MNEMONIC EFFECTS IN CHILDREN'S ASSOCIATIVE LEARNING:

A THEORETICAL AND EXPERIMENTAL ANALYSIS

by

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ABSTRACT

An attempt was made to shed new light upon the controversy between semantic overlap (e.g., Rohwer, 1973) and interacting imagery (e.g., Paivio, 1970) interpretations of mnemonic effects in children's associative learning. Two approaches were taken to this task. First, several conflicting predictions of the semantic and imagery models were pinpointed and subjected to experimental analysis. Second, in an attempt to supercede the semantic versus imagery issue, the Piagetian (e.g., Piaget and Inhelder, 1973) conception of memory was considered and some predictions, derived from an extrapolation of this model to associative learning were examined experimentally. In terms of the former approach, the results of the four experiments generally were more consistent with the imagery perspective. However, since only peripheral features of the semantic model were contradicted, no clear choice between the two positions was warranted. Inclusion of several measures of delayed recall in order to pursue the second, Piagetian-based, approach did point out the inadequacy of the semantic and imagery models with regard to longer retention intervals. From the Piagetian perspective the various memory-improving effects, rather than being attributable to operative (i.e., assimilatory) processes, instead, seemed more appropriately assigned to a figurative-level mnemonic.

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CHAPTER 1

Three Views of the Nature of Children's Memory - A General Introduction

A. Introduction

Until recently the two dominant hypotheses as to the nature of children's memory have assumed information retention to rest upon either a modal-specific or an amodal type of storage. Paivio (1969, 1971, 1975), a strong proponent of the former view, has proposed a model of memory[1] in which the majority of encoded information is processed and stored in one or both of a verbal and visual (imagery) mode. While abstract information is, according to Paivio, only amenable to verbal storage (i.e., mono-coded), concrete material is represented visually as well as verbally and, as a consequent of this dual coding, is better remembered. In addition to hypothesizing that two codes are better than one, Paivio (e.g., 1975) has speculated as to the properties of each of these two systems. While representing information verbally is proposed to be particularly effective for remembering the order of information input, representing material visually (i.e., by means of images) can be especially valuable for storing pieces of information together such that presentation of one item will readily yield its partner(s). This additional (i.e., above and beyond dual coding) memory facilitation occurs if visually represented items are stored as a single (compound) visual image. Such

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[1] Though Paivio's model is based primarily upon research with adults he believes it to be equally applicable to children. Yuille (1973, 1974) and his associates have provided much support for this extrapolation.

images can result from an interacting visual stimulus display, can be prompted by verbal descriptions of interactions, or can be deliberately created by the individual if he/she is properly instructed. Synchronous storage within the visual mode is, according to Paivio, a particularly effective method for storing concrete material and hence plays a major role in children's memory, due to the primarily concrete content of the types of situations which children must remember.

In contrast to Paivio's model in which storage is modal-specific, Rohwer (e.g., 1973) and his associates have developed an amodal model of children's memory based upon storage of semantic or meaning-based attributes of information. While Paivio's model deals with memory for individual (via dual coding), as well as multiple items, Rohwer's model is primarily directed toward explaining the latter case. Memory for such situations hinges, says Rohwer, upon the generation of a semantic relationship among items within a group. If a semantic overlap is formed then improved cued recall or recognition will result. In this model the likelihood of semantic overlaps being formed is dependent upon the age of the child as well as the manner in which the materials are presented. Presentation and/or instructional manipulations which according to Paivio prompt compound image formation, are, in Rohwer's view, effective because of their capacity for cueing semantic overlap and hence taking advantage of the meaning-based nature of memory.

