychonomic Science, 1967, 9, 79-80.

Dale, H. C. A., and Gregory, M. Evidence of semantic coding in short-term memory. Psychonomic Science, 1966, 5, 75-76.

Dallett, K. M. The effects of within-list and between-list acoustic similarity on the learning and retention of paired-associates. Journal of Experimental Psychology, 1966, 72, 667-677.

Delattre, P. The physiological interpretation of sound spectrograms. Modern Language Association Publications, 1966, 1051, 864-875.

Denton, D. N. Educational Crises. The Maryland Bulletin, 1971, 17, 2-5.

Ellis, H. C. Fundamentals of Human Learning and Cognition. Dubuque, Iowa: Wm. C. Brown Col, Publishers, 1972.

Ervin-Tripp, S. Some strategies for the first two years. In Cognitive Development and the Aquisition of Language,

Ewing, I. R., and Ewing, W. G. New Opportunities for Deaf Children. Warwick Square, London: University of London Press, L.T.D., 1961.

Fisher, C. G., and Husa, F. A. Finger spelling intelligibility. American Annals of the Deaf, 1973, 118, 508-510.

Frijda, N. J. Simulation of human long-term memory. Psychological Bulletin, 1972, 77, 1-31.

Furth, H. G. Influence of language on the development of concept formation in deaf children. Journal of Abnormal Social Psychology, 1961, 63, 386-389.

Furth, H. G. Research with the deaf: implications for language and cognition. Psychological Bulletin, 1964, 62, 145-164.

Furth, H. G. Thinking Without Language. London: Collier-Macmillan, 1966.

Furth, H. G. Linguistic deficiency and thinking: research with deaf subjects. Psychological Bulletin, 1971, 76, 58-72.

Gaeth, J. G. Verbal and Nonverbal Learning in Children Including Those with Hearing Losses. Part II. Final Report, Cooperative Research Project No. 2207, Wayne State University. 1966.

Garnett, C. B. The World of Silence: A New Venture in Philosophy. New York: Greenwich, 1967.

Garnett, C. B. The Exchange of Letters Between Samuel Heinicke and Abbe Charles Michel de l'Epee. New York: Vantage Press, 1968.

Giangreco, J., and Giangreco, M. R. The Education of the Hearing Impaired. Springfield, Illinois: Charles C. Thomas, 1970.

Hall, J. F. Learning as a function of word frequency. American Journal of Psychology, 1954, 67, 138-140.

Hall, J. F. The Psychology of Learning. New York: J. B. Lippincott Company, 1966.

Hall, J. F. Verbal Learning and Retention. New York: J. B. Lippincott Company, 1971.

Hintzman, D. L. Articulatory coding in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 312-316.

Hodgson, K. The Deaf and Their Problems. New York: Philosophical Library, 1953.

Jacobs, A. Formation of new associations to words selected on the basis of reaction-time-GSR. Journal of Abnormal Social Psychology, 1955, 51, 371-377.

Jenkins, J. J., Foss, D. J., and Greenberg, J. H. Phonological distinctive features as cues in learning. Journal of Experimental Psychology, 1968, 77, 202-205.

Johnson, D. M. Systematic Introduction to the Psychology of Thinking. New York: Harper and Row, 1972.

Joos, M. Acoustic phonetics. Supplement to Language Monograph, 1948, 24, 1-136.

Kirk, R. E. Experimental Design: Procedures for the Behavioral Sciences. Belmont, California: Brooks/Cole Publishing Company, Inc., 1968.

Knauf, V. H. Meeting speech and language needs for the hearing impaired. In Handbook of Clinical Audiology, Edited by Katz, J., Baltimore, Maryland: The Williams and Wilkins Cc., 1972.

Lane, H. The motor theory of speech perception: A critical review. Psychological Review, 1965, 72, 275-309.

Liberman, A. M. Some results of research on speech perception. Journal of the Acoustical Society of America, 1957, 29, 117-123.

Liberman, A. M., Cooper, F. S., Shankweiler, D. P., and Studdert-Kennedy, M. Perception of the speech code. Psychological Review, 1967, 74, 431-461.

Locke, J. L. Short-term memory encoding strategies of the deaf. Psychonomic Science, 1970, 18, 233-234.

Locke, J. L. Subvocal speech and Speech. Asha, 1970, 12, 7-14.

Locke, J. L. Phonemic processing in silent reading. Perceptual and Motor Skills, 1971, 32, 905-906.

Locke, J. L., and Locke, V. L. Deaf children's phonetic, visual, and dactylic coding in a grapheme recall task. Journal of Experimental Psychology, 1971, 89, 142-146.

