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One hundred, forty-four subjects, 48 at each of grades kindergarten, third, and sixth (with equal representation of boys and girls), were presented with either 30 auditory (A) or 30 visual (V) items for the purpose of a subsequent recognition memory test. The modality of the test items--the initial 30 items plus 30 intermixed distractors--was also either auditory (A) or visual (V) in factorial combination with the two presentation modalities. Teacher's ratings of each subject's reading ability were obtained for third and sixth grade subjects.

It was hypothesized that (1) reading ability would relate significantly to task performance both within and across age levels, (2) pictorial stimuli would produce better performance than verbal stimuli, and (3) that age would interact significantly with performance in the four presentation mode-test mode combinations.

Accuracy and reaction time (RT) measures of recognition performance indicated an overall advantage with visually presented materials over auditorially presented materials. Modality of test items was highly significant in determining the speed (RT) of recognitions, with auditory test items producing much shorter latencies than visual test items. Modality of test probe was marginally significant in its effect on the accuracy measure, with visual test items

producing better performance than auditory test items. Congruent presentation mode-test mode combinations (the V-V and A-A groups) resulted in better performance than incongruent (A-V and V-A) combinations. A significant grade x presentation mode x test mode interaction with the accuracy data largely reflected the lack of proficiency on the part of the two younger groups at processing across modalities. Performance did not differ across grades in the congruent conditions, but in the incongruent conditions sixth graders were superior.

Reading ability was found to relate significantly to accuracy and latency of responding for sixth grade subjects in the two congruent conditions. High reading scores were associated with high accuracy for sixth graders in the A-A condition; whereas, high reading scores were associated with low accuracy scores for those sixth graders in the V-V combination. High reading scores were also associated with shorter latencies in the V-V condition. It was concluded that in tasks where verbal processing is necessary, e.g., in the A-A condition of the present study, reading competence facilitates performance; but, in tasks where verbal processing is not necessary, but may be helpful, e.g., in the V-V condition of the present study, high reading competence is not necessary, and in fact, may be a hindrance to successful performance.

THE EFFECT OF AGE, READING ABILITY, AND REPRESENTATIONAL MODE ON RECOGNITION MEMORY PERFORMANCE

by

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APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

The investigation reported here centers on children's recognition memory for information presented in visual (picture) and verbal (auditory) form. The hypothesis which generated the inquiry is that preliterate children are predisposed to store and process information in the visual mode, and therefore, exhibit difficulty in recognizing information originally presented in verbal form. By contrast, older children and adults, who presumably store and process information according to either or both dimensions of the stimuli, can successfully recognize information regardless of initial input mode. An assumption fundamental to this research is that as children acquire reading skills, and thus receive experience in transforming visual information into a verbal code, they become predisposed to store and process information according to the verbal or semantic attributes of presented stimuli.

Theoretical Rationale

One of the most heuristic exposés regarding the development of the ability to represent environmental experiences was that of Bruner (1964). He discussed the sequential emergence of three modes by which the child represents or comes to know his environment. The "enactive" mode is the first, and only, mode available to the infant, who comes to know his environment through perceptual-motor acts--grasping, crawling, touching. This mode of representation has its limitations in that it is a highly concrete system related to particular acts and directly controlled by the environment (Paivio, 1971). Subsequently, "ikonic" representation emerges as the child becomes able to use imagistic, spatial, and/or sensory attributes to encode and retrieve information. This second stage (dominant up to 7-8 years of age) is more abstract, and hence more flexible, than the preceding one; however, it is limited to the extent that representation is directly dependent upon sensory features of environmental stimuli (Paivio, 1971). The distinctive feature of the final stage, "symbolic" representation, is language. The language or symbolic system is the most useful of the three by virtue of its "arbitrariness," and its "productiveness in combination" (Bruner, 1964, p. 2). That is, words do not resemble their referents, and new thoughts can be formed by various combinations of words. The symbolic system is more useful than enactive or ikonic representation in dealing effectively with more abstract concepts (Paivio, 1971). According to the Bruner notion, these three modes of representation occur sequentially, with developmental level, in an additive manner. That is, the emergence of the ikonic system does not displace the previous (enactive) system; use of a particular representational system is dependent upon the demands of the task.

In short, the Bruner framework posits that young children develop the efficient use of visual stimulus attributes before they develop efficiency with verbal cues.

This view has been challenged by Rohwer (1970) and his associates (e.g., Lynch & Rohwer, 1972) who maintain that the ability to make use of verbal stimulus attributes develops before the ability to use visual attributes. This view is contrary to most general theoretical models of cognitive development (Bruner, 1964; Inhelder & Piaget, 1964; Werner & Kaplan, 1963). Accordingly, both children and adults make equal use of imaginal representation in processing visual stimulus information, but only adults and older children are likely to spontaneously and simultaneously generate a verbal tag in association with a visual presentation. The superiority of pictures to words as stimulus items depends on the ability to simultaneously store a verbal referent along with the visual representation. According to Rohwer, this is an age-dependent phenomenon, in that the capacity for simultaneous storage increases with age. Young children are less able to dually-encode visual stimuli than are older children and adults. Rohwer (1970) reviewed data which showed that the provision of labels along with to-be-remembered visual stimuli enhances performance less and less as age increases. For children in grades kindergarten, one, and three using the method of paired-associates, Rohwer found that providing the label along with a visual stimulus made no difference in the performance of the older subjects, but significantly enhanced that of the younger ones. The data suggest, then, that older children spontaneously generate a verbal code to visually presented stimuli while young children do not. These data received further support from Lynch and Rohwer's (1972) data with 3rd and 6th graders in which the age x stimulus mode interaction disappeared (in congruent presentation-mode test-mode conditions) when labeling instructions were administered. That is, no age differences were found when labels were provided during the presentation of visual stimuli (when both the presentation and test items were in the pictorial form).

Rohwer agrees that children do use imagery to represent and store information. However, "a preference for and a capacity to make effective use of visual representation and storage develops later than is the case for verbal modes of representing and storing information" (Lynch & Rohwer, 1972, p. 401). To derive optimal benefit from the stored visual image of an object, one must have the capacity for verbally representing that object at the same time. This capacity develops with increasing age. He views language as a "coherent, well-organized system" (Ibid.), unlike imagery; and since well-organized systems are easier to deal with than those that are less organized, it follows that verbal information processing should be easier to maintain and should occur ontogenetically earlier than efficient imaginal processing.

There is little evidence to support this position however. What evidence there is suggests: (1) that subjects younger than seven years have trouble in decoding visual stimuli into a verbal code, or (2) that they are able to verbally encode visual stimulus material, but in a very cursory manner much less efficient than that of older children and adults. Paivio (1970) suggested that young children have difficulty in transforming a visual image into a verbal response, such that if test stimuli are presented in visual form (e.g., picture-picture and word-picture) and a verbal response is required (e.g., in the P-A paradigm), young children are less able to decode the imaginal trace into its verbal equivalent. He views this as a problem of "response retrieval" rather than an "associative learning" problem (Dilley & Paivio, 1968, p. 238). That is, children are not deficient in forming associations between S and R units; rather, they are deficient in transforming a picture response term into the verbal response required by the experimental task. Hence, in his 1968 (Dilley & Paivio) study with nursery, kindergarten, and first graders, children performed better (in a paired-associate task) when stimuli were pictures and responses were words (P-W condition) than in conditions involving verbal stimuli and visual responses (W-P) or in the congruent (P-P and W-W) conditions. Since the task required the subjects to verbally respond, they had less trouble in the picture-word condition since they did not have to transform or decode the word response term in order to make their verbal response. Conversely, the W-P condition requires that subjects transform the picture response term into a verbal code in order to make a verbal response. Dilley and Paivio expected to find developmental differences in the ease with which these children were able to store and retrieve information, however, no main effect of age was found. Instead, a difference was found between these children and the adults of another study (Paivio & Yarmey, 1966) in that pictures had a deleterious effect on learning for children but not for adults when used as response terms. Pictures facilitated learning for children and adults when used as stimulus terms; but when pictures were used as response terms, children had difficulty in retrieving the verbal equivalents of those pictures. Paivio emphasized that this was not a problem of the failure to verbalize the pictorial stimuli, since he demonstrated that his (child) subjects were able to name the stimuli before the experiment. Rather, it is a problem of "symbolic transformation from a nonverbal to a verbal mode of thinking" (Dilley & Paivio, 1968, p. 239). Further, this "implies that the development of verbal skills with increasing age and education is accompanied by increased skill in translating from nonverbal images to verbal modes of cognitive representation where the overt task requires such transformation" (Ibid.).

Jones (1973) addressed herself to the methodological inconsistencies inherent in the research related to children's deficit for nonverbal information processing. These inconsistencies narrow the generality of the data. She eliminated the necessity to decode the visual test response into the verbal mode as was the case in Paivio's (Dilley & Paivio, 1968) research. A modified recognition task enabled her to test 3-year-old children in the same mode as that in which the items were originally presented. Jones presented material either visually, verbally, or visually and verbally in an effort to examine young children's ability to encode visual or verbal material alone and to assess their ability to dually encode information. She concluded that her data clearly contradict the Rohwer notion that preschoolers perform better with verbally presented material than with visually presented material; preschool children are able to effectively use nonverbal processes. The W-P and the P-W conditions were equally effective, so the decoding difficulty was not just in the direction from pictures to words as Dilley and Paivio (1968) suggested. Further, these two conditions both exceeded the W-W condition, so that crossing these two modalities was easier than encoding and retrieving in the verbal mode alone. The redundant picture-word presentation conditions were superior to all other combinations suggesting that children were also making use of the verbal information in storing and processing the items. In these redundant conditions, performance was better when subjects were tested with pictures than with words, lending further support for the notion that young children process pictures with more ease and efficiency than they process words.

Mowbray and Luria (1973) tested both the Rohwer and the Paivio notions regarding the deficit in young children's visual information processing relative to that of older children and adults. They tested kindergarten, third, and sixth graders in a continuous visual recognition task, with pictures of familiar and nonsense objects, and three labeling conditions: no label, experimenter-produced label, or covert subject-produced label. Data from the unlabeled nonsense pictures suggested that all three age levels possessed equivalent visual memories, contrary to Rohwer's position. The provision of labels for familiar pictures enhanced performance of the kindergarten subjects but not to the level of the two older groups, and labels made no difference in the performance of the two older groups. The authors concluded, then, that verbal encoding must have been going on in the youngest age group, since the failure to encode verbally should have totally disappeared when labels were provided. Since the groups did not perform equally well with the provision of labels, something else must contribute to young children's poorer performance with visual material relative to older children and adults. Labels for nonsense objects enhanced performance only for the sixth graders. The authors concluded that Paivio's suggestion that children's deficit in visual processing is due to their inability to transform visual material into verbal form must be rejected since in the present study, for which no transformation was required, younger subjects still performed more poorly than older subjects in the unlabeled familiar pictures condition. From the labeling data of the nonsense pictures, it was discovered that young children do not necessarily fail to label visually presented material, but rather they employ less appropriate labels and these labels interfere with later retrieval of the items. The sixth graders produced labels that were more concise and concrete than the younger subjects who used more letter, extended descriptions, and nondistinct responses. Thus the sixth graders used more adult-like mediators than did the two younger groups. The provision of labels to younger subjects replaces a less appropriate label with a more useful one, rather than providing a label where one did not previously exist. The authors suggest an "underlying conceptual difference" responsible for the inferior performance of younger, relative to older, subjects to explain the absence of an effect of labels for the nonsense pictures.

Siegel and Allik's (1973) data lend further support to the notion that children younger than seven years are capable of verbal encoding of visual stimulus material. They tested kindergarten, second, and fifth graders, and college students in a serial position recall task with pictures and aurally-presented words as stimuli and recall cues. They obtained an overall improvement in performance with increasing age, this improvement being greatest between grades two and five. Regarding accuracy data, pictures were easier to remember than words for all age groups, but mode of recall cue had no effect. Reaction time data yielded an interaction of presentation mode and recall cue mode, such that auditory presentation followed by visual response cue (A-V) resulted in faster reaction times than the other three combinations (i.e., V-A, V-V, and A-A) which did not differ from one another. Latencies decreased with increasing age. The authors concluded that even the youngest subjects used labels as mediators in processing visual material and this was responsible for the absence of an effect of recall cue on performance. Subjects of all ages could recall visually presented items when probed verbally.

Hoving, Konick, and Wallace (1975) presented pictures or auditory words to kindergarteners and fourth graders in a matching task where the probe was also either a picture or a word. They obtained no effect of either presentation mode or probe mode. Pictures were just as easy to remember as words, and kindergarten children performed just as well in cross-modal (i.e., picture presentation and word probe and vice versa) as in intra-modal conditions.

Hence, research regarding the effect of age and representational mode on memory performance, can be summarized as follows:

(1) Young children are deficient at simultaneously storing and processing the verbal representation of a visually

presented stimulus, and thus they have difficulty in transforming a visual input into a verbal test response; and this deficiency decreases with increasing age (Paivio, 1970; Rohwer, 1970), except for the Hoving, Konick, and Wallace (1975) results.

(2) Children and adults are able to use imaginal representation for visual experiences; but adults and older children prefer the verbal-symbolic mode (Bruner, 1964).

(3) Young children do process visual information verbally, but they do so very poorly (Siegel & Allik, 1973; Mowbray & Luria, 1973), except for the Hoving, Konick, and Wallace (1975) results.

(4) Children process visually presented material with greater ease than they process verbally presented material (Bruner, 1964; Dilley & Paivio, 1968; Jones, 1973; and Paivio, 1970).

Hence, the present hypothesis with regard to preliterate children is in line with Bruner's position that young children develop the efficient use of visual stimulus attributes before developing efficiency with language symbols.

