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THE ROLE OF MENTAL IMAGERY IN THE FREE RECALL  
OF DEAF, BLIND AND NORMAL SUBJECTS

by

ELLIS M. CRAIG

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## INTRODUCTION

In recent years there has been increased concern with the functional significance of "mental imagery" in learning and memory. Prior to the advent of Behaviorism, mental imagery played a major role in the interpretation of such phenomena. However, the revolution in psychology which accompanied the acceptance of Behaviorism resulted in the banishment of imagery, attention, states of consciousness, and other "mentalistic" concepts. Although many factors were probably responsible for the recent reexamination of many of these areas, an altered philosophical climate was certainly important. As Hebb (1960) wrote:

"In the psychological revolution, the second phase is now getting under way. The first banished thought, imagery, volition, attention, and other such seditious notions. The sedition of one period, however, may be the good sense of another. These notions relate to a vital problem in the understanding of man, and it is the task of the second phase to bring them back." (p. 736)

In spite of the excesses of Behaviorism, it did secure a place for the objective operational method in psychology. Modern research on "mentalistic" concepts has reflected this emphasis.

In the recent research dealing with mental imagery, consideration of its possible role in learning and retention has not precluded the importance of verbal mechanisms. Both processes are operationally defined (e.g., Paivio, Yuille, & Madigan, 1968) and are assumed to function as alternative coding systems (cf. Paivio & Csapo, 1969) or modes of symbolic representation (cf. Bruner, 1964). In addition, chains of associative transformations involving either words or images or both (cf. Paivio, 1970a) presumably can serve a mediational function in learning and retention.

A number of studies conducted by Paivio and his associates (e.g., Paivio, 1969; Paivio & Csapo, 1969; Paivio, Yuille, & Rogers, 1969) compared the contributions of imagery and meaningfulness in various learning and memory tasks. Imagery (I) was defined as the rated capacity of a stimulus (word) to elicit perceptual (mental) images and meaningfulness (m) as the capacity of the stimulus to elicit verbal associates. Normative data on the I and m values of 925 nouns have been supplied by Paivio, Yuille, and Madigan (1968). Using these norms, the above studies demonstrated that performance was influenced more strongly by variations in I than in m.

Tulving, McNulty, and Ozier (1965) suggested that noun vividness, a concept operationally similar to I, influences

free recall performance by facilitating the grouping of words into higher-order memory units. Paivio, Yuille, and Rogers (1969), on the other hand, hypothesized that high I nouns are transformed into nonverbal images in addition to being stored in an auditory code. The greater availability of such a dual code was assumed to be responsible for the greater recall of high I as opposed to low I items when their m values were matched.

The purpose of the present study was to determine the role of mental imagery in the immediate free recall of deaf, blind, and normal human subjects. It might be assumed that the deaf encode information primarily in a visual code, the blind in an auditory code, and normals in either. Assuming this, it would be expected that the deaf would exhibit far greater retention of high I than of low I items. No differences in the retention of either type would be expected for the blind. Normal subjects should recall more of the high I items, but the difference in the retention of the two types of items should not be as great as in the case of the deaf. In addition, imagery instructions might be expected to increase the recall of high I in comparison to low I nouns for normals. This manipulation would not be expected to influence the differential retention of the two types of items by deaf or blind subjects.

A review of the literature pertaining to the role of mental imagery in learning and retention is presented below.

The major topics to be covered in the survey include:

(1) definitions and properties of mental imagery; (2) imagery as a dimension of meaning; (3) effects of imagery in learning and memory tasks; (4) alternative interpretations of the imagery effect; (5) individual differences in imagery; (6) developmental aspects of imagery; (7) imagery and the deaf; and (8) imagery and the blind.

## DEFINITIONS AND PROPERTIES OF MENTAL IMAGERY

In dealing with an inferred process such as mental imagery, the definition of the construct becomes extremely important. Various writers have proposed different properties which are presumably characteristic of the process. The major recurring themes in these definitions will be reviewed. The possible existence of several different types of imagery will also be considered. Finally, both behavioral and physiological evidence relating to imagery will be presented.

### Definitions of Mental Imagery

Carey (1915) stated that a common assumption of psychology from the beginning has been that the memory of an experience is its imaginal reproduction, the imagery being similar to the original experience, although of weakened intensity. As evidence, he quoted a translation of Aristotle's definition of memory:

"...the permanent possession of a sensuous picture as a copy which represents the object of which it is a picture... without the aid of sense-perception we never

come to learn or understand anything; and whenever we consider something in the mind, we must at the same time contemplate some picture of the imagination for the pictures of the imagination correspond to the impressions of the senses, except that the former are without material embodiment." (p. 454)

Another early philosopher, Bishop Berkely, also assumed the presence of imagery in all thinking. However, according to Hebb (1968), Berkely believed that an image represents a specific object or situation and does not have generalized reference. Thus, he considered it to have restricted usefulness.

Carey (1915) also surveyed the positions on imagery held by later psychologists. The adherents of the Structuralist school maintained that images are one of the three basis elements of consciousness. The members of the Wurzburg school, on the other hand, argued in favor of imageless thought. An intermediate position held by such psychologists as Galton, Woodworth, and Thorndike was that imagery can be a component of mental processes, but that its activation is not necessary for their operation.

In initiating the school of Behaviorism, Watson (1913) rejected the study of imagery partly on philosophical grounds and partly on the basis of experimental evidence indicating that individual differences in imagery bear little relation to learning. For Watson, mental images were mere "ghosts"

with no functional significance.

Leuba (1940) suggested that images might be considered as conditioned sensations. Ellson (1941), disagreeing with Leuba's choice of words, stated that conditioned sensations or perceptions might be what the early introspective psychologist called "images." Nevertheless, Ellson interpreted his experiments on sensory conditioning as evidence for the existence of such a phenomenon.

The interpretation of imagery as a conditioned sensory or perceptual response is favored by many psychologists today. Bower (1970), for example, suggested that whole complexes of different modality-specific, sensory responses may become associated through contiguity so that the word representing an object can come to elicit the entire sensory complex. Bugelski (1970) proposed that images might be regarded as indirect reactivations of former sensory or perceptual activity. That is, imagery is composed of some of the same physiological reactions that occurred when the object itself was presented. Presumably, other stimuli can acquire the capacity to elicit these reactions by being associated with the object itself. Paivio (1966; 1969) has explicitly defined images as conditioned sensations for which words serve as conditioned stimuli.

Hebb's (1968) interpretation of imagery bears some similarity to the conditioned sensation notion, although there are distinct differences. He proposed that central processes (higher-order cell assemblies) can be excited associatively by other higher-order cell assemblies in the absence of direct sensory input. Thus, the experience of imagery represents a short-circuiting of the normal sensory-perceptual-motor pathway. Further, the "memory image" (as distinguished from other types of imagery such as eidetic imagery, hallucinations, and hypnagogic imagery) lacks the completeness and vividness of normal perception which follows the activation of first-order as well as higher-order cell assemblies.

Although Paivio (1966; 1969) has defined imagery as a conditioned sensation, he has also described it as possibly representing an alternative or supplementary coding system (Paivio, 1967; 1969; 1970a). That is, one code is comprised of implicit verbal processes whereas the other is nonverbal and presumably represents the private experience called "imagery." Nevertheless, Paivio argues that acceptance of a particular hypothesis is not essential. Instead, he provides operational definitions for both images and verbal processes and concerns himself with their functional significance rather than their origin.

The position that imagery only represents conditioned sensations has not found complete acceptance among contemporary psychologists. Two of the major dissenting positions are those of Bruner (1964) and Piaget (as reported in Youniss & Robertson, 1970).

Bruner hypothesized that humans possess three different systems for processing information: enactive, iconic, and symbolic representation. Enactive representation allows the coding of information through motor responses; iconic representation codes information by means of percepts and images; and symbolic representation utilizes language for the coding of information. According to Bruner, these three modes appear in a developmental sequence. Enactive representation is the dominant mode for infants; young children rely more on iconic representation; and with the development of language, symbolic representation becomes dominant. Thus, Bruner views imagery as being a rather primitive information-processing system. Its main restriction is that it is tied to the immediate present or the "point-at-able" spatio-qualitative properties of events. In contrast, symbolic representation provides a means of transforming information into unique combinations.

Youniss and Robertson (1970) have outlined Piaget's theory of imagery. In contrast to Bruner, Piaget does not

view images as primitive symbols which are superceded by linguistic representation, nor that they are mere replications of reality. According to Piaget, images are symbolic expressions for certain intellectual operations. Thus, the nature of imagery is dependent on the development of thinking operations and follows a developmental course similar to that of the thought operations themselves. In young children imagery is restricted to the reproduction of specific perceptual events. However, as the intellectual operations become more complex, imagery also becomes more productive and capable of transforming information into new combinations. The essential point of Piaget's theory is that the development of symbolic behavior is dependent on the growth of intelligence and not vice versa.

As distinguished from the foregoing theoretical definitions of imagery, the construct has also been given several operational definitions. Probably the most widely accepted such definition is that provided by Paivio, Yuille, and Madigan (1968). They presented subjects with 925 nouns taken from the Thorndike-Lorge word book (Thorndike & Lorge, 1944). The subjects were asked to rate the words on a scale from 1 to 7 with regard to the ease with which each aroused a mental image (i.e., a mental picture, or sound, or other sensory experience). Words which aroused images most readily

were given a rating of 7, while those that aroused images only with great difficulty or not at all were given a rating of 1. This type of procedure, then, defines imagery as a measure of stimulus meaning. Other measures of imagery have included scores on a test of spatial ability (Ernest & Paivio, 1969), scores on an imagery questionnaire (Sheehan & Neisser, 1969), and the latency of a drawing response (Dominowski & Gadlin, 1968).

### Types of Imagery

The assumption that there are various forms of imagery has been made by many authors. Holt (1964), for example, defined 12 different types including thought images, phosphenes, synesthesia, body images, phantom limbs, hypnagogic images, eidetic images, hallucinations, paranormal hallucinations, pseudohallucinations, dream images, and sensory conditioning. An image per se was defined as "a generic term for all conscious subjective presentations of a quasi-sensory but nonperceptual character." (p. 255)

Hebb (1968) also distinguished between several different types of imagery. According to him, a "memory image" results from the excitation of higher-order cell assemblies by other higher-order cell assemblies in the absence of the appropriate sensory stimulation. An "eidetic image", on the other hand, occurs only after stimulation. Hebb assumes that this type

of imagery results from first-order cell assemblies remaining excitable for a longer period than is the case in normal perception. The "hypnagogic image" is similar to the eidetic image in that it is an aftereffect of stimulation. However, in this case there may be a gap of hours instead of seconds between stimulation and onset of the imagery. It usually occurs in the period just before sleep. An "hallucination" is similar to the memory image in that its occurrence is not dependent on sensory stimulation. The two differ, however, in that the "spontaneous firing" of cell assemblies often occurs in first-order cell assemblies in the case of the hallucination. This results in an hallucination often being confused with normal perception.

Hebb's conception of the memory image is very similar to Holt's (1964) "thought image." Holt defined the latter as:

"...a faint subjective representation of a sensation or perception without an adequate sensory input, present in waking consciousness as part of an act of thought. Includes memory images and imagination images; may be visual, auditory, or of any other sensory modality, and also purely verbal." (p. 255)

A distinction between memory imagery and imagination was made by Bower (1970). He defined imagination as the process by which memory images are manipulated and combined into

complex scenes. The present investigation is concerned with both types of phenomena.

Several authors (e.g., Holt, 1964; Sheehan, 1967a; Paivio, Yuille, & Madigan, 1968) have assumed that imagery can be representative of any of the sensory modalities. Sheehan (1967a) devised a questionnaire for rating the mental imagery associated with the visual, auditory, cutaneous, kinaesthetic, gustatory, olfactory, and organic sensory modalities. Davis (1932) gave subjects a variety of memory tasks and had them report whether they used visual, auditory, or kinaesthetic imagery in remembering the items. Bowers (1931) had subjects rate the imagery value of words which were presumably high in visual, auditory, or kinaesthetic imagery and then tested their retention of these items. Although Paivio, Yuille, and Madigan (1968) instructed their subjects to rate the imagery value of words on the basis of any of the sensory modalities, these authors have discussed imagery effects primarily in terms of visual imagery. Since their imagery norms are to be used in the present investigation, the present emphasis will also be on visual imagery.

#### Properties of Thought Imagery

Traditionally there has been little agreement on the defining criteria for when a person is having a "genuine"

mental image or how to compare imagery in different people. Weber and Castleman (1970) suggested that the reason some people report difficulty in experiencing visual imagery may be that they use different defining and decision criteria for the nature of an image. In the same vein, Skinner (1953) stated that it is difficult to teach people to have the same referent for names of private events. Bower (1970) asserted that people's introspections frequently may not be particularly valid since they often can be easily influenced by leading questions. Bugelski (1968), however, reported that his subjects exhibited strong resistance to accepting suggestions about the nature of their images.

In spite of his original assertion, Bower (in press) has also stated that the memory image of a visual scene is usually quite congruent with the original perception in terms of perspective, relative sizes, and locations of the objects. However, only part of the scene is "focused" as figure, the rest being indeterminate ground which may be filled in later much as is done in normal perception when one moves his eyes over actual scenes. Hebb (1968) made a similar analysis, stating that part-images are integrated sequentially through eye movements.

Even though an imaginary scene may be integrated through sequential ocular movements, Paivio (e.g., Paivio, 1969;

1970a; 1970b; Paivio & Foth, 1970) has stressed the spatial nature of imagery. He argues that visual imagery and visual perception are parallel-processing systems in that information is organized spatially rather than sequentially. The verbal symbolic system, on the other hand, processes information sequentially because of the temporal nature of auditory-motor speech system. Further, he views visual imagery as being specialized for the symbolic representation of concrete events, whereas the verbal system is capable of dealing with more abstract stimulus information.

Two opposing views with regard to the complexity of thought images have been proposed. Bower (1970) claimed that the information contained in a memory image is "largely conceptual, generic, schematic-hinted-at 'ghosts' of objects distributed about a schematic theatre space" (p. 502). Hebb (1968) stated that memory imagery lacks the completeness and vividness of normal perception and other types of imagery because it does not involve the activation of first-order cell assemblies. Paivio (1970a) suggested that images may be schematic rather than highly specific forms of representation. In contrast to these positions, Bugelski (1970) reported that his subjects' reports regarding their imagery were characterized by a great deal of extra detail such as

color, size, number, ownership, and direction. Reese (1970) suggested that extra details might be normally present in images and that such details might be essential to the effective utilization of images as mnemonics for memory.

#### Physiological Evidence of Imagery

Most scientists do not feel comfortable with speculations such as the above regarding imagery. Therefore, in studying "private events" such as imagery they usually attempt to obtain some sort of public measurement of them to supplement the subject's introspections. This, of course, has been done for many years in the study of emotions. Similarly, the relationship between eye movement (REM) and dreams has been investigated (Dement & Wolpert, 1958).

The relationship between eye movement and visual imagery was studied by Singer and Antrobus (1965). They found that minimal eye movements were recorded when the subject was instructed to form a visual image. However, when the subject was instructed to follow moving objects in imagery, eye movements increased. Bower (in press) reported a paired-associate (PA) learning experiment in which subjects were instructed to generate visual images of the nouns in each of the pairs. Some subjects were instructed to close their eyes and scan each image as they constructed it. Others were

told to fixate their gaze on a wall while constructing the images. No differences in learning were found between the two groups. Bower concluded that the relationship between eye movement and visual imagery was still uncertain and required further investigation.

Another possible measure of visual imagery is pupil size. Colman and Paivio (1970) proposed that although pupillary dilation is usually attributed to some form of emotional arousal, it may also be related to the difficulty of cognitive tasks. They required subjects to learn PA lists under either imagery mediation instructions, verbal mediation instructions, or no-set instructions. Under both of the former conditions, the magnitude of pupillary dilation decreased over trials while it remained about the same for the no-set condition. They interpreted these results as evidence that the latter task was more difficult. In addition, during the first trial when the subjects were forming either their imagery or verbal mediators, the latency of pupillary dilation was shorter for the imagery condition. Paivio and Simpson (1966) found greater pupillary dilation to abstract than to concrete words when subjects were instructed to generate mental images of each of the words. Pupillary dilation did not vary with word pleasantness-

unpleasantness. However, the problem of distinguishing imagery from other types of cognitive processing on the basis of pupillary dilation remains unresolved.

Several studies (e.g., Short, 1953; Barratt, 1956; Simpson, Paivio, & Rogers, 1967) have attempted to isolate distinctive EEG patterns that correlate with subjective reports of imaging. All of these studies found some correlation between reports of visual imagery and a suppression of the alpha rhythm, but none were able to identify the act of imagery as the single most important factor.

