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Encoding And Retrieval Differences In Verbal And Nonverbal Processing

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ENCODING AND RETRIEVAL DIFFERENCES IN VERBAL AND NONVERBAL PROCESSING

by

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ABSTRACT

The purpose of the reported research was to investigate the organizational processes that determine how words and pictures are encoded into complex memory structures, and the effects of these processes on incidental recall. The research was motivated by theoretical considerations from Paivio's (1969, 1971) two process theory. The theory suggests memory processing is a product of the interplay between verbal and nonverbal coding systems. Involvement of these codes is operationally related to the image-arousal properties of the stimuli, i.e., the probability of nonverbal coding increases from abstract to concrete nouns to pictures. Moreover the organizational processes are presumed to differ for the two systems. The verbal system is assumed to be an ordered system in which linguistic units are organized by grammar in a sequentially constrained manner; whereas the nonverbal system is seen as relatively unconstrained and consequently organizes referent images synchronously. The three experiments presented all used the same paradigm. In the first two experiments sets of 2, 3, or 4 high or low imagery nouns were presented for encoding as images or sentences. Experiment 3 used pictures and their labels. The latency of encoding was measured. Following the encoding task, free recall was tested; in Experiments 2 and 3 cued recall was tested.

The encoding latency data replicated previous research in that concrete nouns were more rapidly encoded as images than abstract nouns (Experiments 1 and 2), and that image coding of pictures was

faster than for their noun labels (Experiment 3). A notable departure from previous findings that verbal encoding of single nouns or noun pairs was unaffected by stimulus imagery was obtained. When set size exceeded a pair, verbal encoding of concrete nouns was faster than for abstract nouns. This suggested that imagery was involved in sentence encoding. Consistent with this interpretation, verbal encoding latencies were found to be faster for pictures than for their labels.

Differences in organizational processes for encoding sentences and images were revealed as increases in set size were presumed to increase the degree of sequential constraint on encoding. Assuming that sentence encoding is a sequential process and image encoding a synchronous process, the prediction was that sentence encoding time should increase more dramatically than image time as set size is increased. Consistent with this prediction, in all cases the slope of the verbal latency function was significantly steeper than the image function.

Incidental recall predictions were based on the dual coding and image organization hypothesis. Dual coding allowed the prediction that conditions that facilitate the activation of two codes (image instructions and high imagery nouns) should produce better recall than single encoding conditions. In general, the results supported these predictions. In Experiment 1 recall was better for imagery encoded than verbally encoded nouns, and more high imagery than low imagery nouns were recalled; only a noun imagery effect was obtained in Experiment 2. The free and cued recall data from Experiment 3 was also found to be generally consistent with the dual coding hypothesis.

as conditions that were constructed to produce dual coding produced better recall than single coding conditions. The image organization hypothesis suggests that images are more integrated verbal structures. Consequently it was expected that the recall advantage of imagery conditions would increase directly with set size. No support for this hypothesis was obtained in the proportion of a set recall data.

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The purpose of this dissertation was to study the organizational processes that determine how words and pictures are encoded into higher-order cognitive structures, and the effects of these processes on subsequent memory performance. To date research has been primarily concerned with the effects of organization on memory performance. From this research two consistent findings have emerged: (1) recall and recognition are generally better for word lists that are presumed to be organized in accord with experimenter-defined associative or conceptual relations, as compared to memory for which no apparent organizational strategy is readily available; and (2) output organization as indexed by measures such as Intertrial Repetitions (Bousfield & Bousfield, 1966) is generally greater for conceptually or associatively related word lists than for "unrelated" words. While research has suggested that the locus of the effect of organization on memory is at storage (Tulving, 1964, 1968) or retrieval (Slamecka, 1968, 1969), little research, if any, has centered on determining the nature of the organizational process itself. For all intents and purposes, the organizational process has its origin at the encoding stage of information processing, i.e., when the stimulus information is transformed for storage in a new format. It is this stage in the information processing flow that this thesis is concerned about.

When faced with a situation that requires the novel organization of information, the subject must make use of existing memory structures and apply this "knowledge" to encode new higher-order cognitive structures. That is, the subject must use what he already knows about the just presented "new" information, and then integrate the old with the new to create a new organization. The present research was an attempt to investigate the process of organization at encoding. It was motivated by theoretical considerations of Paivio's (1969, 1971) dual coding approach to memory. Dual coding deals explicitly with the nature of encoding and organizational processes. It assumes that memory processing is the product of an interaction between distinct verbal and nonverbal (imaginal) representational systems. These systems are presumed to encode and organize stimulus information in different ways. The main purpose of this thesis was to investigate the effects of these postulated organizational differences on stimulus encoding.

Three experiments are presented in the thesis; all used the same experimental paradigm. In the first two studies, subjects were presented with sets of two, three or four nouns rated high or low on image-arousing capacity and asked to encode the nouns into compound images or meaningful sentences. The third study involved sets of pictures as well as words as stimuli. The time needed to encode a stimulus set was used as an index of encoding processes. The encoding latencies comprise the major emphasis of this dissertation. Following encoding, however, the subjects were also asked to recall the material. In the first experiment free verbal recall was assessed, whereas in the last two studies either free or cued recall was measured. The variables of interest in the present research were stimulus imagery (low and high imagery nouns, or pictures), instructional strategy, and the size of the stimulus set.

Predictions concerning the outcome of the experiments were made on the basis of dual coding theory as well as previous research. Predictions about encoding latency were made on the basis of the theory. Predictions concerning recall are based on generalizations from prior research that concerned differential performance as a function of the image-arousing capacity of the stimulus material and instructional strategy.

Although the theoretical and empirical emphases of the thesis are cast in the context of memory functioning, the research has more general implications pertaining to understanding the processes involved in thinking. Memory is essential to thought inasmuch as thinking clearly requires information processing in memory. A more complete discussion of the relevance of the present research to thought processes is provided later in the thesis.

The theoretical approach that guided the present investigations will now be described in more detail in order to establish a basis for prediction of encoding and recall performance.

THEORETICAL CONSIDERATIONS

This section will be concerned with a brief discussion of assumptions from the dual coding approach, and their empirical tests. Only the assumptions relevant to the present investigation will be treated. Discussion of theoretical alternatives to dual coding will appear later in the thesis with reference to the obtained data.

The Dual Coding Approach

The dual coding approach (Paivio, 1969, 1971) suggests that memory processing is the product of the interplay between imaginal and verbal representational systems. Imagery here is not limited to visual imagery but refers in a larger sense to nonverbal processing in other modalities, such as auditory, kinesthetic, haptic, olfactory, etc. According to Paivio, the two representational systems are seen as independent in that the same stimulus event can be coded in different formats; as a verbal representation in the verbal system and/or as an image in the nonverbal system. The two systems are further postulated to be interconnected or interfaced in the sense that the two systems "communicate" with each other. This interface can be understood by the observation that it is possible to output the verbal description of a nonverbal image, as is the case when describing from memory the contents of a room. The room description task typically calls up from the experience of visual imagery. The interconnectedness of codes is further illustrated by the ability to generate images from the verbal description, a process widely experienced when reading a novel describing environmental events or objects.

The involvement of these two cognitive systems has been theoretically and experimentally linked in part, to the abstractness-concreteness of the stimulus event. The verbal system is specialized for encoding, organization, storage, and retrieval of abstract relations, classes, linguistic units, and additionally it is the verbal cognitive structures that underly the generation of speech. Verbal cognitive structures are presumed to involve discrete sequentially arranged informational units ("mental words") that are only indirectly related to things. In contrast, the imagery system is viewed as an analog system (e.g., Arnheim, 1969; Attneave, 1972; Cooper, 1975; Cooper & Shepard, 1973; Paivio, 1974a, 1974b) which represents and processes relatively concrete information concerning objects and events.

While the systems are theoretically specialized in ways stated above, it should be noted that the verbal system is capable of dealing with both concrete and abstract stimulus information. The imagery system, however, deals primarily with concrete stimulus information although in some cases abstract information may be represented by imagery, but these imaginal processes are considerably less available. To summarize, two codes are available for concrete materials, but with increasing abstractness the verbal mode of representation is favored.

Empirical evidence for the assumption of verbal and imaginal code independence has been obtained by many investigators and in various paradigms. This evidence need only be briefly and selectively discussed here as it has been treated in detail elsewhere (see Paivio, 1975a).

At the neuropsychological level, memory performance of patients having undergone therapeutic surgical separation of the cerebral hemispheres (e.g., Gazzangia, 1970; Sperry, 1973) or lesions located in one hemisphere (Milner & Teuber, 1968) suggest that linguistic (verbal) processing is lateralized in one hemisphere, whereas nonverbal processing occurs predominantly in the other. Lateralization effects consistent with dual coding have also been obtained in studies in which verbal and nonverbal materials were selectively presented to the right or left hemispheres (Kimura, 1973) and when imagery instructions have been used (Seamon & Gazzaniga, 1973). Thus the evidence from various sources converge to suggest that verbal and imaginal processes are independent in the sense that they seem to be localized in distinct areas of the brain.

Studies using the selective interference paradigm (e.g., Brooks, 1967, 1968; Segal & Gordon, 1968; Segal & Fusella, 1970; Pellegrino, Siegel, & Dhawan, 1975) also provide support for the independence assumption. Memory and perceptual processing have been found to selectively interfere with one another in such a way that the interference is greater when both processes are assumed to involve the same sensory channel, than when different channels are involved. For example, Brooks (1968) found that reading (a visual process) interfered more with visual memory for prose passages conveying spatial relations, while listening interfered relatively more with verbal memory. These results suggest that interference with verbal and nonverbal memory processing is modality specific. Atwood (1971) extended this line of research by demonstrating that the recall of high imagery phrases was more impaired by a visually presented perceptual task than by an auditory task, whereas for low imagery phrases the reverse occured. Baddeley, Grant, Wright and Thomson (1973) failed to replicate Atwood's results. However, Klee and Eysenck (1973) found that the recall advantage of high imagery over low imagery sentences was reduced more under visual than verbal interference conditions. In general, the results from the selective interference studies indicate that the distinct perceptual-mnemonic channels are independent in the sense that memory processing can go on in one channel while concurrent perceptual processing is occuring in the other, but efficient perceptual and memory processing cannot occur within the same channel. Furthermore, the evidence is completely consistent with dual coding in suggesting two distinct memory processing systems, verbal and nonverbal.

Further evidence for the independence of codes has been obtained in tasks designed to look at the effect of item repetitions on recall (e.g., Paivio & Csapo, 1973). Previous research suggested the repetition paradigm could be used to induce differential encoding of the same stimulus event (e.g., Gartman & Johnson, 1972; Glanzer & Duarte, 1971: Madigan, 1969; Theios, 1972). Paivio and Csapo reasoned that if the coding of a repetition of a stimulus event is in a different symbolic modality (verbal and imaginal, or vice versa) additive effects on recall should be obtained, whereas nonadditive effect should be found if the repetition is coded in the same manner as the original stimulus event. In this context, additive effects on recall were assumed to provide direct evidence of independence of memory codes, whereas nonadditive effects suggest code interdependence.

The results of several incidental and intentional free recall studies in which dual coding was manipulated by the nature of the stimulus event (words or picture) or by orienting tasks theoretically linked to the two codes (imaging or pronouncing) were fully consistent with predictions. Additive recall effects were found under massed presentation (0-lag) only in conditions where dual coding was induced; nonadditive effects were obtained when the repetition was presumed to be coded in the same symbolic system as its initial encoding. The Paivio and Csapo study therefore provides strong evidence for the dual coding assumption of code independence.

Other investigators have, on the basis of their memory data, suggested the independence of imagery and verbal processes (e.g., Bahrick & Bahrick, 1971; Rowe, 1972; Nelson & Brooks, 1973; Snodgrass, Wasser, Finkelstein & Goldberg, 1974). Inferences of the same nature have been made from sentence memory studies (e.g., Begg, 1971; Begg & Paivio, 1969) in which memory for wording of high imagery, concrete sentences has been shown to be forgotten independently of memory for meaning.

As mentioned above, while dual coding presumes the codes to be independent, it further assumes that the coding systems are interfaced, i.e., interconnected. The assumption of interconnectedness implies that images can be encoded from word stimuli and that verbal descriptions can be generated from images. Of course imagery processes are relatively more direct in the case of concrete nouns which have objective referents, than for abstract nouns which may be only indirectly related to an object or event. Empirical evidence bearing on the interconnectedness assumption comes from studies in which the time to generate images or verbal associates to individual concrete and abstract words (e.g., Ernest & Paivio, 1971; Paivio, 1966) or word pairs (e.g., Colman & Paivio, 1970; Paivio & Foth, 1970; Yuille &

Paivio, 1967) was measured. These studies have consistently shown that the two kinds of associates occur equally quickly to concrete nouns, but images are formed more slowly than verbal associates to abstract nouns. No differences between abstract and concrete nouns have been found on verbal associative reaction time. Taken together, the data suggest that imaging to abstract words involves an extra mental transformation as compared to imaging to concrete words or forming verbal associates to either concrete or abstract nouns.

More central to the purposes of the present investigation are the postulated theoretical differences in organizational processes that characterize verbal and nonverbal systems. According to dual coding theory the verbal system is conceived of as an ordered system in which linguistic units are organized into higher-order sequential structures. The encoded verbal representation is postulated to be constrained in a sequential or successive manner by the rules of grammar. This type of sequential constraint has been called by others syntagmatic constraint (e.g., Jenkins, 1954; Saporta, 1955). The verbal representation is presumed to be organized sequentially in the sense that the orderliness imposed by grammatical rules does not permit free patterning of elements within the cognitive structure. Such constraint on verbal cognitive structures is reflected in meaningful linguistic output. For example, speech is a temporal process in that the acoustic signal and verbal output are sequenced, but also because the syntax that gives linguistic units their meaning involves sequential structure. There is flexibility in the ordering of verbal output only to the extent that permissible grammatical transformations can be used to say the same thing in a different way, or in the sense that synonyms may be substituted (paradigmatic relations; cf. Saussure, 1959). Note, however, that the information communicated in the temporal sequence is dependent, to a great extent, on the verbal context in which it is embedded. In this fundamental sense the verbal system must be viewed as a sequential processing system.

In contrast, the imagery system is assumed to be relatively unconstrained by grammatical rules and consequently organizes referent images into higher-order cognitive structures in such a manner that the representation is of a spatial or synchronous nature (cf. Paivio, 1975b). It is the freedom from sequential constraint that characterizes imagery as a dynamic and transformable process as opposed to the less transformable verbal process. Other investigators as well, have also characterized imagery as a dynamic and transformable process (e.g., Berlyne, 1965; Hebb, 1968; Piaget & Inhelder, 1966). In addition to the relative freedom from sequential constraint a further functional characteristic of synchronous organization is that the informational units within the cognitive structure are simultaneously available for retrieval, although retrieval itself may be serial due to limitations of the output system. Thus, in comparison to the sequential verbal system the imagery system can be a parallel processor in the operational as well as spatial sense (cf. Neisser, 1967).

To illustrate the above outlined organizational difference between verbal and imaginal representational systems consider the task of describing from memory the contents of a room. Typically, people report that they scan their image and proceed to describe the contents of the room from left to right. However, if you ask the person to start describing at the right or center of anywhere else in their image the responses appear to come equally quickly and efficiently. The right to left order of report usually found seems only to reflect a well over learned habit rather than any directional constraint in the system. The fact that retrieval can effectively begin at any point in the image suggests that the image is free of sequential constraint. In addition, the observation that responding appears to be equally rapid and efficient no matter where access to the image is made, suggests that the components of the image are simultaneously available. The illustration of the imaged room can be contrasted with an analogous verbal task cited by Paivio (1975b, p. 149). The task is one of reciting a familiar short poem. The task is easily performed if the recitation begins at the beginning of the poem, but becomes awkward if the person is asked to recite the poem backwards, or starting from the middle. The point of this last example is to suggest that the organization of a retrieval from the verbal system is constrained to an extent not characteristic of the imagery system. To summarize the theoretical organizational differences between verbal and nonverbal systems: the verbal system is characterized as a sequential processing system in which the organization of higher-order linguistic units is sequentially constrained by the rules of grammar. The imagery system is characterized as a parallel processing system in which referent images are organized into higher-order cognitive structures that are relatively free from the sequential constraint of grammar.

One implication of the above analysis is that imagery should be particularly beneficial in nonsequential memory tasks that require synchronous organization, whereas verbal processes should be superior in sequential memory tasks. Paivio and Csapo (1969) compared memory for pictures, high imagery nouns, and abstract nouns in serial learning, memory span (sequential tasks) free recall and recognition (nonsequential) tasks. The rate of successive presentation of stimulus items was also manipulated to experimentally control the availability of dual coding. The rationale behind the rate variable was that words could be read faster than objects could be named. Therefore at a sufficiently fast rate of presentation subjects could read a word (verbally code) but not have time to label a picture (imaginal code). At a slower rate dual coding was possible. Thus in the Paivio and Csapo study the availability of memory codes was varied by the type of stimuli (picture vs. concrete vs abstract nouns) and by the rate of presentation.

The specific predictions from theory were that at the fast rate memory for pictures should suffer relative to words in memory span and serial learning tasks, which require memory for order. Pictures, however, should not suffer at the fast rate in nonsequential free recall and recognition tasks since the verbal labels presumably can be retrieved to designate the contents of the imagery system. At the slow rate of presentation, where dual coding of pictures and concrete nouns can occur, memory for pictures should be better than memory for words, and concrete nouns should be remembered better than abstract. This pattern of results was expected in free recall, recognition and serial learning tasks, because dual coding, in general enhances the probability of retrieval. Furthermore, no differences would be expected between concrete and abstract nouns on any task at the fast rate since only the verbal code should be involved. On the other hand, a similar picture-word difference at the slow rate would not be expected in memory span since the task involves ordered recall from short-term memory. The results of the Paivio and Csapo (1969) study fully confirmed the expectations from theory and strongly suggested that information stored in the verbal and imaginal system is organized in very different ways.

Other studies involving comparisons of memory for nonverbal environment sounds (e.g., train whistles, telephone, etc.) and their verbal labels, in sequential and nonsequential memory tasks have been generally consistent with predictions from the dual coding theory (Paivio, Philipchalk, & Rowe, 1975; Philipchalk & Rowe, 1971; Rowe, 1974). These studies found memory for sounds to be inferior to their verbal labels in sequential memory tasks but not in free recall. Comprehensive discussion of these studies and others, some of which found data discrepant with dual coding, (e.g., Nelson, Brooks & Borden, 1973; Snodgrass & Antone, 1974) will not be attempted here as detailed treatment appears elsewhere (Paivio, 1975b).