The present investigation sought to demonstrate a relation between the preference for verbal information processing and the capacity to read written language. It was predicted that verbal ability will correlate significantly with the incidence of verbal information processing, such that as the child comes to master reading, he will make the transition from a predominantly visual orientation to a visual-verbal one, and will ultimately develop a preference for the verbal mode. This was based, in part, on Paivio's (1970) suggestion that around the age of 7-8 years, children become capable of making "symbolic transformations" (p. 391) between images and words. This prediction also stemmed from Otto's (1961) study with second, fourth, and sixth graders, of poor, average, and good reading ability, and of average intelligence. Using the method of paired associates, he found that good, average, and poor readers took increasingly more trials to master the task which involved associating a geometric form with a CVC trigram. Stimuli were presented either visually, auditorially, or kinesthetically.

In addition, the present study sought to demonstrate not only an overall developmental increase in the ability to process visual and verbal information; but it sought an interaction between age and performance with pictures versus words as stimuli, such that the difference between younger children and older children should be greater for words than it is for pictures. This is based on what is known (Cramer, 1975; Lynch & Rohwer, 1972; Mowbray & Luria, 1973) about young children's abilities to spontaneously generate labels for visual stimulus material. They tend to exhibit less evidence of verbalizing to visually presented items than do older children and adults.

The present study differed from previous research on several dimensions of contribution:

(1) All combinations of visual (V) versus auditory (A) presentation and test items (V-V, V-A, A-A, A-V) were used.

(2) Subjects of three different developmental levels (5-, 8-, and 11-year-olds) spanning a wide range of ages were tested.

(3) A visual recognition task was employed that eliminates the necessity to transform visual items into a verbal response, and which provides latency as well as accuracy data.

(4) Familiar, realistic stimuli known to be readily labelable by all ages under investigation were employed.

(5) Auditorially presented words were used to eliminate confounding effects of visual attributes of visually presented words.

(6) A reading ability measure was used as an independent variable with which recognition performance was correlated.

Hence, the present investigation systematically combined auditory and visual presentation and test modalities so that subjects were either presented with pictures and tested with words, or presented with words and tested with pictures, or presented with pictures and tested with pictures, or presented with words and tested with words.

Hypotheses:

It was predicted that visual stimulus presentations would result in superior performance overall relative to verbal stimuli. This owes to the fact that pictures produce richer memory representations than do words. Pictures produce unique visual representations, and hence are more readily discriminable than words, which may produce a variety of visual associations (Berkeley, cited by Paivio in S. J. Segal, 1971; Groninger, 1974; Jenkins, Neale, & Deno, 1967; and Jones, 1974).

These predictions were made primarily with reference to the RT data. It was likely that accuracy data would not lend itself to depicting age trends or condition effects as well as RT data, since it was suspected that many of the older subjects would have approached ceiling on the recognition task (Ward & Naus, 1973). RT data, on the other hand, might not have been as sensitive an index of performance for the youngest group since most of those subjects were likely to produce generally long latencies. For the youngest group, then, accuracy data would be more useful. Multiple dependent measures become necessary to detect differences in such a paradigm where one must contend with ceiling effects, as well as age differences. The RT measure reflects processing at a more molecular level, not possible with the simple accuracy measure. Most subjects can recognize items as old or new; but they are likely to process and retrieve varying <u>types</u> of stimuli at different speeds. Furthermore, crossing perceptual modalities to retrieve information should have different, and interesting effects as a function of age. Both dependent measures were examined for each of the three ages under investigation; however, it was expected that the two measures would differ in their usefulness, as a function of the age group being tested.

It was assumed that a certain hierarchy exists regarding one's natural predisposition in dealing with the four presentation-recognition test modality combinations described above. This hierarchy is different for younger children than it is for older children, reflecting encoding abilities, mnemonic strategies, (or the lack of strategies), verbal ability, and/or general cognitive capacity. The order of this hierarchy for younger children (i.e., the 5-year-olds) was assumed to follow the order (from highest to lowest) V-V, V-A, then A-A and A-V, the last two not differing in their effect on memory performance. The V-V superiority notion followed from the fact that both presentation item and test probe match perceptually and are in the mode to which young children are most accustomed. Further, there is no transformation or recoding of information necessary for correct recognition performance. V-A was assumed to yield longer search times since a transformation is involved from auditory probe back to the imaginal trace supposedly left from the initial visual presentation. It has been found (Lynch & Rohwer, 1972; Rohwer, 1970) that younger children are less adept at making these cross-modality comparisons relative to intramodal comparisons. Also, the V-A combination does not involve a perceptual match, inasmuch as young children are unlikely to verbalize in response to an initial visual presentation (Cramer, 1975). The remaining two combinations involve verbal presentations which were assumed to be generally inferior to their visual counterpart since young children are not as skilled yet in the use of verbal material (Cramer, 1975; Flavell, Beach, & Chinsky, 1966; Keeney, Cannizzo, & Flavell, 1967; Kendler, 1963; Kingsley & Hagen, 1969). It was felt that these two combinations would cause the most difficulty with young children.

The hierarchy for older children (i.e., the 8- and 11-year olds) was presumed to follow the order V-A, V-V, then A-A and A-V, the latter two combinations not differing from one another. This arrangement was predicted in line with a presumed transition period in children's processing, from a predominantly visual orientation, to a verbal-symbolic one (e.g., Bruner, 1964; Flavell, Beach, & Chinsky, 1966). V-A superiority stemmed from the assumption that older children spontaneously verbalize in response to visual stimulus presentations (Lynch & Rohwer, 1972; Paivio, 1971; Peterson & Peterson, 1959), and this verbal tag would match directly with the verbal test probe resulting in faster search times. Wallach and Averbach (1955) suggested that a "direct recognition" is possible only when the probe item is in the same modality as that of the memory trace initially left for that item. The evokation of multiple traces for an item enhances the likelihood of that item being remembered, since that item has more than one perceptual mode by which it can be matched. Dual encoding, then, was the essence of the V-A superiority prediction. Also, Chase and Calfee (1969) stated that it is a "well-known fact that RT to auditory stimuli is faster than to visual stimuli" (p. 512). This was with respect to adult data in a Sternberg recognition memory task. V-V should result in slightly slower search times since the visual test probe must be transformed into a verbal code for the purpose of comparison with the verbal trace left by the initial visual presentation. Also, the visual test modality should yield slower RTs than the verbal mode for older subjects (Chase & Calfee, 1969), given that items were initially presented visually. (Therefore, V-V surpasses A-A, since visual presentation yields faster RTs than auditory presentation overall.) The last two combinations involve verbal stimulus presentations which are either (a) less likely to evoke visual associations (Paivio & Csapo, 1973), i.e., are less likely to be dually encoded; or (b) if they do evoke imaginal representations, the images are less likely to match the picture probes (in the case of the A-V combination) than the verbal representations of pictures are likely to match the word probes (in the case of the V-A combination) (Paivio & Begg, 1974; Snodgrass, et al., 1974). Also, verbal stimuli are not as rich and unique as visual stimuli, and hence, they (verbal) should be less readily distinguishable relative to visual stimuli.

Regarding the developmental trend in representational abilities, it was hypothesized that some time between the ages of 7-8 years a transition occurs from a more childlike orientation to a more sophisticated adultlike strategy. It was predicted that the greatest amount of change--i.e., increment--in retention would occur between the 5-year-old group and the 8-year-old group in the present investigation. This was based on the findings of Paivio (1970 & 1971) regarding imagery and verbal processing, Siegel and Allik (1973) regarding auditory and visual short-term memory, the verbal mediation studies of Flavell, Beach, and Chinsky (1966) and Stevenson, Iscoe, and McConnell (1955), and the reversal and nonreversal shift research of the Kendlers (Kendler & Kendler, 1959 & 1961, and Kendler, Kendler, & Learnard, 1962). They generally agree that the incidence of verbal mediation is closely related to age, with young children showing a lesser propensity to do so. This transition also reflects the acquisition of reading skills, which marks the single-most contributing factor to higher-level cognitive functioning.

Definition of Terms

The following terms will be used in the following contexts for the purposes of the present investigation:

1. Code--A representation of a stimulus input in memory, e.g., a visual, verbal, or kinesthetic code.
2. Cross-modality vs. intramodality encoding--Cross-modality refers to processing that requires a transformation of a stimulus input from one mode into an alternate mode. The input might be visual and the output verbal. Intramodality encoding refers to the instance in which a stimulus is inputted, processed, and outputted in a single mode; no transformation is required.

3. Decoding or transformation--The reduction and/or translation of information from one form into another (Horowitz, 1970).
4. Dual-encoding--The redundant processing of a stimulus input in alternate representational modalities. Used here, it will connote the simultaneous storage of both a visual and a verbal code.
5. Encoding--Encoding is synonymous with processing--see below.
6. Imagery--Refers to a nonverbal (visual) sensory record of an object, event, or experience. Paivio (1971) uses imagery to refer to "nonverbal memory representations of concrete objects and events, or nonverbal modes of thought (e.g., imagination) in which such representations are actively generated and manipulated by the individual" (p. 12). "Conscious images derive content from two sources: perception and memory" (Horowitz, 1970, p. 107).
7. Information processing--Refers to the various stages or operations involved between the input of information to its eventual output. Information processing theory uses the language of computer science, e.g., input, output, storage, retrieval, and processing (Kausler, 1974). Norman (1969) provides a very apt description of this phenomenon:

> First, we view the human as a processor of information. In particular, we are concerned primarily with verbal, meaningful information in acoustical and visual form. The aim is to follow what happens to the information as it enters the human and is processed by the nervous system. The sense organs provide us with a picture of the physical world. Our problem is to interpret the sensory information and extract its psychological content. To do this we need to process the incoming signals and interpret them on the basis of our past experiences. Memory plays an active role in this process. It provides the information about the past necessary for proper understanding of the present. There must be temporary storage facilities to maintain the incoming information while it is being interpreted and it must be possible to add information about presently occurring events into permanent memory. We then make decisions and take actions on the information we have received. (pp. 3-4)

8. Input--Stimulation impinging upon or entering the memory system. It may take various forms, e.g., visual, verbal, kinesthetic, or olfactory.

9. Memory system--The network by which an event, object, or experience is represented and stored for later access. It consists of three phases: acquisition ("the sensory input is encoded"--Norman, 1969, p. 152), memory itself (the process related to decay of information), and decision (the information is "analyzed to determine what action shall be taken"--Ibid., p. 151).

10. Method of paired-associates--A widely used experimental paradigm for the study of verbal learning, whereby "Items (usually verbal) are presented in pairs for learning; then the first of each pair (usually not

in the original series order) is presented for a brief time and the subject endeavors to reproduce the second. The score is the number of successes or of retained members" (English & English, 1968, p. 467).

11. Output--Information retrieved or accessed from the memory system.

12. Recognition memory--An experimental paradigm "in which the subject is first presented with a list of items to be learned and then is presented with test items. His job is to decide whether each item is an old one (whether it occurred in the previous list)" (Norman, 1969, p. 149).

13. Representational mode--Any of the various forms by which an object, event, experience, or thought can be encoded or stored in memory, e.g., acoustic, visual, verbal, or kinesthetic modes. The modes of interest in the present investigation are visual and verbal.

14. Retrieval--The calling forth or accessing of information from storage in the memory system. Retrieval is regulated by "control" processes (Kausler, 1974), e.g., rehearsal, subjective organization, or other "cognitive input provided by the subject himself" (Ibid., p. 52).

15. Storage--The maintenance of information in memory for subsequent retrieval.

16. Verbal processing or verbalization--Used here to refer to the covert or implicit rehearsal of the semantic attribute of a stimulus input, whether the input is verbal or visual. Verbalization can act as an effective mediator in visual information processing (Flavell, Beach, & Chinsky, 1966; Stevenson, Iscoe, & McConnell, 1955).

CHAPTER II

REVIEW OF RELATED LITERATURE

The review of related literature will proceed in five sections concerning the most pertinent issues with regard to developmental changes in the use of representational modes. These are: the coding redundancy hypothesis, the dual coding hypothesis, the conceptual-peg hypothesis, the cross-modality or transformation problem, and methodological considerations.

A. Coding Redundancy Hypothesis

Paivio (1971) has contributed most substantially to the literature on imagery and verbal information processing. His coding redundancy hypothesis states that memory for an item is a direct function of the "number of alternate memory codes available for an item" (p. 181). Inasmuch as a concrete verbal stimulus presentation evokes both a visual and a verbal code, it has a higher memory potential than a more abstract verbal presentation, since the latter is likely to evoke only a verbal code. To the extent that both memory modalities are evoked, the likelihood of item retrieval increases, since retrieval can be from either store--visual or verbal. Therefore, recall (and recognition) is lowest for abstract words, higher for concrete words, and highest for pictures. The coding redundancy hypothesis assumes "independent storage systems" for imaginal and verbal codes associated with a given object.

Lynch and Rohwer (1972) suggested that pictures are not easier to remember than words unless a verbal tag is simultaneously stored with the picture. Otherwise, words versus pictures do not differ in ease of processing. The superiority of pictures to words is contingent upon developmental level, such that young children, who do not yet readily verbalize the name of a visual stimulus, find words easier to process than pictures.

Relevant to Paivio's hypothesis, is Shapiro's (1966) data with 10-11-year-olds and 13-14-year-olds in a paired-associate task. Her younger age group performed better with aurally presented lists, while her older group did equally well in both visual and verbal presentation conditions. This trend follows Paivio's (1970) predictions related to the transition period in children's processing, from a preference for imaginal processing to a verbal-symbolic orientation occurring around 7-8 years of age. This trend is also in line with the predictions made in the present investigation.

Horowitz (1969) found better performance with visual and audio-visual presentation than with auditory presentation with kindergarten and third-grade subjects in a recall and clustering study. However, he found no age by presentation mode interactions, nor did he obtain an expected difference between the visual and the audio-visual conditions. He concluded that his data were contrary to the "additivity-of-cues" hypothesis which states that "recall increases as the number of modalities in which stimulus cues are presented is increased" (Horowitz, 1969, p. 297). These findings can be taken as support for Paivio's redundancy notion in that since visual stimuli evoke both a visual and a verbal memory component, performance with visual stimuli would equal performance with audio-visual stimuli since both types of stimulus presentation involve redundant processing.