Both Holt (1964) and Bower (1970) reviewed several studies which attempted to link imagery with specific neurological structures. These structures included the reticular activating system, the temporal lobe, and the corpus callosum. Bower speculated on the basis of some suggestive studies that speech is interpreted, organized, and generated in the left hemisphere of the brain while similar functions involving nonverbal imagery occur in the right hemisphere. However, Bower (in press) concluded that the physiological evidence for imagery thus far obtained has not been notably useful in understanding the process.

#### Behavioral Evidence of Imagery

In contrast to the rather undeveloped state of physiological evidence for imagery, research on behavioral

indicants has been fairly promising. The following sections will describe this research in some detail and provide support for the position that imagery is a useful construct.

## IMAGERY AS A DIMENSION OF MEANING

### The Nature of Meaning

In the area of verbal learning and memory much research has been directed toward the problem of stimulus meaning. Stimulus meaning is usually viewed in terms of the overt or covert reactions elicited by a particular stimulus, i.e., these reactions are the "meaning" of the stimulus (e.g., Staats, 1961; Paivio, 1970a). In attempting to study the covert meaning responses, several different approaches have been taken. Following Watson's (1913) declaration that imagery is unimportant in thought, the dominant trend in psychology was to view explicit verbal behavior as a model for the presumed implicit verbal processes of thought (e.g., Deese, 1965).

With this assumption, it follows that the meaning of a stimulus can be determined by examining the verbal response which it elicits. Noble (1952) assumed that the more verbal associates a stimulus elicits, the more meaning it has. Therefore, he identified the stimulus attribute of meaningfulness (m) as the average number of verbal associates elicited by a word within a 60 second period. A similar

concept is associative frequency (Feuge & Ellis, 1969).

A widely held assumption has been that the m value of stimuli is one of the most important variables influencing learning and retention. That is, high m material is learned more quickly and is more likely to be remembered than low m material (e.g., Underwood & Schulz, 1960).

However, both the view that Noble's m is the best index of stimulus meaning and that it is an important variable in learning and retention have come under attack. Since it is a common finding that a number of different word characteristics covary (e.g., Frincke, 1968), it is possible that some stimulus attribute or attributes other than m may be equally or more influential in learning and retention.

Wimer (1963) noted that m, familiarity, and intralist semantic similarity have been reported to be the stimulus variables most strongly affecting the learning of paired-associates. She conducted a factor-analytic study in an attempt to determine the relative contributions of each of these variables. Her findings were that neither meaningfulness nor familiarity, as traditionally defined, were related to difficulty of learning, while associative similarity was

strongly related. However, she did identify a Meaningfulness factor that was related to learning. This factor appeared to reflect intensity of meaning rather than extent of usage and availability.

Other investigators have also suggested alternatives to production m as measures of stimulus meaning. Saltz and Modigliani (1967) found that dm (number dictionary meanings associated with a word) was more strongly related to learning than m. Staats, Staats, Finley, and Heard (1963) argued that meaning is best measured by semantic differential techniques, which they demonstrated as being independent of m. Palermo (1970) has also suggested that meaning and meaningfulness are different processes.

Paivio (1970a) has argued in favor of an expanded view of meaning. Generally, he views meaning as a series of transformations and elaborations of incoming stimulus information. This processing may take place at four different levels. The first level represents Neisser's (1967) "iconic memory" or Waugh and Norman's (1965) "primary memory." Both of these concepts refer to relatively untransformed information that is retained very briefly following stimulus input. Paivio views this stage as a zero-point along a scale of meaning reactions. The second stage is the representational level. Paivio assumes that symbolic

representations in the form of concrete images or implicit auditory-motor representations are stored in long-term memory. Incoming stimulus information activates these resulting in the implicit or explicit labelling of the stimulus. This level of meaning corresponds to "familiarity." The third stage, the referential level, refers to the associative connections between the imaginal and auditory-motor representations. These allow an object to be named or a word stimulus to elicit an image. The fourth stage of information processing is associative meaning. At this level either verbal or imaginal representations initiate a sequence of either intraverbal associations, imaginal associative chains, or both. The availability of each of these levels of meaning presumably can be discovered through latency measures.

#### Stimulus Attributes Affecting Learning and Retention

Paivio, Yuille, and Madigan (1968) noted that production m has been found to correlate with performance in verbal learning situations generally. They pointed out, however, that much of this research has involved relatively unfamiliar words or paralogues as low m items and that there is some uncertainty about the effects of m when varied among "real" words.

In a factor-analytic study correlating a number (27) of word attributes with PA learning and free recall (FR) scores, Paivio (1968a) identified six different factors: Concreteness-Imagery, Impressiveness, Familiarity, Specificity, Associative Variety, and Learning. The learning score variables had significant loadings only on the first and last of these factors.

Frincke (1968) used the factor-analytic technique to examine the relationships between Noble's m, rated meaningfulness, rated familiarity, Thorndike-Lorge frequency, trigram frequency, word goodness, evaluative polarity, and word length as well as their relations with free recall learning. Two common factors emerged: Meaningfulness-Familiarity and Imagery-Concreteness. Only the latter factor was related to the learning measure.

Paivio and his associates (see Paivio, 1969 for a review) have compared the effects of m and I in a variety of learning and memory tasks. The bulk of their studies have indicated that with m values of stimuli held constant, variations in I are significantly related to learning and retention scores. On the other hand, with I held constant, variations in m have negligible effects on these scores. On the basis of these results, Paivio suggested that a number of studies (e.g., Saltz, 1967) reporting a positive

relation between the m value of items and their learnability could have involved words varying in I. For example, Paivio, Yuille, and Madigan (1968) found a correlation of .72 between the I and m values of the nouns in their normative sample.

The stimulus attribute dimension of frequency-familiarity is a possible alternative measure of stimulus meaning. Saltz and Modigliani (1967) reported that the Thorndike-Lorge (T-L) frequency counts of words have been used as an operational definition of meaningfulness. Several studies have found a positive relation between frequency and at least some task performances. Winnick and Kressel (1965) found that high frequency (F) words, facilitated PA learning, but had an unclear effect on free recall. Murdock (1960), on the other hand, found a positive relation between F and free recall scores. Using a sequential-memory task, Lloyd (1964) found that F facilitated performance. Paivio and Madigan (1970) reported that F had a positive effect on the response side but tended to be negative on the stimulus side in PA learning. They suggested that low F stimuli are more facilitative in this task because the elicited imagery would tend to be unusual and less likely to suffer from interference.

In contrast to these findings, several studies have indicated that F had a negative effect on performance. Gorman (1961) discovered a negative relationship between F and recognition. She suggested that the high F words were more subject to interference effects than the low F words. Similarly, Paivio and Rowe (1970) found that subjects made more errors in a verbal discrimination task with high F items. Saltz (1967) reported that increased T-L frequency of stimuli resulted in significant decrements in learning rates for PA learning.

Several experiments have demonstrated that F bore no relation to task difficulty. Frincke's (1968) factor-analytic study yielded a Meaningfulness-Familiarity factor, but the free-recall learning measure did not have a significant loading on it. Paivio's (1968a) Familiarity factor was not significantly related to either PA learning or free-recall scores. Similarly, Wimer's (1963) Familiarity factor did not correlate significantly with difficulty of PA learning. Paivio (1967) reported correlational analyses which indicated that F was not a significant variable in PA learning or free-recall.

Other experiments have indicated that some of the effects obtained with F can be explained on the basis of other stimulus attributes. Paivio (1965), for example,

demonstrated that with either I or m held constant, the correlation between stimulus frequency (as measured by ratings of auditory familiarity) and recall in a PA task was approximately zero. In addition, Paivio, Yuille, and Madigan (1968) found a significant correlation between I and T-L frequency. Thus, it is possible, as seems to be the case with m, that some of the effects obtained with variations in F might actually be due to the covarying I attribute. While Rowe and Paivio (1970) reported that differences between high and low F words were significant in a verbal discrimination task, the effect was restricted to low I pairs. In contrast, in the remaining cases where F had no effect, I was strongly effective regardless of the F values of the items.

Nevertheless, there does exist a set of findings which indicate that frequency-familiarity is an important variable. In tests of perceptual recognition thresholds, either T-L frequency or rated familiarity have consistently been found to be the most highly correlated variables with ease of recognition (e.g., Winnick & Kressel, 1965; Neisser, 1967; Paivio & O'Neill, 1970). Variations in other stimulus attributes have been notably unreliable with regard to performance on this task. These results are congruent with Paivio's (1970a) analysis of meaning. That is, the initial

recognition of a stimulus or the "representational meaning" response is assumed to be dependent on the availability of a label for the stimulus. Frequency counts or rated familiarity seem to be adequate measures of such availability.

However, Paivio assumes that once the representational level of information processing has occurred, other processes become dominant. These are assumed to include intra-verbal and imaginal associative chains. Presumably, such associations or mediators are responsible for the level of performance on learning and memory tasks.

The problem remains, however, to isolate the relevant stimulus attributes that facilitate the formation of these associative chains. The stimulus dimension of concreteness-abstractness seems a likely possibility. As long ago as 1898, Calkins reported that concrete (C) words are remembered better than abstract (A) words. However, as late as 1961, Gorman noted that studies attempting to measure meaning had made little reference to a concrete-abstract dimension. Therefore, she constructed such a scale herself which included 1061 nouns that were classified by judges as being either concrete or abstract. The two types of items were distinguished on the basis of the directness of their reference to sources of sensation. She compared the two types of items in a recognition test and found greater retention

of the C words. She concluded that concreteness-abstractness is an important dimension of denotative meaning.

Concreteness has been found to correlate with performance in free-recall (Dukes & Bastian, 1966; Borkowski & Eisner, 1968; Bugelski, 1970), PA learning (Paivio, 1963; 1965; 1966; Winnick & Kressel, 1965; Dominowski & Gadlin, 1968), and verbal discrimination learning (Rowe & Paivio, 1971). Paivio (1969) has interpreted these results in terms of his imagery hypothesis. He claims that concrete words obtain their meaning through association with both concrete objects and other words. Therefore, they acquire the capacity to elicit both nonverbal images and verbal processes as associative or meaning reactions. Abstract terms, on the other hand, derive their meaning largely through intraverbal experiences and are likely to elicit only verbal associative chains. Thus, concrete words benefit from a dual code, whereas abstract words probably have only auditory-motor symbolic representations.

Yarmey and O'Neill (1969) presented a theoretical continuum of the image arousal capacity of stimuli. This includes, from highest to lowest: an object itself, a picture of the object, concrete specific words, concrete general words, abstract specific words, abstract general words, high association value (AV) nonsense syllables, and

low AV nonsense syllables. Although the generality-specificity issue has not been resolved (e.g., Paivio & Olver, 1964), numerous experiments have lent support to Yarmey and O'Neill's theoretical continuum as well as Paivio's dual coding notion in finding that ease of learning or amount of retention correlates highly with the predicted order (e.g., Lieberman & Culpepper, 1965; Paivio & Yarmey, 1966; Paivio, Rogers & Smythe, 1968; Sampson, 1969, 1970; Rowe & Paivio, 1971) although there have been exceptions (Brenner, 1940; Dominowski & Gadlin, 1968; Bugelski, 1970).

It might be argued that the facilitating effect concreteness has on mediation is entirely verbal since C words typically have higher m values than A words (e.g., Paivio, 1965; Winnick & Kressel, 1965). However, Borkowski and Eisner (1968) found that concreteness affected free-recall performance when varied independently of m. In contrast, m effects were only significant when degree of concreteness was not controlled.

Paivio, Yuille, and Madigan (1968) commented on several problems associated with Gorman's (1961) scale of concreteness-abstractness. First, her judges classified words on the basis of conventional dictionary definitions. It is plausible to assume that some of the definitions are

unfamiliar to subjects and therefore without significance with regard to the formal definition. Second, Gorman's two-point scale is unnecessarily restrictive. Finally, her scale lacked normative data on correlated attributes such as the m values of the words.

To circumvent these shortcomings, Paivio, Yuille, and Madigan had groups of subjects rate 925 nouns on a 7-point rating scale in terms of the concreteness-abstractness of each item. The definitions of concreteness and abstractness were similar to those used by Gorman. In addition, other groups either rated the items in terms of their imagery-evoking value (I) or wrote down verbal associates to each item for a 30 second period for a measure of m. The correlations between the concreteness ratings (C) and I were .83; with m, .56; and with T-L frequency, .12. All were statistically significant.

Paivio assumed in much of his earlier work (e.g., Paivio, Yuille, & Smythe, 1966) that C and I are measures of a common underlying process. The most likely one refers to the availability of a nonverbal imagery code. However, certain findings have indicated that C and I effects can be differentiated. Although Paivio, Yuille, and Smythe (1966) found that both C and I facilitated learning even when the other was controlled, they suggested that this might have

been an artifact of insensitive measurement. The normative data collected on these attributes by Paivio, Yuille, and Madigan (1968) permitted the inspection of items which differed on these two attributes. Of the 925 nouns in the sample, 51 were found to have I ratings higher than C by at least two scale units. These words were characterized by either strong emotional-evaluative connotations or were the names of fictitious creatures. Their common property seems to be having been associated with sensory experience but not specific things. In contrast, only 17 words had C ratings which exceeded I by at least two scale units. Most of these items have extremely low T-L frequencies. Thus, it may be that while these words are recognized as referring to concrete objects, their low I ratings are due to infrequent association with concrete sensory experience. Yuille (1968) demonstrated that C effects can be attributed almost entirely to the I value of a stimulus. He selected 20 of the 51 nouns that have higher I than C values and compared them with 20 nouns that were comparable in I value but had higher C values. Emotionality ratings were also obtained for each of the items. Partial correlations computed between PA performance and C with emotionality ratings partialled out indicated that C was not related to recall. Further

support for this hypothesis comes from observations by Paivio (1969) and Bugelski (1970) that some subjects can make effective use of imagery even with abstract items.

Although these results strongly indicated that I is one of the most potent stimulus attributes yet identified for learning and retention, it is possible that some other unidentified correlate of I might be responsible for the observed effects. Paivio (1969) has emphasized that his dual coding hypothesis and analysis of meaning in terms of levels are not intended as a complete theory of meaning. Rather, they have provided a theoretical framework which possibly may have a great deal of heuristic value.

## EFFECTS OF IMAGERY IN LEARNING AND MEMORY TASKS

Regardless of whether imagery per se or some unidentified correlate or correlates are responsible, variations in the I values of nouns have been found to have significant effects on learning and retention scores. However, a close examination of these findings should prove instructive in interpreting the basis of the effect.

### Imagery and Learning

Rohwer (1970) observed that the bulk of the research ostensibly involving imagery has been done with PA tasks. He further noted that this work can be categorized into two major strains of interest. The first includes studies in which the major focus of attention has been on the properties of the items themselves. Typically, these have contrasted high versus low I items, C versus A nouns, or picture or object material versus words. The second categorization includes those studies in which the effects of various types of instructions was studied.

Paivio (1969) noted that a common empirical generalization with regard to PA learning is that response factors

are critical whereas stimulus factors are relatively unimportant. This maxim, however, has come under question. A number of studies have found that C or high I nouns are learned more easily than A or low I nouns and that the effect is most significant when the C or high I nouns serve as stimuli rather than responses (e.g., Paivio, Yuille, & Smythe, 1966; Paivio, 1967; Paivio, Smythe, & Yuille, 1968; Yuille & Paivio, 1968; Paivio & Madigan, 1970). Both Paivio (1965) and Yarmey, O'Neill, and de Ryk (1968) reported that the four stimulus-response combinations involving C and A were learned in the order, C-C, C-A, A-C, A-A, in increasing order of difficulty. Yarmey and Thomas (1966) presented to different groups lists of either all A-A or C-C pairs. Then each group was given the opposite type of list. Under both conditions, learning was superior on the C-C lists.

Similar effects have been obtained in studies where C and A nouns have been paired with nonsense syllables (NS). Yarmey (1967) found that C-NS pairs were better recalled than A-NS pairs. Paivio and Madigan (1968) investigated the retention of pairs involving high and low I nouns and high or low association value nonsense syllables. They found that high I nouns, when serving as stimuli, consistently produced greater learning than low I nouns regardless of the type of

nonsense syllable as a response. When the nouns served as responses, a much smaller effect was observed.

At least one study, however, has not supported the generality of these findings. Yarmey and O'Neill (1969) found that while the learning of A-A pairs was significantly inferior, there was no difference between C-C, C-A, and A-C pairs. Nevertheless, it was discovered in an R-S test phase of the experiment that C items facilitated such learning to a greater degree than the A words.