The paired-associate learning paradigm also allows for a test of the synchronous-sequential organizational distinction of imaginal and verbal codes. In this paradigm the distinction relates to the issue of associative directionality. Predictions from theory are direct. If the imagery system organizes information synchronously (in an operationally-parallel manner; cf. Neisser, 1967) then recall of the response term of a pair of concrete nouns or pictures given the stimulus as a cue should be equally as effective as recall of the stimulus given the response as a cue, i.e., associative symmetry. On the other hand if verbally coded information is sequentially constrained, associative asymmetry should be observed with response recall exceeding stimulus recall.

Smythe (1970) tested the above predictions in a series of seven studies. In general, recall of concrete-concrete noun pairs and picture pairs was symmetrical i.e., stimulus and response pair members were equally good retrieval cues, whereas in the case of abstract-abstract pairs forward recall exceeded backward recall. These data are consistent with the findings of an earlier study by Yarmey and O'Neill (1969). Smythe's recall results were further supported, in the same study, by the finding that the latency of recall of concrete pairs was symmetrical with respect to cue type while asymmetry favoring forward recall was found for abstract pairs. In similar experiments Mondani and Battig (1973) replicated the essential aspects of the Smythe studies.

In a recent series of experiments using a variety of recall procedures Begg (1972, 1973) tested an important implication of synchronous-sequential distinction. He suggested that compound images could be integrated in the sense that multiple components of information are unitized in memory, whereas the same was not true for verbal structures. He reasoned that a compound image takes up no more storage space in memory than any of its separated components, and further that each component could redintegrate the whole when provided as a retrieval cue. Verbal representations on the other hand, being sequentially organized require more memory space in the sense that each discrete verbal item is presumed to occupy a separate storage space. The rationale behind Begg's storage space deduction was that if given the word "door" to image, it does not require any additional memory space to image a square door. Thus the image of the phrase "square door" exemplifies a single memory unit. On the other hand, the abstract phrase "basic truth" does not readily lend itself to similar integration. Instead, more storage space is required.

In support of the storage space hypothesis, Begg found that subjects could free recall proportionally half as many abstract words from abstract adjective-noun phrases or lists of individual words, than was found in the concrete phrase or individual word conditions. Thus, concrete phrases functioned as if they were unitary in memory and abstract phrases functioned like separated linguistic units. Begg (1972) also found that presentation of the adjective or the noun as a retrieval cue increased proportionate recall relative to free recall only with the concrete phrase. The suggestion from these results is that images and concrete phrases are integrated so that redintegration was made possible. In the abstract sequential case, the components behave as contiguity cues which have been shown to be ineffective cues for recall (Bregman, 1968). In another study, Begg (1973) found further support for imagery unitization by demonstrating that cued recall exceeded free recall when high imagery word pairs were stored as integrated images (cf. Bower, 1970) but not when the referents were imaged separately.

The research summarized thus far suggests that imaginal and verbal representational systems organize information differently. Moreover, the evidence is consistent with theoretical assumptions from dual coding suggesting that complex information is stored in the nonverbal system in the form of higher-order synchronously organized cognitive structures, whereas representation in the verbal system is sequentially constrained.

While the evidence is consistent with dual coding theory regarding the organization of stored information, little consideration has been given to the nature of the organizational process at encoding. One study involving the Brown-Peterson paradigm provided tentative evidence of differences at this information processing stage (Segal, O'Neill, & Paivio, 1971). Segal et al. suggested that if organizational differences exist that distinguish imaginal and verbal codes at encoding, then conditions that facilitate synchronous organization should result in better recall of concrete than abstract nouns. However, in conditions that facilitate sequential organization, no recall differences should be found because the verbal code is equally available to both kinds of stimuli. They reasoned that simultaneous presentation of all the elements of a word triad would encourage synchronous organization, whereas successive presentation of triad elements would encourage sequential organization. These modes of presentation were factorially crossed with noun concreteness and rate of presentation (cf. Paivio & Csapo, 1969). As predicted, regardless of rate, simultaneous presentation facilitated the recall of concrete more than abstract words. Moreover, under successive presentation conditions no recall differences as a function of concreteness were found. The results of this study suggest that recall differences were attributable at least partly to the theoretically predicted organizational differences at encoding.

The interpretation of the Segal, et al. study as well as other studies using memory performance data to make inferences concerning difference in encoding processes, suffer from a confounding of input processes with storage and retrieval processes. The suggestion here is, that what might be considered to be organizational effects at input might be the product of specific retrieval strategies. In light of Fillenbaum's (1970) criticism of the use of memorial techniques to draw inferences about the nature of the representation, what apparently is needed is a test of dual coding theory's organizational distinction that does not solely depend upon recall measures. The use of encoding latencies in the present investigation provided such a test.

Rationale For The Present Investigation

As mentioned above, the present series of investigations was primarily concerned with the efficiency of encoding multiple units of information into compound images and sentences; and secondarily, with the effect of such encoding on incidential recall. The research can be viewed as an extension of earlier experiments which required subjects to generate images or verbal associates to individual words or word pairs (e.g., Ernest & Paivio, 1971; Paivio, 1966; Yuille &

Paivio, 1967). The above mentioned earlier research was designed to demonstrate the independence of verbal and imaginal codes, whereas in the present studies, larger groupings of words as well as pictures were used in order to increase organizational and memory demands, thereby revealing differences in the way complex information is encoded and processed in the verbal and imagery systems.

As mentioned earlier, predictions concerning encoding latency were based upon prior research and theoretically based assumptions concerning the organization of information in the verbal and nonverbal systems. Earlier research permitted the strong prediction that the latency for generating images would be generally less for stimuli that have more direct access to referential images (pictures and concrete nouns), whereas sentence latencies would be little affected by stimulus concreteness-abstractness.

The above effects were expected to be qualified by set size in ways suggested by the postulated organizational differences between imaginal and verbal processes. Visual imagery involves synchronous organization of object images in memory, resulting in a unitized compound analogous to a visual scene, whereas verbal processes retain the sequential patterning that is reflected grammatical language (Paivio, 1972a, 1972b). Synchronous organization implies that imagery encoding is relatively free from the sequential constraint imposed by grammar on verbal encoding. Simply put, things can be joined together in a variety of ways to form a meaningful image, but words do not enjoy this freedom in their formation into sentences. The organizational distinction has implications regarding the time needed to encode (encoding efficiency) and memory capacity that are crucial to the present investigation. Encoding efficiency should be directly related to the degree of sequential constraint involved in generating an organized cognitive structure. As the generation of compound imagery of the type required in the present task involves, at most, minimal sequential constraints, the encoding of separate units into higher order structures should be relatively unaffected by the number of items in the set. On the other hand, the generation of a meaningful sentence involves a high degree of sequential constraint that should increasingly hinder the encoding of items into higher-order verbal structures as set size increases. Therefore, the specific prediction is that verbal encoding time should increase more dramatically than image time as set size is increased.

Detailed predictions of memory effects will be discussed in the context of the experiments. Some general predictions can, however, be made. Previous research (e.g., Paivio & Csapo, 1973; Paivio & Foth, 1970) suggested that recall would be generally higher for pictures than for concrete words, and in turn, the recall of concrete nouns would be higher than for abstract nouns.

EXPERIMENT 1

This study involved a comparison of high imagery, concrete nouns and low imagery, abstract nouns in order to determine if encoding processes were in line with suggestions from dual coding theory. Following the encoding task described earlier, memory for the items of the stimulus list was tested by free recall.

The specific predictions regarding encoding latency were that imagery encoding latencies would be affected by the concreteness of the stimulus items, i.e., longer latency would be associated with abstract nouns rather than concrete nouns, whereas verbal encoding latencies would be unaffected by concreteness. Secondly, and more importantly for the purposes of the present investigation, encoding latencies should increase more steeply with set size under sentence (verbal) than under image instructions.

Free recall predictions were based upon the storage space corollary of the differential organization hypothesis (Begg, 1972, 1973). The storage space notion suggests that imagery coded information is more integrated than verbally coded information. If this were the case one would expect that the superiority of imagery over verbal conditions should increase directly with set size. Therefore, the predictions were that as the set size increased, the recall superiority of concrete over abstract nouns and of imagery over verbal encoding conditions would increase.

METHOD

Design and Materials

The experiment was a 2 x 3 x 2 x 10 factorial design with repeated observations on the last factor. The design involves two levels of word imagery (high vs. low), three levels of set size (2, 3 and 4 word/set), two types of encoding instructions (imagery vs. verbal) and ten test trials.

Table 1

Abstract and concrete nouns lists used in Experiment 1

Concrete Nouns

BODY	JOURNAL	SKIN	ENGINE
BREAST	LETTER	SQUARE	NAIL
BUILDING	LIP	STRING	GOLD
CIRCLE	MACHINE	STUDENT	BAR
CORNER	MOTHER	VILLAGE	LIBRARY
DRESS	OFFICER	FACTORY	FLOOD
FLESH	PERSON	TEACHER	PIPE
GENTLEMAN	PROFESSOR	HALL	TOWER
GIRL	ROCK	INDUSTRY	AUTOMOBILE
HOTEL	SHADOW	WOMAN	SLAVE

Abstract Nouns

ADVICE	HONOUR	QUALITY	EVIDENCE
AMOUNT	HOPE	SPIRIT	EXPRESSION
ATTITUDE	HOUR	STYLE	FREEDOM
CHANCE	INTEREST	THEORY	HISTORY
CUSTOM	LENGTH	THOUGHT	JUSTICE
DEED	MAJORITY	TROUBLE	KNOWLEDGE
DUTY	METHOD	ANSWER	LAW
EFFORT	MIND	COST	MORAL
EVENT	NECESSITY	DEVELOPMENT	POSITION
HIDE	OCCASION	DIRECTION	SOUL

Forty high imagery (I range = 5.60 - 6.83) and 40 low imagery words (2.13 - 3.83) were selected from the Paivio, Yuille and Madigan (1968) norms. The word lists were matched for Thorndike-Lorge frequency, but Kučera-Francis (1967) frequency favored the abstract list i.e., the abstract nouns were of higher frequency. The lists were also matched for verbal associative meaningfulness. The stimulus lists are presented in Table 1. From this pool of 80 nouns, six lists of items were selected randomly to comprise the set size conditions. Homogeneous lists of 20, 30 or 40 concrete and abstract nouns were constructed. Ten word-sets made up a list, i.e., ten pairs, triads or four-tuples. The individual word sets were typed on 5 x 8 inch index cards for presentation to subjects. Three randomizations of items of a list were used.

Latency measures were recorded by a Hunter Model 120 clock counter which was started by a Gerbrands Model 730 Voice-activated relay and stopped by the subject's key press.

Subjects

The subjects were 108 University of Western Ontario introductory psychology students. Nine subjects were assigned randomly in order of appearance at the laboratory, to each of 12 experimental conditions.

Procedure

The experiment involved two phases, an encoding phase and an incidental free recall phase. All subjects were tested individually.

Encoding: Upon being seated in the laboratory, the subject was read a set of encoding instructions (imagery or verbal) which explained that the purpose of the experiment was to determine how long it takes to generate sentences (or images) to sets of words. The imagery instructions stressed that the subject should form meaningful compound (interactive) images of objects that could stand for the nouns presented to them on the index cards. The verbal instructions asked the subject to make up a meaningful sentence that included all the nouns presented to them (the text of all the instructions is presented in Appendix A.1). The instructions further stressed that encoding should be done as quickly as possible. Following the instructions, the subject was given three sets (trials) to practice the instructed encoding strategy.

Next, ten test trials were administered. A test trial was started by the presentation of a stimulus card. As the stimulus cards were exposed manually by the experimenter, the trial number was spoken aloud, thereby activating the voice key which in turn started the clockcounter. Once a sentence or image had been formed the subject responded by depressing a telegraph key which stopped the clockcounter. The stimulus card was then removed from view and the subject immediately drew a picture of the image or wrote a sentence that reflected the encoded structure (cf. Paivio & Foth, 1970). Up to twenty-five seconds was allowed for drawing or writing.

Incidental Free Recall: Following the completion of the entire encoding task, i.e., after all stimulus cards were presented, subjects were unexpectedly requested to free recall, in writing, as many of the presented words as could be remembered. Three minutes were allowed for recall, after which time the subjects were asked whether a memory test had been anticipated. No subject reported that recall had been expected. Subjects in the verbal encoding conditions were additionally asked if they had experienced any mental imagery prior to the generation of a sentence.

RESULTS

Encoding Task

Table 2 presents the mean encoding latencies for all experimental conditions, collapsed over trials.

Analysis of encoding latencies as a function of noun imagery, set size, encoding instructions, and trials showed no main effect or any interactions ($p > .10$) involving trials. Significant main effects were obtained for noun imagery, set size, and encoding instructions. High imagery nouns were encoded faster than low imagery nouns, min F (1,146) = 86.27, $p < .001$. Encoding latencies increased directly with set size, min F (2,146) = 21.66, $p < .001$, all possible set size comparisons being significant by Scheffé a posteriori analysis ($p < .01$). The instruction main effect showed the verbal encoding was generally faster than imaginal encoding, min F (1,150) = 6.15, $p < .025$.

The main effects were qualified by two significant interactions. Figure 1 shows the interaction between noun imagery x encoding instructions, min F (1,150) = 24.84, $p < .001$. The Scheffé analysis indicated that low imagery nouns took longer to encode into images than into sentences, F (1,96) = 53.82, $p < .001$ but no difference as a function of type of encoding instruction was found for high imagery nouns, Scheffé F (1,96) = 6.01, $p < .10$. One additional significant effect emerged. Overall it took longer to encode sentences of low

Table 2

Mean encoding latency (in seconds) as a function of encoding instructions, noun imagery and set size

Encoding Instructions	Stimulus Type	Set Size 2	3	4
Imagery	High	3.77	5.05	5.79
	Low	12.38	13.77	14.56
Verbal	High	3.70	5.99	9.76
	Low	3.87	9.20	13.30

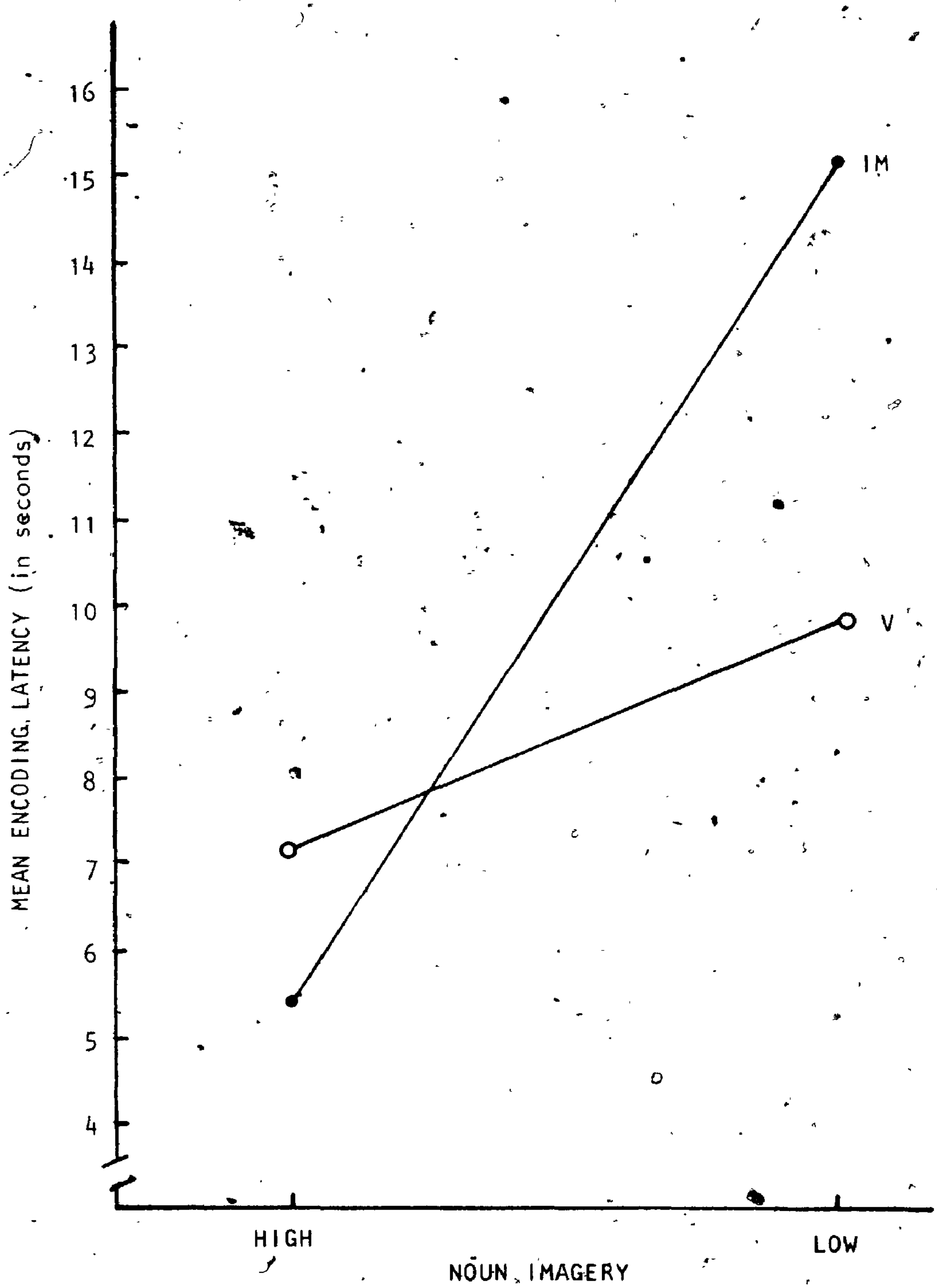


Figure 1: Mean verbal and imagery encoding latency in seconds as a function of high and low imagery noun sets.

imagery nouns than high imagery nouns, Scheffé F (1,196) = 13.60, $p < .01$. In light of the results of previous research (e.g., Yuille & Paivio, 1967) demonstrating a nonsignificant verbal encoding latency difference between concrete and abstract noun pairs, it is reasonable to suggest that the obtained verbal encoding effect can be attributed to differences at set sizes exceeding a pair. In the absence of a three-way interaction of encoding instruction with noun imagery and set size, inspection of the overall pattern of results of the present study seems to be generally consistent with the above interpretation.

Figure 2 presents the significant encoding instruction x set size interaction, min F (2,150) = 6.64, $p < .005$. A Scheffé analysis indicated that imaginal encoding time did not differ significantly as a function of set size. In the case of verbal encoding, however, increases in the size of the set were accompanied by significant increases in the time needed to encode ($p < .01$; by Scheffé). This interaction is generally consistent with predictions from the differential organization hypothesis.

Incidental Recall

Three measures of recall were analysed: (1) the total proportion of items correctly recalled, (2) the number of sets recalled, and (3) the mean proportion of a set recalled, conditionalized upon the number of recalled sets. In the first and third analysis the effect of set size is confounded with list length, consequently main effects of set size are uninterpretable. However, the crucial predictions involved interactions with set size, and there are interpretable.