Max, L. W. An experimental study of the motor theory of consciousness: III, Action-current responses in deaf-mutes during sleep, sensory stimulation and dreams. Journal of Comparative Psychology, 1935, 19, 469-486.

Max, L. W. An experimental study of the motor theory of consciousness: IV, Action-current responses in the deaf during awakening, kinesthetic imagery, and abstract thinking. Journal of Comparative Psychology, 1937, 23, 301-304.

MacDougal, J. C., and Rabinovitch, M. S. Imagery and learning in deaf and hearing children. Psychonomic Science, 1971, 22, 347-349.

Mackworth, J. F. Auditory short-term memory. Canadian Journal of Psychology, 1964, 18, 294-303.

Markowicz, H. Some sociolinguistic considerations of American Sign Language. In Sign Language Studies, Edited by Stokoe, W. C., The Hague, the Netherlands: Mouton Publishers, 1972.

McClure, W. J. Current problems and trends in the education of the deaf. The Deaf American, 1966, 18, 8-14.

McGeoch, J. A., and Underwood, B. J. Tests of the two-factor theory of retroactive inhibition. Journal of Experimental Psychology, 1943, 32, 1-16.

Meadows, K. P. Early manual communication in relation to the deaf child's intellectual, social, and communication functioning. American Annals of the Deaf, 1968, 113, 29-41.

Melton, A. W. Implications of short-term memory for a general theory of memory. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 1-21.

Mindel, E. D., and Vernon, M. They Grow in Silence. Silver Spring, Maryland: National Association of the Deaf Press, 1971.

Moores, D. F. Psycholinguistics and deafness. American Annals of the Deaf, 1970, 115, 37-48.

Morkovin, B. V. Thought patterns of deaf children. What does this imply for the classroom teacher? Volta Review, 1964, 66, 491-494.

Morton, J. A functional model for memory. In Models of Human Memory, Edited by Norman, D. A., New York: Academic Press, 1970.

Murdock, B. B., and Walker, K. D. Modality effects in free recall. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 665-676.

Myklebust, H. R. The Psychology of Deafness. New York: Grune and Stratton, 1960.

Norman, D. A. Memory and Attention. New York: John Wiley and Sons, Inc., 1969.

Novikova, L. A. Electrophysical investigation of speech. In Recent Soviet Psychology, Edited by O'Connor, N., Elmsford, New York: Pergamon Press, 1961.

Odom, P. B., Blanton, R. L., and McIntyre, C. K. Coding medium and word recall by deaf and hearing subjects. Journal of Speech and Hearing Research, 1970, 13, 54-58.

Olsson, J. E. The influence of language experience on visual memory span. Unpublished master's thesis, Catholic University of America, 1963.

Olsson, J. E., and Furth, H. G. Visual memory span in the deaf. American Journal of Psychology, 79, 480-484.

Paivio, A. Imagery and Verbal Processes. New York: Holt, Rinehart and Winston, 1971.

Penfield, W., and Roberts, L. Speech and Brain Mechanisms. London, England: Oxford University Press, 1959.

Pintner, R., and Paterson, D. G. A comparison of deaf and hearing children in visual memory for digits. Journal of Experimental Psychology, 1917, 2, 76-88.

Putnam, V., Iscoe, I., and Young, R. K. Verbal learning in the deaf. Journal of Comparative and Physiological Psychology, 1962, 55, 843-846.

Quigley, S. P. The Influence of Fingerspelling on the Development of Language, Communication, and Educational Achievement in Deaf Children. Washington, D. C.: Department of Health, Education and Welfare, 1967.

Ranson, S. W., and Clark, S. L. The Anatomy of the Nervous System, Its Development and Function. Philadelphia: W. B. Saunders Company, 1959.

Rupp, R. R., and Mikulas, M. Some thoughts on handling the communication needs of the very young child with impaired hearing. The Volta Review, 1973, 75, 288-295.

Sapir, E. Language. New York: Harcourt, Brace and World, 1921.

Schlesinger, H., and Meadow, K. P. Sound and Sign: Childhood Deafness and Mental Health. Berkeley, California: University of California Press, 1972.

Shulman, G. G. Encoding and retention of semantic and phonemic information in short-term memory. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 499-508.

Shulman, H. G. Similarity effects in short-term memory. Psychological Bulletin, 1971, 75, 399-415.

Slobin, D. I. Psycholinguistics. Glenview, Illinois: Scott Foresman and Col, 1971.

Sperling, G. The Information available in brief visual presentations. Psychological Monographs, 1960, 74, Whole number 498.

Sperling, G. A model for visual memory tasks. Human Factors, 1963, 5, 10-31.