Paivio (1969) has assumed that objects or their pictures represent the extreme end of the concrete-abstract dimension. In support, Iscoe and Semler (1964) reported that object pairs were easier to learn than picture pairs. Wimer and Lambert (1959) found that PA learning was easier when the stimuli were the actual objects rather than object names. Paivio and Yarmey (1966) studied the effect on PA learning when either pictures (P) or the names for the pictures (N) served as either the stimulus or the response. The order of difficulty for such items, from least to most, was P-N, P-P, N-P, and N-N. This is somewhat at variance with previous findings with regard to concreteness since they would indicate that the P-P pairs should be the easiest to learn. Dilley and Paivio (1968) also found better learning with P-N than with P-P pairs. A possible explanation

of this phenomenon suggested by the authors was that the requirement that the response be given verbally hindered the learning of pictures as responses because more time is needed to label a picture than to recall a noun.

Dominowski and Gadlin (1968) examined the rate of PA learning for picture (P), object name (ON) and category name (CN) pairs. These items did not differ in m value. The number of trials required to reach criterion was significantly different for each type of pair with P pairs being learned the fastest and CN pairs the slowest. However, presenting the appropriate picture along with ON and CN stimuli did not facilitate performance on either type of list.

As mentioned previously, the second category into which most imagery research fits involves the effects of instructions. Most such studies have examined the consequences of giving subjects different instructional sets such as imaginal mediation, verbal mediation, verbal repetition, or no set at all.

Several experimenters have reported that imaginal mediation instructions lead to greater PA learning than other sets. Bower (1970), for example, reported that imagery instructed subjects typically recall from  $1\frac{1}{2}$  to 3 times as many responses as no set subjects. In addition, Bugelski

(1970) and Hulicka and Grossman (1967) found that imaginal mediation subjects performed at a higher level than verbal mediation subjects. Bower (in press) reported an experiment in which subjects rated the vividness of the imagery which they used to mediate each pair. Subsequent recall data indicated greater recall for the more highly rated pairs. Both Bower (in press) and Yarmey and Barker (1971) have used a procedure in which the same subject uses imaginal mediation for some pairs and verbal repetition for others. Both experiments showed higher recall for the imaginably mediated pairs. Bower (in press) has also reported that subjects given both imaginal and verbal mediation sets perform better than those given only the verbal mediation instructions.

Several studies have investigated the interaction between noun concreteness and type of instruction. Paivio and Foth (1970) required the imaginal mediation subjects to draw a picture of their image linking each pair. Similarly, the verbal mediation subjects wrote down their mediating sentences. A subsequent recall test revealed that the imaginal mediation subjects performed better on concrete pairs whereas the verbal mediation group was superior on abstract pairs. Yarmey and Csapo (1968) gave subjects one of four instructional sets: verbal, imaginal, both verbal

and imaginal, and control (no set). All three of the mediation conditions facilitated learning, with no differences between them for concrete pairs. The verbal mediation group was superior to the imaginal mediation and control subjects on abstract pairs. However, in a post-session interview most subjects reported using imaginal mediators for concrete pairs and verbal mediators for abstract pairs. Paivio, Yuille, and Smythe (1966) asked subjects after a PA learning experiment which type of mediator they used for each pair. Imaginal mediators were reported most often for concrete pairs and verbal mediators for abstract pairs. Learning scores were highest for pairs presumably learned with imaginal mediation, intermediate for verbally mediated pairs, and lowest for non-mediated pairs. Paivio and Yuille (1967) instructed various groups to use either imaginal mediation, verbal mediation, or verbal repetition in learning PA items. Both mediation conditions resulted in higher recall than the repetition condition. The two mediation conditions, however, did not differ with respect to the retention of high or low I items. Post-learning interviews, however, indicated that the subjects did not uniformly follow a given mediation set with all types of pairs. This phenomenon of a changing associative strategy was examined

further in a study by Paivio and Yuille (1969). The instructional conditions were imagery, verbal mediation, rote repetition, and a no-set control group. Subjects were asked after one, two, or three trials about the type of strategy they were using. The imaginal and verbal mediation groups performed at a higher level than the other two groups only on the first two trials. Imaginal and verbal mediators were most often reported by the subjects given the corresponding instructions. The majority of the rote repetition subjects reported abandoning that strategy after the first trial. Regardless of the instructional condition, reports of the use of imagery mediators were most often reported for concrete pairs.

In contrast to the results of these studies, other experiments have revealed either no differences between imaginal and verbal mediation groups or that the latter was superior. Both Bower (1970) and Yuille and Paivio (1968) reported no differences between these conditions. Milgram (1967) had children learn PA picture lists under one of three conditions. The subjects in the visual compound condition were shown a special picture which combined each of the pair items. Verbal context subjects were asked to repeat a sentence containing each of the pair items. The

third group was a control. Both the verbal context and visual compound groups performed at a higher level than the controls, but the verbal context group was superior to the visual compound group. Likewise, Davidson and Adams (1970) found that children's PA learning was facilitated more by having the experimenter verbally connect each pair with a preposition than by showing the subject a picture with the items in a similarly interactive position.

Much of the above evidence with regard to PA learning appears to support the value of the imagery hypothesis. This is especially true with regard to item attributes. Although the data are more equivocal with regard to instructional effects, the majority of those studies showed at least equivalent effects for imaginal and verbal mediation instructions.

### Imagery and Memory

Memory techniques based on mediating imagery have a history dating back to the ancient Greeks (see Yates, 1966). A modern-day counterpart of such mnemonic systems is one based on a numerical rhyme scheme such as one-bun, two-shoe, three-tree, etc. In order to memorize a series of items, one generates an image including the item and the rhyming word. For example, if the first item to be remembered were

"horse," one might construct an image of a horse eating a hot-cross bun. Presumably, use of the technique results in greater retention of the items than would normally be the case. Typically, a series of items are presented and the subject is later asked to repeat them in what is essentially a free-recall situation. Paivio (1969) has argued, however, that the use of the rhyming scheme changes the situation into a PA learning task.

Bugelski (1968) compared the retention of lists of words by subjects who were taught a mnemonic rhyme scheme with that of subjects who were not given such instructions. The subjects were tested by being asked for the words by number in a random order. The level of retention for the experimental subjects varied little from the first to the last list given. Control subjects, on the other hand, exhibited a tendency to have alternating high and low scores throughout the sequence. The experimental subjects showed consistently superior performance on all lists. Following the last list, the subjects were asked to recall the items in all the lists that had been presented. Again, the experimental subjects were superior. An examination of these data revealed that the mnemonic group recalled about equally well from all the lists whereas the control subjects' recall

was mainly from the last two lists. Verbal reports obtained following the experiment disclosed a much higher incidence of imagery reports by the experimental subjects.

Paivio (1968b) tested the effect of imagery instructions and the concreteness of the mnemonic rhyme on recall. Different groups received mnemonic instructions, with or without reference to the use of imagery, and training on either a concrete or abstract rhyme. The imagery-mnemonic group was told to construct images containing the rhyme words and the to-be-remembered items. A verbal mnemonic group was instructed to repeat to themselves the rhyming words and presented items. The concrete rhyme was the same one used by Bugelski (1968). Its rhyming words are relatively concrete and have high I values. The abstract mnemonic rhyme included words such as fun, true, free, bore, etc. These words all had lower I values than the corresponding concrete-mnemonic words. The results indicated that the mnemonic groups given imagery instructions recalled more items than the verbal-mnemonic groups who tended to exhibit lower recall than control subjects. For the imagery groups, concrete and abstract mnemonic rhymes led to equivalent recall.

Wood (1967) has conducted a rather extended analysis of the contribution of mnemonic systems in free recall

performance, with the following results: (1) Groups given mnemonic instructions emphasizing either imagery or verbal associations showed higher recall than controls or groups told only to form images of each of the items. (2) Mnemonic groups did not exhibit the typical bowed serial-position effect whereas the other groups did. (3) Mnemonic groups made more intrusion errors than non-mnemonic groups. (4) Mnemonic groups showed improvement with practice, while the other groups did not. (5) Imagery- and verbal mediation-mnemonic groups did not differ in their performance in a negative transfer task (A-B, A-D). (6) Imagery- and verbal mediation-mnemonic groups did not differ among themselves in their recall of lists of either high- or low-interference words. (7) There was a tendency for concrete mnemonic rhyming words to produce greater recall than abstract words, but the effects of the two types of words did not differ for the imagery- and verbal mediation-mnemonic groups.

The effect of imagery has also been investigated in the more standard type of free recall experiment. As in the case of much of the PA work, this research has focused on the effects of stimulus attributes which are presumably related to imagery. A common finding has been that more words with high C or I values are recalled than are abstract

or low I words (e.g., Bowers, 1931; Tulving, McNulty, & Ozier, 1965; Winnick & Kressel, 1965; Dukes & Bastian, 1966; Paivio, 1967; Paivio, Yuille, & Rogers, 1969; Pavio & Madigan, 1970). In addition, several investigators have reported greater recall for objects or pictures than for words (e.g., Lieberman & Culpepper, 1965; Scott, 1967; Paivio, Rogers, & Smythe, 1968; Paivio & Csapo, 1969; Sampson, 1969, 1970). On the basis of these results, Bower (in press) concluded that the I values of words is one of the most potent attributes known for predicting free recall performance.

Similar results have been obtained in recognition tasks. Gorman (1961) reported higher recognition scores for concrete than for abstract words. Shepard (1967) found greater recognition for pictures than for words. Paivio and Csapo (1969) reported higher recognition scores for pictures than for concrete words, which in turn were superior to abstract words. This was only at a slow presentation rate, though. At faster rates, there were no differences between the three types of items. A further negative finding was reported by London and Robinson (1968). They presented drawings to children and then had them identify them in a multiple-choice recognition test. The

subjects were instructed to either visualize the items mentally or learn them by naming them. The latter group exhibited superior recognition.

Imagery effects in the Peterson and Peterson (1959) short-term memory paradigm have been investigated by several experimenters. Borkowski and Eisner (1968) found greater retention of concrete than of abstract words with retention intervals of both 3 and 18 seconds. Dominowski and Gadlin (1968) tested for the retention of pictures (P), object names (ON), and category names (CN) with retention intervals of 0, 3, and 18 seconds. No differences were observed between ON and CN items at the 0 delay, but pictures were significantly inferior to both, probably reflecting perceptual recognition threshold differences. With the 3 sec. delay interval ON items were superior to the other two types, which did not differ. The level of recall after an 18 sec. delay was equivalent for the three types of items. Wickens and Engle (1970), however, reported that the retention of high I words was superior to low I words after a retention interval of 20 sec.

Of the various memory tasks, imagery effects appear the weakest in the memory span or serial recall task. Equivalent recall for concrete and abstract words was

reported by Brener (1940) for such a task. Paivio, Yuille, and Rogers (1969) found a positive effect for I in this task, but it was only slightly greater than similar variations in m. Paivio and Caspo (1969) reported that the retention of picture stimuli was significantly inferior to that of concrete and abstract words in a memory span task. However, this was only at a fast presentation rate. With a slower rate, there were no differences between the three types of items. The authors concluded that imagery effects are significantly weakened in sequential memory tasks, especially if the presentation rate is fast. It would appear, then, that one of the chief values of imaginal mediation is that it produces greater organization of stimulus input. However, unless sufficient time is allowed for this, there will be more reliance on the auditory-motor representation system.

#### Presentation Rate

The interaction of presentation rate with presumed imagery effects has been studied by several investigators. Bugelski, Kidd, and Segman (1968) discovered that mnemonic-instructed subjects had greater recall than controls at 4 and 8 second per item rates, but not at a 2 second rate. Bugelski (1970) stated that subjects need from 4 to 8 seconds

to form a useful image. Further, he noted that subjects under self-paced conditions usually average about 7 seconds in forming images. Wood (1967) presented items at either a 2 or 5 second per word rate to imagery-mnemonic groups and subjects given standard recall instructions. Significant main effects indicated that both the 5 second rate and imagery-mnemonic instructions produced higher recall. However, a significant Rate X Instruction Condition interaction revealed that the mnemonic system strategy was superior only at the slower rate.

Several PA studies are also relevant to this question of presentation rate. Paivio (1969) reported a study by Gruber, Kulkin, and Schwartz in which it was found that imagery instructions facilitated recall at rates as fast as one word per second. Yarmey, O'Neill, and de Ryk (1968) examined the effects of recall rates, length of between-trial intervals, and noun concreteness on PA learning. The presentation rate was 2 seconds per pair. Recall intervals of 3, 5, and 8 seconds did not result in significantly different learning scores. Also, no differences were associated with 0, 10, and 60 second between-trial intervals. In addition, the effect of pair concreteness-abstractness did not interact with the length of the recall interval. Yarmey (1967),

however, found that the rate of pair presentation was a significant variable. Learning scores were higher with a 5 second per pair rate than with a 3 second rate. However, presentation rate did not interact with the concreteness of the pairs. Paivio and Csapo (1969) compared the retention of pictures, concrete words, and abstract words at two different presentation rates (5.3, or 2 items per second) in sequential (immediate memory span and serial learning) and nonsequential (free recall and recognition memory) tasks. Their findings were as follows: (1) Memory for pictures was inferior to words only in the sequential tasks, and then only at the faster rate. (2) Both pictures and concrete words were learned quicker than the abstract words in serial learning at the slow rate. (3) Pictures were superior to abstract words in both nonsequential tasks, with concrete words of intermediate difficulty in both cases. Further, Dornbush (1968) has noted that, with fast presentation rates, auditorily presented information is retained better than visually presented material. As the presentation rate is decreased, the retention of auditory information decreases while that of visual information increases until a point is reached (2 seconds per item in a study by Laughery

and Fell, 1969) at which there is no difference between the two modalities.

The findings with regard to the interaction between presentation rate and imaginal mediation appear to support Paivio's (1969) dual coding hypothesis. That is, with fast presentation of material, verbal processes are predominant. Several studies which supposedly measured the latencies of imaginal and verbal mediator formation lend support to this conclusion. Paivio (1966) and Paivio and Foth (1970) reported that the latencies for reports of verbal mediators were faster than those for imaginal mediators. A number of experiments (e.g., Paivio, 1966, 1970a; Dominowski & Gadlin, 1968; Paivio & Foth, 1970) indicated that both imaginal and verbal mediators are generated more quickly with concrete than with abstract words. However, Yuille and Paivio (1967; 1968) reported that the speed of forming verbal mediators was unaffected by the concrete-abstract dimension. Weber and Castleman (1970) compared the rates for imaginal and verbal processing of serially presented information. The subjects were required to either say the letters of the alphabet aloud, say the letters to themselves, or visually imagine each letter in turn. The results indicated that the subjects in both verbal conditions

processed about 6 letters per second while the visual imagery subjects could process only about 2 letters per second. Nevertheless, this suggests a latency for imagery formation on the order of .5 sec. Paivio (1970a) has data suggesting a comparable value. Both of these results appear to contradict the findings of the earlier studies which reported latencies of mediator discovery ranging from 2 to 10 sec. It is possible, however, that these differences reflect the different latencies associated with Paivio's (1970a) referential and associative levels of meaning. Nevertheless, it seems probable that the associative level of meaning is the most important for successful learning and memory performance. Thus, verbal processing would be the optimal strategy at fast presentation rates. With slower rates, however, it would appear imaginal processing would improve performance.

## ALTERNATIVE INTERPRETATIONS OF THE IMAGERY EFFECT

### Verbal Hypothesis

It might be argued that the alleged "imagery" effects in learning and retention can be explained more parsimoniously in terms of covert verbal processes. That is, imagery may accompany the implicit verbal processes that are "thought," but it certainly cannot be considered synonymous with thinking or memory.

There are several problems with such an hypothesis. First, there is evidence that people often remember information that they did not or could not have described verbally. Tulving and Madigan (1970), for example, point out that the recognition of faces and familiar scenes occurs without any apparent verbal mediation. Further, it seems unlikely that the storage of much spatial information could be handled by verbal processes alone. Second, the numerous studies showing higher retention or greater learning with concrete than with abstract words is difficult to explain within a strictly verbal framework. Many of these studies matched the two types of items on meaningfulness (m). Third, a number of the experiments found that subjects given verbal

repetition instructions actually performed worse than controls. Fourth, Bower (in press) noted that many uninstructed subjects spontaneously report the use of imagery for learning or remembering items. Finally, Paivio (1969) has noted that the classical behavioristic argument is that imagery is subjective and inferential whereas words are objective and manageable. Some of the most convincing evidence for imagery has come from studies in which various word attributes were the main focus of concern. Simply because the material used in most imagery studies has been of a verbal nature does not necessarily lead to the conclusion that the mental processes involved are also verbal. Implicit verbal processes of thought are no less inferential than imagery.