The total proportion of items correctly recalled was analysed as a function of noun imagery, set size, and encoding instructions. Table 3 presents the mean proportion of items corrected recalled. Analysis of variance showed that high imagery nouns were recalled better than low imagery nouns, F (2,96) = 95.63, $p < .001$. Recall decreased with increases in set size, F (2,96) = 6.19, $p < .01$. A Scheffé analysis revealed that the set size main effect was due solely to differences between noun sets of size 2 and 4, F (2,96) = 11.11, $p < .01$. Lastly, regardless of noun imagery, imaginally encoded words were better recalled than verbally encoded words, F (1,96) = 9.10, $p < .05$.

Since the items in the encoding task were presented to the subject in sets, and since the instructions required unitization of the presented groupings, it was possible to analyse recall in terms of the number of sets recalled. A set was considered recalled if one of the nominally presented items of a group appeared in the subjects' recall protocol (cf. Cohen, 1963). Table 4 presents the mean number of sets recalled for all conditions. Analysis of variance showed that more sets of high imagery than low imagery nouns were recalled F (1,196) = 18.00, $p < .001$. In addition, imaginally encoded sets were recalled better than verbally encoded groupings F (1,96) = 22.32, $p < .001$.

The efficiency of retrieval from a set was analysed in terms of the mean proportion of items recalled from a set, conditionalized on the number of sets recalled. This dependent measure was obtained for each subject by the following formula (cf. Cohen, 1966):

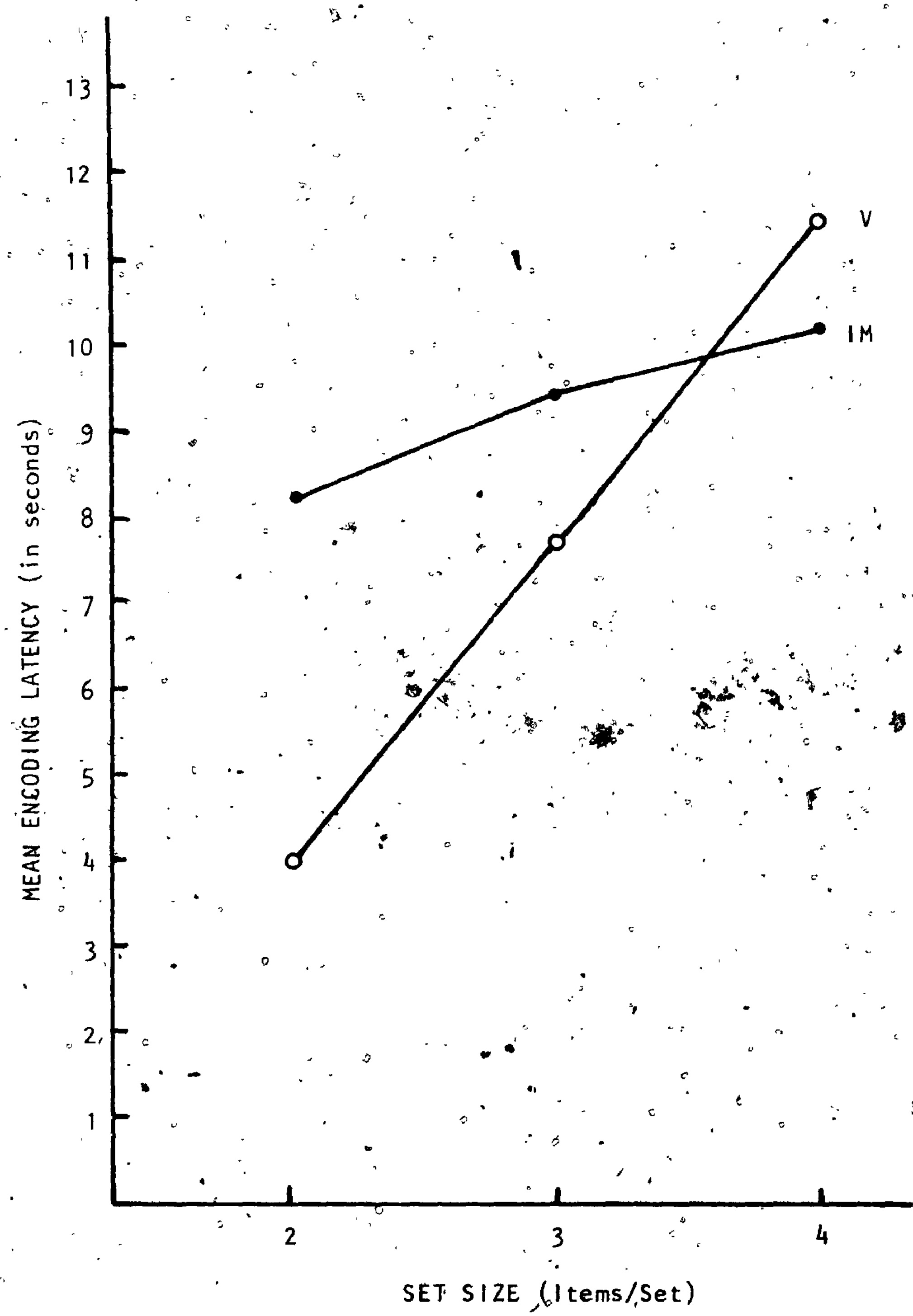


Figure 2: Mean verbal and imagery encoding latency in seconds as a function of the number of nouns in a set.

Table 3

Mean proportion of items correctly free recalled for all experimental conditions

Encoding Instructions	Stimulus Type	Set Size 2	3	4
Imagery	High	.68	.65	.57
	Low	.43	.44	.29
Verbal	High	.64	.53	.50
	Low	.32	.34	.31

Table 4

Mean number of sets recalled for all experimental conditions

Encoding Instructions	Stimulus Type	Set Size 2	3	4
Imagery	High	7.89	8.22	7.44
	Low	5.89	6.89	6.56
Verbal	High	6.56	6.33	6.11
	Low	4.22	5.67	5.89

$$\text{Mean proportion of set recalled (efficiency of retrieval)} = 1 - \left(\frac{\text{mean number of items/set not recalled}}{\text{set size} - 1}\right)$$

This index answers the question, given that one word of a set was recalled, what percentage of the remaining words of a set were recalled? Please note that this index is only normalized for set size comparisons, consequently inferences regarding differences in recall efficiency as a function of noun imagery and encoding instructions would only be warranted if interactions of these factors occur with set size.

An analysis of variance revealed that a greater proportion of items were recalled from high imagery than from low imagery noun sets, $\underline{F}$ (1,96) = 79.37, $\underline{p}$ <.001. Further, the mean proportion of items of a set correctly recalled decreased as set size increased, $\underline{F}$ (2,96) = 4.36, $\underline{p}$ <.05. Scheffé a posteriori analysis showed significant ($\underline{p}$ <.05) recall differences for all set size comparisons. No interactions were obtained with this dependent measure.

The use of the subject-paced encoding task in the present investigation brings with it a problem regarding the interpretation of the recall data; namely, that the length of the retention interval varies with experimental conditions. More specifically, combinations of experimental conditions that correlate with short encoding latencies produce short retention intervals, and conversely. Thus the possibility exists that some portion of the recall effects can be attributed to the differences in retention interval or some combination of the effects of the interval and experimental variables.

If differences in retention interval alone exert an influence to alter the recall performance then such an effect would be expected to be significantly apparent in the recall of the last few items of the stimulus lists. An analysis of variance was performed on the total recall data for the last six items of the lists. So as not to have dichotomous data adjacent serial positions were combined, producing three levels of the serial position factor. If differences in retention interval alone contribute significantly to recall performance, then interactions of serial position and the experimental variables should be obtained. The analysis revealed only two significant main effects: noun imagery, $\underline{F}$ (1,96) = 29.76, $\underline{p} < .001$, and serial position, $\underline{F}$ (2,192) = 5.01, $\underline{p} < .05$. The noun imagery effect suggested that more high than low imagery nouns were recalled. No significant interactions were obtained. An analysis of variance was also performed removing the last six items from the overall total recall. Results comparable to the original overall analysis were obtained, thus on the basis of these analyses, it appears that any differences attributable to retention interval alone failed to produce differential recall effects.

One other potential problem inherent in the subject-paced task is that stimulus exposure time varies directly with encoding latency. Typically longer stimulus exposure has been shown to exert a positive effect on memory. To determine if exposure time influenced recall in the present research, an analysis of covariance was performed on the recall data with encoding latency as the covariate. No qualification of any of the existing results were justified by this analysis and similar analyses in the remaining two experiments.

DISCUSSION

This discussion deals in turn with three issues, the efficiency of encoding multiple word units into higher-order imaginal and verbal cognitive structures, the role of noun imagery in the speed of verbal encoding, and incidental recall as it related to the differential organization and dual coding hypotheses.

The results are quite clear regarding the efficiency of encoding multiple word units into imaginal and verbal cognitive structures. The study replicated and extended the findings of previous research in that complex verbal and imaginal encodings were formed equally quickly to sets of concrete nouns, but it took longer to generate compound images than sentences to abstract nouns (Figure 1). These results support the view that imaginal and verbal associates are equally available to concrete words that have objective referents, but not to abstract nouns which lack such referents. The present findings extend previous ones, however, in regard to the effect of noun-concreteness on verbal encoding. Typically, verbal associations occur equally quickly to concrete and abstract words or word pairs. This pattern held in the present study for noun pairs, which require only a minimal degree or relational organization, but subjects took significantly longer to generate a meaningful sentence from abstract than concrete nouns when greater organizational demands were imposed by larger set sizes. This suggests that complex linguistic structures are more readily generated with concrete than with abstract nouns. One possible explanation for this difference is that sentence generation was facilitated by imagery in the case of concrete nouns; that is a complex image was first formed integrating the noun referents into a synchronously organized cognitive structure, and a sentence was then generated to describe the image. Abstract nouns, on the other hand, must depend upon sequentially constrained verbal processes at all stages of sentence processing. Consistent with this interpretation, 25 of a possible 27 subjects reported that "involuntary" imagery was often used as a basis of sentence generation. No subjects reported a similar experience in the abstract noun condition. Thus the verbal coding task may reflect in part the interconnectedness of the system. A possible alternative interpretation is that semantic selection restrictions or lexical complexity (cf. Kintsch, 1972) is greater for abstract than concrete nouns, with the result that it requires more time to encode sentences containing the former. The data do not allow for a decision between these two alternative hypotheses, but regardless of which interpretation is favored, this finding is interesting in its own right and deserves further study.

The effects of the encoding instructions on encoding speed were as predicted on the basis of the differential organization hypothesis. Figure 2 shows that increasing the number of nouns in a set from two to four increased the time for sentence generation (verbal encoding), whereas no significant change was found in the latency of image encoding. It is not surprising that the analysis of variance performed on the latency data indicated a nonsignificant increasing trend for image time as a function of set size. Such an increase would be expected on the basis of the set size manipulation alone. The failure to obtain a significant change in image latency can reasonably be attributed to the moderate power of overall between subjects analysis, or the conservativeness of Scheffé a posteriori tests. Despite the absence of a significant change in image latency the results are in complete agreement with predictions from dual coding theory (see earlier section of introduction, "Rationale for the present investigation") in that verbal encoding time increased more dramatically with set size than did image time. These results are consistent with the way linguistic units and nonverbal images are presumed to be organized into higher-order cognitive structures. Specifically, the increase in sentence generation time with set size reflects the increasing sequential constraints that verbal encoding entails. Such constraint presumably involves temporal and syntactic component; temporal, because speech (including inner speech) is a temporal process; syntactic, because English grammatical rules do not permit free ordering within the temporal stream of speech or thought. Conversely, the image latency function strongly suggests that the generation of compound images is relatively free from such sequential constraint. This is consistent with the view that imaginal units are organized synchronously into higher-order memory structure.

It could be argued alternatively that subjects simply adopted different response criteria for verbal and imaginal encoding. Specifically, they may have been more stringent in what they accepted as a meaningful sentence than as a meaningful image. This hypothesis will be discussed later in the thesis.

In regard to the incidental memory task, the general effectiveness of imagery was indicated by the finding that total recall was generally better for items encoded imaginally than those encoded verbally, regardless of noun concreteness. In addition, high imagery, concrete nouns were better recalled than low imagery, abstract nouns. Similar results were found in the analysis of the number of sets recalled, i.e., set recall was higher for concrete than for abstract nouns, and for imaginally encoded than verbally encoded noun groups. The results are generally consistent with a dual coding hypothesis (e.g., Paivio & Csapo, 1973) which maintains that high imagery conditions are effective in memory because they increase the probability that both imaginal and verbal processes will be involved in information retrieval. Concrete words have a higher probability than abstract words of being imaginally and verbally coded; imagery instructions further increase the probability of dual coding. Thus concrete words coded in two ways have a higher probability of recall than singly coded abstract words. The dual coding notion will again be discussed in relation to empirical findings in Experiment 3.

The image organization hypothesis (Begg, 1972, 1973) suggests that information in synchronously organized images takes up less "storage space" than sequentially organized verbal information in the sense that images can be more effectively accessed and integrated in memory. The expectation from this hypothesis was that the advantage of imagery conditions would increase directly with set size. This expectation was not supported by the total recall or set recall data, inasmuch as both types of recall decreased equally for all conditions as set size increased. Similarly the proportion of a set recalled data, a measure of the integrity of the encoded representation and consequently a more direct test of the storage space notion, failed to support the "storage space" hypothesis. Imagery conditions and set size failed to interact in the predicted manner. This suggests that image and verbal instructions apparently resulted in equally integrated cognitive structures. Perhaps one reason for the failure to confirm any aspect of the storage space hypothesis can be attributed to the uncontrolled arousal of imagery in the verbal high imagery noun conditions. Imagery in these conditions could have wiped out any effects due to organizational differences. One suggestion might be to extend the present study to include cued recall, a test of associative recall, inasmuch as cued recall appears to be particularly sensitive to the degree of integration of memory structures (Begg, 1972, 1973). This experimental extention will be considered in Experiment 2 in order to provide a stronger test of the hypothesis.

EXPERIMENT 2

This experiment was designed as a replication and extention of the previous experiment. It was a replication in that concrete and abstract words were again used in the encoding task. It was an extention in that the memory testing phase of the previous design now included a comparison of incidental free and cued recall. Cued recall was added to provide a stronger test of Begg's storage space hypothesis.

Two methodological changes were made in Experiment 2. The confounding of set size and list length was removed. Lastly, the encoding instructions were changed to put more emphasis on the meaningful integration of images and the grammaticality of sentence encodings.

Predictions regarding encoding latencies were identical to those of Experiment 1. However, with the inclusion of a cued recall test the memory predictions changed somewhat.

On the basis of dual coding theory and the results of Experiment 1, it was again expected that more high imagery words would be recalled than low imagery words; that more words would be recalled from imagery encoded sets than verbally coded sets, and that, overall, recall would vary inversely with set size.

Begg's research (Begg, 1972, 1973; reviewed earlier) and the storage space hypothesis suggested that the above effects would be qualified by the interaction of imagery conditions with set size and type of recall. The rationale for these predictions was that if imagery and verbal cognitive structures differ with regard to the degree of unitization in such a manner that imagery results in greater integration of a memory structure than verbal coding, then the consequence of integration, namely redintegration via cueing, should be greater for imagery than verbal conditions. Further, the superiority of images over verbal conditions should increase with set size. Specifically it was expected that cued recall would become increasingly superior to free recall as a function of increases in set size for imagery encoding conditions, whereas the same should not hold for verbal encoding conditions. Noun imagery should similarly interact with set size and type of recall task (free vs. cued recall task). That is, the advantage of cued recall over free recall should be greater for high imagery, concrete nouns than for low imagery, abstract nouns, and this difference should increase directly with set size.

METHOD

Design and Materials

The experiment was a 2 x 3 x 2 x 2 factorial design involving two levels of noun imagery (high vs. low), three levels of set size (2, 3 and 4 word/sets), two types of encoding instructions (image vs. verbal) and two types of recall task (free recall vs. cued recall).

Forty-eight high imagery (I range = 5.60 - 6.83) and 48 low imagery (2.13 - 3.83) nouns were selected from the Paivio, Yuille and Madigan (1968) norms. The high and low imagery lists were chosen so that they were matched for Kûcera-Frances frequency and verbal associative meaningfulness. The stimulus lists are presented in Table 5. Lists homogeneous with respect to noun imagery were systematically constructed to comprise the various set size conditions.

All lists contained a total of 48 words. Thus, there were 24 noun pairs, 16 triads and 12 four-tuples.

The following list construction procedure was used as a control device for the cued recall portion of the experiment: first, the 48 items of the word lists were randomly paired to comprise the set size 2 conditions. Then 16 of these 24 pairs were randomly selected to be used as intact units in the construction of triads. The remaining 16 items (of the 48) were randomly inserted into the middle position of the maintained pairs to make up the set size 3 conditions. Lastly, to make up the set size 4 conditions, 12 of the 16 triads were randomly selected to be maintained for elaboration into four-tuples. The remaining 12 items were then included randomly in the third position in the 12 maintained triads. Such procedures were needed to control for differential prompt effectiveness in the cued recall portion of this experiment.

As in Experiment 1, the stimulus sets were typed on index cards for presentation to the subjects. Two different randomizations of items of a list were used. The equipment and technical design were identical to Experiment 1.

Subjects

The subjects were 192 University of Western Ontario introductory psychology students. Eight subjects were assigned at random, in order of appearance at the laboratory, to each of the 24 experimental conditions.

Procedure

As in Experiment 1, all subjects were individually tested on the encoding and incidental free and cued recall phases of the experiment.

Encoding: The procedure for the encoding phase of this experiment was identical to Experiment 1 in every respect except that the encoding instructions were changed to emphasize the interactive nature of images, and grammaticality of sentences. The text of the revised instructions appears in Appendix A.2.

Incidental Free and Cued Recall: Following completion of the encoding task, subjects were unexpectedly asked to recall as many of the words they had been presented as could be remembered. For half of the subjects, written free recall was requested. The remaining subjects were given cued recall tests. In the cued recall conditions, a sheet of paper containing the prompts was provided to each subject for written recall. Half of the prompts were the first items of the nominally presented stimulus sets, whereas the remaining half were the last items of the sets. Because of the set construction procedures described earlier, the cues were the same nominal items for all set size conditions thus providing a control for differences in prompt effectiveness.

As in Experiment 1, following the three minute recall period, subjects were asked whether a memory test had been anticipated. Again no subject reported that recall had been expected. Subjects in the verbal encoding conditions were additionally asked at that time, if they recalled experiencing mental imagery prior to sentence formation.