Stokoe, W., Casterline, C. C., and Croneberg, C. G. A Dictionary of American Sign Language on Linguistic Principles. Washington, C. C.: Gallaudet College Press 1965.

Stokoe, W. C., CAL conference on sign languages. The Linguistic Reporter, 1970, 12, 5-8.

Stoyva, J. M. Finger electromyographic activity during sleep: its relation to dreaming in deaf and normal subjects. Journal of Abnormal Psychology, 1965, 70, 343-349.

Streng, A. Children with Impaired Hearing. Washington, D. C.: Councel for Exceptional Children, NEA, 1960.

Stuckless, E. R., and Birch, J. W. The influence of early manual communication on the linguistic development of deaf children. American Annals of the Deaf, 1966, 111, 452-462.

Thorndike, E. L., and Lorge, I. The Teacher's Word Book of 30,000 Words. New York: Teacher's College, Columbia University, 1944.

Tinker, M. The relative legibility of the letters, the digits, and of certain mathematical signs. Journal of General Psychology, 1928, 1, 472-496.

Underwood, B. J., and Archer, E. J. Studies of distributed practice XIV. Intralist similarity and presentation rate in verbal-discrimination learning of consonant syllables. Journal of Experimental Psychology, 1955, 50, 120-124.

Underwood, B. J., and Richardson, J. The influence of meaningfulness, intralist similarity, and serial position on retention. Journal of Experimental Psychology, 1956, 52, 119-126.

Underwood, B. J., and Schulz, R. W. Studies of distributed practice: XIX. The influence of intralist similarity with lists of low meaningfulness. Journal of Experimental Psychology, 1959, 58, 106-110.

Underwood, B. J., and Viterna, R. O. Studies of distributed practice: IV. The effect of similarity and rate of presentation in verbal-discrimination learning. Journal of Experimental Psychology, 1951, 42, 296-299.

Van Riper, C., and Irwin, J. V. Voice and Articulation. Englewood Cliffs, New Jersey: Prentice-Hall, 1958.

Vernon, M., and Koh, S. D. Early manual communication and deaf children's achievement. American Annals of the Deaf, 1970, 115, 527-536.

Watson, D. O. Talk With Your Hands. Manasha, Wisconsin: George Banta Company, Inc., 1964.

Waugh, N. C., and Norman, D. A. Primary memory. In Memory and Attention, by Norman, D. A., New York: John Wiley and Sons, Inc., 1969.

White, A. H. The Effects of Total Communication, Manual Communication and Reading on the Learning of Factual Information in Residential School Deaf Children. Unpublished Ph.D. dissertation, Dept. of Special Education, Michigan State University, East Lansing, Michigan, 1972.

Wickelgren, W. A. Acoustic similarity and intrusion errors in short-term memory. Journal of Experimental Psychology, 1965, 70, 102-108.

Wickelgren, W. A. Auditory or articulatory coding in verbal short-term memory. Psychological Review, 1969, 76, 232-235.

Wrightstone, J. W., Aronow, M. S., and Muskowitz, S. Developing reading test norms for deaf children. American Annals of the Deaf, 1963, 108, 311-316.

Zakia, R. D., and Haber, N. R. Sequential letter and word recognition in deaf and hearing subjects. Perception and Psychophysics, 1971, 9, 110-114.

APPENDICES

APPENDIX A

PA WORD LISTS WITH THEIR RESPECTIVE FREQUENCIES AND WORD LENGTHS

APPENDIX A

PA WORD LISTS WITH THEIR RESPECTIVE FREQUENCIES AND WORD LENGTHS

List 1	Frequency of Occurrence*					Combined Length
pretty - beautiful	147	+	288	=	435	15
coat - sweater	90	+	12	=	102	11
happy - glad	229	+	160	=	389	9
strong - power	227	+	71	=	298	11
clothes - dress	178	+	124	=	302	12
sugar - candy	107	+	87	=	194	10
hear - listen	597	+	230	=	687	8
fire - burn	281	+	35	=	316	8
bring - carry	202	+	213	=	415	10
mad - angry	31	+	116	=	147	8
true - real	258	+	604	=	862	8
begin - start	180	+	246	=	426	10
woman - lady	212	+	176	=	388	9
Total					5,788	139
Mean					206.7	4.96

*Word frequency determined by referrence to Carrol, et al. (1971), based on 5 million words from textbooks from grades 3 through 9. The frequencies shown are from the third grade reading level.