The argument that mental processes are strictly verbal cannot, however, be completely denied. Although the present evidence does not support such an hypothesis, it is possible that covert verbal processes are indeed the basic substrate of all mental activity. Nevertheless, the imagery hypothesis has had heuristic value. Many experimental results have been predicted which could not have been done with the verbal approach in its present state. Attempts to determine why the imagery effects are obtained should

lead to a better understanding of the processes involved in learning and memory. Several alternatives to Paivio's dual coding notion have been offered.

### Motivation

One possible explanation of the imagery effect is that imagery instructions increase the subject's motivation by making the task more interesting for him. Although there have been contradictory results (e.g., Wood, 1967), Paivio's (1968b) finding that imagery mnemonic groups outperformed verbal mnemonic groups would seem to refute the motivation proposition. Paivio argued that it is difficult to see how brief imagery instructions could increase the motivation of subjects to such a great extent when they had already received extensive mnemonic instructions and training. Further, Bower (in press) found that the incidental learning scores of imagery-instructed subjects were superior to the intentional learning scores for the same material by subjects not given imagery instructions. Both Bower (in press) and Yarmey and Barker (1971) found that subjects who learned some pairs by imagery and some by verbal repetition had greater recall of the imagery pairs. Finally, it is difficult to understand why concrete words should be any more interesting or motivating than abstract words.

### Stimulus selection

Another possibility is that concrete words have more incidental cues associated with them or that the imaginal scene used for a mediator contains more such cues than the corresponding verbal mediators. Bugelski (1968) stated that his subjects' imaginal reports were characterized by extra detail, and Reese (1970) suggested that such detail might be the component of imagery which makes it effective. Although it is difficult to experimentally control such variables, Bower (in press) did conduct a PA study which seems to dispute this notion. He found that subjects who had three-word compounds as stimuli performed worse than subjects who received only one-word stimuli.

### Stimulus distinctiveness

A third possibility is that either concrete items themselves or their associated imagery are more distinctive and easily differentiated than the corresponding abstract words or verbal mediation and that this is the basis for the effect. In order to test this hypothesis, Bower (in press) compared a typical imagery-instructed group with subjects who were told to generate an idiosyncratic, personalized descriptive phrase containing the elements in each of the paired-associates. The results showed greater learning for the

imagery-instructed subjects. However, Bower has also shown that subjects who generate their own verbal mediators perform better than subjects who are given similar phrases. Paivio (1965) tested the differentiation hypothesis by examining the associative overlap scores of concrete and abstract words. This measure refers to the number of associates that words have in common. No differences between the two classes of nouns were found. Yarmey and O'Neill (1969) equated the concrete and abstract nouns they used in their study on m, frequency, and word length. In addition, homogeneous word lists were used. They maintained that these controls would negate any stimulus distinctiveness factors, and, yet, the typical superiority for concrete words was found. Bugelski (1970), however, has noted that the imagery reports obtained from subjects are typically idiosyncratic. Paivio (1969) has conceded that the differentiation hypothesis is an attractive theoretical possibility and that the area deserves more systematic research.

### Interference

A fourth possible explanation of imagery effects is that concrete nouns or their correlated imagery are inherently less subject to associative interference than are abstract words or verbal mediation. Either stimulus distinctiveness

or a higher rate of clustering for concrete words could be the mechanism responsible. Bugelski (1968) found that mnemonic-instructed groups exhibited little evidence of proactive inhibition. The performance of the control subjects, on the other hand, was characterized by alternating high and low list recall. He suggested that this might be due to high retention on one list interfering with the next list. The low retention on this subsequent list would consequently produce less interference for the next list, etc. Bugelski (1970) observed that retroactive inhibition was observed in mnemonic instructed groups only when the lists were presented in relatively rapid order. He concluded that the lack of interference in the imagery mnemonic groups was due to the subject's generating images of greater and greater complexity. This was viewed as being somewhat analagous to the clustering phenomenon. Wickens and Engle (1970) made a somewhat different analysis of the imagery effect. They argued that concrete items produce less interference than do abstract words because the latter are broader in meaning. They assumed this to be the responsible mechanism rather than the influence of any type of nonverbal imagery. Before this conflict can be resolved, it will be necessary to replicate Paivio's (1965) finding that concrete

and abstract words did not differ in associative overlap. On the negative side, Wood (1967) discovered that the performance of imaginal and verbal mnemonic groups did not differ on lists of highly interfering items. Both groups performed better on lists of low-interference words.

### Relational organization

In 1929 Kohler proposed that visual imagery aids associative learning because it permits pairs of items to be imagined as a series of pictures which constitute well-organized Gestalts. Bower (in press) has come to a similar conclusion. He stated that imagery is effective in PA learning primarily because the imaginal scenes place the items into a strong relational organization. As support, he reported an experiment in which some subjects were told to imagine a scene in which the elements of each pair were interacting in some way. Other subjects were told to imagine a scene in which each element of the pair was separated in space. The first group showed much higher recall than the second, which did not perform any better than verbal repetition subjects would have been expected to. Bower concluded from this that imagery per se has little effect. The important factor is the interactive relation between the elements in the image. Similar findings have been reported

by Rohwer, Lynch, Levin, and Suzuki (1968) for verbal mediation. Mediating phrases in which the items are connected by verbs and prepositions lead to greater recall than phrases which connect the words with conjunctions. Such parallels led Bower to the conclusion that both processes are governed by a common relational generating system.

In contrast with Bower's relational organization hypothesis is Slamecka's (1968) independence hypothesis. According to this hypothesis, recall is a function of the availability of items as units. This might be considered analagous to the stimulus distinctiveness notion. Several free-recall experiments are relevant to this issue. Scott (1967), Paivio and Csapo (1969), and Tulving, McNulty, and Ozier (1965) all found that clustering or subjective organization increased as a function of word concreteness or imagery value in support of Bower's position. On the other hand, Paivio and Madigan (1970), Paivio, Rogers, and Smythe (1968), and Paivio, Yuille, and Rogers (1969) did not find such an effect. Paivio's (1969) dual coding hypothesis includes features of both the organization and independence hypotheses. He assumes that the effect of concreteness on memory is a function of the availability of both verbal and imaginal codes. The greater availability of both codes in

the case of high-I words is assumed to increase the probability of recall of items as independent units, higher-order organized units, or both. Future research should indicate which of the three hypotheses is most useful.

## INDIVIDUAL DIFFERENCES IN IMAGERY

Watson (1913) justified his dismissal of imagery from psychology on the conclusion that "image types" could not be experimentally tested or verified. Further, Galton (1883) conducted a classic questionnaire study which revealed that some people report having no imagery. Weber and Castleman (1970) have suggested that Watson was one of these and that he generalized "a personal defect into a universal principle" (p. 165). Bower (in press) has suggested that perhaps people who report having no imagery simply do not name as imagery the same private event that others do. Nevertheless, the common finding that subjects' introspective reports regarding the presence or absence of imagery did not correlate with memory performance (e.g., Carey, 1915), was one of the primary factors responsible for abandoning the study of the phenomenon.

The study of imagery has regained some respectability through positive findings with regard to stimulus attributes and experimentally manipulated mediators. In addition, some attention is being paid once again to individual differences,

but it has been one of the most neglected areas in imagery research. Sheehan has conducted most of the recent research in this area. His general method has been to classify subjects as being either vivid or poor imagers on the basis of an imagery questionnaire (Sheehan, 1967a; 1967b), present to them various visual patterns (similar to the Wechsler Block Designs), and then assess their ability to reconstruct the patterns with blocks. Some of the more significant findings from this work have been that a subject's rating of the vividness of his imagery for a particular pattern is highly correlated with the accuracy of the reconstruction (Sheehan, 1966); females report more vivid imagery than males (Sheehan, 1966); vivid imagers perform better than poor imagers on complex designs (Sheehan, 1967c); and the vividness of the reported images correlate highly with incidental memory (Sheehan & Neisser, 1969).

Ernest and Paivio (1969), on the other hand, defined imagery ability in terms of scores on a test of spatial ability. They found no differences between high- and low-imagery subjects in the learning of a PA list, but the high-imagery subjects were superior in incidental memory for irrelevant components of the pairs. In a second series

of experiments (Ernest & Paivio, 1970a), sex differences were examined. The results were somewhat confusing. On some tasks high imagery males performed better than low imagery males, while just the opposite was true on other tasks. Much the same type of finding was reported for females. A positive relation was found between imagery ability and intentional recognition, but equivocal results were obtained for intentional recall and incidental memory tasks. A third set of experiments (Ernest & Paivio, 1970b) investigated the relationship between imagery ability and stimulus attributes in an associative reaction time study. High imagery subjects had shorter latencies for mediator formation, but a predicted interaction involving imagery ability and stimulus attribute was not significant.

The most reasonable conclusion that can be drawn from these studies on individual differences in imagery is that either an appropriate test for differentiating different levels of imagery ability has not been utilized or that individual differences have only a weak effect in tasks supposedly involving imagery. However, this area has not received the same attention that others have, and judgement should be withheld.

## DEVELOPMENTAL ASPECTS OF IMAGERY

Bruner (1964) has maintained that visual percepts and imagery are the primary means by which the prelingual child retains information about his environment. A similar point was made much earlier by Carey (1915). According to this viewpoint, one might expect that children would exhibit imagery effects to a greater degree than adults. However, just the opposite has been observed in several experiments. Davidson and Adams (1970), London and Robinson (1968), and Milgram (1967) all found that instructions emphasizing verbal mediation produced better performance than instructions emphasizing imagery. Paivio and Yuille (1966) reported the typical superior learning of C-A over A-C pairs with children, but the difference was not as large as in the case of adults. Further, Dilley and Paivio (1968) reported an PA experiment with children in which pictures facilitated learning when they served as stimuli, but hindered learning as responses. Nevertheless, age trends have been observed with pictures and imagery instructions having a larger effect with older children (e.g., Rohwer, Lynch, Levin & Suzuki, 1968).

Various interpretations have been made of these results. Rohwer (1970) concluded that imagery is used by children, but to a lesser extent than by adults. He argued further, in contrast to Bruner (1964), that the capacity to use imagery codes effectively develops later than the capacity to use verbal processing. Reese (1970) favored an interpretation based on Bower's (in press) relational organization hypothesis. That is, young children are less able to encode an imaginal scene in which the elements are interacting. As Bower indicated, non-interacting images produce little facilitation of learning or memory. Paivio (1970a), on the other hand, has argued that the primary reason for weaker imagery effects in children is that most tasks require a verbal response. He proposes that children have more difficulty than adults in making the symbolic transformation from the mediating image to the verbal response. Partial support for this hypothesis has been provided in tasks where such transformations presumably are not necessary, such as recognition memory. Corsini, Jacobus, and Leonard (1969) reported that pictures were recognized more easily than names for the same pictures. However, Davidson and Adams (1970) also use a recognition procedure for testing PA learning, and they found verbal mediation instructions to be more facilitating than imagery instructions.

Part of the problem with imagery research in children has been a lack of standard procedures and materials in the various experiments. With closer attention to these variables (e.g., the development of norms similar to Paivio, Yuille, and Madigan's (1968) which are appropriate for young children), progress will probably be made in isolating the variables responsible for the weaker imagery effect in children.

## IMAGERY AND THE DEAF

Although Furth (1970) stated that the deaf are perhaps the least known and understood of persons with a physical handicap, a few investigators have recently noted that they constitute an ideal population for assessing the role of linguistic factors in a variety of cognitive tasks (e.g., Blanton, Nunnally, & Odom, 1967; Bugelski, 1970). Both Blank (1965) and Bugelski (1970) have pointed out, however, that it is difficult to obtain deaf subjects who have not been "contaminated" by language experience. Special education techniques often stress lip reading, vocalization of words, and other types of language development capitalizing on any residual hearing. Thus, their language deficiency might best be considered as only a relative deficiency.

Some studies of word association patterns in the deaf tend to support this point. For example, Koplin, Odom, Blanton, and Nunnally (1967) concluded that the word associations of the deaf are comparable to those of younger hearing subjects. Nevertheless, certain differences between deaf and hearing subjects have been identified. Blanton and Nunnally (1964) noted that the word associations of

the deaf tend to be more concrete or denotative and less evaluative than in the case of hearing subjects. Nunnally and Blanton (1966) reported that deaf subjects gave fewer associates than normals possibly suggesting that words are less meaningful to them. Further, the deaf tended to give more idiosyncratic associates. Finally, these authors noted that the deaf reported fewer associates that supposedly reflect subtle language learning (e.g., synonyms and completions) and more responses that could be based upon visual experience, such as spatial relations. Blanton, Nunnally, and Odom (1967) also reported a higher incidence of graphemic or orthographic associates by the deaf. In addition, these authors gave deaf and hearing subjects a rhyming test and a PA task in which graphemic, phonetic, and associative cues were varied. The normal subjects were far superior to the deaf on the rhyming test. On the PA task, the deaf were superior to the normal subjects on the graphemically-related pairs.

The results of these studies on word associate patterns in the deaf suggest that perhaps the deaf are qualitatively different from normals in their method of retaining information. Allen (1969) has suggested that the deaf have a primarily visual-tactile cognitive structure. Information

is retained through visual and other types of nonverbal rehearsal. In a PA study involving auditorily and visually similar pairs of words, the deaf subjects performed best on the visual pairs. Blanton and Nunnally (1964) found that the pronunciability ratings of items did not affect the performance of the deaf, but did that of the normals. Conrad and Rush (1965) examined the incidence of auditory- and visual-confusion errors in a short-term memory task. A high rate of auditory confusions were made by the normals. The deaf also made consistent errors, but along a dimension that could not be identified. Locke (1970), using a similar procedure, also obtained negative results in terms of the kinesthetic similarity of the dactylic (finger-spelling) representations of the words. At this point, therefore, the encoding modality used by the deaf remains in doubt.

It seems logical that the age of onset and extent of deafness would be important variables with regard to the encoding strategy used by a deaf subject. However, Allen (1970b) found that subjects with only a mild hearing loss (0-25 dB) showed the most dependence on orthographic attributes of stimuli. She suggested that this might be a demonstration of the effects of any degree of early hearing impairment without rehabilitation. Children with such a mild degree of hearing loss typically do not receive

special training whereas those with more severe impairments do. Nevertheless, she did find a positive relation between degree of hearing loss and dependence of visual characteristics of stimuli for the more severely impaired groups.

A number of studies have compared the memory performance of deaf and normal subjects. Blair (1957) compared the two groups on a variety of visual memory tasks. The deaf were superior to the normals on some tasks, equal on others, and inferior on some. Serial memory types of tasks were especially difficult for the deaf. Goetzinger and Huber (1964) reported that the performance of deaf subjects was equal to that of normals on an immediate retention task at two different presentation rates, but significantly inferior on a delayed retention task. Allen (1969) found no difference between the two groups on a Peterson and Peterson (1959) type of short-term memory task. However, the majority of studies (e.g., Hartman & Elliott, 1965; Olsson & Furth, 1966; Sterritt, Camp, & Lipman, 1966; Youniss & Furth, 1966) have found inferior performance with the deaf. Blank (1965) mentioned a number of explanations given for this outcome. They included language deprivation, instructional problems, matching problems, motivational and emotional variables, and the experiential restriction of the deaf child's early life.

## IMAGERY AND THE BLIND

In spite of Furth's (1970) assertion that the deaf are one of the least understood of the physically handicapped populations, there is a dearth of well-controlled studies on memory processes in the blind. Nevertheless, of the studies that have been reported, most indicate that memory is one of the strongest intellectual functions in this population. Olsson and Furth (1966) reported that blind adolescents had oral digit spans far above the average of their seeing peers. Tillman and Bashaw (1968) and Tillman and Osborne (1969) observed that the Digit Span subtest scores on the Wechsler scales were higher for blind than for normal subjects when they were matched on overall IQ. These authors suggested that the blind subjects are more attentive than normals on such tasks.

Although the relevant experiments seem not to have been conducted, the available results suggest that blind subjects encode information primarily in auditory form. For example, Enc and Stolurow (1960) found that the faster of two presentation rates was more effective for the learning

and retention of verbal material in a group of blind subjects. This corresponds to findings with regard to visual versus auditory presentation of material to normals (e.g., Dornbush, 1968).

Several studies have been conducted regarding the presence or absence of visual imagery in the blind. Singer and Streiner (1966) reviewed a number of these, noting that most have indicated that if blindness occurs before ages 5 through 7, visual imagery is absent from dreams. Blank (1958) reported that the content of the dreams of blind children consisted chiefly of conversations. However, well-controlled research in this area seem to be lacking.