RESULTS

Encoding Task

Table 6 presents the mean encoding latencies for all conditions. Two types of analysis of variance was performed on the encoding latency data. Analysis of encoding latencies as a function of noun imagery, set size and encoding instructions was performed, indicating that high imagery nouns were encoded faster than low imagery nouns, $\underline{\min F}$ (1,268) = 144.27, $\underline{p}$ <.001, and that latency increased directly with set size, $\underline{\min F}$ (2,258) = 91.75, $\underline{p}$ <.001. These results are in complete agreement with those of Experiment 1 except that in the present experiment no main effect was obtained for instructions,

Table 5

Abstract and concrete noun lists used in Experiment 2

Concrete Nouns

BODY	FACTORY	VILLAGE	ENGINE
BOARD	FLESH	BUILDING	SHADOW
SQUARE	BAR	MOTHER	STRING
STUDENT	HOTEL	TOWER	ARTIST
CHIN	MONEY	MACHINE	NAIL
BLOOD	ARMY	GIRL	DRESS
SKIN	PIPE	TEACHER	LIP
CORNER	LIBRARY	JOURNAL	BREAST
PROFESSOR	BOX	GENTLEMAN	AUTOMOBILE
OFFICER	GOLD	INDUSTRY	HALL
SEAT	ROCK	LETTER	WOMAN
SLAVE	PERSON	FLOOD	CIRCLE

Abstract Nouns

EXPLANATION	ADVICE	HIDE	EGO	EVIDENCE
THEORY	QUALITY	CHANCE	AMOUNT	LENGTH
FREEDOM	EXPRESSION	NECESSITY	IMMUNITY	COST
ATTITUDE	ANSWER	MAJORITY	VIOLATION	STYLE
SATIRE	JUSTICE	TROUBLE	EFFORT	CUSTOM
GRAVITY	MORAL	HOUR	POSTION	LAW
HONOUR	SOUL	MIRACLE	SPIRIT	PERCEPTION
DEED	HOPE	DEVELOPMENT	KNOWLEDGE	LEGISLATION
DIRECTION	DUTY	DISCIPLINE	OCCASION	
ECONOMY	METHOD	HISTORY	EVENT	

Table 6

Mean encoding latency (in seconds) as a function of encoding instructions, noun imagery and set size

Encoding Instructions	Stimulus Type	Set Size 2	3	4
Imagery	High	3.00	4.58	7.04
	Low	8.39	13.35	18.48
Verbal	High	2.51	6.21	10.64
	Low	4.24	11.95	19.88

$F < .10$.

These main effects were qualified by interactions. Figure 3 illustrates the interaction between noun imagery and encoding instructions, min F (1,230) = 7.46, $p < .01$. The Scheffé tests indicated low imagery noun sets took longer to encode than high imagery sets under both sentence and image instructions. Unlike Experiment 1, the difference between image and verbal encoding of high and low imagery nouns failed to reach significance ($p > .05$). The interaction of noun imagery and encoding instructions can therefore be attributed to the fact that the image latency difference between high and low imagery nouns was greater than the verbal encoding times for the same nouns, i.e., a difference in the slope. Allowing for the above disparity between the present experiment and Experiment 1, the overall pattern of results obtained in the two experiments are in general, the same.

An additional interaction of noun imagery x set size, min F (2,256) = 11.87, $p < .001$, can be seen in Figure 4. The shape of the interaction demonstrates that the relative difficulty of encoding high and low imagery nouns increased directly with set size. Moreover, the interaction suggests that the encoding latency function increased more steeply for low imagery noun sets as a function of set size than for high imagery noun sets. All possible Scheffé a posteriori comparisons proved to be significant ($p < .05$) except the comparison between set sizes 2 and 3 for high imagery noun conditions, F (2,180) = 9.10, $p > .10$. This interaction reflects the increase in difficulty of

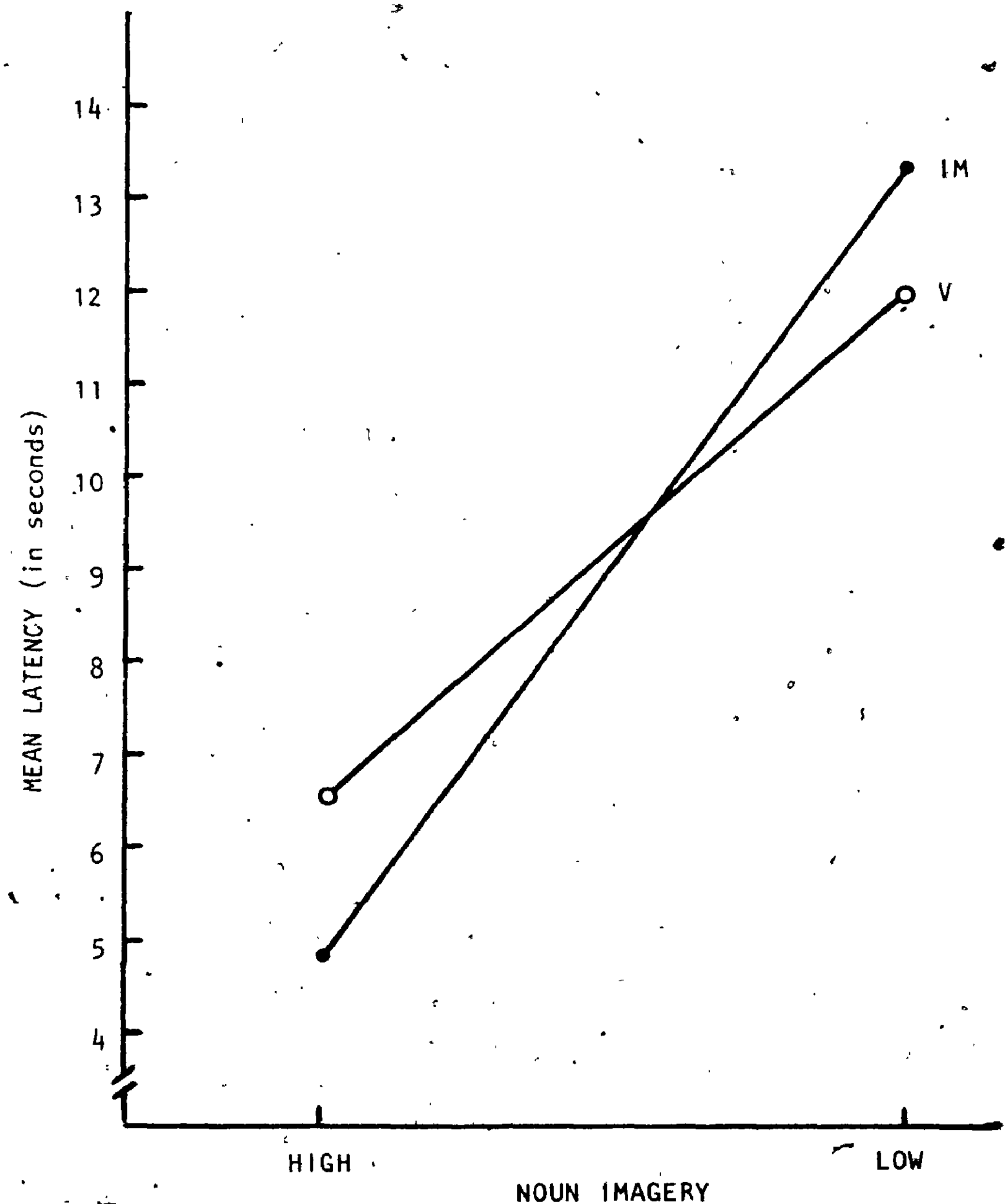


Figure 3: Mean verbal and imagery encoding latency in seconds as a function of noun imagery.

encoding low imagery sets as sentences or images, as well as a general increase in image time (found in this experiment) as set size increased. These results are generally in agreement with prior research.

As in Experiment 1, the predicted interaction of encoding instructions x set size occurred, min F (2,237) = 6.42, $p < .005$. This interaction is depicted in Figure 5. The Scheffé tests suggested that image and verbal encoding latencies increased as a function of set size but verbal encoding time was more effected by the increase in set size than was image encoding time. While the interpretation of this interaction is the same in both Experiments 1 and 2, one difference in the results of the present study should be noted. Image encoding latency increased with set size in this experiment, whereas in the previous study this increase was not significant. The result of the second experiment is probably more realistic as the amount of time needed to read the stimulus card should increase with set size if only because of the increased number of stimulus items. Despite this difference between studies, the form of the interaction is generally as predicted from the differential organization hypothesis.

Incidental Free and Cued Recall

Two analyses were performed on the recall data: the first involved the total proportion of items correctly recalled for all experimental conditions. The second analysis was in terms of proportion of set free recalled.

The total recall data was investigated by a 2 x 3 x 2 x 2 analysis of variance. The analysis involved two levels of noun imagery (high vs. low), three levels of set size (2, 3 and 4), two types of encoding instructions (imagery vs. verbal) and two types of recall test (free

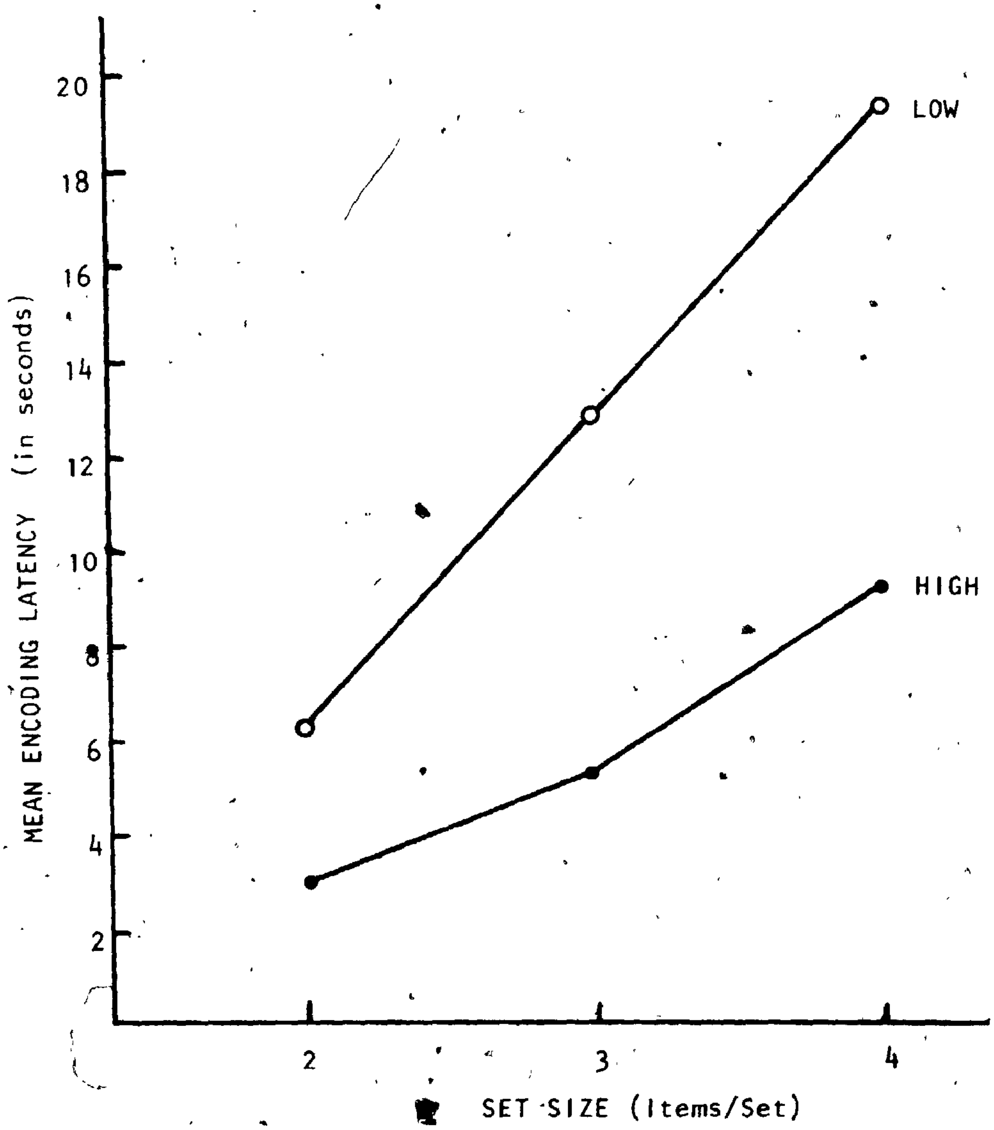


Figure 4 : Mean encoding latency for high and low imagery nouns as a function of the number of nouns in a set.

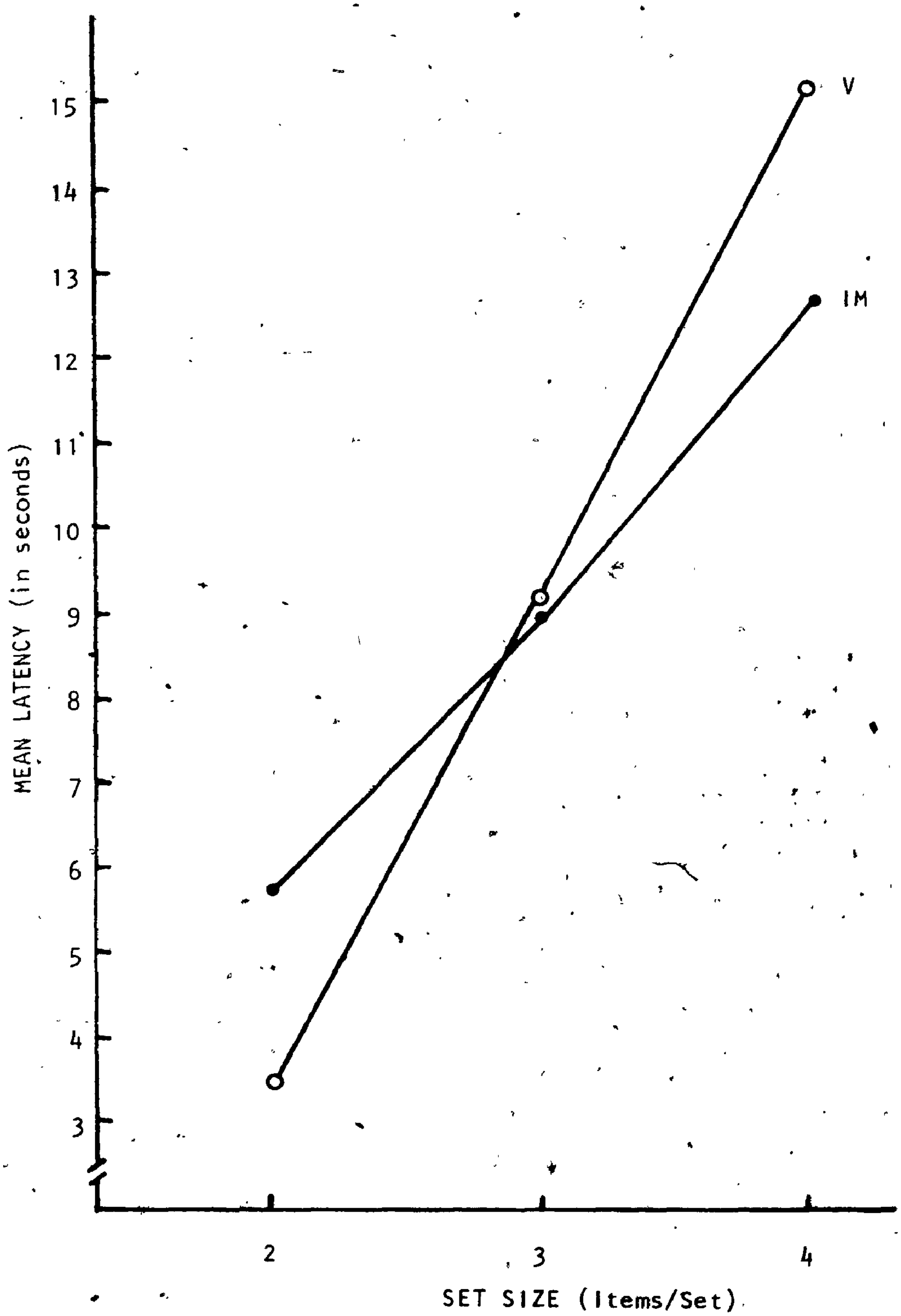


Figure 5: Mean verbal and imagery encoding latency as a function of the number of nouns in a set.

vs. cued recall). Table 7 presents the mean total proportion correctly recalled for all experimental conditions.

The analysis revealed that more high imagery than low imagery nouns were recalled, F (1,168) = 194.89, p <.001, and that recall decreased as a function of set size, F (2,168) = 4.34, p <.05. Scheffé a posteriori analysis suggested this latter effect was due only to an overall decrease in recall from set size 2 to 4 (p <.05).

Several significant interactions were obtained. Figure 6 illustrates a significant noun imagery x recall type interaction, F (1,168) = 13.16, p <.001. The Scheffé a posteriori analysis indicated (p <.05) that cued recall was facilitated relative to free recall in the case of high imagery noun sets; but not for low imagery nouns. This interaction is consistent with the storage space hypothesis and replicates Begg (1971) in principle. However, an interaction of encoding instructions x recall type was also found to be significant, F (1,168) = 3.47, p <.05. Figure 7 depicts this interaction. Inspection of the figure leads to the obvious interpretation that cued recall exceeded free recall only when the nouns were coded verbally.