Corsini (1970) used verbal and nonverbal redundancy to test whether type of redundancy or redundancy per se was the critical factor in (4-year-old) children's retention. The task comprised performing specified manipulations upon familiar objects, e.g., "Put the red car into the blue cup" (p. 117). There were three instructional conditions: verbal, verbal-nonverbal, and verbal-twice. The nonverbal condition consisted of presentation of the actual object. The comparison of major interest was that between the verbal-nonverbal and the verbal-twice conditions. If these conditions produced equal performance, then redundancy per se is the critical factor, not type of redundancy. The superior performance of the verbal-nonverbal group, relative to the verbal-twice group lead Corsini to conclude that redundant information is not the crucial factor, but rather the type of redundancy is important. Providing redundant information in a symbolic (verbal) form doesn't facilitate young children's performance, since they are not yet skilled in the use of verbal-symbolic representational modes of thinking. Their performance can best be facilitated by presentation modes that are in line with their "dominant mode of cognitive representation" (p. 118).

Jones (1973) got superior recognition of pictures relative to words regardless of input mode. She used 3-year-olds as subjects and her stimulus presentation consisted of either pictures, words, or both. Performance was best with the redundant visual-verbal study materials, next best with visual materials alone, and worst with verbal materials alone. The superiority of the redundant condition over the visual alone condition suggests that these very young children are not spontaneously using a verbal code in processing visual information, although they are capable of this dual encoding when the possibility is brought to their attention. This outcome is somewhat akin to Rohwer's notion of young children's inability to supply a verbal tag to visually presented material. This outcome also provides support for the Paivio position regarding the facilitation of performance when both visual and verbal modalities are evoked.

Siegel and Allik (1973) tested the serial recall performance of kindergarten, second-, fifth-grade, and college subjects using visual or verbal presentation. They got superior performance with pictures relative to words at all age levels and suggested that this outcome may have been a function of the simultaneous storage of both visual and auditory-verbal components of pictures as opposed to words.

Jones (1974), in a continuous recognition task, with either pictures, words, or pictures and words found superior performance (in terms of false alarm rates) in the redundant picture plus word condition with first graders. Hit rates did not differ for the three treatments--all were high. Jones suggested that the memory potential for an item is enhanced by providing the name simultaneously with the picture because this provides two sources of information. Further, he found that response bias--the tendency to classify an item as "old"--was greatest for words, next most for pictures, and least of all for picture and word.

Thus, the majority of existing data support Paivio's position. Pictures generally are easier to remember than words and redundant encoding facilitates performance for visual material.

B. Dual Coding Hypothesis

Directly related to the coding redundancy hypothesis is the assumption (Paivio, 1971) that abstract words, concrete words, and pictures have differential probabilities of evoking verbal and imaginal processes. Imagery increases as a function of concreteness, but verbal processing is more likely to be a representational response to words than to pictures. The verbal system is thought to be specialized for sequential processing, whereas the image system is specialized for (spatial) parallel processing. Reaction time data from different experiments has been used to infer the degree of availability or "arousal probability" (Ibid., p. 180), of each type of memory code for various kinds of stimuli. "Image arousal in the case of pictures and verbal coding in the case of words have the highest availability, the verbal code to pictures second, imagery to concrete words third, and images to abstract words fourth" (Ibid).

Kurtz and Hovland (1953) showed 5th, 6th, and 7th grade children an array of 16 familiar objects and asked them to find and encircle the names of those objects on lists provided and to pronounce the names. Control subjects encircled photographs on sheets showing only photographs of these same objects. All subjects were unexpectedly tested for recall or recognition of these items a week later. Half of the recognition test involved visual items and half was in verbal form (printed words). Subjects were required to encircle items that they recognized from the previous week's list. The subjects who verbalized the names of the objects performed significantly better than those who merely encircled photographs of the items. Furthermore, the verbalization group did better on both the verbal and the visual portions of the recognition test, than did the controls. The authors concluded that verbalization forced upon the experimental group at time of access was the crucial factor. Control subjects, on the other hand, would only verbalize spontaneously, and this was regarded as unlikely to occur. The authors found no age differences in their data. These data suggest that the children were not spontaneously processing a verbal component of these visual stimuli; but when forced to do so, this dual-encoding resulted in superior performance as compared to subjects who supposedly used a predominantly single-unit encoding process. Relevant to Paivio's hypothesis, verbal processing was more likely to be a representational response for words than for pictures.

Paivio and Csapo (1973) concluded that the superiority of pictures over words as stimuli in free recall is due to dual coding, and not just to the superiority of imagery to verbal processing alone. In a series of experiments with college student subjects, they demonstrated that the usual superiority of pictures to words vanished when image instructions were applied to word stimuli. This effect was consistently found in three different experiments. The authors explained picture superiority in terms of an "additive contribution of imaginal and verbal memory codes, with the contribution of the former being decidedly greater than that of the latter" (p. 200). Dual encoding of words or of pictures did not enhance performance over imaginal encoding of pictures. The additivity of dual encoding of pictures produces a larger incremenet in recall than does the non-additive effect of imaging to pictures or verbalizing to words. "Imaging to pictures resulted in overlapping traces rather than two independent events in memory" (p. 200).

Mowbray and Luria (1973) tested the notion that adults display superior memory ability relative to children because adults, unlike children, are capable of "dual processing" of visual information. The authors concluded that their data with kindergarten, third, and sixth graders, in a continuous visual recognition task, partially support the dual processing theory. Providing the kindergarten subjects with labels for common objects, or encouraging them to think of their own labels, significantly reduced their error scores. These two manipulations, however, did not enhance performance to the level of the sixth graders.

Paivio and Begg (1974) studied the visual search times of either picture or word targets within either picture or word arrays with college-student subjects. One of the hypotheses tested was the dual coding hypothesis--"subjects will use either imaginal or verbal coding, depending on expectations aroused by contextual information in the experimental setting" (p. 515). Dual coding was supported and the authors concluded that items processed in both visual and verbal modalities can be accessed and compared in either mode depending on task requirements, and hence, on the subject's expectations ascertained from contextual cues. The test modality largely determines the modality used to search for an item.

Snodgrass, et al., (1974) provide evidence for the dual coding hypothesis with college-student subjects. Using a "Yes"-"No" forced-choice recognition paradigm, with confusion or distractor items consisting of corresponding items but in the opposite modality, these authors demonstrated that items initially presented for memory, were coded in both the visual and the verbal mode. Confusion was greatest for picture memory, which lead the authors to conclude that "verbal codes of pictures are more likely to match their corresponding words than visual codes of words are to match their corresponding pictures" (p. 27).

Pellegrino, Siegel, and Dhawan (1975) provided further evidence for dual coding with college-student subjects. They used a Brown-Peterson short-term retention paradigm with pictures and visual words as stimuli. They manipulated stimulus encoding in three experiments by providing distraction to either or both the verbal and the imaginal systems. Distraction was in the form of backward counting by three's or four's, visual presentation of a three-digit number, a modified Hidden Figures Test, or backward counting by 13. Subjects viewed slides of diagonally staggered stimuli. The trials consisted of word triads, picture triads, and picture-plus-word triads--each subject receiving all three types in mixed-list fashion. The subject's task was to orally recall each item and its position. Picture recall was better than word recall in all three experiments with auditory distraction. Visual distraction failed to reduce overall performance for either picture or word stimuli; however, visual plus acoustic distraction for picture stimuli drastically reduced performance. If auditory distraction reduces word recall but not picture recall, then it can be inferred that picture recall might have come from a visual storage system unaffected by auditory distraction. Likewise, if visual distraction had no appreciable negative effect on recall of pictures, then recall was facilitated by a verbal or acoustic code. Thus, the data yield evidence for dual coding of pictures and for the presence of "separate and independent acoustic and visual processing systems" (p. 100).

In an earlier study (Allik & Siegel, 1974) these same authors demonstrated that imagery instructions can produce better serial recall of auditory words than of pictures. Without imagery instructions, there was no difference between pictures and auditory words. Again, the subjects were college students, and again the authors claim evidence for the dual coding hypothesis with regard to visual stimuli. They concluded that the imaginal component of stimuli can facilitate performance.

Bencomo and Daniel (1975) used a same-different continuous recognition task with four presentation-test combinations: picture-picture (P-P), P-W, W-W, and W-P, with college student subjects. They employed five distractor types: orthographic (e.g., nail-pail), acoustic (e.g., nail-whale), schematic (e.g., nail-pencil), conceptual (e.g., nail-hammer), and neutral (e.g., nail-dress). Orthographic and acoustic distractors (i.e., verbal distractors) resulted in longer reaction times for printed words, both as presentation stimuli and as test stimuli. Schematic and conceptual distractors had their strongest negative effect on pictures both as presentation stimuli and as test stimuli. The authors concluded that pictures and words are differentially represented in memory--pictures primarily in the visual-spatial mode and words in the verbal-acoustic and orthographic modes.

Hence, the existing data appear to convincingly support Paivio's dual coding hypothesis. Pictures tend to be dually encoded--imaginally and verbally, while words tend to be coded only in the verbal or acoustic mode.

C. Conceptual-Peg Hypothesis

Paivio's (1963) conceptual-peg hypothesis proved to be the most heuristic proposal regarding representational memory. In it he suggested that high-imagery stimuli act as "pegs" from which "associates can be hung and retrieved by... mediating images" (Paivio, 1970, pp. 387-388). The conceptual-peg hypothesis is a retrieval theory intended to describe paired-associate learning. Differences in the concreteness or in the image-evoking potential of the stimulus term have a greater effect on P-A learning than the same variations in the response term (Paivio, 1971). Thus image-evoking potential or stimulus concreteness has its value on the stimulus side rather than the response side in paired-associate items. The reason for this is that it is the stimulus term that must restore the "mediating image" at test time. Thus when given the paired-associate stimulus-response combinations of picture-word, picture-picture, word-picture, or word-word, the picture-word combination should yield the best performance since no transformation or recoding of response terms is required. Paivio's (1968) data suggest that the overall problem with the word-picture combination is one of decoding from the mediator back to the verbal response, and children and adults differ in the ability to perform these transformations. That is, children are less likely to generate a verbal tag in association with a visual stimulus. Paivio suggests that somewhere between the ages of 7-8 years, along with the transition to verbal symbolic modes of thought, may come the ability to make higher-order transformations, e.g., "from words to images and back to words" (1970, pp. 391-392).

Paivio and Yarmey (1966) found support for the conceptual-peg hypothesis in a paired-associate task involving a factorial combination of pictures and printed words as stimuli and responses with college-student subjects. There was a highly significant main effect of stimulus type, such that pictures produced better recall than words as stimuli. There was no effect of response type; however, an interaction of stimulus type and response type indicated that pictures lead to superior learning regardless of response mode, but the effect was greater for word responses than for picture responses. There was an inconsistent effect of response mode, since picture responses facilitated learning with word stimuli but hindered learning when stimuli were pictures. The authors had no explanation for this finding. The import of this study was the facilitating effect of pictures as stimuli in P-A learning.

Dilley and Paivio (1968) studied the effect of pictures and words as stimuli and responses with young children. The same factorial combinations (as above) were used with nursery, kindergarten, and first-grade children in a P-A task. This time the words were aurally presented. Pictures were superior to words as stimuli, the effect being greatest for first-graders and least for kindergarten children, but they had a negative effect as response units. The authors explained this latter effect in terms of the younger child's deficiency in transforming the visual memory trace into a verbal response as required by the P-A paradigm. This explains the difference in results between the previously mentioned study with adults and the present one. This may also explain the superiority of the P-W combination to the P-P combination of the former study. Pictures as responses require more time and effort to decode or transform the visual image into a verbal response to meet task requirements. An expected main effect of age did not obtain for Dilley and Paivio, but the present author will make developmental differences a major issue of the thesis herewith.

Diveley and Rabinowitz (1974) provided further support for the conceptual-peg hypothesis with children. They factorially combined stimulus mode, study-response mode, and test-response mode (each mode involving either pictures or printed words) in a P-A task with third-grade children. The task involved two phases: original learning, and transfer test (administered after reaching a criterion of learning on the initial phase). In the transfer task, the test-response mode was reversed from pictures to words or vice versa. The purpose of this procedure was to eliminate the need for response learning. In Paivio's work a transformation was required from visual image to verbal response and no verbal labels were provided to the subjects. Diveley and Rabinowitz eliminated this transformation problem in the test phase by "setting" the subjects for a transfer in test-response modality. They provided conditions that would promote dual encoding of the stimuli by reversing the test-response mode after original learning. As trials increased, it was reasoned that the subjects would have an expectancy for this reversal and would henceforth encode the response items in both the visual and the verbal mode. In line with Paivio's theory, pictures were learned faster than words in the stimulus position and in the test-response position. This finding was predicted since subjects were expected to encode or rehearse in the study-response mode early in original learning and then switch to the test-response mode as learning progressed (i.e., transfer task).

Groninger (1974) looked at the locus of imagery as a facilitator in the memory system and found that the enhanced effect of imagery on memory occurs during the storage rather than the retrieval stage of processing. He factorially combined imagery versus neutral instructions, with college-student subjects, at either presentation or at recognition test time and got better performance with imagery at presentation. Image instructions at the retrieval stage created the opposite effect (although not significant). He initially presented 50 high-imagery words and 50 low-imagery words in an interspersed list, then he administered 80 of these along with 80 distractors in a recognition test. High-imagery words were recognized better than low-imagery words, and imagery instructions at storage facilitated performance of high-imagery words more so than low-imagery words. The enhanced effect of imagery on retrieval was said to result from the stronger, more vivid image representation at storage. Consistent with the conceptual-peg hypothesis, high-imagery or concrete words act as efficient stimulus pegs from which "associates can be hung and retrieved by...mediating images" (Paivio, 1970, pp. 387-388).

Thus, the conceptual-peg hypothesis has received much support from the literature. Associative imagery is an important aspect of stimulus encoding and greatly facilitates later retrieval of both pictorial and verbal stimuli.

D. The Cross-Modality or Transformation Problem

The problem involved here is one of processing that requires a transformation of a stimulus input from one mode into an alternate mode. For example, the input might be visual and a verbal output may be required. Cross-modal processing ability is typically inferred from the results of comparisons between cross-modal testing situations and intra-modal situations. Developmental level is the major independent variable of interest with respect to the cross-modality or transformation problem in the present thesis.