Tillman and Williams (1968) reviewed several studies of word associate patterns in the blind. Much of this literature had indicated that blind children give more idiosyncratic and perseverative responses and fewer common responses than hearing children, suggesting that the blind have a restricted field of association. In the study conducted by Tillman and Williams, however, the performance of blind subjects on word association and word usage tasks was very similar to that of normal subjects.

## STATEMENT OF THE PROBLEM

Experimental manipulations involving instructional set and stimulus attributes have been found to affect the learning and memory performance of adults in a variety of tasks. Several authors (e.g., Paivio, 1969; Bugelski, 1970; Bower, in press) have argued that mental imagery plays an important role in many such tasks, although the importance of covert verbalization as a mediator cannot be denied. Experiments with children have not been as supportive of the imagery hypothesis. Rohwer (1970) and Reese (1970) suggested that the effective utilization of imagery might develop later than verbal mediation processes. Paivio (1970b) maintained that task requirements have negated the usefulness of imaginal mediation in the studies involving children.

Studies attempting to link individual differences in imagery ability with performance on other tasks also have not been notably successful (e.g, Ernest & Paivio, 1970a). However, progress in this area might be made by studying the possible role of imagery in the performance of special populations. Allen (1969) and Bugelski (1970) have suggested

that visual imagery might be the most useful mediator for deaf children.

The purpose of the present experiment was to investigate the role of visual imagery in the free recall performance of deaf, blind, and normal subjects. Paivio's (1969) dual coding hypothesis implies that normal people can encode information in either of two modalities, nonverbal imagery and auditory-motor (or articulatory) representation. Paivio suggested that the greater availability of such a dual code might explain the superior performance of subjects who are instructed to use imagery and the higher retention of words that supposedly elicit imaginal processes easily. Further, it might be assumed that the deaf exhibit a higher probability of encoding information in the form of visual imagery whereas the blind are more likely to store information in the form of auditory-motor representations. It is not unlikely, however, that both of these latter groups encode some information in both modalities, especially if their impairment is not congenital.

The present study attempted to provide support for the dual coding hypothesis by examining the effects of instructions and stimulus attributes on the performance of the three groups. Items selected from the Paivio, Yuille, and

Madigan (1968) norms served as stimuli. Homogeneous lists of either high or low I items which were matched on m value and T-L frequency counts were used. It might be argued that these norms are not valid for the deaf and blind populations. The I values of the words certainly might not apply if it is assumed that the blind encode information primarily in an auditory-motor form. Nevertheless, one of the goals of the present study was to verify that this is the case. It was predicted that deaf subjects would exhibit far greater retention of high I than of low I items since the former are presumed to be more easily encoded in the form of visual imagery. Normal subjects should also recall more of the high I items since they would be likely to be stored in both codes whereas the low I items might be stored only in the auditory-motor code. However, the differential retention of the two types of items should not be as discrepant as in the case of the deaf. That is, low I items can be stored in the auditory-motor code by normals, while this is less likely for deaf subjects. Further, the blind should show no differential retention for the two types of items since all of them are likely to be stored primarily in the auditory-motor code.

With regard to the m values of the items, it might be argued that the words are not as meaningful to the deaf and

the blind as they are to normals. This may be the case, but the absolute difference in level of performance between the normals and the other two groups was not the main focus of concern. Further, it might be maintained that the items are differentially meaningful to the deaf and blind populations. For example, high I words might be more meaningful than low I words to the deaf. If so, this would provide further support for the hypothesis that the deaf retain information primarily through nonverbal imaginal mediation. There is no a priori reason to assume that the two types of items are differentially meaningful to the blind, although it is possible that the blind may have had tactual and auditory experience with some of the objects represented by high I words. But such experiences (along with visual experiences) presumably are reflected in the normative m values that have been collected with normal subjects, and, yet, m value matches between the two types of items have been found.

An additional problem might be that the deaf and blind subjects, because of their restricted experiential background, are not familiar with some of the selected words. For example, Furth (1970) has noted that deaf children typically do not rise above a fourth-grade reading level. For this reason, words were selected only if they had a T-L frequency count considered appropriate for fourth-grade children by Thorndike and Lorge (1944).

The final variable to be considered was that of instruction set. Half of the subjects in each of the samples were instructed to make use of imaginal mediation. Previous research with normals has shown this to be a potent variable (e.g., Wood, 1967), although there have been exceptions (e.g., Bower, in press). It was expected that imaginal instructions would increase the retention of high I items relative to low I items in normals. However, this variable was not expected to influence substantially the performance of deaf and blind subjects, on the assumption that they would already be encoding information in the most effective code available to them.

## METHOD

### Subjects

The subjects were 40 college students, 20 deaf adolescents, and 20 blind adolescents. The deaf subjects were summer school students at the Texas School for the Deaf. Their mean chronological age was 14.60 years (SD = 0.88, Range = 13.6 to 17.3). IQ scores for the group were based on the Performance section of the WAIS or WISC. The mean IQ was 105.35 (SD = 9.41, Range = 85 to 127). A related measure was their performance on the Vocabulary subtest of the Gates-MacGinitie Reading Test. The mean grade level for the group was 2.90 (SD = 1.03, Range = 1.4 to 5.0). In 80% of the cases, the deafness was considered congenital. The age at which the hearing loss occurred for the remaining cases ranged from 18 months to 3 years. All of these subjects had a hearing loss of at least 60 db in the best ear based on pure-tone audiometric evaluations.

The blind subjects were summer school students at the Alabama School for the Blind. Their mean chronological age was 17.57 years (SD = 1.68, Range = 14.8 to 21.2). IQ scores for this group were based on the Verbal section of the WAIS

or WISC. The mean IQ was 101.70 (SD = 12.97, Range = 83 to 138). Scores on the Language subtest of the Stanford Achievement Tests yielded a mean grade level of 8.15 (SD = 2.60, Range = 2.4 to 12.7) for the group. All of these students were legally blind and were impaired to the extent that they were enrolled in Braille classes. In 70% of the cases, the blindness was considered congenital. The age at which the vision loss occurred for the remaining cases ranged from 8 months to 6 years. The extent of vision loss ranged from no light perception (50% of the cases) to being able to count fingers at a distance of six feet.

The college students were volunteers from undergraduate psychology courses at the University of Alabama. Half of this group served as a comparison group for the deaf subjects. These 20 college students had a mean chronological age of 20.74 years (SD = 3.47, Range = 17.4 to 31.4). The remaining college students, who served as a comparison group for the blind subjects, had a mean chronological age of 20.94 years (SD = 3.60, Range = 17.8 to 33.7).

### Stimuli

The stimuli were 210 words selected from the Paivio, Yuille, and Madigan (1968) norms. An equal number of high  $\underline{I}$  ( $\bar{X} = 6.07$ , SD = 0.53) and low  $\underline{I}$  ( $\bar{X} = 3.84$ , SD = 0.72) words were selected. High  $\underline{I}$  words were defined as those

with rated I values of 5.00 and above, and low I words as those with I values of 4.99 and below. Pairs of high and low I words were selected so that their m values were matched to within  $\pm 0.10$  and their T-L frequency count was approximately the same. The mean m values of the high and low I words were both 5.92 with SDs of 0.58 and 0.57, respectively. Words with T-L frequency counts of 20 occurrences per million words and above were used. Words with A ratings were assigned a value of 50 occurrences, and AA words a value of 100 occurrences. The mean T-L frequency count for high I words was 55.56 (SD = 31.18) and that for low I words was 55.81 (SD = 31.09). This difference was not statistically significant. Although the mean difference in the I ratings of high and low I words was 2.23, some of the pairs differed to a greater or lesser extent. The smallest pair difference was a value of 0.98.

The mean number of letters and syllables in the high and low I words was also assessed. The mean number of letters in the high I words was 6.06 (SD = 2.01) and 6.74 (SD = 2.10) in the low I words. This difference was not statistically significant. The mean number of syllables in the high I words was 1.99 (SD = 0.85) and 2.20 (SD = 0.93) in

the low I words. This difference was statistically significant ( $t(208) = 2.43, p < .05$ ).

Each of the words was randomly assigned to a list except for certain restrictions. First, each list was homogeneous in terms of I category. Second, for each list of high I words, a comparable list of their low I pairs was constructed. Thus, each high and low I pair occupied the same serial position within a list. Fourteen lists composed of 15 words each were constructed in this fashion.

The order of presentation of the lists was randomly determined except for two restrictions. First, no more than two lists of the same I category followed in sequence. Second, two different orders of list presentation were prepared so that they would be counterbalanced. After the first list order was determined, the second list order was constructed by reversing the position of each of the list pairs in the first order.

#### Apparatus and Procedure

Since Bugelski (1968; 1970) and Wood (1967) noted that imaginal mediation was most effective at slower presentation rates, the stimuli in the present experiment were presented at a 5 second per word rate. Both Bugelski and Wood found this to be within the effective range of presentation rates.

For the normal-deaf comparison, subjects were randomly selected and assigned to a group. Each of these groups were then randomly assigned to either imagery-instructed or standard free-recall instructed conditions and to one of the two different orders of list presentation. The subjects in each of these eight subgroups were tested simultaneously.

Half of the groups received the following instructions at the beginning of the experimental session:

This is a study of memory. You are going to see several series of 15 words which you are to try to remember. (As each word is presented, try to form a "mental image" of whatever the word represents. This will help you in remembering the words). After each series you will see the word "recall." Then the projector will be stopped and you will have 90 seconds in which to write down the words you have just seen. You can write the words in any order. That is, you need not remember the order the words are shown. Just remember as many as you can and write them on your answer sheet. You must not write on your answer sheet until the projector is stopped after each series. I will signal when the recall period is over and a new series is about to begin. Also, the word "ready" will appear on the screen. When you see this word, turn to a new answer sheet and attend to the screen.

The remaining groups received identical instructions except that the underlined portions of the instructions were omitted. A teacher at the School for the Deaf gave the instructions to the deaf subjects. The experimenter gave the instructions to the college students.

The stimulus lists were photographed on 16mm film, one stimulus item per frame, with additional frames inserted as a ready signal ("Ready") before the onset of each list and after each list as a signal for recall ("Recall"). During testing the film was shown to each group with a film-strip projector (L-W, Model 800) modified so that an electric timer automatically advanced each frame every 5 seconds. Following each trial (presentation of one list), the projector was stopped and subjects were allowed 90 seconds to recall the words, responding by writing them down on answer sheets.

For the normal-blind comparison, each of the subjects were randomly assigned to a given instruction condition and order of list presentation. All the subjects were tested individually.

Half of the subjects received the following instructions at the beginning of the experimental session:

This is a study of memory. You are going to hear several series of 15 words which you are to try to remember. (As each word is presented, try to form a "mental image" of whatever the word represents. This will help you in remembering the words). After each series you will hear the word "recall." Then you will have 90 seconds in which to repeat the words you have just heard. You can say the words in any order. That is, you need not remember the order the words are spoken. Just remember as many as you can and say them to me. You must not start saying the words until you hear

the word "recall." I will signal when the recall period is over and a new series is about to begin by saying the word "ready."

The remaining subjects received identical instructions except that the underlined portions of the instructions were omitted. Both sets of instructions were presented to the appropriate subjects by means of a tape-recorder (Roberts 770X).

The stimulus lists were presented to the subjects by tape-recorder with the same time limitations as for the above visual presentation. Prior to each list, the subject heard the word "ready" as a signal that the stimulus words were about to be presented, and, following each list, the subject heard the word "recall," signalling that the recall period was in effect. Both the 5 second inter-stimulus intervals and the 90 second recall periods were timed with a stopwatch during the making of the tape. Thus, once the experimental session began, the tape-recorder was not stopped. During the recall period, subjects reported verbally the words they could remember with the experimenter marking the correct responses on an answer sheet.

Under both the visual and auditory presentation conditions, the time interval between the onset of the last word in a list and the recall signal was 5 seconds. In the visual presentation condition, the duration of each stimulus was 5

seconds. In the auditory condition, each word was spoken only once although there was a 5 second interval between the onset of two successive stimuli.

## EXPERIMENTAL DESIGN

The data for the normal-deaf and the normal-blind comparisons were analyzed separately. The primary analysis in each case employed a Lindquist Type III design (Lindquist, 1956). Groups (Normal versus Deaf or Normal versus Blind), Instructions (imagery instructions versus standard free-recall instructions), and Imagery Level (High I versus Low I items) were the variables of primary concern. Instructions were varied between subjects while Imagery Level varied within subjects.

Additional analyses were conducted in order to examine two variables of secondary importance. First, the two orders of list presentation were examined for differential retention effects. Second, possible interactions between Groups, Instructions, or Imagery Level and Serial Position within a list were investigated.

## RESULTS

The data for the primary analysis were the total number of words recalled by each subject for each of the two types of stimulus items. Any reasonable spelling or pronunciation of a list item was counted as correct. Each score could range from 0 to 105, since 105 words of each type were presented.

A preliminary analysis was conducted to test for differential retention effects for the two orders of list presentation. t-tests indicated that the retention of both high and low I items in one order was not significantly different from the retention of the same items by subjects given the opposite order. This result was consistent across each of the four major groups. Therefore, the results for the two orders of presentation were combined in the following analyses.

The analysis of main concern was that comparing Groups, Instructions, and Imagery Level. Tables 1 and 2 present the results of these analyses. The analyses of variance indicated that the main effects of Groups and Imagery Level were significant in both the normal-deaf and the normal-blind

Table 1  
 Analysis of Variance of Correct Responses  
 for Deaf and Normal Subjects

Source	SS	df	MS	F
Between Subjects				
A (Groups)	35828.06	1	35828.06	120.45**
B (Instructions)	19.00	1	19.00	0.06
A X B	94.56	1	94.56	0.32
Error	10708.38	36	297.45	
Within Subjects				
C (Imagery Level)	3264.00	1	3264.00	122.12**
A X C	0.06	1	0.06	0.00
B X C	19.00	1	19.00	0.71
Error	962.19	36	26.73	
Total	50895.50	79		

\*p < .05

\*\*p < .01

Table 2  
 Analysis of Variance of Correct Responses  
 for Blind and Normal Subjects

Source	SS	df	MS	F
Between Subjects				
A (Groups)	2796.69	1	2796.69	8.18**
B (Instructions)	177.06	1	177.06	0.52
A X B	12301.56	36	341.71	
Within Subjects				
C (Imagery Level)	2194.56	1	2194.56	100.20**
A X C	465.50	1	465.50	21.26**
B X C	37.81	1	37.81	1.73
A X B X C	9.19	1	9.19	0.42
Error	788.44	36	21.90	
Total	18772.81	79		

\*p < .05

\*\*p < .01

comparisons. As expected, the normal subjects exhibited higher recall than either the deaf or blind groups.

There was also greater retention of high I than of low I items. The main effect for Instructions, however, was not significant.

None of the interactions in the normal-deaf comparison were significant. In the normal-blind comparison, however, the Groups by Imagery Level interaction was significant. This interaction was due to a relatively smaller difference in the retention of low-I items than of high-I items by these subjects.

Since the main effects for Instructions were not significant in either the normal-deaf or the normal-blind comparisons, the data for the imagery-instructed and standard free-recall instructed groups were combined in Figures 1 and 2. These figures exhibit the differential retention of the two types of items by the groups in both comparisons.