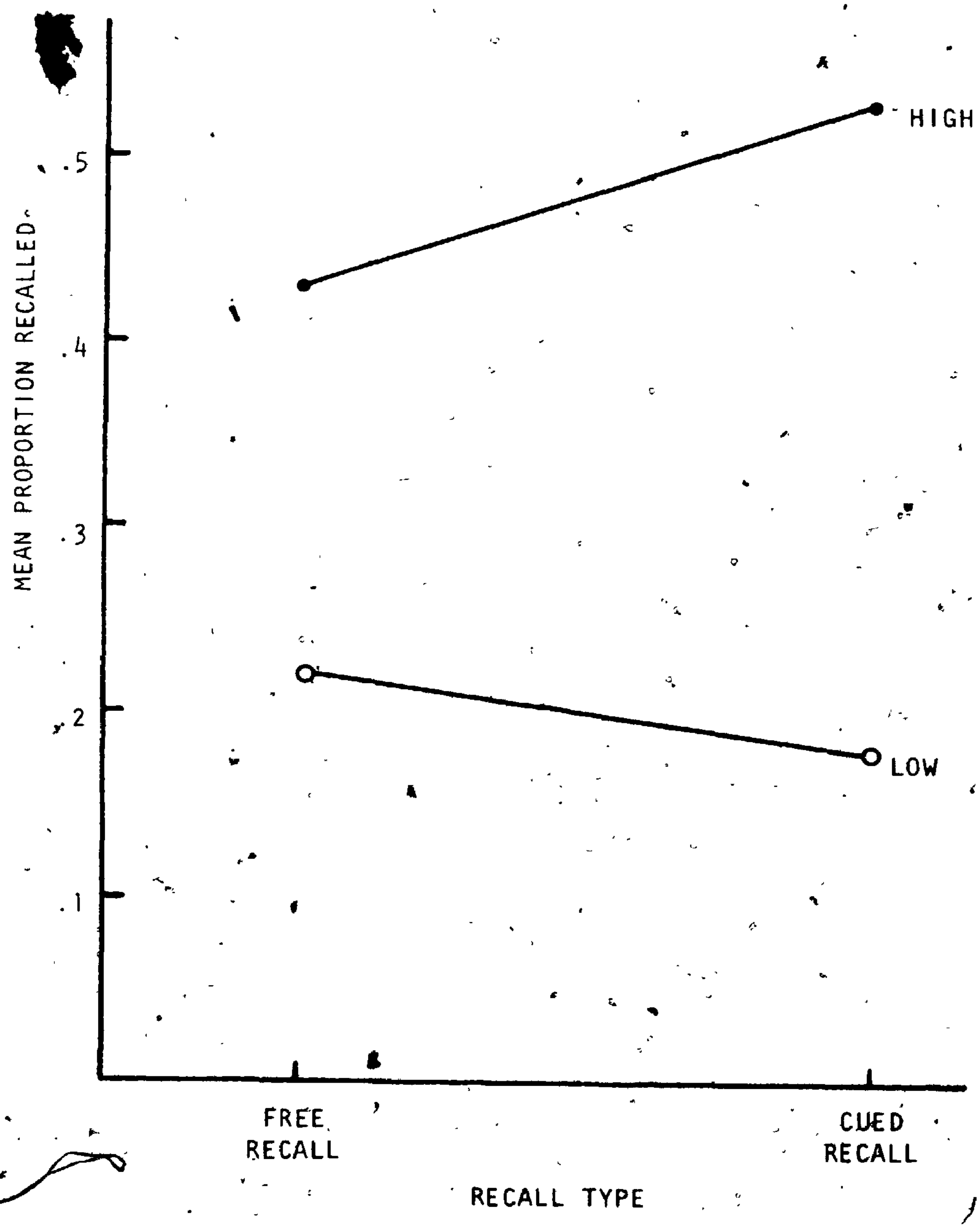
These two interactions were qualified by a three-way interaction involving noun imagery, encoding instructions, and recall type, F (1,168) = 5.76, p <.01. This interaction is shown in Figure 8. A posteriori tests indicated that cued recall was facilitated relative to free recall only when high imagery nouns were encoded verbally. The fact that image coding of high imagery nouns did not likewise facilitate cued recall is inconsistent with the differential organization hypothesis of dual coding theory. Such an increase in cued recall would be expected if the imagery code was truly integrated in memory.

Table 7

Mean proportion of items correctly recalled for all experimental conditions

Encoding Instructions	Stimulus Type	Set Size 2 Free	2 Cued	3 Free	3 Cued	4 Free	4 Cued
Imagery	High	.49	.54	.52	.43	.40	.50
	Low	.24	.30	.25	.08	.18	.21
Verbal	High	.37	.70	.39	.51	.44	.56
	Low	.26	.22	.26	.14	.20	.20

Figure 6: Mean proportion of high and low imagery nouns correctly recalled for free and cued recall conditions.



Set size also interacted with recall type $F(2, 168) = 6.52$, $p < .01$. This interaction suggests that the pattern of results as a function of recall type was different for set size 3 than for set sizes 2 and 4. The inconsistency of set size 3 is probably spurious.

As indicated in Experiment 1, the subject-paced task produced differences in retention interval which might have influenced the recall performance data and consequently qualify the conclusions to be reached. To evaluate this possibility, an analysis of variance was performed on the free recall data for the last six items of the stimulus tests. As in Experiment 1, pairs of adjacent serial positions were combined to avoid dichotomous data. The cued recall data was not similarly analysed as the cues themselves were part of the stimulus list. The analysis revealed that more high than low imagery nouns were recalled, $F(1,84) = 14.93$, $p < .001$, that recall was superior for verbally coded than imagery coded sets, $F(1,84) = 4.44$, $p < .05$, and that recall varied as a function of serial position, $F(2,168) = 7.61$, $p < .01$. No significant interactions were obtained. An additional analysis of variance was performed removing the last few items from the overall total free and cued recall data. The results of the analysis were identical to those obtained in the original analysis with the exception that an additional main effect of recall type was obtained indicating that cued recall exceeded free recall, $F(1,168) = 6.28$, $p < .01$. Thus on the basis of these analyses it appears that any differences in retention interval, alone, failed to produce differential recall effects.

A 2 x 3 x 2 analysis of variance involving noun imagery, set size and encoding instructions was conducted on the mean proportion of a set

Figure 7: Mean proportion of verbal and imagery encoded noun sets correctly recalled for free and cued recall conditions.

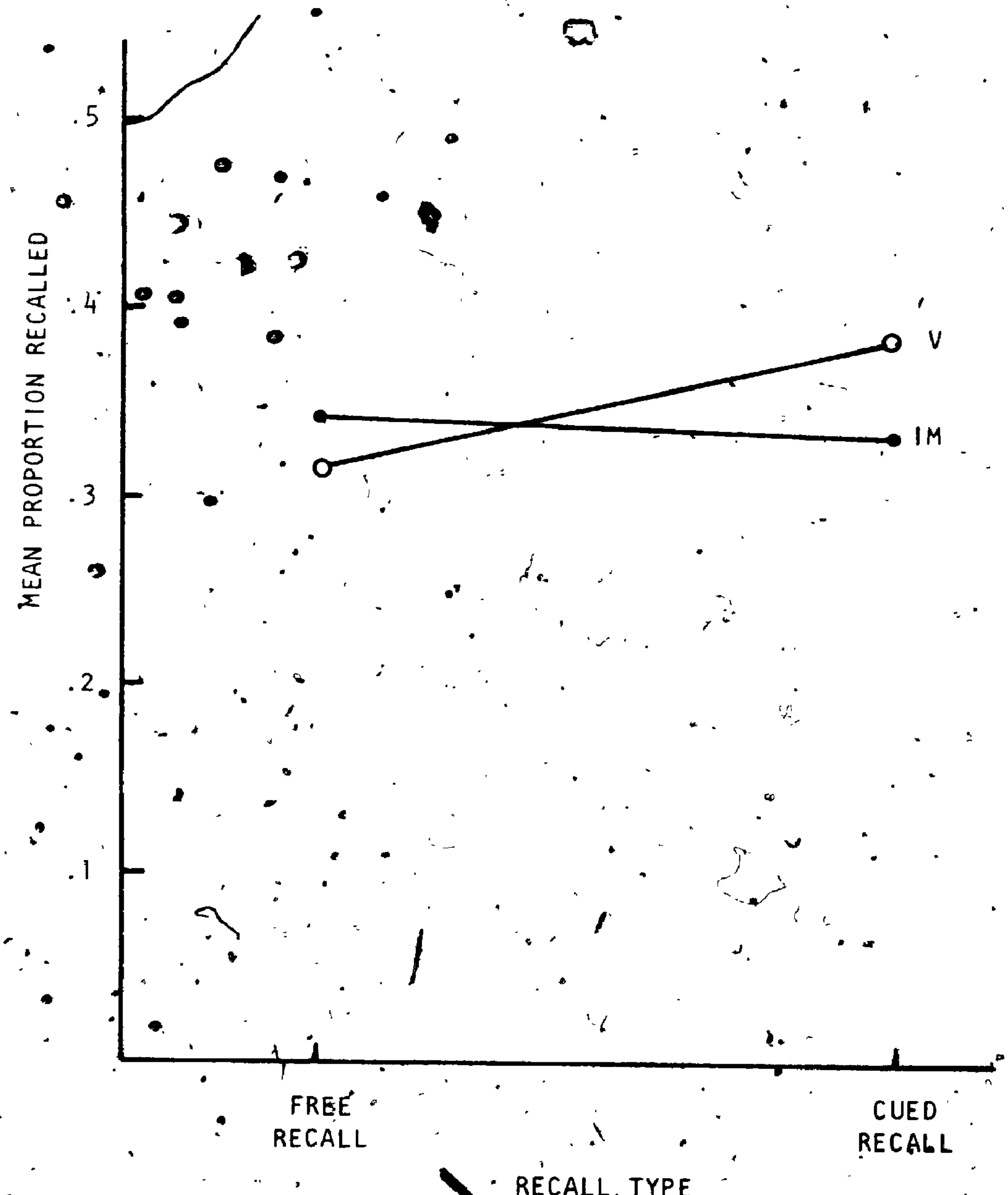


Figure 8: Mean proportion of verbally and imaginally encoded, high and low imagery nouns correctly recalled for free and cued recall conditions.

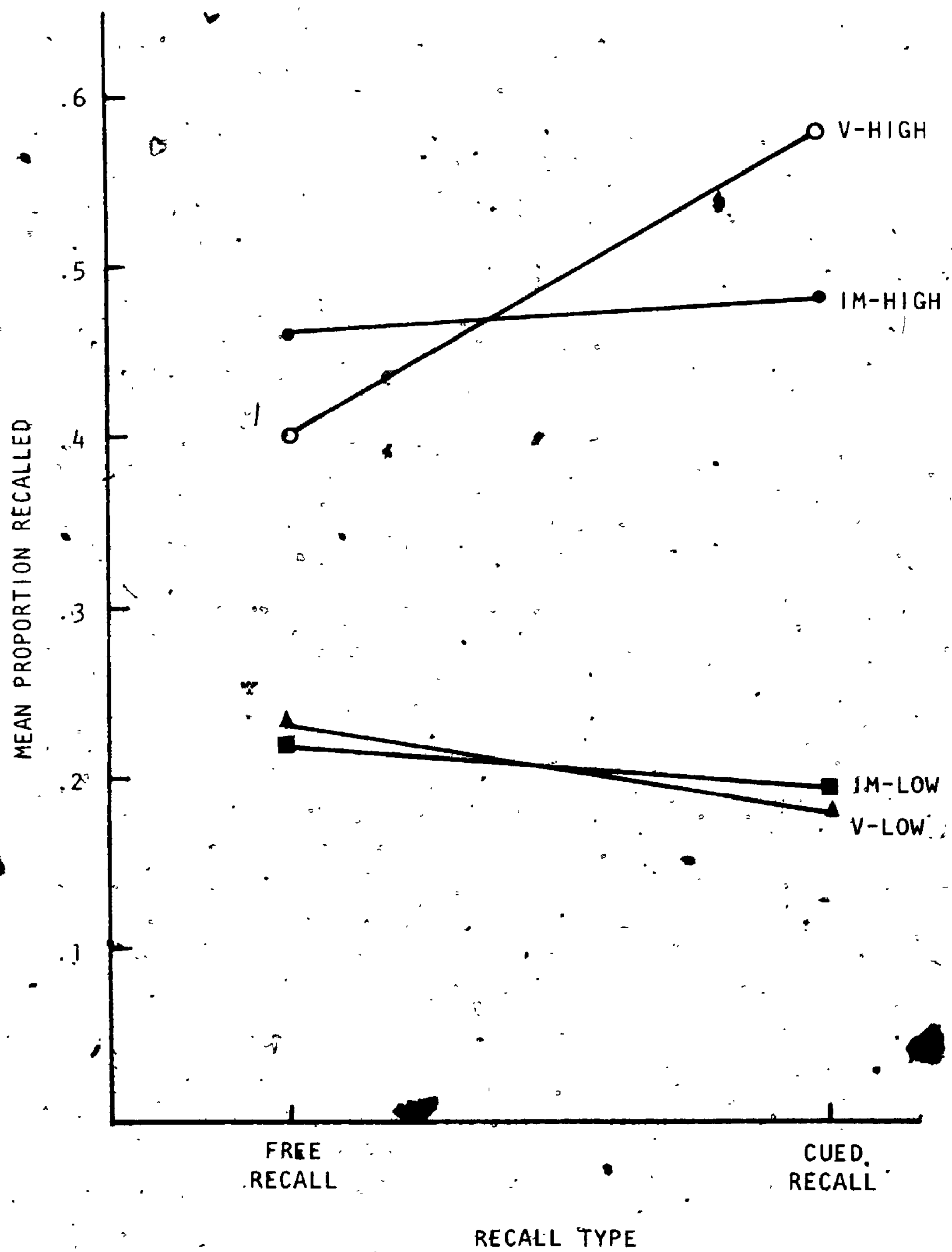


Table 8

Mean proportion of a set correctly free recalled for all experimental conditions

Encoding Instructions	Stimulus Type	Set size 2	3	4
Imagery	High	.75	.64	.47
	Low	.33	.25	.22
Verbal	High	.83	.73	.67
	Low	.49	.44	.31

recalled, conditionalized upon the number of sets recalled. Table 8 presents the mean recall data. A greater proportion of the elements were recalled from concrete than abstract noun sets, F (1,84) = 83.98, p <.001. Secondly, recall decreased with increases in set size, F (2,84) = 8.06, p <.001. And lastly, contrary to the free recall results of Experiment 1, a greater proportion of verbally than imaginally encoded sets was recalled, F (1,84) = 13.31, p <.001. No interactions were obtained with this dependent measure.

DISCUSSION

The encoding latency data from Experiment 2 replicate in principle those of the first experiment. In general it took longer to encode abstract than concrete nouns into verbal and imaginal cognitive structures, and furthermore the difference increased directly with set size. The obtained interactions of noun imagery with encoding instructions and noun imagery with set size attest to the relative difficulty of encoding abstract nouns as images, presumably because such nouns lack direct access to referential imagery.

Experiment 2 also replicates the previous study by showing that it took longer to generate a meaningful sentence from sets of abstract than concrete nouns. Again this suggests that complex linguistic structures are more readily generated with concrete than with abstract nouns. Since printed frequency and meaningfulness were controlled between concrete and abstract noun lists, interpretation of this finding in terms of purely verbal processes is considerably weakened. The suggestion from Experiment 1 that concrete nouns in the verbal conditions were encoded first imaginally and then the image was described by sentences was again supported by subject reports; all of the 48 subjects maintained that imagery occurred on a "good proportion" of the test trials. While the subject reports are not considered strong evidence, they are suggestive that imaginal processing and, consequently dual coding was involved. Further empirical testing is needed to evaluate the dual coding explanations of this effect; Experiment 3 is in part addressed to this issue.

Predictions from the differential organization hypothesis were again supported by the replication of the encoding instruction by set size interaction effect on the latency data. The formation of sentences was increasingly hindered by increases in set size whereas, images were less affected by set size. This finding further supports the position that image encoding is relatively free from sequential constraint; whereas the effects of linguistic constraint on encoding were demonstrated by the verbal latencies. The latency results of Experiments 1 and 2 taken together strongly support the differential organization hypothesis from dual coding theory.

The picture is not as conceptually clear with regard to recall. The results of the analyses of both total recall and proportionate recall are generally inconsistent with theory and previous research. Certain aspects of the both types of recall data agree with previous findings in demonstrating that more high imagery than low imagery nouns were recalled. Also it was found that cued recall of high imagery noun sets exceeded free recall, whereas no significant cued recall facilitation was found in the case of low imagery nouns. This finding is consistent with Begg's (1972) data in which cued recall of adjective and noun phrases exceeded free recall when the stimulus unit was rated high imagery, but not when the unit was rated low. The two additional interactions of encoding instructions by recall type and the three-way interaction involving these two factors as well as stimulus imagery are inconsistent with previous findings. The present data indicated that cued recall exceeded free recall only when high imagery noun sets were encoded by sentences. These findings suggest that concrete information encoded verbally was more integrated in memory than the same stimulus information encoded as interactive images. The fact that verbal encoding apparently resulted in a more integrated cognitive structure than image encoding is inconsistent with all previous research (e.g., directly, Begg, 1972, 1973; and in principal Bower, 1970; Bower and Winzenz, 1970). No further interpretation of these data will be attempted here, as Experiment 3 was in part deisgned to evaluate the reliability of the data. Therefore, discussion of this anomalous result will be postponed until additional data are presented.

EXPERIMENT 3

This experiment was addressed to two questions: (1) are the results obtained in the first two experiments regarding organizational differences generalizable as well to pictorial stimuli, and (2) is there evidence to suggest that imaginal processing has a role in sentence encoding of concrete information? Experiment 3 was a theoretically motivated extension of the first two experiments dealing with encoding and recall of concrete and abstract nouns in that it involved comparisons of sets of pictures (line drawings) and their concrete noun labels. An empirical assumption from dual coding suggests that the imagery dimension extends from pictures at the high end, to concrete nouns and abstract nouns at the intermediate and lower end, respectively. This dimension operationally defines the relative availability of imaginal and verbal processing.

Predictions regarding encoding latency were based upon the previous two experiments and from the dual coding theory. In general it was expected that, as before, encoding latency would increase with set size. Additionally, since pictures are assumed to have more direct access than nouns to referential imagery, and since the previous two experiments have demonstrated an inverse relationship between imagery and sentence encoding latencies, it was predicted that, overall, pictures would be encoded more rapidly than words. Similarly imaginal encoding should be faster than sentence encoding because of the effects of linguistic constraints on sentence generation.

If the results obtained in the previous experiments regarding organizational differences are generalizable to complex pictorial stimuli, then image encoding latency should be less affected than verbal encoding time by increasing organizational demands via increases in set size. That is, increases in set size should increasingly hinder sentence encoding relative to image encoding again because of greater sequential constraint in the case of verbal encoding.

The imagery interpretation of the concrete-abstract sentence encoding effects obtained in the first two studies can also be evaluated by the present experiment. The imagery hypothesis suggests that concrete nouns are encoded into sentences faster than abstract nouns because images are first generated to relate the noun referents and then sentences are encoded describing the image. If this imagery interpretation is at all plausible, the encoding of pictures should be increasingly favored over words with increases in the size of a set. Further, this effect should be qualified by encoding instructions in such a way that in the case of imagery instructions, pictures should be encoded faster than words at all set sizes. This picture-word difference was predicted by dual coding because pictures are assumed to have more direct access to referential imagery than concrete nouns. Thus an extra processing step is presumed to be involved in imaging to nouns as opposed to pictures. In the case of verbal encoding instructions however, no difference should be found between pictures and words at set size 2, but for the remaining set size conditions pictures should be encoded increasingly faster than nouns. The rationale behind the set size 2 prediction stems from previous research showing no differences in similar situations, the suggestion being that at set size 2 organizational demands are minimal. Thus the specific prediction is an interaction of encoding instructions, set size, and item type.

With regard to recall, the use of pictures and words in combination with verbal and imaginal encoding instructions allows for the evaluation of dual coding effects on memory. How this is achieved can be understood by further consideration of the task. In the case of verbal (sentence) encoding of pictures, what is presumed to be encoded in memory is an imaginal construction, generated directly by the pictorial nature of the stimulus, together with a verbal construction generated to meet the instructional set requirements. Thus, dual coding is achieved. Similarly dual coding can be assumed in the case of nouns encoded as images, in that the nouns are encoded directly as a verbal representation and indirectly as an integrated image as a result of the instructions. In the case of imagery to pictures and sentence encoding to nouns, single coding can be inferred. Of course, regardless of instructions, the persistent problem of subjects implicitly labeling pictures and imaging to nouns must be considered as a source that might attentuate the predicted effects.