Wallach and Averbach (1955) were among the earliest investigators of the question of memory modalities. They proposed that a "direct recognition" is possible only when an item is tested in the same perceptual modality as that of the memory trace left by the initial experience. A presented stimulus may evoke "multiple traces," e.g., visual, verbal, conceptual, or contextual, and the duplication of a memory trace enhances later retention. Wallach and Averbach predicted poorer retention for the situation involving "indirect recognition," (e.g., visual presentation and verbal test and vice versa), since a direct recognition is not possible (unless the subject spontaneously verbalizes in the visual-verbal situation--i.e., multiple traces are evoked). "Simple recognition is based on the similarity between the perceptual experience that gives rise to recognition and a more or less identical previous experience currently represented by a memory trace" (p. 250). These authors cited the recognition data of Kurtz and Hovland (1953, described earlier in section B of this chapter) as support for their theory regarding direct and indirect recognition. In the Kurtz and Hovland data, the control group who circled the pictures (rather than circling the names of the objects and pronouncing them), did decidedly worse on the verbal form of the test than they did on the visual form, and they did worse than the experimental group on both forms of the test. Thus the combination involving visual presentation and verbal test was inferior to the other three combinations--visual-plus-verbal and a visual test, visual-plus-verbal and a verbal test, and visual presentation and visual test. The latter three combinations all involved a direct recognition from the learning situation.

Wallach and Averbach had college subjects read (aloud) nonsense words either forward or backward, with the reasoning that forward recognition of the items would be most highly probable for forward-presented items since those items would evoke visual as well as verbal traces. Otherwise, the items would have visually-evoked traces alone. That is, during the recognition test the authors assumed that if the subjects implicitly read the words, they most likely read them in the forward direction as is the case in reading. Therefore, items originally read in the forward direction should have a higher probability of recognition, since they will have had two memory traces: visual and verbal. The items initially read backward should be recognized less readily, since they will have had only a single trace--visual--inasmuch as subjects are unlikely to have read the items backward during the recognition test. This is precisely what happened with the data, and the authors claimed support for their multiple-trace theory and, more importantly, for their theory that "in the absence of a set, recognition is based on the similarity between the perceptual process which gives rise to recognition and the memory of the pertinent previous experience" (p. 256).

In the Paivio and Yarmey (1966) study previously mentioned, college students did best (in a P-A task) with the picture-word (S-R) combination, than with the remaining three combinations of P-P, W-P, and W-W in that order of performance. These results are in line with Wallach and Averbach's (1955) assumptions. The P-W combination is best by virtue of the multiple traces likely to be evoked to the picture stimuli, and the word responses can be accessed directly for the purpose of the verbal delivery of the test response. In essence there is a word-word (W-W) combination of response unit and the verbal response required by the task. The inferiority of the W-W (S-R) combination can be explained in terms of the single memory trace available for the word responses which outweighs any facilitation due to the direct match between the word response unit and the verbal test response. The same reasoning can be applied to explain the results of the remaining two conditions.

Jenkins, Neale, and Deno (1967), also using college students, got a different trend. They used P-P, P-W, W-W, and W-P presentation and recognition test combinations that were intended to eliminate the necessity of an additional transformation for those learning pictures initially and then tested with a verbal response as required by the Paivio and Yarmey (1966) study. Jenkins and his associates employed a recognition test of either pictures or printed words where the subjects had to rate their confidence (on a five-point scale) as to the presence or absence of each item on the original list.

The results of their data (from highest to lowest mean recognitions) were: P-P, W-W, P-W, and W-P, with W-W and P-W not differing reliably. The authors explained the results in terms of pictures being easier to remember than words (therefore, P-P was better than W-W), intramodality conditions being easier than cross-modality conditions (therefore, P-P and W-W were better than P-W and W-P), pictures evoking a verbal code in addition to a visual one (therefore, P-W equals W-W), and the combination of cross-modal interference and the absence of dual encoding of words causing the W-P condition to be the worst. All of these outcomes were predicted at the outset.

Chase and Calfee (1969) investigated the effects of auditory and visual presentation and test modes on the recognition memory performance of female college students, with consonants, that were either visually or acoustically similar or neutral, as stimuli. Neutral letters consisted of letters such as A, D, H, I, M, Q; visually similar letters were of the following nature: B, C, D, G, O, Q; and acoustically similar letters were of the order: B, C, D, E, P, T. A continuous recognition procedure was used and median reaction time was the dependent measure. The result of interest to the present discussion is that involving reaction time and the pairing of presentation and test modality. Search times were significantly faster when items were presented and tested in the same modality, than when they were tested in different modes. The authors regarded this finding as "surprising given the assumption that verbal materials are encoded at a higher level of representation and the original sensory information discarded" (p. 513). Therefore, sensory information must be involved in, and facilitate, the memory for verbal material. This is consonant with the findings of other studies (e.g., Paivio and Csapo, 1973) where visual information assists in the memory of verbal material, and hence, pictures are easier to remember than words.

Swanson, Johnsen, and Briggs (1972) employed physical versus name identity conditions, in a Sternberg "stimulus-classification" task, with college student subjects. They presented a P-A list consisting of two-digit numbers and eight-sided random forms. The numerals were supposed to be names for the forms. On later trials subjects were shown a name and were required to choose the appropriate form from among five forms printed on a sheet. Feedback was provided after each trial. The next phase comprised the experimental task: either (numeral) names or forms were visually presented for memory, then either a numeral or a form was presented and the subject had to indicate whether it matched a previous memory item. A positive match was to be registered if the two items matched physically, or if they matched on the basis of the form associated with a given numeral name. A negative response was to be indicated for non-matching items. Physical identity matches were found to be significantly faster than associational (name) matches by 44 msec. This difference was regarded as a "recoding effect"--associational matches between names and forms and vice versa required a recoding operation that increased the search time required for these items. A test item had to be recoded into the format of the initially-presented stimulus for comparison purposes, before making a decision and then a response. A physical identity match could be made directly, and hence, required less search time. This interpretation is not too unlike the Wallach and Averbach notion regarding direct and indirect recognitions, especially if memory search for a target item is viewed as a recognition task performed when comparing a probe item with those items stored in memory.

Arthur and Daniel (1974) used a continuous visual recognition procedure with college student subjects to examine the effect of picture-word transfer. They used a 3 x 3 matrix in which only the peripheral cells were filled during presentation trials and in which the middle cell was used to present a test stimulus. The subjects first saw eight stimuli (either pictorial silhouettes or four-letter printed verbal equivalents), followed by a 3-second delay interval, then they saw a probe stimulus (in the middle window of the matrix). They depressed a yes or no button to indicate whether the probe was present in the previous array. Each subject served under all factorial combinations of picture and word array and probe possibilities (i.e., P-P, W-W, P-W, and W-P). With regard to accuracy data, the following pattern of results was observed (from highest to lowest hit rates): P-W, W-P, P-P, W-W. Hit rates for the W-W combination were far below those for the other three conditions, which did not differ significantly from one another. Picture arrays produced fewer errors than did word arrays, (primarily because of such low scores for the W-W combination). Reaction time data yielded longer rates for "yes" responses for the P-W and W-P conditions (i.e., the cross-modal conditions) than for the P-P and W-W conditions. "No" responses did not differ significantly. The authors concluded that visual and verbal information processing channels are independent, thus resulting in longer processing time for intermodal transfer.

Bencomo and Daniel's (1975) continuous recognition task (with college students) mentioned earlier, resulted in the following pattern of latency data for "same" judgments (from fastest RT to slowest RT): P-P, P-W, W-W, and W-P. Latencies were shorter for congruent presentation and test conditions (i.e., P-P and W-W) and longer for incongruent (P-W and W-P) conditions. Picture presentations resulted in shorter latencies relative to words. "Different" judgments indicated that mode of presentation was not a significant factor among the groups. Test mode did produce a difference, though, with the word test resulting in shorter latencies than the picture test. Hence, cross-modal conditions require additional processing time relative to intra-modal combinations. Accuracy data did not lend itself to statistical analyses since all subjects reached ceiling.

The Dilley and Paivio (1968) study with children produced better performance with the P-W combination than with W-P, P-P, and W-W which did not differ significantly. No age trends were discovered. This study required a verbal response of the subject in a P-A task.

Lynch and Rohwer's (1972) study with children yielded the following pattern of results: P-P, P-W, W-W for sixth graders and W-W, P-P, and P-W for third graders in conditions where no verbalization was provided. Here, again, a verbal response was required, but the experimenters insured that subjects knew the labels initially so that no response learning was required during the test. More important than congruency versus incongruency of S and R units, seems to be the presentation mode--pictures vs. words. Picture stimuli lead to more efficient learning than word stimuli for the sixth graders, but word stimuli produced more efficient learning for the third graders. This could reflect mediational deficiency (Reese, 1962) on the part of third graders. Even though they knew the labels for the pictures, they failed to use them when a transformation was required. Therefore, they did better in the congruent word condition.

Diveley and Rabinowitz (1974) found less errors in their congruent study and test response mode conditions relative to their incongruent conditions. This was a P-A task with third grade subjects. Subjects apparently learn to expect the test stimuli in the same mode as that of the presentation stimuli. They expect to retrieve in the mode of initial presentation.

If they are taught to expect either of two alternate modes by which to represent a stimulus input, they experience less difficulty when a transformation is required at retrieval. Part of this performance differential is due to an expectancy regarding the particular mode in which to be tested, and part of it relates to actual "exposure to the items in the test modality" (p. 911). It's unfortunate that these authors did not examine this transformation problem with additional age groups. A wider span might have detected differences in the degree to which "setting" the subjects for alternate modalities assists their retrieval.

The final study involving children was the Hoving, Konick, and Wallace (1975) study with kindergarten and fourth-graders in a matching task. Items were presented either as pictures or auditory words, then probed by either a picture or a word. Performance was just as good in cross-modal conditions as it was in intra-modal conditions, contrary to other research reviewed here. They agree with Diveley and Rabinowitz (1974) that item storage is usually in the mode in which the item was initially presented, but they maintain that young children can cross these two modalities without any decrement in performance. Neither presentation mode nor probe mode significantly affected performance, nor did they interact with age.

The majority of the research relating the transformation problem to retrieval indicates that visual and verbal material are maintained in two independent storage systems. Hence, crossing these two modalities to retrieve information requires additional search time. Most of the research completed in this area has been done with adults; the few involving children have either involved only a single age group, or have not obtained age differences when age was the variable of interest. The present study examined this transformation problem with a large span of ages, to allow inferences to be made regarding the effect of developmental level and reading aptitude on representational abilities, and hence, retrieval abilities.

E. Methodological Considerations

Caution must be taken in attempting to compare the results of the various studies reviewed here. Comparisons can only be made indirectly inasmuch as studies have varied so with regard to paradigms used, numbers and kinds of stimuli employed, and the ages of the subjects tested. The paradigmatic difference is a critical one (Corsini, 1971; Jenkins, Neale, & Deno, 1967; Jones, 1973) in that the P-A paradigm, for instance, requires an additional transformation from the response mode (if it is visual) to the test mode which is usually verbal (i.e., oral). This is not the case in a recognition paradigm where the response is merely "yes" or "no." To equate these two paradigms for comparison purposes, it must be established that response learning is not required in the P-A test phase. It must be clear at the outset that subjects are able to name the visual items.

Also, recall and recognition tasks draw upon different information regarding the stimuli to be encoded (Tversky, 1973). The encoding and retrieval processes are different for recall than for recognition. Recall is enhanced by operations that increase associations between stimuli, e.g., subjective organization and clustering. Recognition is enhanced by activities that enforce encoding of the physical details of the stimuli. Consequently, mode of encoding is determined by the subject's expectations regarding the impending retention test.

Additionally, the verbal items should be purely verbal--they should not be visually presented words. The visual attributes of printed words confound a purely verbal interpretation of the data. Also, auditory words make it possible to use preliterate children as subjects for a developmental investigation. Reading skills are not necessary.

The failure to obtain age trends might be a function of too narrow an age span to detect differences. The present study systematically varied age level so as to reach the prereading child as well as children at various levels of reading sophistication, up to adolescence (where they have more or less mastered the skill). The reading ability measure would then help to verify the skill level for subjects both within and across each age level tested.

All of these variables must be considered in order to make justifiable comparisons across studies and in order to obtain data that are free from the confounds of the various extraneous variables mentioned. These considerations will assist researchers in discovering the course of memory development.

> ...memory development is the development of more than 1 factor. It is the development of representational abilities; it is the development of the propensity to represent; it is the development of familiarity with different stimulus representational modes; it is the development of a general information base; and it is, perhaps most importantly, the development of a cognitive operative system. (Corsini, 1971, p. 234)

Summary of Literature with Respect to Present Predictions

The present predictions derived support from the following points made by the literature: visual stimulus presentations should surpass verbal presentations over all by virtue of the coding redundancy notion (Paivio, 1971). Recognition is best for pictures, next best for concrete words, and poorest for abstract words. Also, picture superiority was predicted in line with the dual-encoding hypothesis (Paivio, 1971). Pictures tend to be dually encoded--imaginally and verbally, whereas words tend to be coded only in the verbal or acoustic mode. And, imagery increases as a function of concreteness. In line with the conceptual-peg hypothesis (Paivio, 1963), and the Paivio and Yarmey (1966) study, variations in the stimulus term should affect performance more so than variations in the test probe. It is from the stimulus term that the stored representation must be evoked at test time. Therefore, presentation mode should affect performance to a greater extent than test mode.

Regarding the superiority of the V-V combination over the V-A combination for the youngest group and the reverse for the older groups, Diveley and Rabinowitz (1974) and Paivio and Begg (1974) both concluded that the test modality largely determines the mode used to search for an item. Also, the child expects to be tested in the same mode as that in which stimuli were initially presented (Hoving, Konick, & Wallace, 1975). If both these ideas are true, then the youngest group should perform better when both the presentation stimuli and the test items are in the visual mode. Given that the visual mode is their preferred dimension, they should do better when the test probe is also visual, since (1) it is in line with their expectations (visual presentation, therefore visual test), and (2) they should tend to search for an item in the same mode as that of the test probe; therefore, a direct match is possible.