A post hoc analysis of serial position effects was made for both comparisons. The data for this analysis were the total number of words of each type recalled at each serial position by each subject. Each score could range from 0 to 7, since 7 words of each type were presented at each serial position. Two different strategies were used to assess the possible serial position effects associated

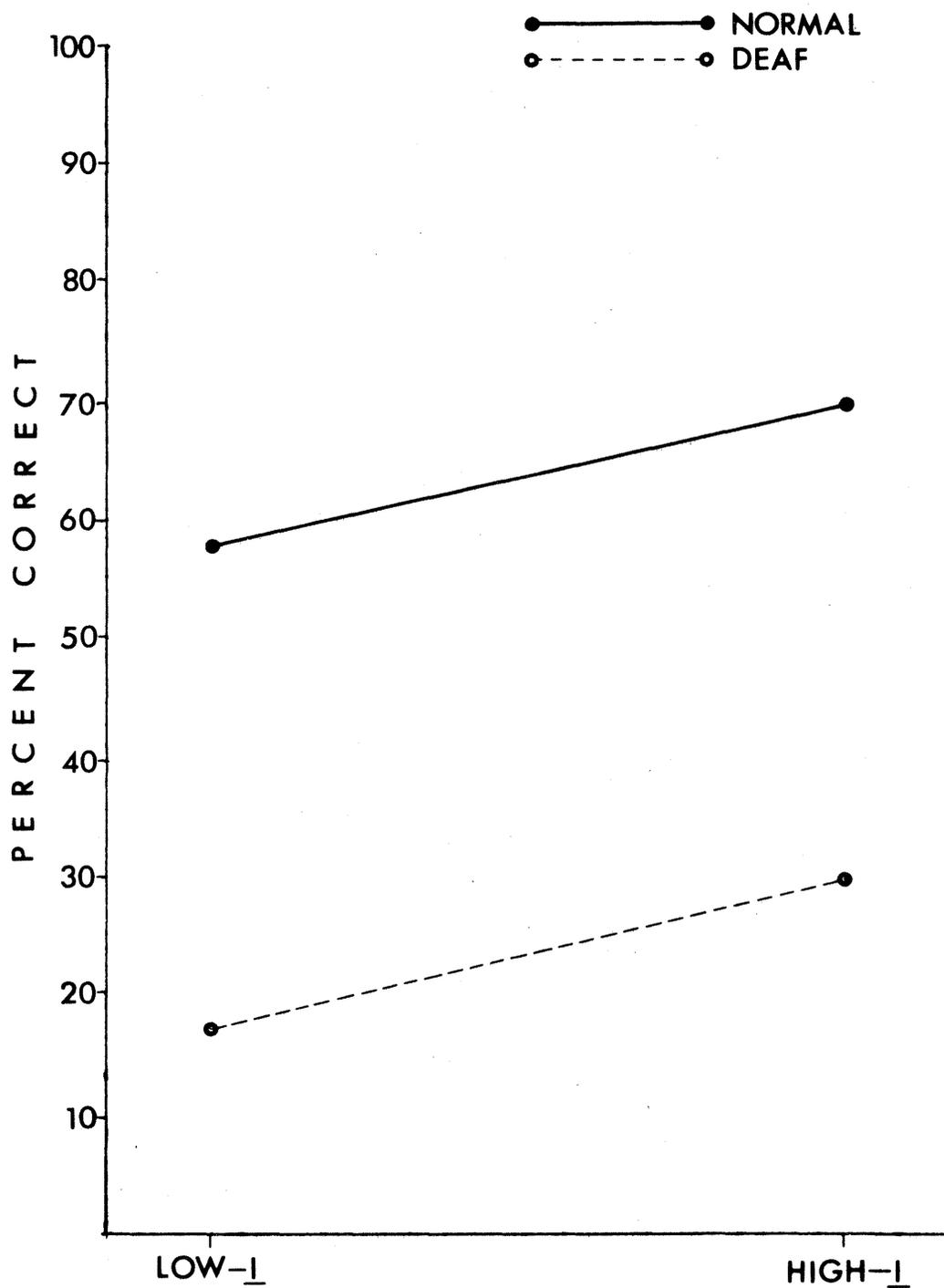


Figure 1. Mean percent correct recall for high and low I words by normal and deaf subjects.

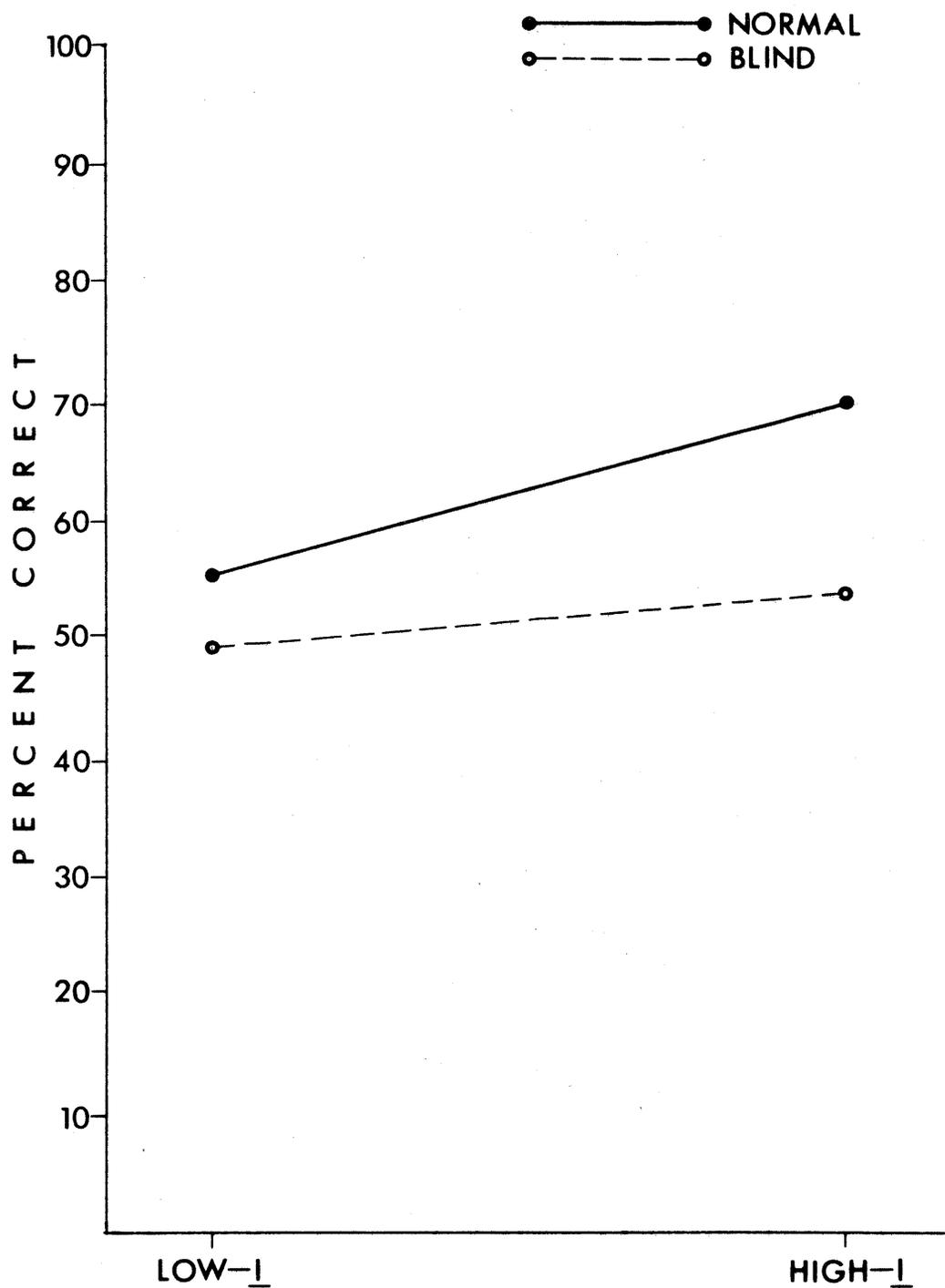


Figure 2. Mean percent correct recall for high and low I words by normal and blind subjects.

with the Groups and Imagery Level variables. First, possible interaction effects between Imagery Level and Serial Position for a given group was examined. Second, possible interaction effects between Groups and Serial Position for either high or low I items was investigated.

The first strategy involved the use of a Treatments X Treatments X Subjects design (Lindquist, 1956). That is, both Imagery Level and Serial Position were within-subject variables. The results of this analysis were consistent across all four groups. In every case there was a significant interaction between Imagery Level and Serial Position. The critical F scores were as follows: Deaf-- $F = 9.57$ ,  $df = 14/266$ ,  $p < .01$ ; Normal (visual presentation)-- $F = 3.98$ ,  $df = 14/266$ ,  $p < .01$ ; Blind-- $F = 2.14$ ,  $df = 14/266$ ,  $p < .05$ ; and Normal (auditory presentation)-- $F = 3.60$ ,  $df = 14/266$ ,  $p < .01$ . Figures 3, 4, 5, and 6 exhibit this relationship. In all the figures it can be observed that high I items were recalled at a higher level at the earlier serial positions, with only small differences in the retention of the items at the later serial positions.

The second strategy involved the use of a Lindquist Type I design (Lindquist, 1956). Each analysis consisted of one between-subjects variable (Groups) and one within-subjects variable (Serial Position) for a given Imagery Level.

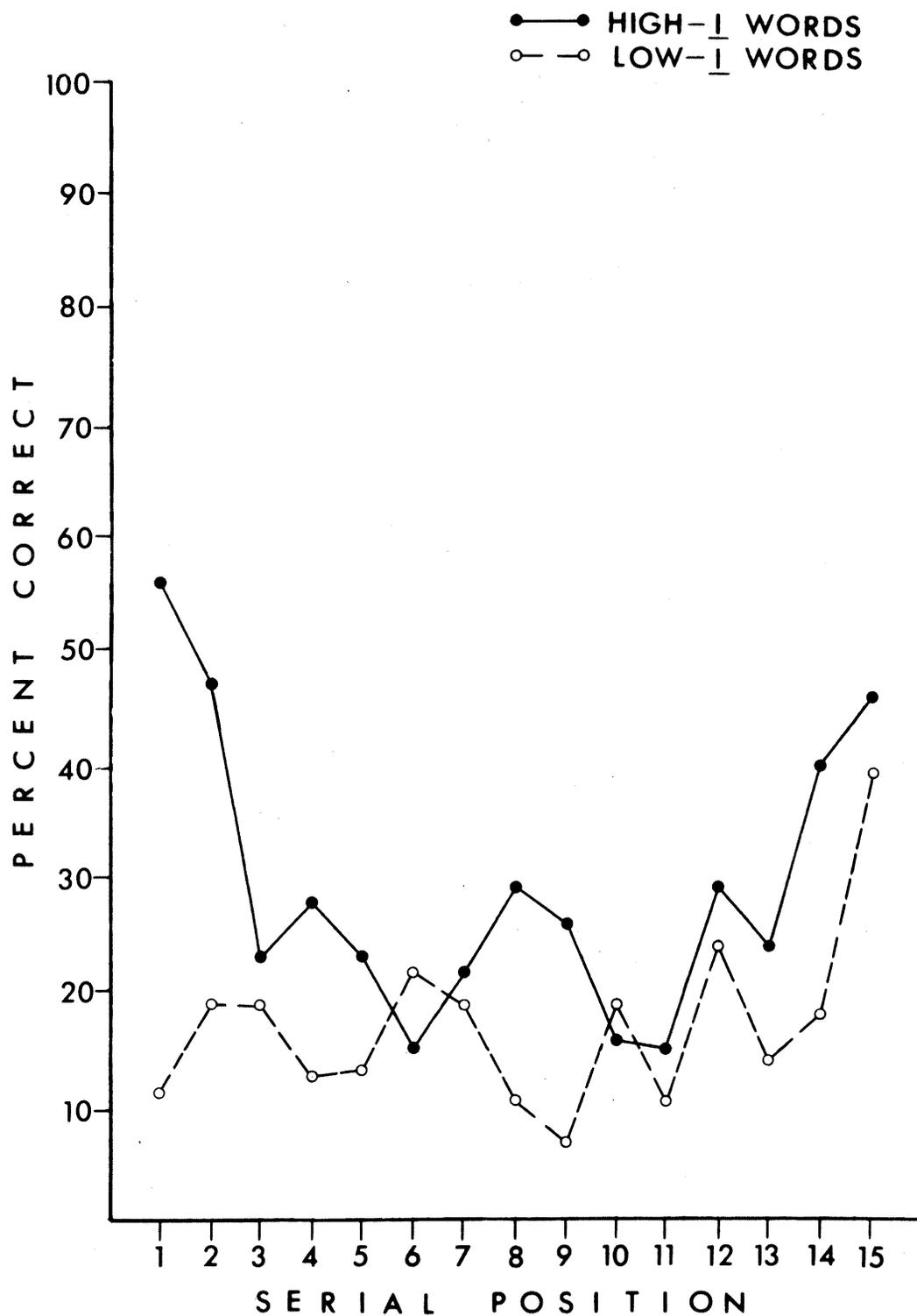


Figure 3. Mean percent correct recall by serial position for high and low I words by deaf subjects.

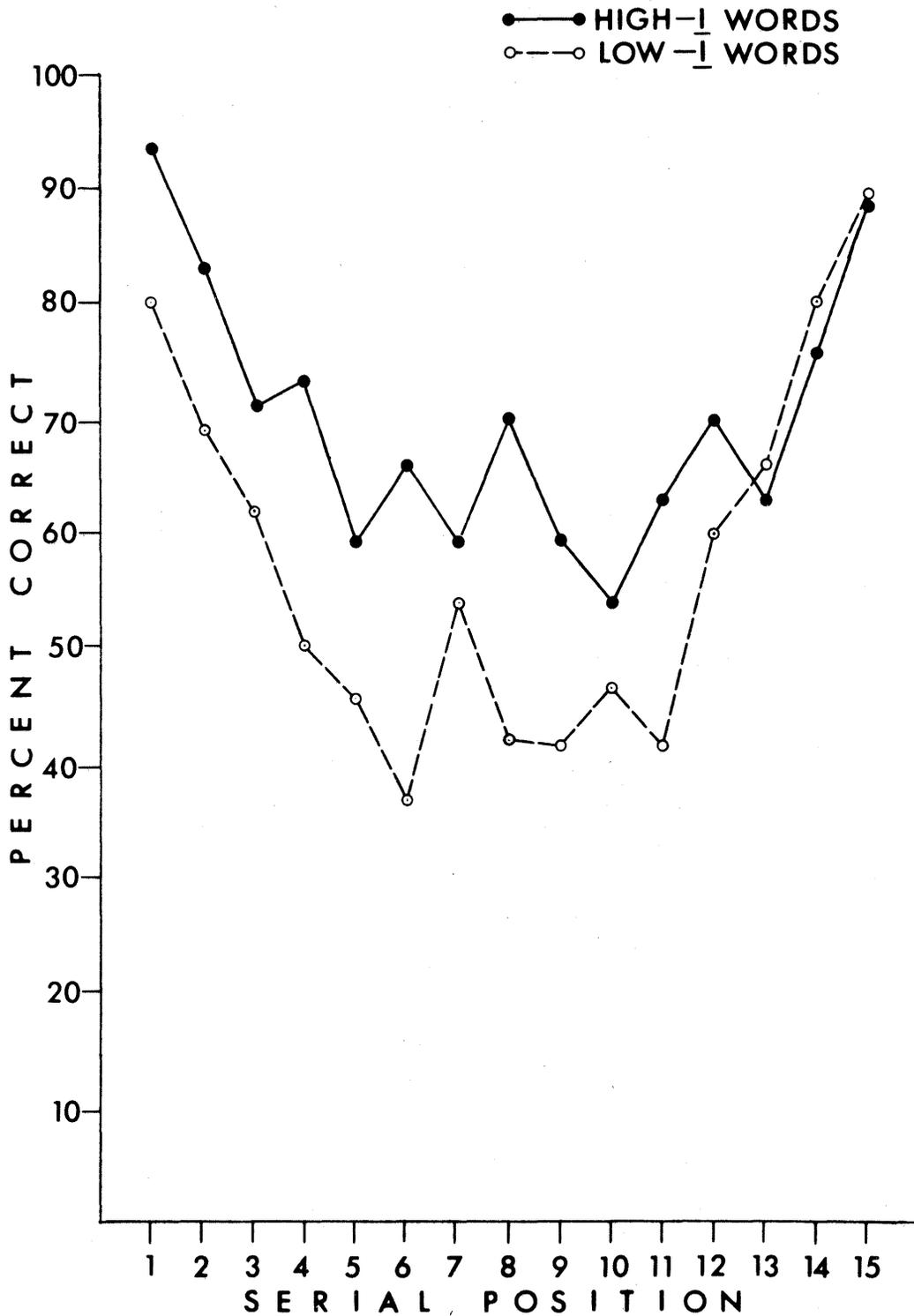


Figure 4. Mean percent correct recall by serial position for high and low I words by normal subjects (visual presentation).