Predictions concerning the effects of encoding instructions and item type on recall were made on the basis of dual coding theory. Predictions involving these imagery conditions in conjunction with recall type (cued vs free) and set size were concerned with the integrity of the representation and were derived from the storage space hypothesis.

The dual coding approach suggests that information coded in two ways, imaginally and verbally, should be remembered better than if that same information is coded in either of the coding systems above. The premise is that two codes are better than one for recall when verbal and non-verbal codes are stored, as is presumably the case if only a single code was stored. The general prediction, then, is that dual coding conditions should produce greater total recall than single coding conditions, i.e., an interaction of encoding instructions and item type was predicted (image to words plus verbal to pictures) (image to pictures plus verbal to words). No main effect showing pictures to be better recalled than words should be expected due to this factor combination with encoding instructions. On the other hand, an effect of encoding instructions might be expected on the basis of Paivio and Csapo's (1973) finding that in free recall the image code appears to be mnemonically stronger than the verbal code.

The storage space hypothesis implies that imaginally encoded information is integrated to a greater degree than verbally encoded information. Such a difference of representational integrity should be apparent in total recall differences between free and cued recall. That is, imagery instructions should enhance cued recall relative to free recall more so than for verbal instructions. Further this recall difference should increase directly with set size, as increasing set size presumably increases organizational demands.

Another set of predictions also concerns the integrity of the representation. As in two previous experiments the proportion of set free recalled, conditionalized on the number of sets recalled was used as a measure of integration. The predictions from the storage space hypothesis were as in previous experiments, i.e., the advantage of imagery conditions should increase with set size.

METHOD

Design and Materials

The experimental design was a 2 x 3 x 2 x 2 factorial design with words and pictures as levels of stimulus type, three levels of set size (2, 3 and 4), imaginal and verbal encoding instructions, and free and cued recall tasks.

Forty-eight highly familiar pictures (line drawings) and their most common concrete noun labels were randomly chosen from unpublished picture norms as stimulus materials (provided by Paivio). Stimulus list construction and randomization procedures were the same as those in Experiment 2. The stimulus lists are presented in Table 9.

Subjects

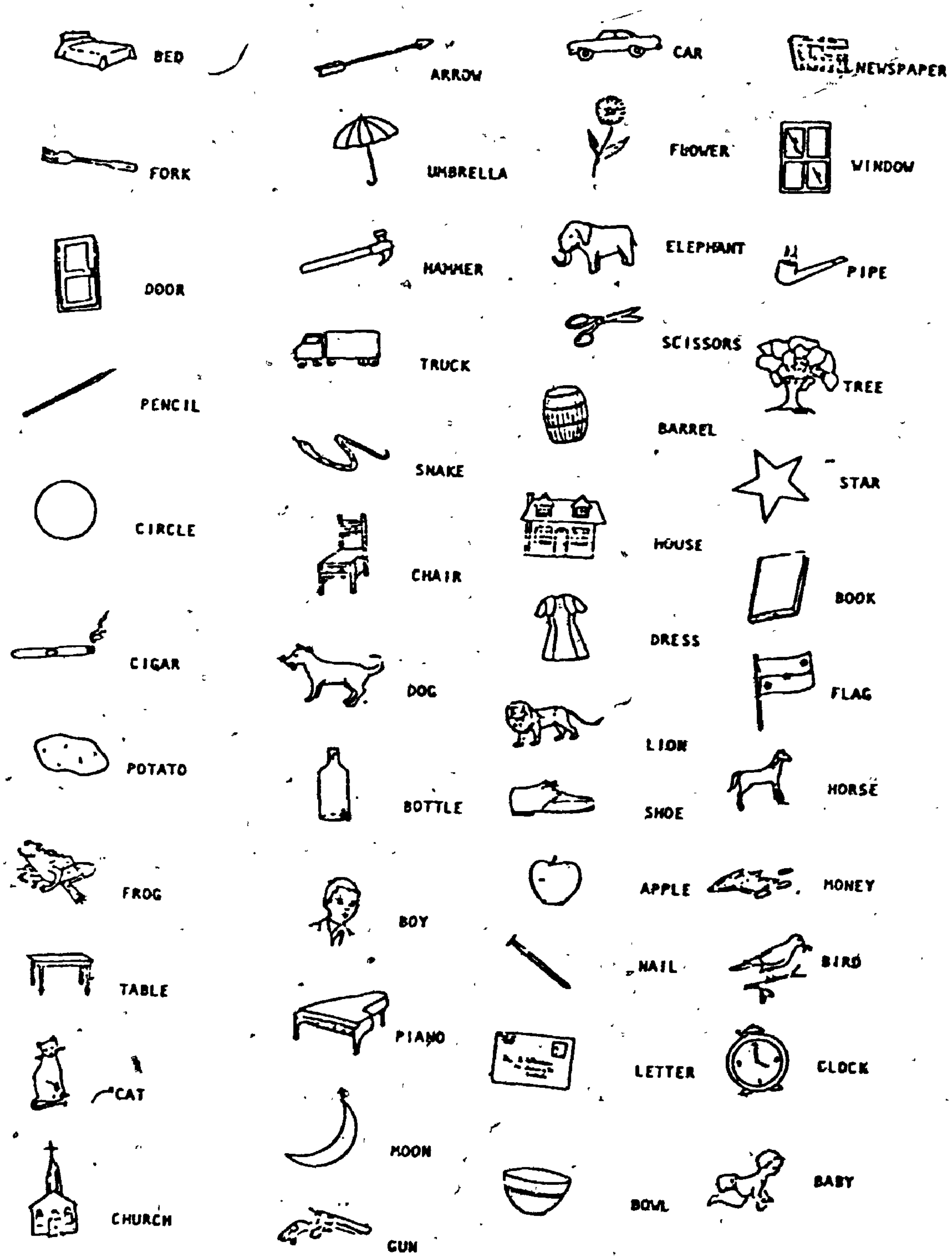
The subjects were 192 University of Western Ontario introductory psychology students. Eight subjects were assigned at random, in order of appearance at the laboratory, to each of the 24 experimental conditions.

Procedure

The experimental procedures for the encoding and incidental free and cued recall tasks were identical to Experiment 2, except that the prompts in cued recall were always pictures in the picture conditions and words in the word conditions. Following the memory test, subjects in the picture conditions were provided a sheet of paper containing all the pictures and they were asked to label each picture. Subjects gave a different label than was used in the word conditions less than 1% of the time. The text of the task instructions are provided in Appendix A.3.

Table 9

Pictures and their most common labels used in Experiment 3



RESULTS

Encoding Task

Table 10 presents the mean encoding latencies for all experimental conditions. A 2 x 3 x 2 x 2 analysis of variance was performed on the encoding latency data. The analysis involved a word vs. picture comparison, set size (2, 3 and 4), image and verbal encoding instructions, and 2 levels of list randomization.

The results of the analysis were in every respect as predicted from prior research and the dual coding approach. Significant main effects were obtained for item type, set size, and encoding instructions. Pictures were encoded more rapidly than their verbal labels, min F (1,252) = 27.49, $p < .001$, imagery encoding instructions resulted in faster encoding than verbal (sentence) instructions, min F (1,263) = 197.17, $p < .001$, and latency increased directly with set size min F (2,225) = 243.69, $p < .001$. All pairwise Scheffe comparisons over set size were significant ($p < .01$).

The main effects were qualified by the three predicted interactions. Encoding instructions interacted with set size, min F (2,235) = 87.41, $p < .001$. The Scheffe tests indicated that, while both image and verbal encoding latencies increased directly with set size, imagery increased at a slower rate than verbal coding. Thus image encoding speed was increasingly favored over verbal coding when the size of the set exceeded two. No difference between instructions was found at set size 2. This interaction is in agreement with predictions from theory and suggests that verbal and imaginal representations are organized in a different manner during encoding. Item type interacted

Table 10

Mean encoding latency (in seconds) as a function of encoding instructions, noun imagery, and set size

Encoding Instructions	Stimulus Type	Set Size 2	3	4
Imagery	Word	2.48	3.63	5.40
	Picture	2.01	2.93	4.43
Verbal	Word	2.31	6.06	11.80
	Picture	2.47	4.89	9.97

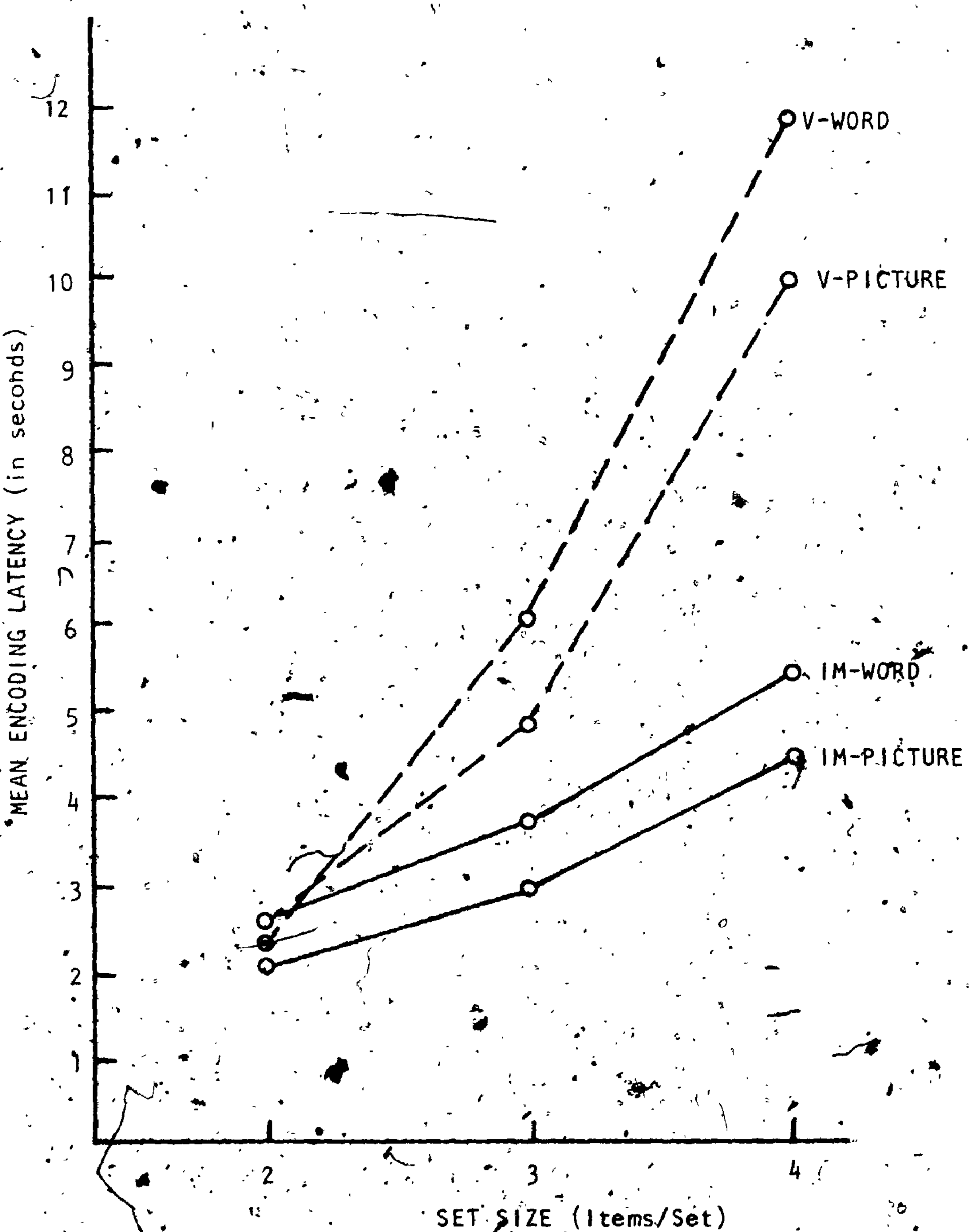


Figure 9: Mean verbal and imagery encoding latency for pictures and words as a function of the number of nouns in a set.

in a similar manner with set size, min F (2,258) = 7.51, $p < .01$, demonstrating that the advantage in speed of encoding of pictures over words increased as a function of set size. Scheffe pairwise comparisons indicated that the encoding latencies for words and pictures did not differ for set size 2; F (2,168) = <1.0 whereas for set sizes 3, F (2,168) = 16.28, $p < .01$, and 4, F (2,168) = 36.66, $p < .001$, word-picture latency differences were significant.

The three-way interaction of item type x set size x encoding instructions qualified the above two interactions, min F (2,256) = 3.37. This interaction is illustrated in Figure 9. Additional two-way analyses of variance treating imagery and verbal encoding instructions separately were performed in order to determine the nature of the interaction. In the image instruction condition, a picture-word main effect suggested that pictures were encoded faster than words for all set sizes, F (1,90) = 31.52, $p < .001$. In the case of verbal instruction, pictures overall were also encoded more rapidly than words, F (1,90) = 17.41, $p < .001$. However, in the case of verbal instructions (but not imagery instructions) item type interacted with set size, F (2,90) = 6.65, $p < .005$, indicating that the encoding latency for words and pictures did not differ for set size 2 but words took increasingly longer than pictures to encode into sentences when set size exceeded a pair. The form of this interaction is perfectly consistent with predictions based upon the hypothesis that imaginal processes are involved in sentence encoding.

Incidental Free and Cued Recall

Recall performance was analyzed in two ways, as in the previous experiments. One analysis involved the total proportion of items correctly recalled in both the free and cued situations. The second analysis involved the proportion of a set recalled, conditionalized upon the number of sets recalled, for free recall only.

The recall data was subjected to a 2 x 3 x 2 x 2 analysis of variance. The analysis involved two levels of stimulus information (words vs. pictures), three levels of set size (2, 3 and 4), two coding instructions (imaginal vs. verbal) and recall type (free vs. cued). The mean total proportionate recall for all conditions is presented in Table 11. The analysis revealed that cued recall performance generally exceeded free recall, $F(1,168) = 112.08$, $p < .001$. Several interactions were also obtained. Item type interacted with encoding instructions, $F(1,168) = 12.90$, $p < .001$, in the predicted manner. This interaction is presented in Figure 10. A Scheffé test indicated that recall was lower for verbally coded word sets (single coding) than image coded word sets (dual coding), $F(1,168) = 12.50$, $p < .05$. In the case of pictures however, single and dual coding conditions did not differ significantly ($p > .10$), although the pattern of results was in the direction favoring dual coding over single coding. This latter effect of pictures may be attributable to the mnemonic superiority of imagery over verbal coding. Such an interpretation is suggested by the Paivio and Csapo (1973) study.

The encoding instructions x item type interaction was qualified

Table 11

Mean proportion of items correctly recalled for all experimental conditions

Encoding Instructions	Stimulus Type	2		Set Size 3		4	
		Recall Type					
		Free	Cued	Free	Cued	Free	Cued
Imagery	Word	.46	.79	.52	.74	.50	.68
	Picture	.50	.67	.51	.59	.48	.55
Verbal	Word	.44	.68	.41	.58	.43	.54
	Picture	.42	.80	.45	.77	.44	.69

by a significant interaction involving these two factors and recall type, F (1,168) = 12.53, p <.001. This three-way interaction is illustrated in Figure 11. Several two-way analysis of variance, treating free recall, cued recall, words and pictures separately were used to determine the nature of the interaction. The results of these two-way analyses indicated that the superiority of the dual coding (verbalizing to pictures and imagery to words) observed in the item type x encoding instructions interaction were due solely to differences in cued recall. Specifically, when free recall was analyzed separately, recall was not facilitated by dual coding conditions, F (1,28) = <1.0. However, consistent with prior research suggesting the imagery code is mnemonically stronger than the verbal code, image instructions produced higher free recall performance than did verbal instructions, F (1,28) = 7.65, p <.005. The separate analysis of cued recall indicated consistent dual coding effects in that imagery to words and sentence encoding to pictures produced significantly higher recall than single coding conditions, i.e., an interaction of item type and encoding instructions, F (1,28) = 17.96, p <.001.

Further, when word conditions were analyzed it was found that cued recall significantly exceeded free recall only in dual coding conditions and when verbal coding was involved. This is evidenced by a main effect of recall type, F (1,28) = 54.61, p <.001, in the absence of an interaction between encoding instructions and recall type, F (1,28) = 2.80, p >.10. When picture conditions were analyzed,

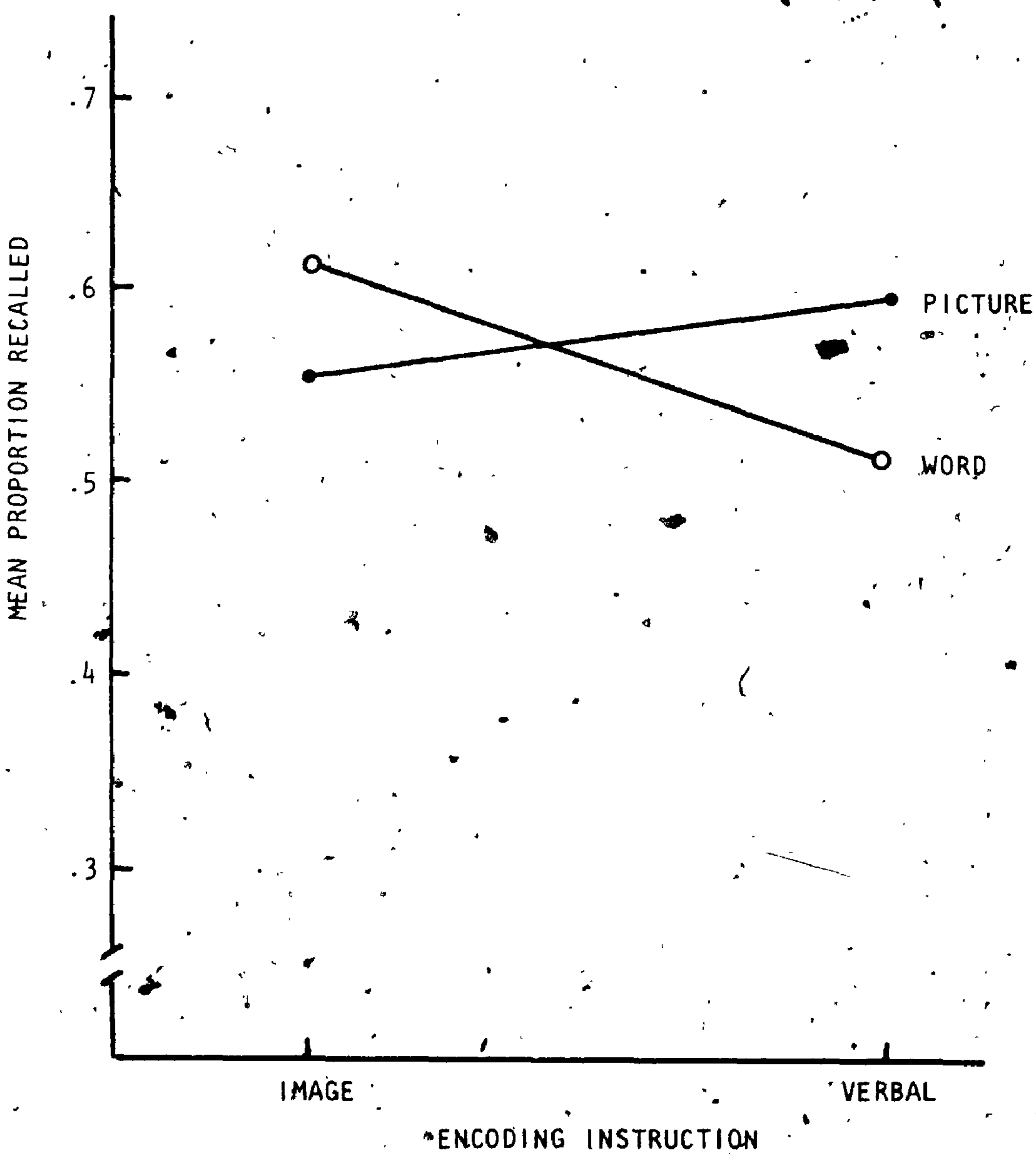


Figure 10: Mean proportion of pictures and words correctly recalled as a function of imagery and verbal encoding instructions.