Recently, Piaget and Inhelder (1973), have proposed a third model of children's memory which, though incorporating both semantic and imagery concepts, does not depend upon the storage of specific items of information in either image or meaning form, as do both the Paivio and Rohwer formulations. According to Piaget and Inhelder (1973), specific information, rather than being stored, is assimilated to and becomes part of the network of understanding[2] (scheme repertoire) currently available to the child, and is represented in memory only in the sense that it is potentially reconstructable through these schemes. Piaget and Inhelder (see also 1971) employ the concept of imagery in their model, however, imagery, in their view, is not the means by which information is stored (since theirs is not a storage-based model) but rather serves as a display screen (c.f. Kosslyn, 1975) which can support assimilation of the stimulus to the schemes and also upon which the desired memory can be reconstructed. The image, in these authors' view is, therefore, a supportive but not constitutive element of memory.Thus Piaget's and Inhelder's view of the importance of imagery in memory might be seen as occupying an intermediate position between the relatively strong imagery stance taken by Paivio (images are a major information storage mode) and the peripheral role of images as seen by Rohwer (while images may be formed they represent a peripheral level of memory and are quickly translated into a "deeper" semantic form).

The specific research area within which the interacting image versus semantic overlap controversy has been most widely investigated is children's associative learning. Several manipulations such as embedding noun pairs in sentence frames, presenting pairs as interacting objects, and instructing children to form covert sentences and interacting images, all result in

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2 Information which is not understandable to the child cannot be recalled since it can not be assimilated to the current repertoire of schemes (unless it is only mildly novel).

cued recall and recognition performance above that obtained in a simple side-by-side noun or object pair learning task. By late adolescence these manipulations have little or no effect upon paired associate performance suggesting that the memory-improving processes which they prompt come to be automatically initiated at later stages of development. Paivio (1971, 1975) and his associates (e.g., Yuille, 1973, 1974) have attributed the memory improvement resulting from such manipulations to the fact that they result in the pairs being stored as interacting images which are readily recovered in entirety if one of the two original pair members is provided. Rohwer (1970b, 1973), however, believes that these types of presentations cause pairs to be stored with a meaningful link between them. In his view cueing with one partner prompts the semantic link which then leads to the second item.

As is outlined in Sections C and D, to follow, proponents of each position have gathered considerable evidence to support their own, and occasionally the opposite, point of view such that to date a clear decision, in favour of a semantic overlap or interacting image interpretation of children's paired associate learning (PAL), is not possible. In light of this theoretical stalemate the intent of the current research was to shed new light upon this controversy by reconsidering it, while keeping in mind Piaget's and Inhelder's conception of memory and memory development. Though Piaget and Inhelder have not dealt specifically with associative learning, interpolations from their overall model to such a task are possible. The success of an attempt to map in some of these authors' ideas to the semantic versus imagery issue, however, first requires a comprehensive consideration of Piaget's and Inhelder's theory. Thus the following section (Section B) presents this model in some detail such that when the Paivio (Section C) and Rohwer (Section D) hypotheses are outlined they can be seen in contrast to the Piagetian conception as well as each others'. Following the theory-and-supportive-data-oriented Chapter 1, Chapter 2 attempts to test the application of Piaget's and Inhelder's model of memory to PAL and also to examine further the semantic versus imagery issue, experimentally. Since a levels of processing model (e.g., Craik and Lockhart, 1972) has recently been applied to children's sentence memory (c.f. Kosslyn and Bower, 1974) this fourth position was also briefly considered, relative to the views of Paivio, Rohwer, and Piaget and Inhelder.