The older two groups, on the other hand, should perform best in the V-A combination since they tend to verbalize in association with the initial visual presentation; and if it is true that the search mode is determined by the mode in which the test probe is presented, then there should be a direct match between the verbal test probe and the verbal trace left by the initial visual experience.

The cross-modal conditions (i.e., V-A and A-V) represent a "recoding effect" (Swanson, Johnsen, & Briggs, 1972)--from words to pictures or vice versa--requiring a recoding operation that increases the search time for such items. The test item must be recoded into the format of the initially-presented stimulus for comparison purposes, before a decision, and a response, can be made. That is, direct matches should be faster than indirect matches. If this is true, then the older subjects should do best in the V-A condition to the extent that they have stored a verbal representation of those visual items, and the verbal representation can be matched directly with the verbal test probe.

For the younger subjects, who cannot be expected to verbalize in association with the visual stimulus presentations, the reverse ordering is expected. V-V should exceed V-A, since the latter involves a recoding operation at which this age group is not proficient. Since they do not verbalize, they should be deficient in transforming a visual stimulus into its verbal equivalent.

The two auditory presentation combinations should yield the poorest performance mainly as a function of poorer performance for words as opposed to pictures, by virtue of Paivio's (1971) coding redundancy hypothesis and his dual-encoding notion. The negative effect of auditory presentation should outweigh any positive effect due to intramodal matching; therefore, there should be no difference between the A-V combination and the A-A condition. Pictures lend themselves to much richer, more vivid perceptual representations than do words. Even if the words are imaged to by the subjects, those images have a very low probability of matching the picture representations used in the visual test combination

(A-V); whereas the words used to represent pictured items, are highly likely to match the words used in the verbal test combination (V-A) (Paivio & Begg, 1974; Snodgrass, et al., 1974). Therefore, dual-encoding should enhance performance more so for the picture stimuli than for the word stimuli.

CHAPTER III

METHODOLOGY

Subjects. A total of 144 subjects, 48 at each of grades kindergarten, third, and sixth, were randomly assigned to the experimental conditions below, equated for sex. The mean ages for the three grade levels were 5.98, 8.90, and 11.84 years. All subjects were drawn from middle-class public schools in Greensboro, North Carolina.

Design. The design consisted of a 3 (grade) x 2 (presentation mode) x 2 (recognition test mode) factorial assignment of subjects to independent groups. Each of the three age groups were further divided into four subgroups and received one each of the following presentation-recognition test combinations: V-V, V-A, A-A, or A-V.

Materials. Sixty-three 35-mm slides of black line drawings of common, readily labelable objects and their tape-recorded verbal equivalents served as stimuli. Thirty of these served as initial presentations. These same thirty items were intermixed with an additional thirty distractor items for the purpose of a 60-item recognition test. The last six items initially presented, along with six distractors, served as practice test items to ensure comprehension of the recognition test procedure. These data were eliminated from the analyses. An additional three items were used as demonstration slides (see Appendix A for data sheet and presentation list). A Kodak carousel projector 650H (with a Wratten Gelatin filter No. 96) was used to back-project pictures onto a small translucent screen, and a Sony portable cassette player with headphones was used to administer the auditory stimuli. A Lafayette Instruments 100-Second Timer (Model 5810) was used to automatically present the visual stimuli at a 4-second rate. Subjects responded by depressing either of two buttons on a response unit to indicate whether or not the test item was among those initially presented. Response latencies were measured to the nearest millesecond by a Lafayette Instruments digital Clock/Counter (Model 54519) attached to a Lafayette Instruments Regulated Power Supply (No. 83617). Accuracy was indicated to the experimenter by either of two small pilot lights (red or blue) wired to the two response buttons and in close proximity to the experimenter. Teachers' estimates of the childrens' reading ability (i.e., ratings on a 1-5 scale) were used for the purpose of a post hoc assessment of the relation between reading ability and performance on the experimental test.

Procedure. Subjects were tested individually in one of the four presentation-recognition test modality combinations described above. Each was instructed to attend to the pictures (or recordings) for the purpose of a subsequent memory test. The specific nature of the test was not revealed. Stimuli were presented at a 4-second rate. Thirty items were presented to each subject.

Auditory presentations were presented to the subjects through headphones. Each item was spoken twice in succession to ensure that the subject had understood the item and to equate auditory exposure times with visual exposure times.

After approximately a minute's rest, all subjects received a 60-item recognition test. Half of the items were identical to those of the original memory set and half were distractors. The subject's task was to indicate, as quickly as possible (with high accuracy), whether or not each test item was included among the original presentation items. No feedback was provided. For half the subjects the recognition test was auditory and for the other half the test was visual. Visual trials consisted of a slide presentation after which the subject had to respond "yes" or "no" by depressing either of two response buttons as fast as possible. The button press activated a microswitch which automatically advanced the projector to the next slide, which was a blank. During this interval, the experimenter recorded the choice and the latency, and then manually advanced the projector (by means of a button press) to the next test slide. This procedure was explained and demonstrated to each subject (see Appendix A for experimental instructions). The last six presentation slides, intermixed with six distractor slides, were then presented to practice the procedure. The remaining 48 test trials followed.

Verbal test trials were analogous to the visual trials except that the items were presented by means of a tape recorder (without headphones). The subject heard each item once and had to depress one or the other button to indicate his choice. Latencies were measured with a stopwatch. The tape recorded items were so spaced as to permit the experimenter to record the data in the manner described above at approximately the same pace.

Trials for which the subject was inattentive, or in which there was mechanical failure, were discarded when calculating each subject's accuracy and latency score.

CHAPTER IV

RESULTS

Percent Correct Recognitions

None of the data for kindergarten or sixth grade subjects were spoiled; however, .08% of the third grade trial data were excluded from the analyses. This percentage reflects the proportion of experimenter failure, apparatus failure, and interruptions that occurred during testing.

The mean percent correct recognitions was calculated for each subject, for target items, distractor items, and for the total (target plus distractor items). The data for total mean percent correct (shown in Figure 1) were subjected to a 3 (grade) x 2 (presentation mode) x 2 (test mode) x 2 (sex) analysis of variance.

The main effect of sex was significant, $F(1, 142)=4.36$, $p < .04$, with the mean percent correct for girls (76.73%) exceeding that for boys (73.47%). Sex did not interact with any of the remaining variables. The grade level main effect was also significant, $F(2, 142)=11.08$, $p < .0001$. However, further analyses with Fisher's least significant difference (LSD) test failed to detect differences between the mean overall performance of sixth graders (79.47%), third graders (75.33%), and kindergarteners (70.49%) ($p > .05$). Perhaps the number of subjects per cell was too small relative to

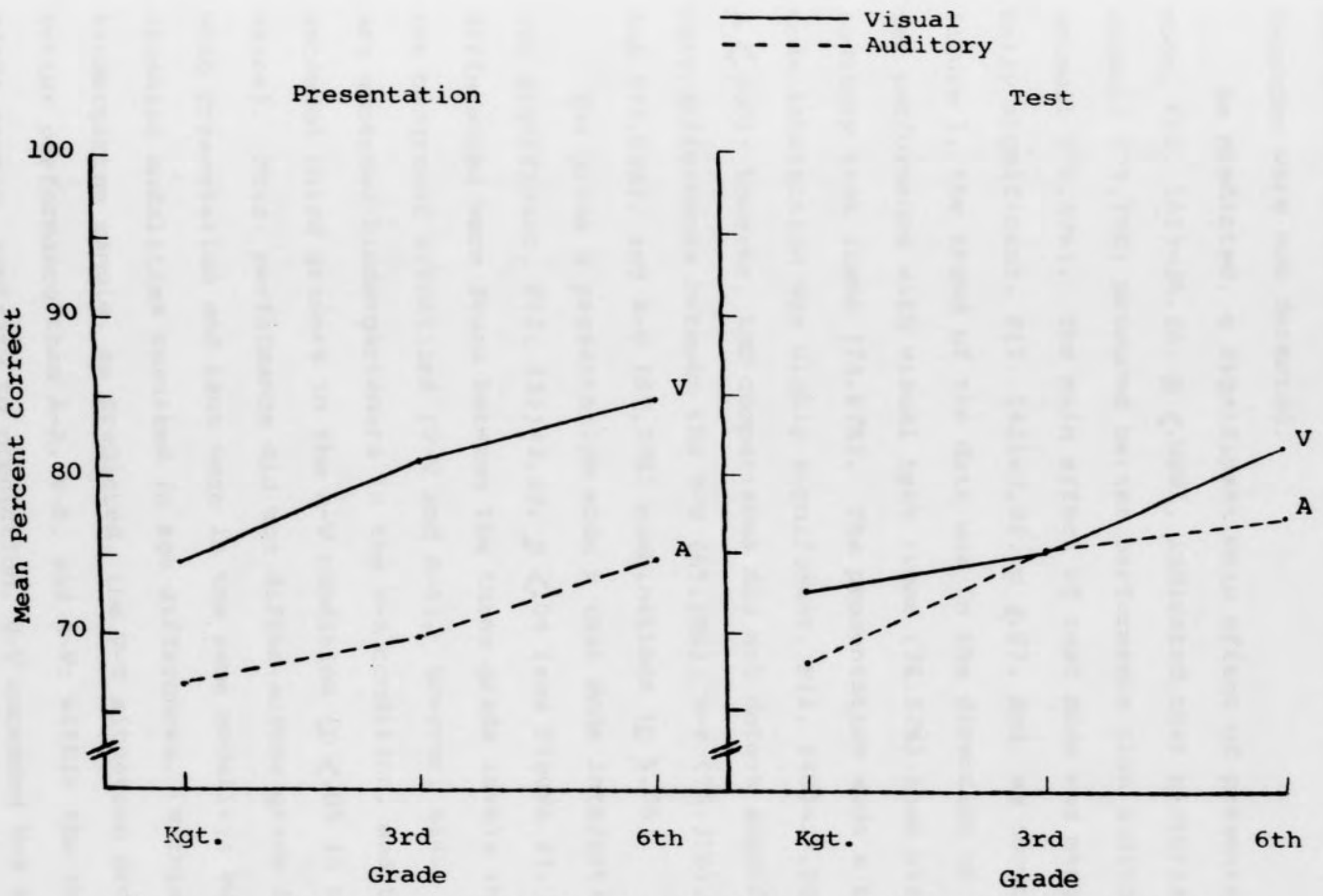

Figure 1. Mean percent correct as a function of presentation mode, test mode, and grade (N=48 per grade, 12 per cell).

the error variances for these young children, and hence differences were not detected.

As predicted, a significant main effect of presentation mode, $F(1, 142)=36.26$, $p < .0001$, indicated that pictorial stimuli (79.79%) produced better performance than auditory stimuli (70.40%). The main effect of test mode was marginally significant, $F(1, 142)=3.35$, $p < .07$, and, as shown in Figure 1, the trend of the data was in the direction of better performance with visual test items (76.52%) than with auditory test items (73.67%). The presentation mode x test mode interaction was highly significant, $F(1, 140)=27.09$, $p < .0001$; however, LSD comparisons did not detect significant differences between the V-V (85.28%), V-A (74.31%), A-A (73.03%), and A-V (67.77%) combinations ($p > .05$).

The grade x presentation mode x test mode interaction was significant, $F(2, 132)=3.29$, $p < .04$ (see Figure 2). No differences were found between the three grade levels in the two congruent situations (V-V and A-A). However, sixth graders exceeded kindergarteners in the V-A condition, and they exceeded third graders in the A-V condition ($p < .05$ in both cases). Thus, performance did not differ across grade level when presentation and test were in the same modality; but crossing modalities resulted in age differences. Within the kindergarten sample, as predicted, the V-V situation produced better performance than A-A, V-A, and A-V; within the third grade sample, contrary to prediction, V-V exceeded V-A and A-V, and A-A exceeded A-V; for the sixth graders, as

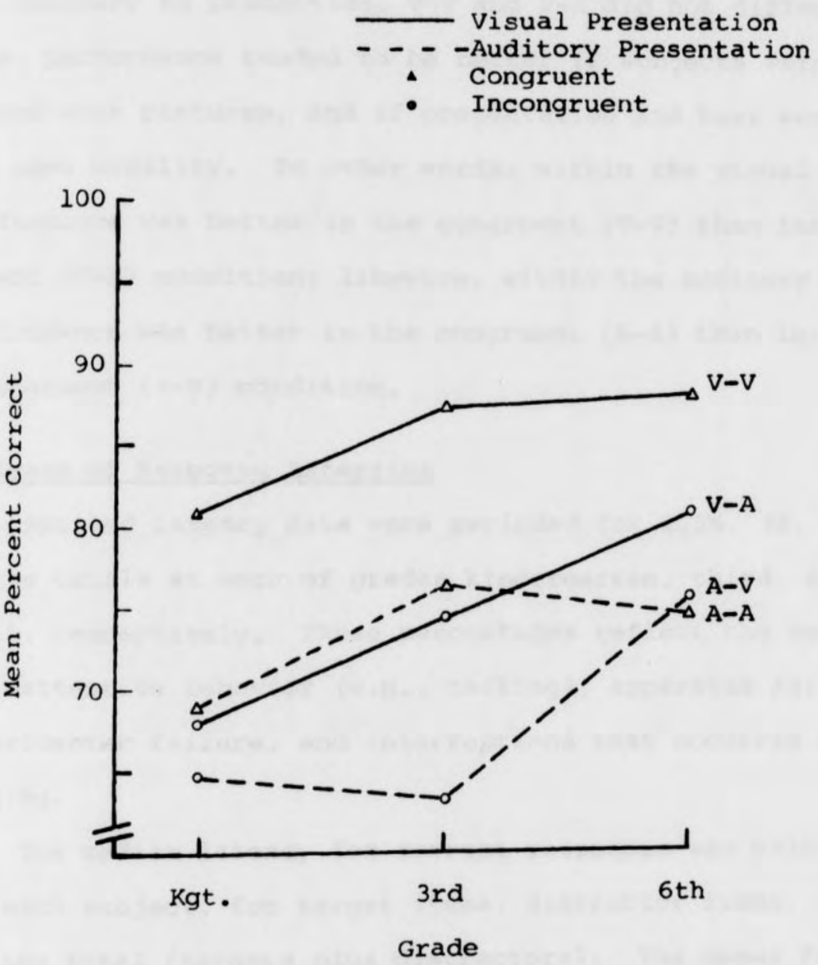

Figure 2. Mean percent correct as a function of grade and presentation-test mode combination (N=48 per grade, 12 per cell).

predicted, V-V surpassed A-V and A-A ($p < .05$ in all cases), but contrary to prediction, V-V and V-A did not differ. Thus, performance tended to be better if subjects were presented with pictures, and if presentation and test were in the same modality. In other words, within the visual mode, performance was better in the congruent (V-V) than the incongruent (V-A) condition; likewise, within the auditory mode, performance was better in the congruent (A-A) than in the incongruent (A-V) condition.