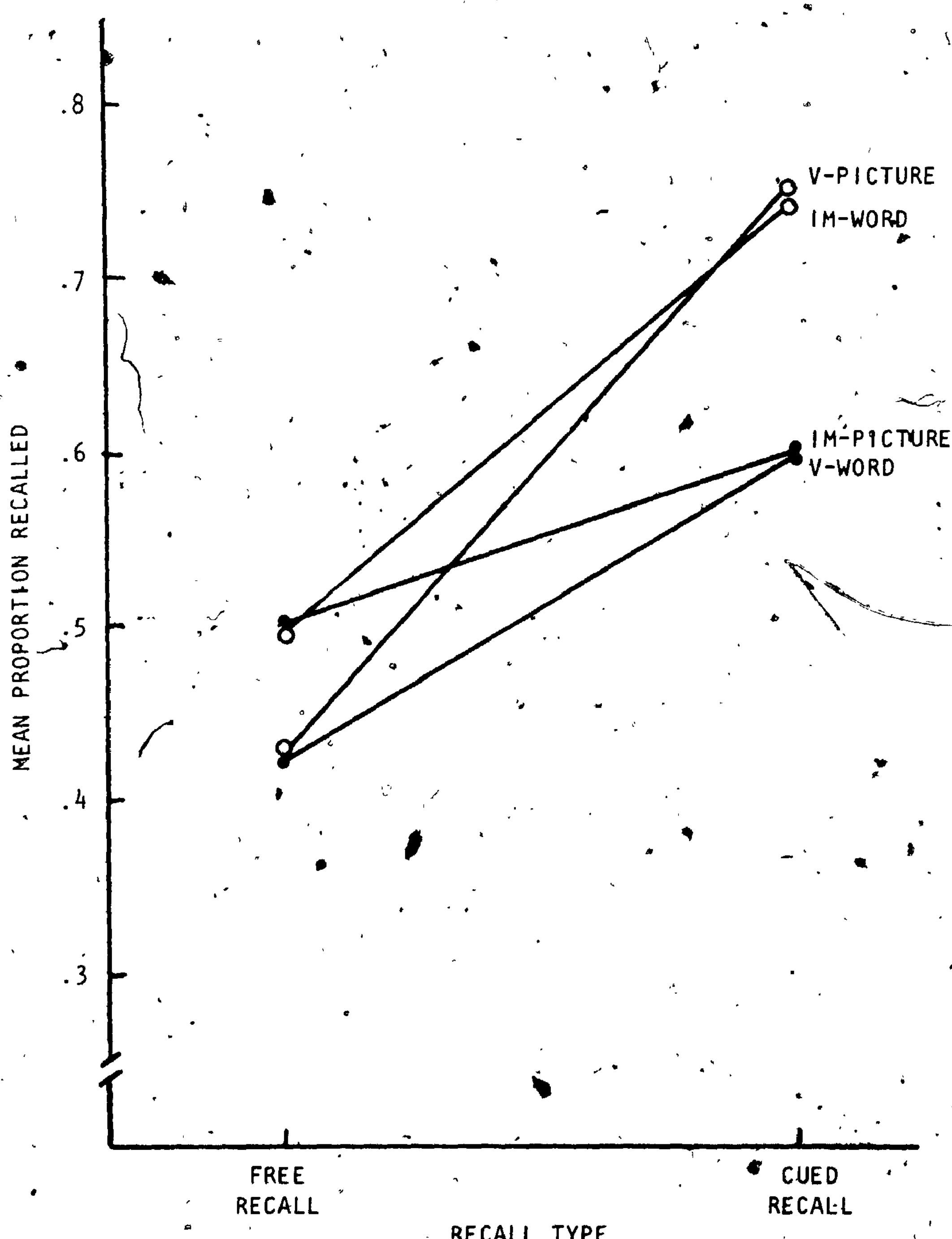


Figure 11: Mean proportion of verbal and imagery encoded words and pictures correctly recalled for free and cued recall conditions.

a main effect of recall type was obtained, $F(1,28) = 47.23$, $p < .001$, indicating that cued recall exceeded free recall; however, this main effect was qualified by an interaction of encoding instruction with recall task, $F(1,28) = 11.13$, $p < .005$. This interaction suggested that when pictures were encoded as mental images (single coding) no significant performance difference between free and cued recall was obtained, Scheffé $F(1,28) = 6.05$, $p > .10$, but when pictures were coded verbally (dual coding) cued recall exceeded free recall, Scheffé $F(1,28) = 9.8$, $p < .10$. The overall three-way interaction, therefore, provides evidence for dual coding processes in memory.

The interaction of encoding instructions x set size x recall type that was predicted from the storage space hypothesis was not significant. Set size did, however, interact with recall type, $F(2,168) = 3.64$, $p < .025$. The Scheffé a posteriori comparisons revealed that free recall performance did not change as a function of set size whereas cued recall resulted in an overall decrease, which was significant between set sizes 2 and 4, $F(2,168) = 12.00$, $p < .10$. Thus, no conclusive support in terms of total recall was found for the storage space hypothesis.

Analyses of variance similar to those in the previous experiment were performed to determine if differences in retention interval produced by the subject-paced encoding task exerted influence on the total recall performance. As in the previous experiment an analysis of variance was performed on the free recall data for the last six items of the stimulus lists. The analysis revealed that free recall

Table 12

Mean proportion of set correctly free recalled for all experimental conditions

Encoding Instructions	Stimulus Type	Set Size 2	3	4
Imagery	Word	.77	.59	.59
	Picture	.73	.52	.50
Verbal	Word	.77	.57	.59
	Picture	.70	.64	.62

of the last six items decreased with increases in set size only between set sizes 2 and 4, F $(2,84) = 38.54$, $p < .001$, and recall varied with serial position, F $(2,168) = 4.12$, $p < .05$. Serial position also interacted with set size, F $(4,168) = 3.42$, $p < .05$. This interaction is solely attributable to the middle serial position for the set size 4 condition which unexplainably produced inordinately low recall relative to the other conditions. Therefore, the interaction does not suggest any regular decrement in recall for the set size 4 condition relative to the other set size conditions. An additional analysis of variance was performed on the recall data from all conditions (including cued recall) with the last six items removed from calculation. No differences in the type and pattern of significant effects between this analysis and the original overall analysis were found. Taking both analyses into consideration and the nature of the set size x serial position interaction, it is reasonable to suggest that as in the previous two experiments, differences in retention interval alone fail to qualify the existing recall conclusions.

DISCUSSION

This discussion deals in turn with three issues: (1) the efficiency of encoding multiple word and picture units into higher-order verbal and imaginal cognitive structures, (2) the role of imagery in verbal encoding, and (3) free and cued recall results as they relate to dual coding and differential organization hypotheses.

The results of the encoding portion of this experiment are quite clear regarding the efficiency (speed) of encoding word and picture sets as imaginal and verbal cognitive structures. In every instance the pattern of results is exactly as predicted from the dual coding and differential organization hypothesis in that pictures, which presumably have more direct access to imaginal processes, were encoded more rapidly than their verbal labels when subjects were instructed to encode by imagery. On the other hand, the encoding latency for pictures and words did not differ at set size 2 when sentence instructions were given, but when the set size exceeded 2, pictures again resulted in faster latencies. This is consistent with the results of Experiments 1 and 2 in suggesting that when minimal relational organization is required in encoding (as is the case with a pair of words) no differences should be found in the latency of encoding concrete and abstract noun sets or picture and word sets. However, increasing the organizational demands by increasing set size revealed differences in organization at encoding.

The picture-word difference for verbal encoding increases the plausibility of the imagery interpretation of the concrete-abstract difference under verbal encoding conditions in Experiment 1 and 2, i.e., that a complex image was first formed to the concrete words and then a sentence was generated to describe the image. (This interpretation will be discussed further below, in the General Discussion section.) On the other hand it might be alternatively argued that pictures simply can be scanned and/or recognized faster than words and one need not consider an imagery interpretation. If this were the case, however, it would be expected that the same advantage would be apparent at set size 2. This was not the case, as the verbal encoding latency for pictures and words did not differ significantly. Additionally, empirical evidence from another study (e.g., Ernest, 1972) determined that recognition time was greater for pictures than for their verbal labels. Consequently differences in recognition time alone cannot reasonably account for the picture-word encoding latency differences.

Organizational differences between verbal and imaginal codes are further suggested by the finding that verbal encoding latency increased more steeply with set size than did image encoding latency. This finding is also consistent with the dual coding theory in that the verbal encoding is presumed to be sequentially constrained to a greater degree than imagery encoding. If sentence encoding of concrete stimulus material involves two components, imagery and verbal, as was suggested above, then the increase in sentence generation time with set size primarily reflects the sequential component of sentence encoding. Conversely, the relatively flatter function for image latency suggests strongly that encoding into compound images is relative free from such grammatical constraints. This is consistent with the view that imaginal units can be organized synchronously into higher-order memory structures.

With regard to the recall data, the total recall analysis resulted in an interaction of item type by encoding instructions by recall type. This interaction is generally consistent with a dual coding approach to memory coding. The finding that no dual coding effect was apparent in incidental free recall conditions can be attributed to the mnemonic superiority of imagery. If imagery is the "stronger" code in this task, as previous results indicate (e.g., Paivio, 1975c; Paivio & Csapo, 1973), then any dual coding effect might be expected to be attenuated. Dual coding effects, however, were quite dramatic in the case of incidental cued-recall in that dual coding (image to words and verbal to pictures) always exceeded single coding. One additional aspect of this three-way interaction that must be accounted for is the finding that cued recall exceeded free recall for dual coding and verbal coding or words (single coding) conditions, but not when pictures were encoded as images (single coding). It would be premature to conclude that this finding suggests that the verbal code is more integrated than the image code, since much evidence to the contrary has been found (Begg, 1972, 1973). A better interpretation might be that dual coding increases the availability of memory structures and that presentation of a cue increases the likelihood of accessing at least one of the available structures. The results are then consistent with the dual coding hypothesis. However, verbal encoding of concrete noun sets also facilitated cued recall relative to free recall. This effect can be reconciled with the dual coding interpretation by following the suggestion from the latency findings of this experiment as well as Experiments 1 and 2. The latencies and subjective reports both indicated that imagery was involved on some occasions in the encoding of concrete words into verbal structures, i.e., a compound image was generated, then a verbal description was encoded and reported. It might be that at least part of the time dual coding took place when concrete words were to be encoded verbally. If this were the case, it would be expected that cued recall would be facilitated by such dual coding relative to single coding of pictures as images.

With regard to the storage space hypothesis, the data are generally not consistent with predictions in that it was expected that imagery instructions should have enhanced cued recall relative to free recall more than verbal instructions, and this recall difference should have increased directly with set size (i.e., interactions of encoding instructions x recall type and encoding instructions x set size x recall type). These interactions failed to appear. The present experiment disagrees with Begg's findings, suggesting instead that verbal and imaginal cognitive structures are integrated to the same extent, but the integrative (organizational) processes are qualitatively different in that verbal cognitive structures appear to be sequentially constrained at encoding to a degree not characteristic of images. It is unclear at the present time why the recall results of the present study concerning organization differ from previous research. No attempt will be made at this point to reconcile these differences.

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GENERAL DISCUSSION

Encoding

The primary purpose of the present series of experiments was to investigate the empirical consequences of dual coding theory for encoding. Two issues were investigated. The first dealt with the efficiency (speed) of encoding. The second concerned differences between verbal and imaginal organizational processes at encoding.

The results are quite clear regarding the speed of encoding multiple word and picture units into imaginal and verbal cognitive structures. The research replicated and extended the findings of previous research (e.g., Ernest & Paivio, 1971; Paivio, 1966; Yuille & Paivio, 1967). As in the earlier research, verbal and imaginal encodings were formed equally quickly to sets of concrete nouns, but it took longer to encode compound interactive images than sentences to abstract nouns. This supports the view that imaginal and verbal cognitive structures are equally available to concrete nouns that have objective referents but not to abstract words which lack such referents. The theoretical extension of these effects to pictures and words was also found to be in complete agreement with theory in that pictures, which presumably have more direct access to the imagery system, were encoded more rapidly than their verbal labels into compound images. Also as predicted, verbal encoding time for pairs of pictures and words did not differ significantly, presumably because sequential constraints are minimal when only two items are involved.

The extention of the encoding task to include larger groupings of stimuli produced one notable difference between the present findings and previous research. This difference concerns the effects of stimulus imagery on verbal encoding. Typically, verbal associates have been found to occur equally quickly to concrete and abstract nouns or noun pairs (e.g., Ernest & Paivio, 1971; Yuille & Paivio, 1967). This pattern held in two of the present experiments (1 and 2) for noun pairs. The present investigation indicated that when the set size exceeded a pair, subjects took significantly longer to construct a meaningful sentence from abstract than from concrete nouns. All things being equal, this result would be unexpected if it is assumed that sentence generation to concrete and abstract words was mediated entirely by the verbal system. The latency data from Experiments 1 and 2 suggested that imagery might facilitate the generation of complex linguistic structures in the case of concrete nouns. Additionally, subjects retrospective reports were found to be consistent with the interpretation.

Possibly sentences were generated more quickly to concrete than abstract nouns because an image was first formed integrating the noun referents and then a sentence was constructed describing the image. Abstract words on the other hand, having less direct access to images, must rely more heavily on the sequantially constrained verbal process. It is this differential dependence upon the sequential verbal process that presumably produced the verbal encoding latency differences between concrete and abstract nouns. In Experiment 3, pictures and words were used to test the plausibility of the imagery hypothesis. If the hypothesis that sentence encoding was preceded by image encoding is at all plausible, it follows that sentence generation would be easier to pictures than words, particularly with larger set sizes (> 2). If one assumed, on the other hand, that sentence generation is mediated entirely by verbal mechanisms, then verbal encoding latency should be generally faster for words than for pictures because the former have more direct access to the verbal system. The results were consistent with the imagery interpretation in that verbal encoding latencies were generally faster for pictures than for words when set size exceeded two. These results are as predicted from dual coding theory. They suggest further that the imagery system maybe significantly involved in the generation of sentences, and may even underly verbal processing when the stimulus information is concrete.

Predictions from the differential organization hypothesis were repeatedly confirmed by other aspects of the encoding latency data in all three of the present investigations. Recall that the differential organization hypothesis predicts that verbal encoding time should increase more dramatically than image time as set size is increased. The verbal (sentence) encoding latency function was consistently found to increase more steeply with increases in set size than did the image encoding function. No differences related to instructions were found at set size 2, and therefore the interactions can be attributed to processes occurring when three or four words (or pictures) were to be encoded. These results are in perfect accord with the postulated organizational differences between verbal and imaginal coding systems in that the encoding of a pair of stimulus items (concrete words, abstract words, or pictures) involves only a minimal degree of relational organization. That is, there is a great deal of flexibility in the way two events can be related and it should be equally easy to represent the relation as an image or as a sequentially organized verbal cognitive structure. However, with more items in a set, imagery was increasingly favored (in terms of latency) as an encoding process, presumably because the relative freedom from sequential constraints that theoretically characterizes imaginal processes permitted rapid encoding of the elements into synchronously-organized cognitive structures. On the other hand, the sequential constraints associated with verbal processes increasingly hindered the encoding of the elements into higher-order structures as set size increased.

The interaction of encoding instructions x set size obtained in the latency data of all three experiments could be alternatively attributable to decision processes at encoding rather than to differences in organizational processes. More specifically, perhaps the instructions failed to set equivalent decision criteria for deciding whether the generated sentence or image was acceptable. It might be that no exact criteria exists for deciding whether an image is meaningful and interactive whereas the same is not true in determining whether a linguistic sequence is a sentence. If this was indeed the case then increases in set size should compound the decision process. Under these conditions perhaps subjects in the imagery instructed conditions adopted increasingly lax decision criteria with increasing set size, while in verbal conditions less of a criterion shift would be expected. Thus with increases in set size and a shifting decision criterion, image latencies would be relatively unaffected when compared with the sentence conditions. The existing latency data do not allow for a choice between the above decision explanation and the differential organization hypothesis.[1]

Two theoretical alternatives to dual coding remain to be considered in light of the present data. The first is the levels of processing approach. This approach is considered to be a theory of memory performance rather than a theory of representation. No commitment is made regarding the nature of the representation. Instead this approach relates memory performance to the level or depth to which a given stimulus event is processed following its presentation. Basically these approaches advocate two levels of processing, deep and superficial (Craik & Lockhart, 1972; Hyde & Jenkins, 1973; Walsh & Jenkins, 1973) corresponding to semantic and nonsemantic processing, respectively. This type of theory is similar to dual coding inasmuch as both postulate memory performance differences as a function of depth of processing. Dual coding distinguishes the representational level (superficial) from the deeper referential and associative levels of processing. The representational level deals

[1] If the decision explanation is at all viable then it might be conceivable to observe deterioration in the apparent integrity (quality) of the subjects' picture reproduction of their imaginal cognitive structure. In order to evaluate this alternative explanation, two productions from all subjects in the imagery conditions of Experiment 2 and Experiment 3 were randomly chosen and rated (5 point scale) for their integrity. Two psychology graduate students served as "expert" raters. An analysis of variance was performed on the rating data with stimulus type, set size and rater as factors. No statistically significant effects were obtained for either experiments indicating that the raters did not observe any deterioration in quality of the subjects drawings. However, the interater reliability coefficients were low, .46 and .44 for Experiments 2 and 3 respectively. The magnitude of these coefficients reflects the difficulty of trying to understand what the subjects had initially attempted to illustrate in their pictures. This kind of information is admittedly weak and consequently no inferences should be made from the data. Further experimental work is indicated.

with the registration of the stimulus information in memory. The deeper referential and associative levels deal with the semantic elaboration of the representation. (For further elaboration of the dual coding levels see Paivio, 1971, Chap. 3). The Craik, Lockhart and Jenkins approach differs in important ways from the processing levels involved in dual coding in that the levels approach includes no commitment to representational or functional differences between memory codes at any depth, whereas such a distinction is maintained at every processing level in the dual coding approach. A second difference between approaches concerns where the emphasis is placed in explaining memory effects. The depth hypothesis attributes memory differences to the hypothetical depth variable, in that semantic (deep) processing is related to higher memory performance than superficial processing; whereas, dual coding attributes the effects to the number of codes activated and the functional distinctions between verbal and imaginal processing systems. Still further, the depth variable is not necessarily assumed to be based in real time, i.e., a short processing time does not necessarily indicate that only superficial processing has occurred. Instead the depth variable is related to the language user's experience with the information and can be experimentally manipulated by well known variables such as word frequency or familiarity. Thus the more familiar a person is with the stimulus information the more quickly deeper processing will occur. Since the concrete and abstract word lists were equated for frequency and the pictures were all highly familiar it is difficult to determine how latency differences between item types could be predicted by the levels model. The levels approach, therefore, does not appear at present to have the capability of predicting the obtained results.