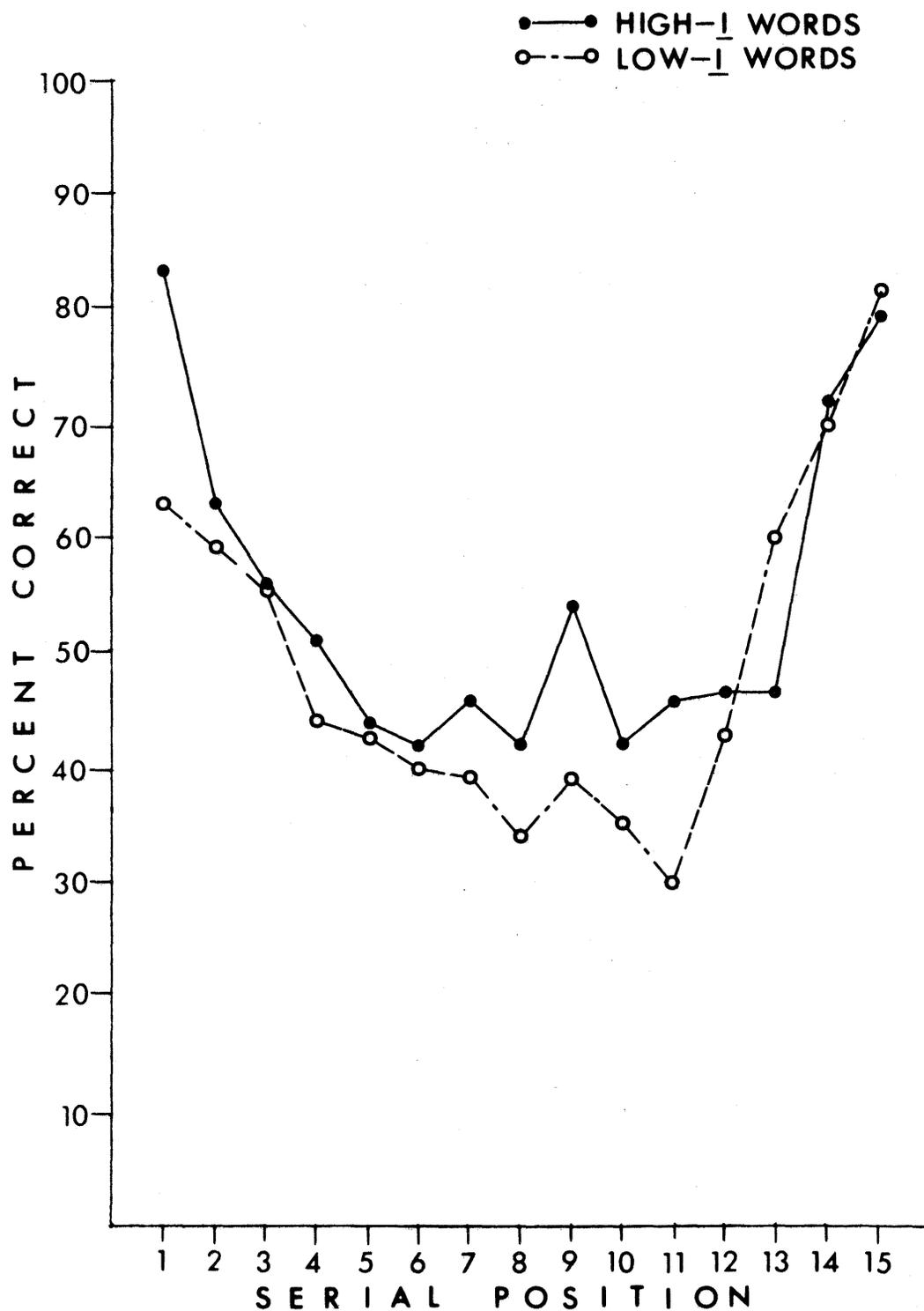


Figure 5. Mean percent correct recall by serial position for high and low I words by blind subjects.

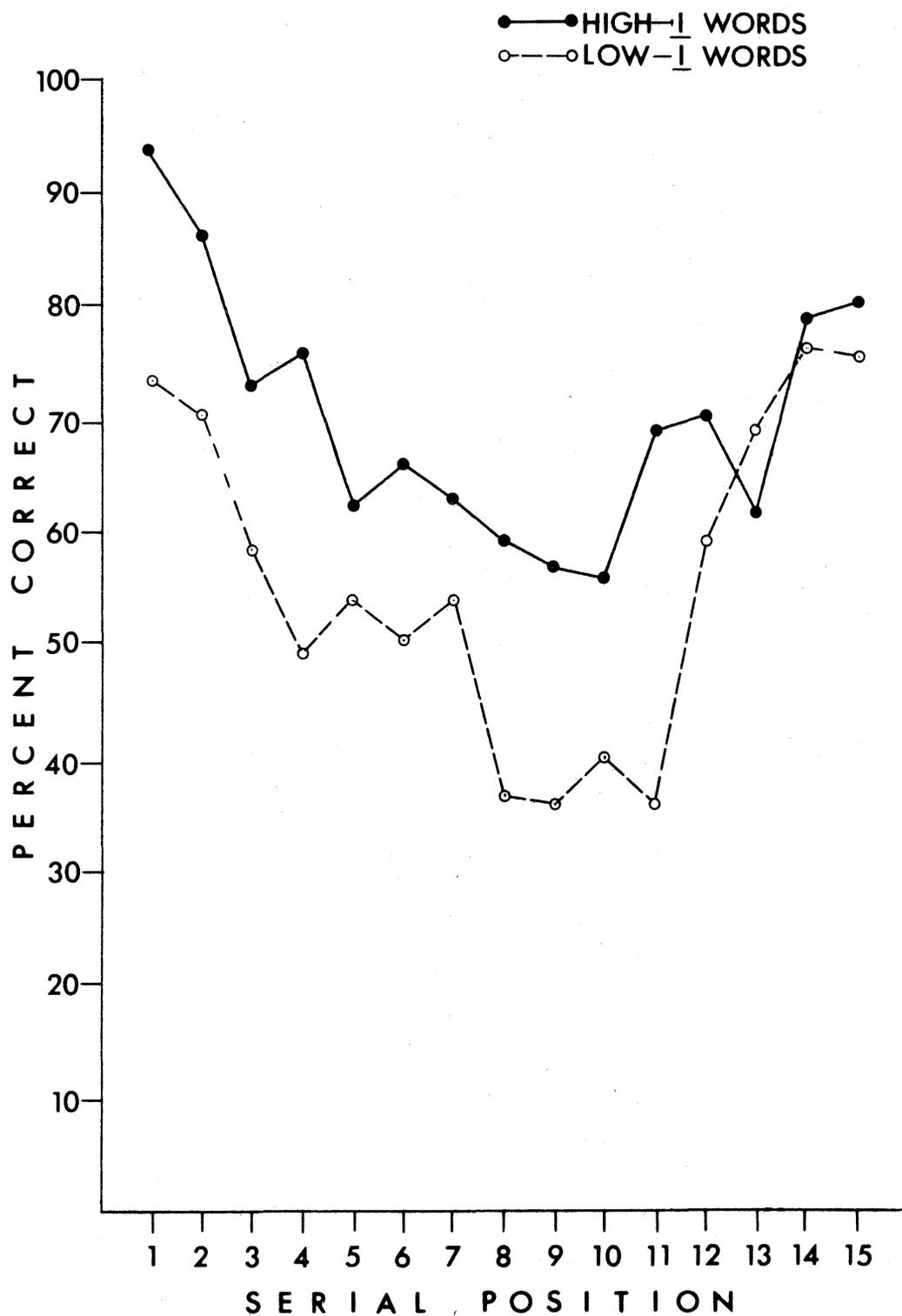


Figure 6. Mean percent correct recall by serial position for high and low I words by normal subjects (auditory presentation).

In the normal-deaf comparison, there was a significant interaction between Groups and Serial Position for low I items ( $F = 8.06$ ,  $df = 14/532$ ,  $p < .01$ ). This interaction can be observed in Figure 7. The normal subjects exhibited the typical U-shaped serial position curve while the deaf subjects performed at about the same level throughout the early and middle positions, with only a weak recency effect. However, the interaction between Groups and Serial Position was not significant with the high I items ( $F = 1.24$ ,  $df = 14/532$ ,  $p > .05$ ). Figure 8 shows the approximately parallel serial position curves for deaf and normal subjects for these items.

In the normal-blind comparison, there was a significant interaction between Groups and Serial Position for high I items ( $F = 2.77$ ,  $df = 14/532$ ,  $p < .01$ ). This interaction can be observed in Figure 9. The normal subjects were superior to the blind subjects in the earlier serial positions, while this difference tended to decrease at the later serial positions. The interaction between Groups and Serial Position was nonsignificant for the low I items ( $F = 1.28$ ,  $df = 14/532$ ,  $p > .05$ ). The serial position curves for blind and normal subjects for these items can be observed in Figure 10. The two curves were approximately parallel.

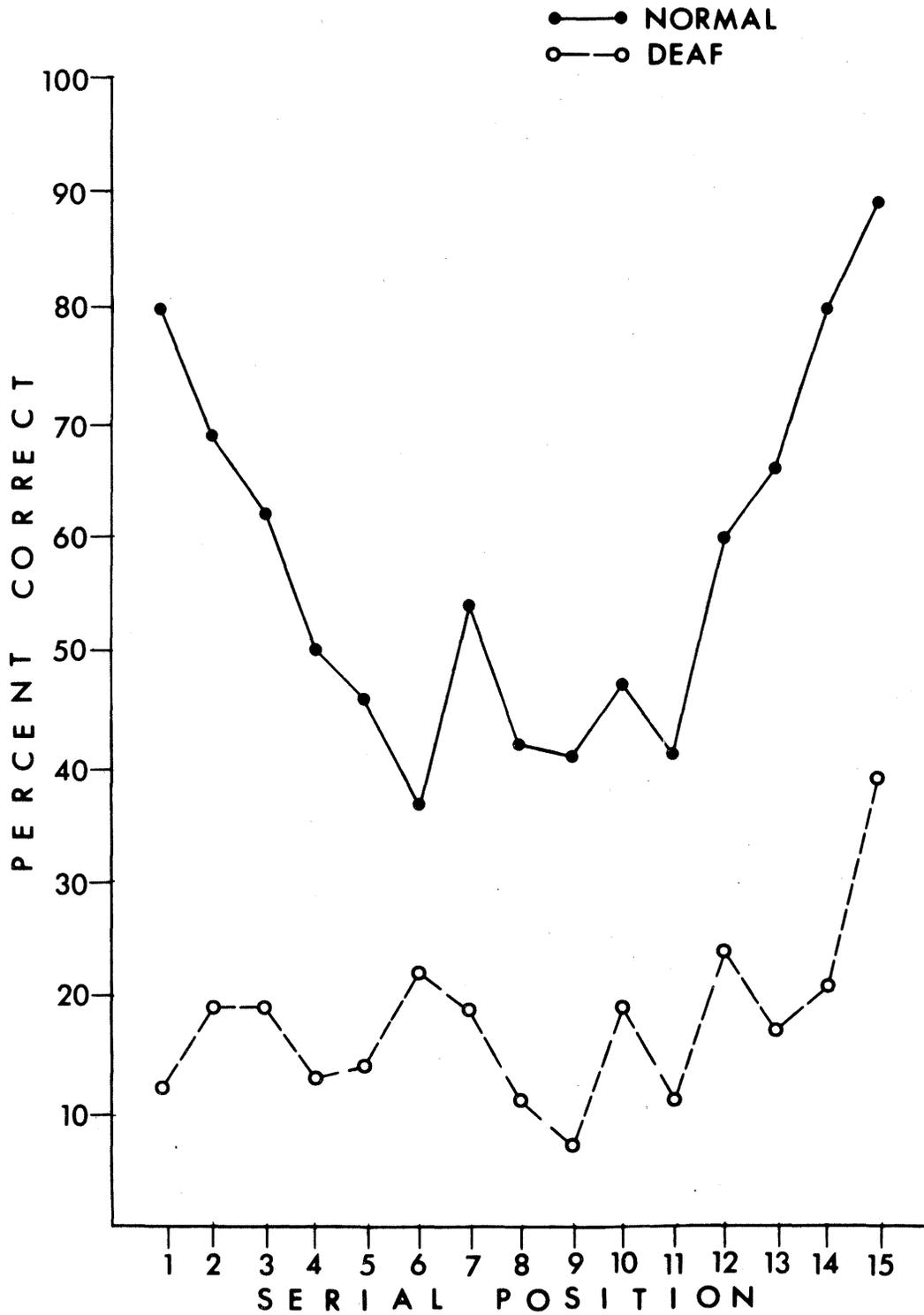


Figure 7. Mean percent correct recall by serial position for low I words by normal and deaf subjects.

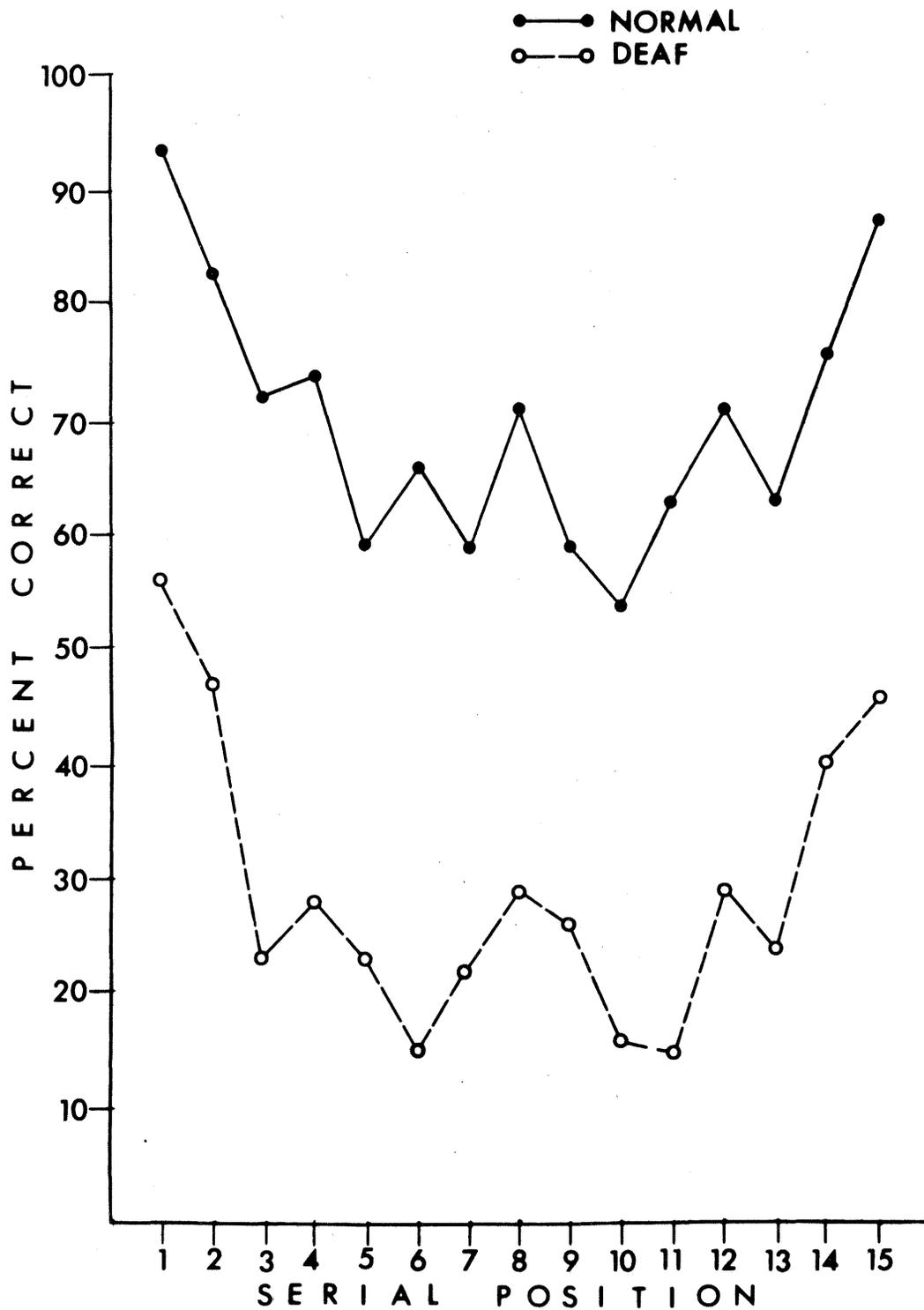


Figure 8. Mean percent correct recall by serial position for high I words by normal and deaf subjects.