Analyses of Response Latencies

Spoiled latency data were excluded for 1.5%, 3%, and .5% of the trials at each of grades kindergarten, third, and sixth, respectively. These percentages reflect the degree of inattentive behavior (e.g., talking), apparatus failure, experimenter failure, and interruptions that occurred during testing.

The median latency for correct responses was calculated for each subject, for target items, distractor items, and for the total (targets plus distractors). The means for the totals of these medians are shown in Figure 3. A grade x presentation mode x test mode x sex analysis of variance of these data failed to yield a sex effect, but did reveal a significant main effect for grade level, $F(2, 141)=4.87$, $p < .01$. However, here again, LSD comparisons failed to detect differences between the latencies of the sixth graders (1774 msec), third graders (1894 msec), and kindergarteners

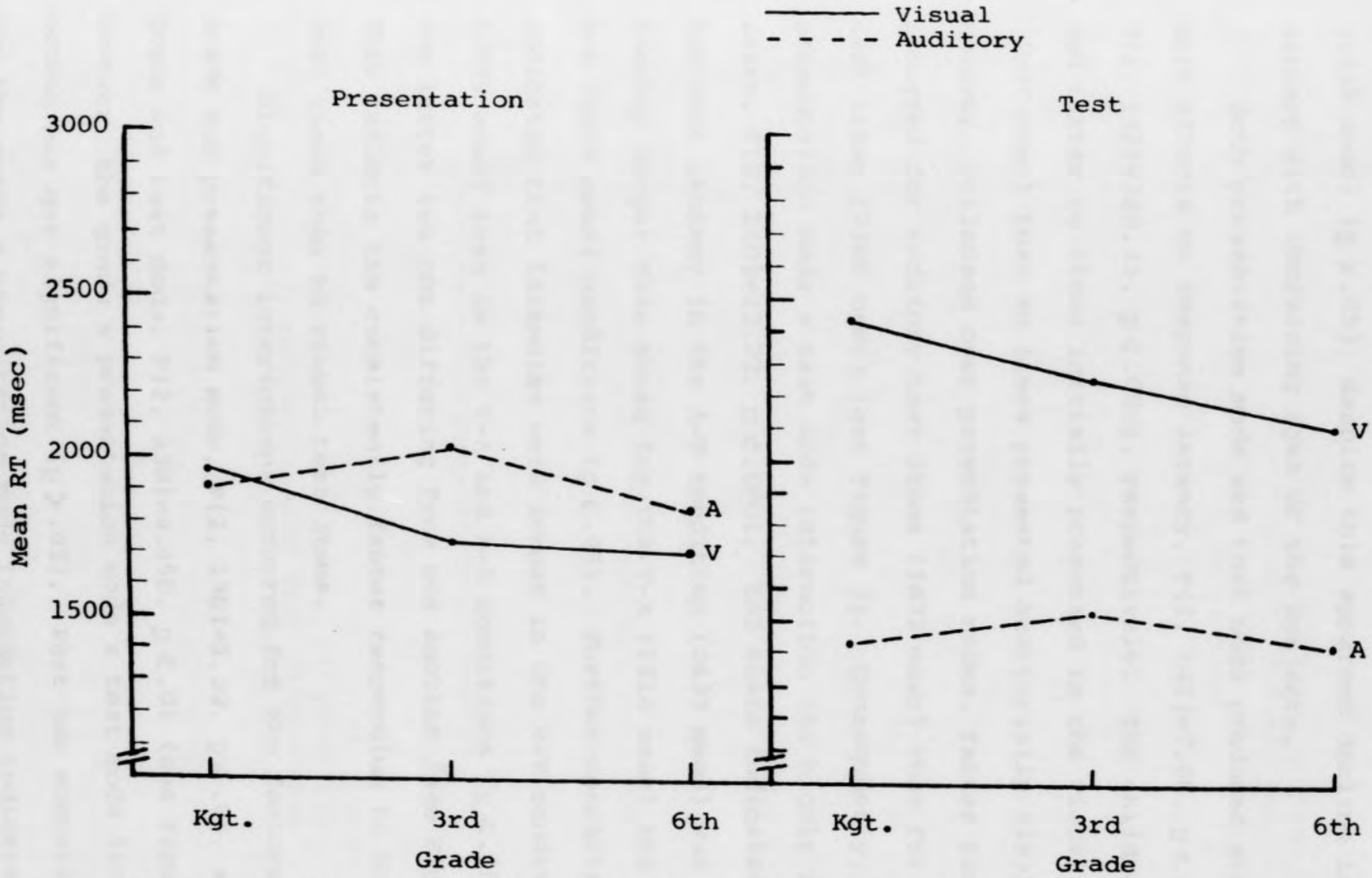

Figure 3. Mean RT as a function of presentation mode, test mode, and grade (N=48 per grade, 12 per cell).

(1938 msec) ($p > .05$), despite this apparent decline in latency with increasing ages of the subjects.

Both presentation mode and test mode produced significant main effects on response latency, $F(1, 142)=7.88$, $p < .01$ and $F(1, 142)=320.35$, $p < .0001$, respectively. The children responded faster to items initially presented in the visual mode (1807 msec) than to items presented auditorially (1931 msec). However, collapsed over presentation modes, faster responses occurred for auditory test items (1472 msec) than for visual test items (2266 msec) (see Figure 3). Consequently, the presentation mode x test mode interaction was highly significant, $F(1, 140)=22.23$, $p < .0001$. LSD tests indicated that the mean latency in the A-V condition (2433 msec) was significantly longer than those for the V-A (1514 msec) and the A-A (1429 msec) conditions ($p < .05$). Further comparisons indicated that latencies were longer in the V-V condition (2099 msec) than in the V-A and A-A conditions ($p < .05$), the latter two not differing from one another (see Figure 4). This reflects the consistently faster responding to auditory test items than to visual test items.

Significant interactions occurred for the factors of grade and presentation mode, $F(2, 138)=5.39$, $p < .01$, and for grade and test mode, $F(2, 138)=4.458$, $p < .01$ (see Figure 3); however, the grade x presentation mode x test mode interaction was not significant ($p > .05$). Post hoc comparisons for the grade x presentation mode interaction indicated

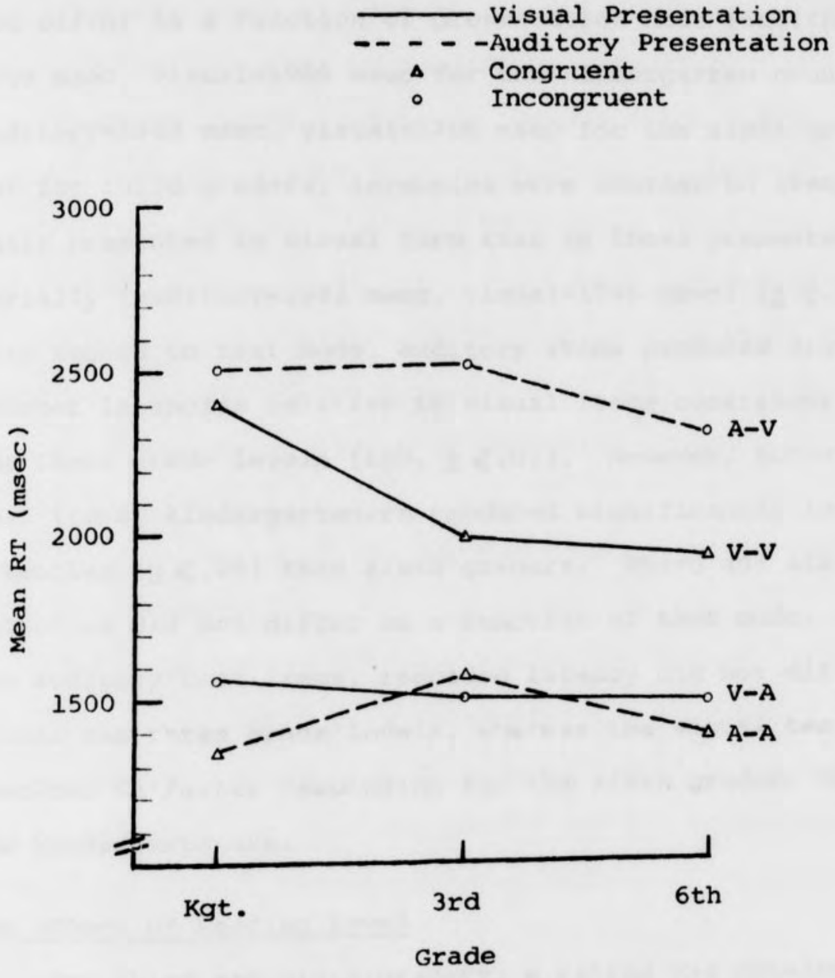

Figure 4. Mean RT as a function of grade and presentation-test mode combination (N=48 per grade, 12 per cell).

that for kindergarteners and sixth graders, latencies did not differ as a function of presentation mode (auditory= 1909 msec, visual=1968 msec for the kindergarten group and auditory=1843 msec, visual=1706 msec for the sixth graders); but for third graders, latencies were shorter to items initially presented in visual form than to those presented auditorially (auditory=2043 msec, visual=1746 msec) ($p < .05$). With regard to test mode, auditory items produced significantly shorter latencies relative to visual items consistently across the three grade levels (LSD, $p < .01$). However, for visual test items, kindergarteners produced significantly longer latencies ($p < .05$) than sixth graders. Third and sixth grade latencies did not differ as a function of test mode. Thus for auditory test items, response latency did not differ across the three grade levels, whereas the visual test mode resulted in faster responding for the sixth graders than for the kindergarteners.

The Effect of Reading Level

For third and sixth graders, a rating was obtained of their relative reading ability on a scale of 1-5, where 5=very good, 4=good, 3=average, 2=below average/fair, and 1=poor. These ratings were made for each subject by his teacher, and were supposed to reflect his reading ability relative to the others in his class. Table 1 (of Appendix B) contains the means of these ratings at each grade, by presentation mode and test mode. A correlational analysis of reading scores and the two performance measures indicated that, for the sixth graders in the A-A condition, accuracy was positively related to reading scores, r=.57, $p < .05$. Alternatively, sixth graders in the congruent visual (V-V) condition, displayed an inverse relationship between reading and accuracy, r=-.61, $p < .03$. Thus, when items were presented and tested in the visual mode, the higher one's reading score, the lower his accuracy was on the recognition test; when items were presented and tested in the auditory mode, high reading scores were associated with high accuracy in the recognition test.

No other correlations between reading scores and accuracy were significant.

The relationship between reading scores and latency of responding approached significance for sixth graders in the V-V condition, r=-.54, $p < .07$, indicating that the better one's reading score was, the faster was his responding. No other correlations between reading scores and response latency were significant.

Thus, within the sixth grade, it appears that once children have attained competence in reading, better readers show a greater facility for processing items of the A-A combination. On the other hand, those older children most accomplished in reading appear to process visual materials less effectively than their peers. More specifically, better readers among the sixth graders, respond faster and make more errors than do poor readers.

Since it was hypothesized that differential reading ability across experimental conditions would affect performance outcomes, and since reading was found to correlate significantly with task performance, the reading data were used as a covariate measure in a further analysis of the accuracy and reaction time data of the third and sixth graders. However, separate analyses of covariance on the adjusted latency and accuracy data failed to yield a significant main effect of reading ($p > .05$). Consequently, the analyses showed similar results to the previously reported ANOVAs except that there were no grade x presentation mode, nor grade x test mode, interactions for the latency data ($p > .05$); also, there was neither a main effect of sex, nor a main effect of test mode on accuracy data ($p > .05$) (see Tables 2 and 3 of Appendix B). When the two dependent variables were combined into a single measure and submitted to a multivariate analysis of variance (MANOVA), reading was found to have a significant effect on performance, $F(2, 79)=3.475$, $p < .03$, using Hotelling-Lawley's Trace criterion statistic for multivariate analyses. Drawing from the correlational findings for reading scores and the two performance measures, this MANOVA result must have been partially due to the fast, but inaccurate, responding of the better readers among the sixth graders in the V-V situation, and the more accurate performance by better readers in the A-A condition (although latency did not relate to reading here). In other words, the combined RT and accuracy measure differed as a function of reading score, and was probably largely due to this differential performance by sixth graders in the V-V and A-A conditions. This result lends support to the fundamental assumption of this research--that reading ability has an effect on the degree to which children can process visual and/or auditory information.

CHAPTER V

DISCUSSION

As predicted, overall performance with both visual and auditory materials increased with age, i.e., errors and latencies decreased with increasing age. However, contrary to prediction, the trend in accuracy was a gradual, linear increase, rather than a sudden increment from kindergarten to third grade as found by Siegel and Allik (1973). Thus, it is difficult to conclude from these data the point (developmentally) at which children make major advances in processing within and across visual and verbal modalities.