List 2	Frequency of Occurrence*	Combined Length
steal - robber	22 + 1 = 23	8
floor - ground	186 + 372 = 558	11
finish - end	98 + 591 = 689	9
clean - wash	118 + 64 = 182	9
enough - full	433 + 192 = 625	10
house - building	785 + 165 = 950	13
sad - cry	99 + 77 = 176	6
wrong - mistake	107 + 31 = 138	12
between - middle	315 + 144 = 459	13
laugh - smile	59 + 32 = 91	10
hurry - fast	87 + 354 = 441	9
cold - freeze	361 + 14 = 375	10
baby - young	288 + 269 = 557	9
wait - stay	181 + 270 = 451	8
Total	5,715	139
Mean	204.1	4.96

*Word frequency determined by referrence to Carrol, et al. (1971), based on 5 million words from textsbooks from grades 3 through 9. The frequencies shown are from the third grade reading level compilation.

List 3	Frequency of Occurrence*					Combined Length
fork - mean	18	+	201	=	219	8
egg - short	114	+	314	=	428	8
farm - dry	189	+	226	=	415	7
soft - wet	145	+	133	=	278	7
hamburger - marry	11	+	36	=	47	14
hungry - wish	109	+	163	=	272	10
black - summer	307	+	253	=	560	11
salt - chair	103	+	78	=	181	9
voice - stuck	182	+	45	=	227	10
kind - world	430	+	399	=	829	9
almost - easy	372	+	141	=	513	10
family - important	309	+	278	=	587	15
paper - school	663	+	488	=	1151	11
pig - dirt	47	+	53	=	100	7
Total					5,807	136
Mean					207.4	4.46

*Word frequency determined by referrence to Carrol, et al. (1971), based on 5 million words from textbooks from grades 3 through 9. The frequencies shown are from the third grade reading level compilation.

List 4	Frequency of Occurrence*	Combined Length
money - bear	367 + 116 = 483	9
rain - stand	240 + 210 = 450	9
hand - best	345 + 347 = 692	8
heart - class	97 + 216 = 313	10
train - spell	173 + 274 = 447	10
pencil - bread	74 + 140 = 214	11
morning - girl	484 + 285 = 769	11
basketball - milk	12 + 284 = 296	14
apple - learn	94 + 335 = 429	10
draw - letter	426 + 411 = 837	10
broke - funny	60 + 100 = 160	10
math - ugly	1 + 51 = 52	8
doctor - green	60 + 344 = 404	11
bed - coke	214 + 3 = 217	7
Total	5,763	138
Mean	205.8	4.93

*Word frequency determined by referrence to Carrol, et al. (1971), based on 5 million words from textbooks from grades 3 through 9. The frequencies shown are from the third grade reading level compilation.

List 5	Frequency of Occurrence*	Combined Length
rain - coffee	240 + 28 = 268	10
win - lazy	73 + 30 = 103	7
smell - live	80 + 689 = 769	9
shoes - answer	140 + 353 = 493	11
drop - taste	71 + 38 = 109	9
add - yesterday	378 + 269 = 647	12
silly - hard	60 + 460 = 520	9
tomorrow - key	83 + 91 = 173	11
meat - problem	135 + 149 = 284	11
home - test	786 + 64 = 820	8
year - idea	412 + 171 = 583	8
nothing - both	235 + 331 = 566	11
eight - class	88 + 216 = 304	10
hate - telephone	12 + 61 = 73	13
Total	5,712	139
Mean	204.0	4.96

*Word frequency determined by referrence to Carrol, et al. (1971), based on 5 million words from textbooks from grades 3 through 9. The frequencies shown are from the third grade reading level compilation.

APPENDIX B

RESPONSE FORM

APPENDIX B

RESPONSE FORM

Name________________________ Group____________

List____________

Trial____________

1. ________________ - ________________
2. ________________ - ________________
3. ________________ - ________________
4. ________________ - ________________
5. ________________ - ________________
6. ________________ - ________________
7. ________________ - ________________
8. ________________ - ________________
9. ________________ - ________________
10. ________________ - ________________
11. ________________ - ________________
12. ________________ - ________________
13. ________________ - ________________
14. ________________ - ________________

APPENDIX C

INSTRUCTIONS TO SUBJECTS

APPENDIX C

INSTRUCTIONS TO SUBJECTS*

I want to see if you can remember words. First you will see two words, and then two more words, and then two more. You will see many of these words two at a time. Try to remember the words but do not write or copy the words when you see two of them. Later you will see one word and then I want you to write the missing word. Any Questions? Let's practice and learn a list of words just for fun.

*These instructions were given to the subjects by a trained, experienced teacher of the deaf. During the instructional session, the directions were administered via a combination of signs, fingerspelling, writing, and speechreading.