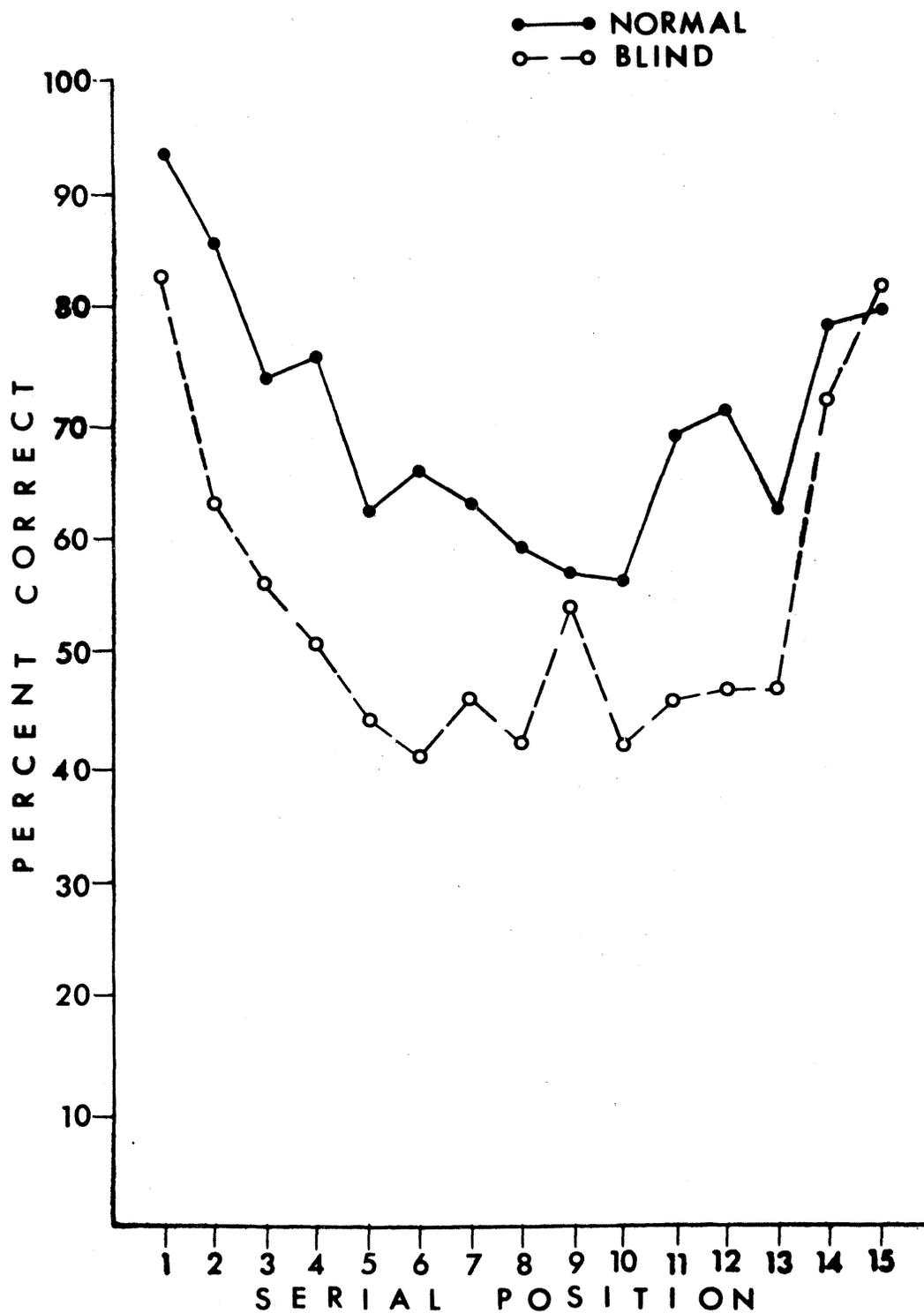


Figure 9. Mean percent correct recall by serial position for high I words by normal and blind subjects.

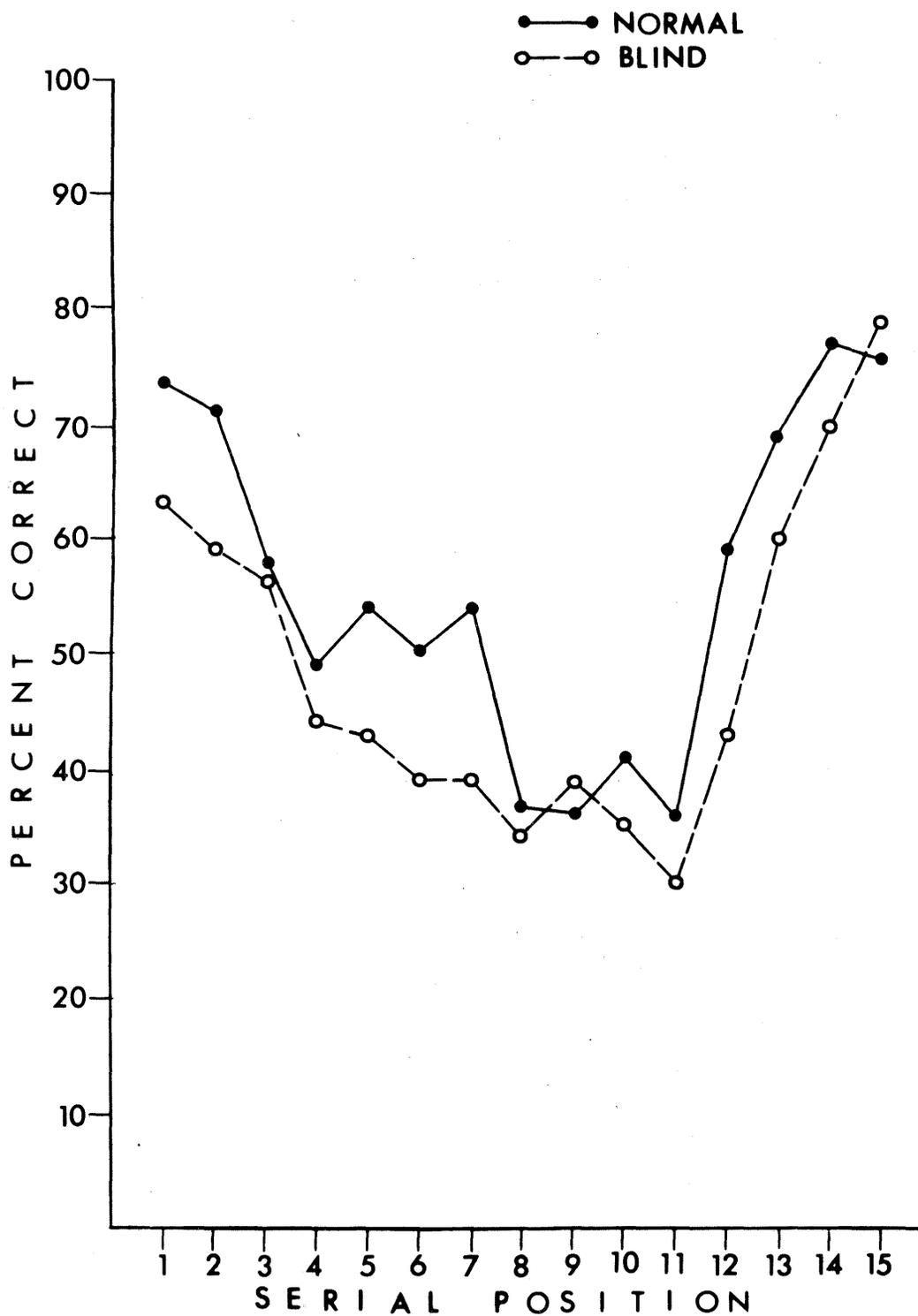


Figure 10. Mean percent correct recall by serial position for low I words by normal and blind subjects.

## DISCUSSION

The primary purpose of the present investigation was to test Paivio's (1969) dual coding hypothesis of information storage and retrieval. Assuming the validity of the hypothesis, it would seem that deaf individuals would most effectively store information in a nonverbal code, whereas blind individuals would rely most heavily on an auditory-motor (verbal) code. Normal individuals presumably would store information in either or both codes. With this line of reasoning, it seems logical that a comparison of the memory processes of these groups would constitute a valid test of the hypothesis.

In the normal-deaf comparison it was predicted that both groups would exhibit greater retention of high I than of low I words. The results supported this prediction. Deaf subjects recalled 30% of the high I and only 17% of the low I words, while the comparable values were 70% and 58%, respectively, for the normals.

In both groups the superiority of the high I words was most evident at the earlier serial positions, with a relatively

smaller difference between the items at the later serial positions. Several interpretations of the primacy effect could be made. According to the dual coding hypothesis there is more efficient retrieval of the dually-coded high I words than of the singly-coded low I words in the case of the normals. With regard to the deaf it might be maintained that the high I words have a higher probability of being stored. However, alternative interpretations cannot be rejected. It might be that the high I words are either easier to rehearse, are less subject to proactive interference, or are less subject to decay than are low I words.

As for the smaller differences in the recency portion of the curve, Neisser's (1967) concept of echoic memory seems to provide an adequate explanatory model. This stage of information processing presumably lasts for a period of several seconds following stimulus input and is assumed to be primarily auditory in nature. Thus, no differences between high and low I words would be expected during this period. Such an interpretation can logically account for the performance of the normal subjects, but it is weak in the case of the deaf subjects. Nevertheless, there was a larger difference between the two types of words in the recency portion of the curve for deaf subjects than there was for normal subjects.

However, the expected interaction between these groups and the two types of words was not found when the total number correct for each type of item was analyzed. It had been predicted that the deaf would exhibit a larger relative difference in the retention of the two classes of words than would the normals. Although the serial position analyses were post hoc, the Groups X Serial Position interaction for low I words lends support to the dual coding hypothesis. Whereas the normals showed the typical U-shaped serial position curve, the deaf subjects exhibited an approximately equal level of recall across the early and middle serial positions and only a weak recency effect. It might be argued that the normal subjects were able to store these items in an auditory-motor code, while the deaf subjects had great difficulty in storing such information at all. In fact, there was a floor effect with these subjects. Further, the nonsignificant interaction between these groups and serial position for high I words suggests that there is a greater relative difference between the retention of the two types of words for deaf subjects than for normal subjects. It may be that collapsing across serial positions covered up the predicted interaction between Groups and Imagery Level where the data were the total number of each type of word recalled. Also, the floor effect observed in the deaf subjects for

low I words may have contributed to the nonsignificant interaction. Nevertheless, the predicted interaction was not obtained which weakens somewhat the support for the dual coding hypothesis.

In the normal-blind comparison it was predicted that the normal subjects would exhibit differential retention of the two types of items but that the blind subjects would not. The results for the normal subjects in this comparison were very similar to those for the normal subjects used in the normal-deaf comparison. The normal subjects given auditory presentation of the material recalled 70% of the high I words and only 55% of the low I words. However, a significant difference in the retention of the two types of items was also found for the blind subjects. The difference was of a smaller magnitude, however, with 54% of the high I and 49% of the low I words being recalled. This result could be interpreted to indicate that the blind have some capacity to store information in a nonverbal code. In constructing their norms, Paivio, Yuille, and Madigan (1968) defined a mental image as "a mental picture, or sound, or other sensory experience." Since the blind presumably should have difficulty in generating a "mental picture," these "other sensory experiences" might account for the slight but reliable superiority of high I word recall.

As in the case of the normal (visual presentation) and deaf subjects, the superiority of the high I words for the normal (auditory presentation) and blind subjects was most evident at the earlier serial positions, with relatively smaller differences between the items at the later serial positions.

The predicted interaction between Groups (normal and blind) and Imagery Level was found when the total number correct for each class of word was analyzed. There was a relatively small difference between the two groups in their retention of low I words, but the normals exhibited far greater retention of high I words. This result suggests that both groups were primarily using an auditory-motor code for the storage of low I words. However, the normals apparently were able to make greater use of a nonverbal code as an additional storage system for high I words than were the blind subjects.

Although post hoc in nature, additional support for this hypothesis is provided by the serial position analyses. A significant interaction was obtained between Groups and Serial Position for the high I words. The normal subjects showed relatively greater performance at the earlier serial positions, while there was less difference between the groups at the later serial positions. Neisser's (1967) echoic

memory can once again be invoked to explain the recency effect. On the other hand, the additional use of a nonverbal code by normals seems to be a plausible explanation for the primacy effect. Further, the nonsignificant interaction between these groups and serial position for low I words suggests that both groups were encoding them in the same way.

Although some of the results of this investigation appear to support Paivio's (1969) dual coding hypothesis, the relatively higher performance of blind as opposed to deaf subjects suggests that the hypothesized auditory-motor code is more important for memory than is a nonverbal code. Although it is hazardous to try to compare the two groups directly since they differed in several respects and received different experimental treatments, such extreme differences indicate that a verbal code is of primary importance. While a nonverbal code may be the only one available to deaf individuals, it appears to function primarily as a supplementary coding system in normal individuals.

The final variable to be considered is that of instructions. It was predicted that instructions to form "mental images" of each of the words would facilitate the recall of high I words in comparison to low I words for normal subjects. Such an effect should have produced an interaction between instruction condition and type of word. No such interaction was predicted for the deaf and blind groups on the assumption

that they would only be able to store information in one of the two codes.

The results did not support the predictions for the normal subjects. Neither the main effect for instructions nor the interaction between instruction condition and type of word was significant. Similar results were obtained with the deaf and the blind groups.

Past research on instructional effects have been contradictory (e.g., Bower, 1970; Bugelski, 1970). Perhaps as Bower (in press) suggested, imagery per se has little effect. He argued that the elements of an image must be placed in some type of relational organization for memory or learning to be facilitated by this type of mediation.

The lack of an effect for instructions presents problems for the interpretation of the differential retention of high and low I words. Perhaps some uncontrolled stimulus attribute which covaries with I was responsible for the results. On the other hand, it is possible that both imagery instructed and standard free-recall instructed subjects were making supplementary use of a nonverbal code in the storage of high I words. The recall patterns of the deaf and the blind subjects provide indirect evidence that this might have been the case. Nevertheless, future research must focus on

controlling these possibly extraneous variables if the imagery hypothesis is to gain wider acceptance.

## SUMMARY

An experiment was conducted to test Paivio's (1969) dual coding hypothesis. On the assumption that deaf individuals would be most likely to store information in a nonverbal code and blind individuals in an auditory-motor code, differential retention effects were predicted for the two groups for words which presumably differ in the ease with which they elicit nonverbal imagery. Normal subjects, who should be able to utilize both codes, were also used in the comparison. In addition, half of each group of subjects were instructed to use imaginal mediation, while the remaining subjects were given standard free-recall instructions.

The results indicated that neither the main effect for instructions nor any interactions involving this variable were significant. However all the groups exhibited higher recall of high I words. This result had been predicted for the normal and the deaf, but not the blind subjects. Nevertheless, the predicted interaction between Groups (normal and blind) and the type of word was found. However, a comparable interaction in the normal-deaf comparison was not significant. Post hoc analyses of serial position

effects did provide some support for the dual coding hypothesis, but it must be concluded that the present investigation provided only partial support for the hypothesis.

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APPENDIX

Total Correct Responses for the Deaf Subjects  
for High I Words

Imagery Instructed Condition

Subject #	High I	Low I
1	41	20
2	35	16
3	30	13
4	41	29
5	53	34
6	35	23
7	32	20
8	28	17
9	11	7
10	15	7
Mean	32.15	18.50

Standard Free-Recall Instructed Condition

11	28	14
12	39	25
13	59	38
14	51	28
15	39	29
16	1	0
17	20	9
18	27	16
19	17	10
20	19	13
Mean	30.00	18.20

Total Correct Responses for the Normal  
(Visual Presentation) Subjects for  
High and Low I Words

Imagery Instructed Condition

Subject #	High I	Low I
1	65	45
2	68	57
3	68	53
4	68	44
5	79	67
6	63	68
7	79	56
8	69	60
9	85	69
10	80	66
Mean	72.40	58.50

Standard Free-Recall Instructed Condition

11	80	59
12	99	93
13	70	52
14	61	62
15	75	57
16	79	72
17	69	54
18	77	78
19	45	32
20	90	68
Mean	74.50	62.70

Total Correct Responses for the Blind Subjects  
for High and Low I Words

Imagery Instructed Condition

Subject #	High I	Low I
1	50	45
2	52	49
3	53	48
4	50	46
5	48	51
6	55	62
7	63	57
8	50	46
9	43	41
10	81	64
Mean	54.50	50.90

Standard Free-Recall Instructed Condition

11	70	59
12	70	63
13	89	82
14	37	36
15	80	61
16	37	28
17	41	32
18	48	40
19	71	60
20	49	54
Mean	59.20	51.50

Total Correct Responses for the Normal  
(Auditory Presentation) Subjects  
for High and Low I Words

Imagery Instructed Condition

Subject #	High I	Low I
1	69	50
2	60	40
3	71	55
4	92	74
5	63	53
6	59	39
7	67	63
8	77	64
9	82	61
10	75	70
Mean	71.50	56.90

Standard Free-Recall Instructed Condition

11	91	77
12	54	38
13	76	58
14	73	51
15	87	62
16	67	63
17	96	77
18	53	44
19	78	52
20	80	73
Mean	75.50	59.50