The overall superiority of pictorial stimuli over verbal stimuli, in terms of both accuracy and latency, is consistent with past research (e.g., Arthur & Daniel, 1974; Dilley & Paivio, 1968; Diveley & Rabinowitz, 1974; Jones, 1973; Paivio, 1970; and Siegel & Allik, 1973), and can be explained on the basis that (a) the image value of pictures produces a more enriched and unique representation for the purpose of encoding which is superior in elicitation value to the representational mode elicited by concrete words, be it imaginal or verbal (Groninger, 1974); and, to a lesser extent, (b) the dual-codability of pictures which is more frequent and more accurate (i.e., matches visually and verbally) than that for words (Paivio & Csapo, 1973; Snodgrass, et al., 1974). The differential richness of the memory code for pictures versus words is intensified, here, given that the words are auditory, and therefore, contain only one sensory code, as opposed to the visually-presented words used in other studies which contain both visual and verbal attributes. In the present study, the subject does not process an image of the printed word. Paivio and Csapo (1973) demonstrated the validity of the imagery and dual-encoding notion by applying image instructions to word stimuli in a free recall task with college students. They found that the typical picture-superiority vanished when image instructions were applied to word stimuli. Allik and Siegel (1974) showed similar results when they applied image instructions to auditorially-presented words in a serial recall task with college students. Image instructions produced better serial recall of auditory words than of pictures. Thus, at least for older subjects, it appears that the degree of imagery and the ensuing verbal association attached to that image, that occurs for pictures, but which is absent or less frequent for words, (especially auditory words as used in the present study) is responsible for the typical superiority of pictures over words as stimuli.

The present finding of a marginally significant main effect of test modality on accuracy was surprising in view of past research which has failed to obtain an effect of recall of probe cue (Hoving, Konick, & Wallace, 1975; Siegel & Allik, 1973), or of response term in a P-A task (Paivio, 1971; Paivio

& Yarmey, 1966). In the present study, recognition performance was better if subjects were tested with pictures than if they were tested with words, regardless of the mode in which items were initially presented. This effect lends support to the greater ease, i.e., access, of pictures over words in memory that can be attributed to the richer, more unique memory representation available for pictures that is unavailable for auditory words. This more vivid representation assists in the matching of the test probe with the initially-presented stimulus.

Test mode had a highly significant main effect on RT, with auditory test items yielding shorter latencies than visual test items. This is consistent with the results of Chase and Calfee (1969) who claim support for "Sternberg's (1967) two-stage memory search model; i.e., test mode affects only the encoding time, not the rate of search through memory" (p. 512). In other words, the verbal-acoustic test stimulus is encoded more rapidly than the visual test item.

The effect of test modality on the two performance measures indicates, then, that auditory test items produced faster responding and more errors at each grade level. It is likely that because the auditory representation is more transitory and, hence, less available at test time, and because young children are likely to react impulsively, the auditory test condition produces guessing responses. Guessing, as a result of uncertainty, yields more errors for auditory test items than for visual test items.

The highly significant presentation mode x test mode interaction reflects the overall inferiority of the A-V combination, relative to the V-V combination, in terms of accuracy, and the inferiority of A-V relative to V-A and A-A in terms of latency. At each grade level, errors were more frequent and latencies were longer when subjects were presented with auditory words and tested with pictures. The ordering of mean latency across the four presentation mode-test mode combinations exactly duplicates the ordering obtained by Chase and Calfee (1969) in their recognition study with college student subjects. Likewise, when the two congruent situations (V-V and A-A) are combined and the two incongruent situations (A-V and V-A) are combined, it is clear that congruent presentation and test mode combinations produced better accuracy and RT performance than the incongruent combinations. This finding is consistent with those of Diveley and Rabinowitz (1974), Paivio and Begg (1974), and Wallach and Averbach (1955). The fact that subjects performed better in the congruent conditions than in the cross-modal conditions indicates that they tended to store items mainly in the modality of initial presentation, (despite any tendency to dually encode items) and hence, experienced difficulty when confronted with tests in the opposite mode (Diveley & Rabinowitz, 1974). Along this same line of reasoning, Wallach and Averbach (1955) predicted better performance in congruent presentation mode-test mode combinations than in incongruent combinations, since a direct recognition is possible only when the probe item is in the same modality as that of the memory trace initially left for that item. This direct versus indirect recognition theory is a likely explanation for the present results. The availability of direct matches between presentation and test items enhances performance.

Similarly, Siegel and Allik (1973) explained their A-V inferiority result in terms of the availability of an "immediate match" between the test stimulus and the presentation stimulus. In the A-V situation the visual test item requires a transformation into verbal form to enable a search for, and match with, the corresponding stimulus item. The V-V, V-A, and A-A situations, however, may all be handled through direct matching of presentation and test items. Direct matching is possible through the availability in storage of a verbal-acoustic code associated with the richer visual stimuli. This dual-encoding of pictures which is less frequent, and less accurate than for auditory words, is perhaps partially responsible for the present finding of V-V superiority and A-V inferiority in terms of accuracy, and also might explain the A-V inferiority in terms of RT.

Another hypothesis that has been offered to explain A-V inferiority suggests that subjects develop a set or expectation of being tested in the mode in which they initially experienced the items (Hoving, Konick, & Wallace, 1975; Paivio & Begg, 1974), but they tend to search for items in the same mode as that of the test probe (Paivio & Begg, 1974). Therefore, when placed in the A-V situation, subjects set themselves for an auditory test; but when they are presented with visual test items, their search is in the visual mode. Since they were set verbally, and hence were unlikely to have produced visual images to the words, a visual search at test time slows down the output process and causes errors. This set explanation can also be applied to the overall decline in performance from V-V to V-A. This hypothesis is closely connected with the notion that stimulus information is stored in the mode of initial presentation, but it is hereby regarded as secondary in importance. Young subjects are less strategy-oriented (Stevenson, 1972), and hence, are less likely to be thinking ahead to what the test will involve. They are more concerned with the present task of inputting the information.

Dilley and Paivio (1968), who found the A-V combination to produce the most errors in a P-A task, demonstrated that children could name the stimuli prior to the experimental task. Hence, the result was not a function of the children's inability to verbalize the pictorial stimuli. Rather, it was a problem of "symbolic transformation from a nonverbal to a verbal mode of thinking" (p. 239). This is consistent with Mowbray and Luria's (1973) conclusion from the results of their recognition task with children. They found that young children did not necessarily fail to label visually-presented material, but rather they employed less appropriate labels which interfered with later retrieval of the items. This would be especially applicable to the present A-V situation, since if the subject used an inappropriate name for a pictorial item, he would be highly likely to respond negatively in the recognition test since his label would not match the name initially presented to him. This was sometimes the case in the present experiment; some of the subjects at each grade level tested evidenced overt forms of verbalization to pictures. The labels of the younger subjects, however, were not always appropriate, although mislabeling occurred only infrequently. Hence, the failure to verbalize at time of initial presentation must be rejected as the cause for the age differences in the A-V and V-A conditions found in the present children. Mediation deficiency (Reese, 1962) might be a more accurate explanation of young children's memory deficiencies. They know the labels of pictorial items and produce them during presentation, but labels do not produce the expected facilitative effect on test performance. Even though young children can label pictorial items, labels are not operative in the processing and retrieval of items.

Conceptual malfunction is another highly likely causal factor for memory deficiencies across age (Mowbray & Luria, 1973; Stevenson, 1972). The inability to conceptualize the demands of the task, i.e., "what the experimenter wants me to do," is quite possibly responsible, at least in part, for young children's inferior memory performance.

The significant grade x presentation mode x test mode interaction with regard to accuracy, but not latency, involves a variety of contrasts. First of all, across grades, performance did not differ in the congruent (V-V and A-A) conditions; all grade levels did better in the congruent conditions than in the incongruent conditions. Hence, direct matching facilitates recognition performance at all grades tested. It was for the incongruent (A-V and V-A) conditions that age differences were found. Sixth graders surpassed kindergarteners in the V-A condition, and they surpassed third graders in the A-V condition. The younger subjects, even though they often produced labels, apparently were not using labels effectively in the encoding of picture presentations, whereas the older subjects did so and performed significantly better than the youngest subjects. Without some form of verbal mediation to the visual presentations, a direct recognition in the V-A condition is not possible.

Third grade performance was poorer in the incongruent auditory (A-V) condition, relative to the congruent auditory (A-A) condition, to the same extent that their incongruent visual (V-A) performance fell short of their congruent visual (V-V) performance. Thus, direct matching seems to be a critically important prerequisite for correct recognition performance for this age group, although for sixth graders direct matching was not necessary. Further, neither the third graders nor the kindergarteners appear to have been producing a visual representation of auditorially-presented material; otherwise, their performance would have been better in the A-V condition. The auditory-presentation conditions, in general, produced poorer performance than the visual-presentation conditions, again, supporting the notion of less enriched and unique memory representations available for auditory words than for pictures. The picture stimuli evoke an episodically constrained representation in memory, one that is peculiar to this task alone. Auditory words, however, are not unique, relative to the countless other words in the child's storage space, and hence both commission and omission errors are more likely than with picture stimuli. This lesser uniqueness of words is highly likely since the present stimulus words were selected for their common, highly frequent usage (as indicated by their Thorndike-Lorge, 1944, frequencies).

The developmental results, then, may be summarized as a lack of proficiency by kindergarteners in transforming (i.e., mediating) visual information into verbal form, i.e., they do not effectively use labels to process visual information. Third graders show a greater tendency to do so, but it appears from developmental comparisons of the V-A data, that it is not until sixth grade that proficient transformations are made. The availability of a direct match between stimulus presentation and test probe seems to be a necessary condition for recognition performance of the two younger age groups.

Within grade levels, the V-V condition produced by far the best performance. This condition will be regarded as the standard to which all others will be compared. V-V superiority reflects the highest degree of episodic constraint among the four presentation mode-test mode combinations. The picture items are highly enriched presentations, are unique to the experimental situation, and can be directly matched at test time. Within the kindergarten sample, V-V surpassed all three of the remaining conditions, which did not differ from one another. Within the third grade sample, V-V surpassed V-A and A-V, and A-A surpassed A-V; hence the congruent conditions produced better performance than the incongruent conditions for this grade level. Furthermore, for both kindergarten and third graders, the V-A task produced poorer performance even than the congruent auditory condition (which is well known to be poorer than the congruent visual situation). Hence, switching modalities on these younger children drastically reduces their recognition performance.

For the sixth graders, performance did not differ as a function of congruity of presentation and test modes. That is, sixth graders were able to make transformations across modalities. Differences occurred, though, between the congruent visual (V-V) condition and the two auditory-presentation conditions (A-A and A-V), yielding better performance with the V-V condition. Hence, auditory presentations, in general, produce poorer performance than visual presentations.

Regarding response latency, the significant grade x test mode interaction was due to the longer latencies of the kindergarteners compared to the sixth graders when tested with pictures, but the relatively comparable performance (i.e., consistently shorter latencies) of the three age groups when tested with auditory words. Perhaps the younger children became too involved with inspecting the pictures, because of their attractiveness, relative to words, and hence their RTs were slower. Or maybe, the sixth graders' higher level of cognitive sophistication enabled a more efficient level of picture processing.

The grade x presentation mode interaction with latency data reflected the faster responding of the third graders when presented with pictures than when presented with words, as opposed to the performance of the kindergarteners and sixth graders which did not differ as a function of the mode in which items were initially presented.

Of particular interest in the present study is the relation of reading ability to recognition performance. Reading ability was found to relate significantly to only the performance of the sixth graders, the age group chosen for their relatively proficient mastery of the reading skill. For the early readers, i.e., the third graders, reading skills did not relate significantly to recognition memory performance. For the oldest group, reading proficiency as estimated by teacher ratings was positively related to accuracy in the A-A condition and negatively related to accuracy and latency in the V-V condition. Thus, when the task was purely verbal (A-A), those children with greater reading facility performed better on the memory task even though this condition produced poorer performance than the V-V condition. Conversely, when the task was purely visual (V-V), which was the easiest of the four conditions, the better readers made more errors and took longer to respond than the poor readers. Thus, it appears that once children have attained competence in reading (i.e., the sixth graders here), higher levels of reading facility enables them to better establish and identify encoded verbal representations. Further, it appears that in tasks where verbal processing is required, e.g., in the A-A condition of the present study, reading competence facilitates task performance. On the other hand, in tasks where verbal processing is not necessary, but may be helpful, e.g., the present V-V condition which was the easiest for all subjects, high reading competence is not essential and, in fact, may hinder performance. This is a very interesting finding which warrants further investigation and evaluation with a more refined measure of reading ability. For the easiest task, V-V, reading competence was not necessary for performance; but for the more difficult, A-A, task reading competence assisted performance.

Tangential to the major focus of the study are the target versus distractor variables, which are of interest in themselves. Tables 4 and 5 (of Appendix B) contain the mean percent correct and mean latency for targets and for distractors at each grade, by presentation mode and by test mode. Although these data were not submitted to statistical test, the trend was in the direction of shorter latencies to target (Yes) items than to distractor (No) items, and higher accuracy to distractors than to targets. It appears to have been easier for subjects to rule out a distractor as incorrect than it was to recognize a target as correct; and it took longer for them to negate a distractor than to admit a target. These results are consistent with the results of Arthur and Daniel (1974) in their continuous recognition task with college students.

Conclusions

It is apparent from the present investigation that preadolescent children are more proficient at processing pictorial information than auditory-verbal information. The image value of pictorial information, which enables a more enriched, unique memory representation is far superior to either the image value of concrete words or to their verbal codability at all ages tested. Hence the educational system would do well to employ pictorial information along with verbal tasks. In addition, situations that enable a direct match between the initial memory representation and the test probe are essential to optimum recognition performance for younger elementary school children but are not necessary for older children. Individual reading ability is very likely to determine how well children will remember verbal input, but is less likely to affect their memory in purely visual tasks.

Suggestions for Future Research

A replication of the present results with a more refined index of reading ability and with the addition of adult subjects would lend further to our understanding of the course of memory development. The adult sample would add information regarding memory development beyond adolescence and would help to determine if the sixth graders have attained maximum proficiency in the processing of visual and verbal information.

A replication with the same three age groups would help clarify the present problems of interpretation regarding the poor performance of the third graders in the A-V condition, and the poorer performance of the sixth graders in the A-A condition relative to the third graders.