The common code approaches are the second type of current theoretical alternative to dual coding. This class of theories differs from dual coding in the assumption that both verbal and nonverbal information are represented in the same format in long term memory. This representation is postulated to be abstract and neutral with respect to the nature of the stimulus information as well as sensory input modality. These approaches, while computer based in nature, have a logical predecessor in the literature of psychology. Osgood's (1957) mediational formulation is probably the earliest version of a common code approach. While Osgood's approach, like dual coding, recognized that the representation is multidimensional, the nature of the stored information was seen as abstract and neutral with respect to the nature of input (e.g., linguistic or pictorial).

Recent cognitive approaches that fall into the common code class suggest abstract descriptions or propositions as a form of the representation (e.g., Anderson & Bower, 1973; Chase & Clark, 1972; Pylyshyn, 1973; Rumelhart, Lindsay & Norman, 1972). The above theories differ from each other in many nontrivial ways (see Anderson & Bower, 1973) however, they all differ from dual coding in their insistence that verbal and nonverbal information is represented in a common format. Further they differ from dual coding as to the importance of stimulus imagery, a variable directly derived from dual coding. The Anderson and Bower model, HAM for example, attributes imagery effects to differences in the encoding of access relations; i.e., concrete word lists are presumed to lead to a greater degree of elaboration than abstract. More specifically, under high imagery conditions, subjects are assumed to generate "auxiliary propositions" interconnecting the elements of the representation. These elaborated propositions benefit memory by increasing the accessibility (retrievability) of the memory structure. The model, HAM[2] is not articulated in such a way as to make explicit predictions for encoding; at least in the present context. Consequently, no speculations will be made from HAM's existing general structure. Of course the HAM model could easily be modified to explain the obtained latency results if it is further assumed that verbal and imaginal instructions require different amount of processing time and that pictures, concrete nouns, and abstract nouns differ in some basic way, such as lexical complexity (cf. Kintsch, 1972). Since the present form of HAM is inadequate to predict the overall pattern of the latency data and since dual coding theory can, the latter theoretical position is favored, at least in this situation.

It should be mentioned that recent models, other than HAM, have attempted to reconcile the differences between dual coding and common code theories. For example, Collins and Quillian (1972) also suggest that imagery is a by-product, generated from the abstract propositional

[2] HAM has been singled out here for discussion for two basic reasons: (1) it is one of the only extant models that explicitly deals with imagery related effects, and (2) it is fairly representative of the common code models.

base). Jorgensen and Kintsch (1973) distinguish between propositions and images and go further to suggest that they are independent classes of representations.

Recall

The present investigation was also concerned with differences in the amount of information retained following encoding. In general, some aspects of the incidental recall results can be explained by dual coding. Other aspects of recall are explained by a combination of dual coding and the assumption that the two codes have different organizational properties.

Dual coding effects were suggested by the total recall results of Experiment 1 and 2. Consistent with dual coding were the findings that more concrete than abstract nouns were recalled, and that more imagery encoded than verbally encoded words were free recalled. Similar results from Experiment 1 were obtained in the analysis of the number of sets recalled, i.e., set recall was higher for concrete than for abstract nouns and for imaginally encoded than verbally encoded noun groups. Experiment 3 provided stronger support for dual coding using direct manipulation of encoding instructions with pictures and words as stimuli. The cued recall data demonstrated that dual coding conditions always resulted in greater total recall than did single coding. The free recall data from this same experiment, however, failed to show dual coding superiority. This failure might be attributable to the mnemonic superiority of the image code, which may have overridden dual coding effects (cf. Paivio & Csapo, 1973). Apart from the uncertainty of the free recall data, the results are generally consistent with a dual coding hypothesis which maintains that high imagery conditions are effective in memory because they increase the probability that both imaginal and verbal processes will be involved in information retrieval. Concrete nouns have a greater probability of dual coding than abstract nouns; instructions to encode words by imagery further increase the probability of dual coding. In a similar manner verbal encoding of picture stimuli increases the probability of dual coding. Thus dual coding conditions result in a greater probability of recall than would be the case for single coding conditions.

Differences in memory organization can be inferred from other aspects of the recall data. The differential organization hypothesis (Begg, 1972) suggests that information in synchronously organized images takes up less "storage space" than sequentially organized verbal information. The set size manipulation was intended to test the storage space notion directly in that increasing the size of the grouping should reveal recall differences that were related to memory capacity. The specific expectation was that imagery conditions (high imagery words or image encoding instructions) would not show as rapid a decrement in free recall as would low imagery nouns or verbally encoded sets as set size was increased. This expectation was generally not supported by the total recall or proportion of a set recalled data in any of the present studies.

Further predictions from the storage space hypothesis concerned the differential effects of imagery conditions, set size, and recall type (free vs. cued). Cued recall appears to be particularly sensitive to the degree of integration and therefore performance differences between free and cued recall should be directly related to the amount of integration in the memory structure. That is, cued recall should exceed free recall by a greater amount when the memory structure is more integrated than would be the case when the representation is integrated to a lesser degree. Experiments 2 and 3 provided a comparison of incidental free and cued recall. Analysis of Experiment 2 failed to produce results consistent with the integration notion. However, in Experiment 3, when word stimuli were considered separately, the results supported differential integration. In Figure 11 it can be seen that greater facilitation of cued recall relative to free recall was obtained when the nouns were encoded imaginally than verbally. These results are consistent with the Begg data. On the other hand, when picture recall was treated separately, exactly the opposite results were obtained, i.e., verbal encoding of pictures resulted in a greater increment of cued recall relative to free recall than did imagery encoding of pictures. Thus the overall pattern of results seem more appropriately interpretable in terms of dual coding without the differential integration assumption.

More General Implications

It can be suggested that the results of the present investigation have more general implications regarding the nature of thought processes. Thinking clearly involves the encoding of stimulus information, its organization and storage in memory and retrieval of that information for use in performing a task. Bourne, Ekstrand, and Dominowski (1971) assert that the key to understanding thinking is to understand the nature of the organizational processes that underly behavior. Therefore, it follows that knowledge about the processes by which complex stimulus information is organized and the new organization encoded, is potentially useful in understanding thought processes.

Using dual coding theory as a conceptual framework for the investigation of thought processes, as has been suggested by Paivio (1975b), several speculations can be made about these processes on the basis of the present data. First, the data suggest that imaginal thinking is highly efficient in terms of speed of encoding and flexibility of processing. Complex information (multiple word or picture units), up to some as yet unspecified number, can be encoded and organized quickly into visual images that function as units in memory storage. Verbal processes appear to be generally slower presumably because of the involvement of sequential constraints at encoding; whereas, images on the other hand appear to be relatively free from similar constraints. Additionally, memory seems to be enhanced when nonverbal processes are assumed to be involved. Thus imaginal thinking can be seen as more efficient than verbal thought in the sense that concrete informational units can be encoded more rapidly without any compensatory memory loss when the information is later to be retrieved. This at least appears to be the case when memory for order information is not essential to the task.

Secondly, the latency data allow for the speculation that imagery processes may be involved in verbal thought. The data on sentence generation to concrete nouns and pictures demonstrates the plausibility of the above speculation. The suggestion may even be made that imagery in some cases supports verbal thinking, i.e., it acts as a base from which logical verbal thought may be derived. At the very least the data indicate that there is a considerable amount of interplay between verbal and imaginal thought processes. For a more detailed discussion of dual coding theory's relation to thinking the reader is directed to Paivio (1975b).

Conclusions

Five conclusions emerge from the present investigation. First, the latency data provided support for the dual coding theoretical predictions concerning verbal and imaginal processes. Increases in the number of words or pictures in a set resulted in a greater increase in sentence generation than image generation time, suggesting that verbal encodings are sequentially constrained by grammar to a degree not characteristic of synchronously organized images. Second, the sentences were more easily generated from concrete than from abstract nouns, and from pictures than from words, suggesting that the speed of verbal encoding is influenced by the availability of referential imagery as part of the representation of concrete nouns. Third, the latency results attest to the relative speed and flexibility of imaginal thought. Fourth, recall data were consistent with dual coding predictions concerning the effect of verbal and imagery conditions on memory retrieval, and lastly, predictions from the storage space hypothesis of imager organization generally failed to be supported.

APPENDIX A.1

The purpose of this experiment is to determine how quickly people can make up sentences (mental images) to groups of words. This information is needed so that future research can be more tightly controlled.

In this experiment I will display a number of index cards to you. One at a time I will place them directly in front of you for you to see. On each card will be printed 2/3/4 nouns. Your task will be to generate a meaningful sentence (an interactive mental image) containing:

for verbal conditions: the words on the card. The nouns on the card can appear in the sentence in any order you wish.

for image conditions: mental pictures, i.e., mental images of objects that stand for each of the nouns.

For example, if I present to you a card with the word:...

for set size 2: CAT - DOG

for set size 3: CAT - DOG - CHURCH

for set size 4: CAT - DOG - CHURCH - HOUSE

you could easily make up a sentence (mental image) combining the nouns (image objects).

For example a possible sentence (image) could be:

for verbal set size 2 condition: The DOG chased the CAT.

for verbal set size 3 condition: The DOG chased the CAT toward the CHURCH.

<u>for verbal set size 4 condition</u>: The DOG chases the CAT toward the CHURCH next to the HOUSE.

<u>for image set size 2 condition</u>: A DOG chasing a CAT.

<u>for image set size 3 condition</u>: A DOG chasing a CAT toward a CHURCH.

<u>for image set size 4 condition</u>: A DOG chasing a CAT toward a CHURCH with a HOUSE beside it.

<u>For image condition add</u>: Remember that the images are to be interactive, that is the pictured objects in the image are in an active relationship with one another.

<u>For image abstract conditions only add:</u> Some words do not readily bring to mind images of objects. These words can be called abstract nouns. In this part of the experiment you will be presented with words that are difficult to generate images to. You should then use an image of an object that could more or less directly remind you of the presented words. For example, if a word presented was "LIBERTY" you might generate an image of the Statue of Liberty or something else that would remind you of LIBERTY. Likewise when several of this type of abstract words are presented, you should combine these types of images into a compound interactive image.

In the experiment I will present to you ten cards, one at a time. Upon the presentation of a card I will say a number from one to ten to let you know how far along we are in the experiment. When I present the card you should <u>as quickly as possible</u> generate your sentence (image). When the sentence (image) is completely formed, press the telegraph key in front of you. This will stop the timer and allow me to determine how long it took you to complete the task. Let me suggest that you keep your hand on the telegraph key so that I am able to obtain an accurate timeing.

After you press the key, pick up the pencil sitting in front of you and quickly write down the sentence you have just generated (roughly draw a picture of the image you have just generated). Drawing quality is NOT important. Let me remind you to do your writing (drawing) as quickly as possible as you will be given only a small amount of time.

Now to make sure you understand the task when the card is presented:

1. look at the card.
2. generate your sentence (image) as quickly as possible.
3. press the telegraph key when you have completely generated your sentence (image).
4. write down (draw) the sentence (image).

Do you have any questions?

Now to make sure you understand the procedure, I'm going to give you some practice. I'll present several cards one at a time and you are to proceed in the way I have just instructed you.

APPENDIX A.2

The purpose of this experiment is to determine how quickly people can make up meaningful sentences (mental images) to groups of words. This information is needed so that future research can be more tightly controlled.

In the experiment I will display a number of index cards to you. One at a time I will place them directly in front of you for you to see. On each card will be printed 2/3/4 nouns. Your task will be to make up a meaningful sentence (interactive mental image) containing...

<u>for verbal conditions</u>: the words on the card. The nouns that appear on the card can appear in any order you wish.

<u>for image conditions</u>: mental pictures, i.e., mental images of objects that stand for each of the nouns.

For example, if I present to you a card with the words...

<u>for set size 2 condition</u>: CAT - DOG

<u>for set size 3 condition</u>: CAT - DOG - CHURCH

<u>for set size 4 condition</u>: CAT - DOG - CHURCH - HOUSE

you could easily make up a meaningful sentence (interactive mental image) combining the nouns (imaged objects). For example a possible sentence (image) could be: ...

<u>for verbal set size 2 condition</u>: The DOG chased the CAT.

<u>for verbal set size 3 condition</u>: The DOG chased the CAT toward the CHURCH.

for verbal set size 4 condition: The DOG chased the CAT toward the CHURCH next to the HOUSE.

for image set size 2 condition: A DOG chasing a CAT.

for image set size 3 condition: A DOG chasing a CAT toward a CHURCH.

for image set size 4 condition: A DOG chasing a CAT toward a CHURCH with a HOUSE beside it.

for image conditions: Please remember that the images you make up are to be interactive, that is, the pictured objects in the image are to be in an active relationship uniting each other. Note that this is the case in the example I just gave you.

for verbal conditions: Please remember that the sentences you make up are to be meaningful. Note that this is the case in the example I gave you.

For image abstract conditions only: Some words do not readily bring to mind images of objects. These words can be called abstract nouns. In this part of the experiment you will be presented with words that are difficult to make up images to. You should then use an image of an object that could more or less directly remind you of the presented words. For example, if a word presented was "LIBERTY" you might generate an image of the Statue of Libery, or something else that would remind you of LIBERTY. Likewise when several of this type of abstract words are presented, you should combine these types of images into a compound interactive image.

In the experiment I will present to you 24/16/12 cards one at a time. Upon the presentation of a card I will say a number from one to ten to let you know how far along we are in the experiment. When I present the card you should as quickly as possible generate your sentence (interactive image). When the sentence (image) is completely formed press the telegraph key in front of you. This will stop the timer and allow me to determine how long it took you to complete the task. Let me suggest that you keep your hand on the telegraph key so that I am able to obtain an accurate timing.

After you press the key, pick up the pencil sitting in front of you and quickly write down the sentence you have just generated (roughly draw a picture of the image you have just generated, drawing quality is NOT important). Let me remind you to do your writing (drawing) as quickly as possible as you will be given only a small amount of time.

Now to make sure you understand the task - when the card is presented: -

1. look at the card.
2. generate your sentence (image) as quickly as possible.
3. press the telegraph key when you have completely generated your meaningful sentence (interactive image)
4. write down (draw) the sentence (image)

Do you have any questions?

Now to make sure you understand the procedure, I'm going to give you some practice. I'll present several cards one at a time and you are to proceed in the way I have just instructed you.

APPENDIX A.3

The purpose of this experiment is to determine how quickly people can make up meaningful setences (mental images) to include groups of words (pictures) that I will present to you. I need this information so that future research that I am planning will be more tightly controlled.

The instructions are quite simple. In the experiment I will display to you a number of index cards. I will place them one at a time directly in front of you so that there will be no difficulty for you to see them. On each card you will find 2/3/4 nouns (pictures). The nouns (pictures) are all ones that you are highly familiar with so that you will have no difficulty recognizing them. As the card is presented to you, your task begins. Your job is to make up a meaningful...setence (interactive mental image) containing...

<u>for verbal-word conditions</u>: The nouns printed on that card. The nouns can appear in any order in the sentence: not necessarily the order presented on the card.

<u>for image-word conditions</u>: mental images, i.e., mental pictures of objects that represent the words on the card.

<u>for verbal-picture conditions</u>: The name for each of the object pictures presented on the card. The names for the objects can appear in any order in the sentence; not neces-

sarily the order presented on the card.

for image picture conditions: mental images, i.e., mental pictures of objects or similar objects to those presented on the card.

For example, if I present to you a card with the words (pictures)...

for set size 2 condition: KING - TOWER

for set size 3 condition: KING - TOWER - PIE

for set size 4 condition: KING - TOWER - PIE - CANDLE

you could easily make up a meaningful sentence (interactive image) containing the words (mental images of the objects). For example:

for set size 2 verbal condition: The KING kicked the TOWER.

for set size 2 image condition: A KING kicking a TOWER.

for set size 3 verbal condition: The KING threw a PIE at the TOWER.

for set size 3 image condition: A KING throwing a PIE at a TOWER.

for set size 4 verbal condition: The KING used the light from the CANDLE to throw a PIE at the TOWER.

for set size 4 image condition: A KING using the light from a CANDLE to throw a PIE at a TOWER.

For image conditions add: Notice what I mean by interactive image is that the mentally pictured objects in the image are in an active relationship with one another. Note that this is the case in the example I just gave you.

For verbal conditions add: Please remember that the sentences you make up are to be meaningful. Note that this is the case in the example I just gave you.

The entire experiment will consist of me presenting to you 24/16/12 cards. Therefore you will have to make up 24/16/12 sentences (images). I will present the cards one at a time. Upon the presentation of a card you should as quickly as possible make up your sentence (image). When the sentence (image) is completely formed I want you to press down the telegraph key in front of you. Your key press will stop the clock and allow me to determine how long it took you to complete the task. Let me suggest you rest your hand on the telegraph key so that I get an accurate estimate of the time taken.

There is only one additional thing for you to do; after you press the telegraph key indicating the sentence (image) is formed, then immediately write down (roughly draw) on the blank paper in front of you the sentence (image) you have just made up.

For image conditions add: Drawing quality is NOT important. Do your writing (drawing) as quickly as you can as you will be given only a small amount of time.

Now to make sure you understand the steps let me review:

when a card is presented: -

(1) Look at the card

(2) Make up your sentence (image) as quickly as you can. Let me remind you that the sentence (image) must be as meaningful as possible.

(3) Press the telegraph key.

(4) Quickly write down (draw) the sentence (image).

Do you have any questions?

Before we begin, I'd like to make sure you understand the task so I'm going to give you some practice. I'll present several cards one at a time and you should do what you have just been instructed.

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