The employment of a more precise measure of auditory RT, comparable to that for visual RT, would lessen error within the auditory test conditions and would equate the latency measure of the auditory tests with that of the visual tests.

It is also desirable to somehow demonstrate that subjects at all grade levels can correctly label the picture stimuli, without confounding their natural orientation to the task.

More importantly, it would be desirable to ensure that even the youngest subjects understood the nature of the recognition task. If the recognition procedure was demonstrated prior to the input of the to-be-remembered material, perhaps subjects would employ a better encoding strategy.

Lastly, it would be interesting to obtain a measure of the children's reflection-impulsivity characteristics to determine if this type of variability relates to their recognition performance.

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APPENDIX A

TESTING MATERIALS

Demonstrations

1. lion
2. fence (p)
3. chimney

Presentations

1. SHEEP
2. CUP
3. HORSESHOE
4. BABY (P)
5. HAND (P)
6. CRIB (P)
7. DOG
8. WAGON (P)
9. LEAF
10. WHEEL
11. TANK (P)
12. UMBRELLA (P)
13. CAN (P)
14. CAMEL (P)
15. BEAR
16. CAR (P)
17. KNIFE
18. BELL
19. TELEVISION
20. NET (P)
21. LAMP (P)
22. RING
23. ANCHOR
24. KITE (P)
25. FLAG (P)
26. SCISSORS
27. BRUSH (P)
28. CHAIR
29. TRAIN (P)
30. TURTLE

NAME________________________________ DATE______________ ID ______

AGE/DOB_____DOM. HAND: L R

SEX: M F GRP: V-V V-A A-V A-A

TEST

	Response	*T's	D's
1. SLED	Y N		________
2. BRUSH (P) *	Y N	________	
3. BASEBALL BAT (P)	Y N		________
4. TRAIN (P) *	Y N	________	
5. SCISSORS *	Y N	________	
6. PUMPKIN	Y N		________
Practice			
7. FROG	Y N		________
8. CHAIR *	Y N	________	
9. TURTLE *	Y N	________	
10. TIRE (P)	Y N		________
11. WINDOW (P)	Y N		________
12. FLAG (P) *	Y N	________	
------------------			
13. PIPE	Y N		________
14. UMBRELLA (P) *	Y N	________	
15. TANK (P) *	Y N	________	
16. TELEVISION *	Y N	________	
17. KITTEN (P)	Y N		
18. CUP *	Y N	________	________
19. DOG *	Y N	________	
20. MOON	Y N		________

ID ______

		Response	*T's	D's
21.	HORSESHOE *	Y N	______	
22.	TABLE (P)	Y N		______
23.	MONKEY	Y N		______
24.	GUN (P)	Y N		______
25.	SHEEP *	Y N	______	
26.	HAND (P) *	Y N	______	
27.	TIE (P)	Y N		______
28.	BIRDNEST (P)	Y N		______
29.	COWBOY	Y N		______
30.	CAR (P) *	Y N	______	
31.	DUCK	Y N		______
32.	LAMP (P) *	Y N	______	
33.	LEAF *	Y N	______	
34.	CAMEL (P) *	Y N	______	
35.	CHICKEN (P)	Y N		______
36.	IRON (P)	Y N		______
37.	BEAR *	Y N	______	
38.	HAMMER	Y N		______
39.	BEE (P)	Y N		______
40.	KNIFE *	Y N	______	
41.	BELL *	Y N	______	
42.	CAN (P) *	Y N	______	
43.	GOAT (P)	Y N		______
44.	PIANO	Y N		______

ID______

		Response	T's	D's
45.	ANCHOR *	Y N	______	
46.	BALL (P)	Y N		______
47.	TELEPHONE	Y N		______
48.	CRIB (P) *	Y N	______	
49.	BABY (P) *	Y N	______	
50.	HOUSE	Y N		______
51.	DRUM (P)	Y N		______
52.	WHEEL *	Y N	______	
53.	FOOTBALL	Y N		______
54.	NET (P) *	Y N	______	
55.	WAGON (P) *	Y N	______	
56.	BUCKET (P)	Y N		______
57.	RING *	Y N	______	
58.	CAKE	Y N		______
59.	KITE (P) *	Y N	______	
60.	BIRD	Y N		______

No. correct: ______ + ______ = Tot. corr: ______

Mdn. lat. ______ ______

Verbal score: ______

PRESENTATION INSTRUCTIONS

Visual

We're going to play a memory game. I'm going to show you a bunch of pictures, and then later I'm going to see how well you can remember them.

The pictures will be shown on this screen, one at a time. Each one will be on for about 4 seconds, and then the next one will come on automatically. O. K., here are 3 examples of what you will see. (SHOW 3 DEMONSTRATION PRESENTATIONS)

I want you to watch the screen and try to remember each picture. O. K., do you understand how the game will work? Try to remember these pictures. (SHOW 30 VISUAL PRESENTATIONS)

TEST INSTRUCTIONS

V-V: Now this is the fun part of the game. Again I'm going to show you one picture at a time; sometimes it will be just like one you just saw, and sometimes it will be a new picture, one that you did not see before. You have two buttons in front of you. If the picture is just like one you saw before, I want you to press the right-hand button. That button means "YES," you saw the picture before. If the picture is a new one, that you did not see before, I want you to press the left-hand button. That button means "NO," you did not see that picture before. I want you to put your hands on the buttons so you'll always be ready to push them. Only press <u>one</u> at a time.

Also, I want you to push the button as quickly as you can; so as soon as you have decided whether or not you saw the picture before, press the button that you think is correct. You should try to get as many correct as possible.

Just press the button once, real hard, then let go. Remember, push the right botton--the YES button--if you think you saw the picture before, and press the left one--the NO button--if you did not see that picture before.

After you press the button, a colored slide will automatically come on. You shouldn't push any buttons then, just rest. I will write down your answer, then I'll show you another picture and you'll do the same thing again--you'll press one of the buttons. We're going to practice a few first till you've got the hang of it. O. K., ready? (SHOW 12 PRACTICE VISUAL TESTS)

O. K. Do you have any questions? Now these ones will be for real. Ready? (SHOW 48 VISUAL TESTS)

<u>V-A</u>: Now this is the fun part of the game. This time, instead of showing you pictures, I'm going to let you hear words on this tape recorder. The words will come on one at a time just like the pictures you saw. Sometimes the word will be the name of one of the pictures you just saw, and sometimes the word will not be the name of <u>any</u> of the pictures you saw. You have two buttons in front of you. If the word you hear is the name of one of the pictures you just saw, I want you

to press the right-hand button. That button means "YES," you saw a picture with that name before. If the word you hear is not the name of one of the pictures you just saw, I want you to press the left-hand button. That button means "NO," you did not see a picture with that name before. I want you to put your hands on the buttons so you'll always be ready to push them. Only press one at a time. Just before each word comes on, you'll hear a little noise; that noise means that you should listen for the word and be ready to push one of those buttons.

Also, I want you to push the button as quickly as you can; so as soon as you have decided whether or not you saw a picture with that name before, press the button that you think is correct. You should try to get as many correct as possible.

Just press the button once, real hard, then let go. Remember, push the right button--the YES button--if you think you saw a picture with that name before, and press the left one--the NO button--if you did not see a picture with that name.

After you press the button, I will write down your answer, then you'll hear the next word and you'll do the same thing--you'll press one of the buttons. We're going to practice a few first till you've got the hang of it. O. K., ready? (ADMINISTER 12 PRACTICE AUDITORY TESTS WITHOUT HEADPHONES)

O. K. Do you have any questions? Now these ones will be for real. Ready? (ADMINISTER 48 AUDITORY TESTS)

PRESENTATION INSTRUCTIONS

Auditory

We're going to play a memory game. I'm going to let you hear a bunch of words, and then later I'm going to see how well you can remember them.

You'll hear the words on these headphones, one at a time. Each word will be said two times in a row, and then the next one will come on right after it. O. K., here are 3 examples of what you will hear. (ADMINISTER 3 DEMONSTRATION AUDITORY PRESENTATIONS WITHOUT HEADPHONES)

I want you to listen very carefully to the words and try to remember each one.

O. K., do you understand how the game will work? Try to remember these words. (ADMINISTER 30 AUDITORY PRESENTATIONS WITH HEADPHONES)

TEST INSTRUCTIONS

A-A: Now this is the fun part of the game. Again, I'm going to let you hear some words; but this time you'll only hear each word once, and we won't be using the headphones. Sometimes the word will be one that you heard before on the head phones, and sometimes it will be a new word, one that you did not hear before. You have two buttons in front of you. If it's a word that you heard before, on the headphones, I want you to press the right-hand button. That button means YES, you heard that word before. If the word is a new one, that you did not hear before, I want you to press the left-hand button. That button means "NO," you did not hear that word before. I want you to put your hands on the buttons so you'll always be ready to push them. Only press <u>one</u> at a time. Just before each word comes on, you'll hear a little noise; that noise means that you should listen for the word and be ready to push one of those buttons.

Also, I want you to push the button as quickly as you can; so as soon as you have decided whether or not you heard the word before, press the button that you think is correct. You should try to get as many correct as possible.

Just press the button once, real hard, then let go. Remember, push the right button--the YES button--if you think you heard the word before, and press the left one--the NO button--if you did not hear that word before.

After you press the button, I will write down your answer, then you'll hear the next word and you'll do the same thing--you'll press one of the buttons. We're going to practice a few first till you've got the hang of it. O. K., ready? (ADMINISTER 12 PRACTICE AUDITORY TESTS WITHOUT HEADPHONES)

O. K. Do you have any questions? Now these ones will be for real. Ready? (ADMINISTER 48 AUDITORY TESTS)

<u>A-V</u>: Now this is the fun part of the game. This time, instead of letting you hear words, I'm going to show you pictures. The pictures will be shown on this screen, one at a time. Sometimes the picture will be one with the same name as one of the words you just heard on the headphones, and

sometimes the picture will not have the same name as <u>any</u> of the words you just heard. You have two buttons in front of you. If the picture has the same name as one of the words you just heard, I want you to press the right-hand button. That button means "YES," you heard a word with that same name before. If the picture does not have the same name as one of the words you just heard, I want you to press the left-hand button. That button means "NO," you did not hear a word with that same name before. I want you to put your hands on the buttons so you'll always be ready to push them. Only press <u>one</u> at a time.

Also, I want you to push the button as quickly as you can; so as soon as you have decided whether or not you heard a word with that same name before, press the button that you think is correct. You should try to get as many correct as possible.

Just press the button once, real hard, then let go. Remember, push the right button--the YES button--if you think you heard a word with that same name before, and press the left one--the NO button--if you did not hear a word with that name.

After you press the button, a colored slide will automatically come on. You shouldn't push any buttons then, just rest. I will write down your answer, then I'll show you another picture and you'll do the same thing again--you'll press one of the buttons. We're going to practice a few first till you've got the hang of it. O. K., ready? (SHOW 12 PRACTICE VISUAL TESTS)

O. K. Do you have any questions? Now these ones will be for real. Ready? (SHOW 48 VISUAL TESTS)

APPENDIX B

TABLES

TABLE 1

Mean Reading Score as a Function of Grade and Presentation-Test Mode Combination

Grade	Presentation-Test Mode	Reading Score
3	A-A	4.16
3	A-V	3.66
3	V-A	3.25
3	V-V	3.58
6	A-A	2.91
6	A-V	4.00
6	V-A	3.08
6	V-V	3.25

TABLE 2

ANOVA Summary Table for Accuracy Data
for 3rd & 6th Graders Adjusted for Reading Score

Source	df	F	Prob > F
Grade (A)	1, 94	7.3259	.0083
Presentation Mode (B)	1, 94	44.1311	.0001
Test Mode (C)	1, 94	.9866	.3235
Sex (D)	1, 94	.7494	.3892
A x B	1, 92	.2865	.5939
A x C	1, 92	.9047	.3444
B x C	1, 92	23.7822	.0001
A x B x C	1, 88	7.1345	.0092
A x B x C x D	1, 80	3.4644	.0664

TABLE 3

ANOVA Summary Table for RT Data
for 3rd & 6th Graders Adjusted for Reading Score

Source	df	F	Prob > F
Grade (A)	1, 94	4.1263	.0455
Presentation Mode (B)	1, 94	14.5288	.0003
Test Mode (C)	1, 94	157.6105	.0001
Sex (D)	1, 94	.8927	.3476
A x B	1, 92	2.1855	.1432
A x C	1, 92	.0282	.8670
B x C	1, 92	17.3485	.0001
A x B x C	1, 88	.0788	.7796
A x B x C x D	1, 80	.2033	.6533

TABLE 4

Mean Percent Correct for Targets and Distractors by Grade and Presentation-Test Mode Combination

	Item Type	Presentation-Test Mode Combination V-V	V-A	A-A	A-V	Grade Means
Kgt.	Targets	71.88	56.25	58.68	56.25	60.77
	Distractors	89.58	79.17	78.82	73.26	80.21
3rd	Targets	80.48	71.18	69.10	57.64	69.60
	Distractors	90.58	77.78	76.39	69.10	78.46
6th	Targets	81.60	74.65	72.91	72.92	75.52
	Distractors	94.10	86.81	75.35	77.43	83.42
	Condition Means	T=77.99 D=91.42	T=67.36 D=81.25	T=66.90 D=76.85	T=62.27 D=73.26	

T = Targets

D = Distractors

TABLE 5

Mean (of median) Latency (in msec) for Targets and Distractors by Grade and Presentation-Test Mode Combination

	Item Type	Presentation-Test Mode Combination V-V	V-A	A-A	A-V	Grade Means
Kgt.	Targets	2386	1471	1338	2410	1901
	Distractors	2414	1663	1421	2502	2000
3rd	Targets	2009	1379	1425	2335	1787
	Distractors	1998	1579	1704	2747	2007
6th	Targets	1885	1346	1304	2142	1669
	Distractors	1981	1592	1492	2395	1865
	Condition Means	T=2093	T=1399	T=1356	T=2296	
		D=2131	D=1611	D=1539	D=2548	

T = Targets

D = Distractors