B. Piaget

a) Introduction: The extensive work of Jean Piaget (and Inhelder) on imagery, memory, and the relationship between the two has been largely ignored by the mainstream of North American researchers. This is unfortunate since the Piagetian developmental approach has provided several original ideas concerning the topics of memory and imagery. This advantage accrues in a large part because of the close integration of Piaget's experimental investigations into his overall theory. Most recently he and Inhelder have published two books: Mental Imagery in the Child (1971) and Memory and Intelligence (1973) which have focused directly upon the current topics of interest. In addition to a wealth of experimental studies these publications also contain considerable theoretical substance that serves to synthesize the experimental results into Piaget's overall theory of cognitive development. Because Piaget's hypotheses about mental imagery and memory follow so closely from his more general theory, it is necessary to consider briefly some aspects of this broader issue prior to focusing upon the current problem. Furth (1969) has pointed out that unlike all other theories of cognition "Piaget's theory is unique in dispensing with a mediating representation as far as the essential aspect of critical objective knowing is concerned" (p. 75). That is, in contrast to other cognitive psychologists, Piaget holds the view that the development of knowledge or understanding within the child (or adult) is not a question of taking in outside reality. Furth elaborates on this point saying "...in all these (i.e., non-Piagetian) theories including the recent cybernetic and computer-based models of intelligence, the internal representation of outside reality is not only crucial but constitutes the chief explanatory factor in intelligent behavior" (p. 74, parentheses mine). Piaget, however, does not regard cognitive development as the taking in and storing of reality by means of images, verbal mediators, or any other encoding mechanism. This opposition of Piaget's to knowledge as the importation of outside reality places him, as will be seen in the following sections, in direct contrast to the views of Paivio and, to a lesser extent, Rohwer. In Piaget's view cognitive development results from the formation of schemes or understandings. These schemes are constructed within the child and are never discovered in or imported from outside reality. This is why, explains Furth, "...it takes children so long to recognize simple logical rules (because) these rules are not 'out there' but must be constructed from the activity of the child himself" (p. 231, parentheses mine).

This crucial constructive aspect of Piaget's theory is reflected in his distinction between figurative and operative thinking. Operative thought is the higher plane of scheme formation, it refers to "...acting on and transforming a reality state (and is) the basis of intellectual understanding" (Furth, 1969, p. 99, parentheses mine). Figurative thought, on the other hand, refers to "...the static configuration" (ibid., p. 99) and is dependent upon the currently attained level of operativity. That is, advances on the lower plane of figurative thought, says Piaget, can only follow prerequisite advances on the operative plane. This is why, for example, it takes the child so long (two years) to develop the notion of the permanent object. If an image of an object could be formed prior to the disappearance or concealment of that object, and if this image could be stored, then one would expect the child to be unsurprised at the object's reappearance and/or therefore be able to retrieve it from behind or beneath the concealing item. However, because this ability to expect the reappearance of objects and (in certain cases) to effect their reappearance depends, according to Piaget, upon the construction of the appropriate schemes of understanding (which can only occur on the operative plane) the child is unable to perform this task (or expect this reappearance) until about two years of age. In other words, since the child does not yet <u>understand</u> that objects which disappear from view may reappear or can be made to reappear he/she cannot anticipate or bring about this reappearance. Once, however, such an attainment on the operative plane is realized then the child can form a supportive figurative representation of an object that disappears from view. Always, however, knowing that the object still exists is the critical achievement, with the figurative representation simply a useful addition to this operative construction.

Furthermore, as is discussed later, this figurative representation is also constructed and like operative schemes is never imported to the system.

Having briefly outlined some major aspects of Piaget's theory of cognitive development it is now possible to look in closer detail at the two subprocesses of memory and imagery. The broader topic of memory will be discussed first followed by a presentation of Piaget's views of mental imagery. It is, however, important to remember that Piaget does not believe imagery to be limited to the realm of memory processes since it also may function in problem solving and reasoning.

b) Memory: The memory, in Piaget's view, is that aspect of operational thought directed towards the retrieval of the specific past. Piaget and Inhelder (1973) say it is "...oriented not toward present reality with its possible transformations but towards the comprehension of the past, with its limited and frozen characteristics" (p. 399). Not only, however, does operational intelligence guide the memory, but also "...by its very use of the schemes[3] of the intelligence, the memory leads to their infinite differentiation" (p. 397). Thus, the act of remembering is functional in the improvement of operational intelligence just as the advancement of operational intelligence is functional in the improvement of memory. This latter point is well illustrated by Piaget's demonstration that memory can

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[3] Unfortunately the translation (or authors) of Memory and Intelligence (1973) did not follow the scheme-schema distinction employed in Mental Imagery (1971) and originated by Furth (1969). This dissertation does do so, thus scheme(s) refers to a general understanding on the operative plane while schema(ta) refers to particular images on the figurative plane. All (1973) quotations have been altered to coincide with the correct notational system.

improve over time if relevant operational schemes are established in the intervening period. For example, Piaget and his colleagues have found that a child at a certain stage of development (the preoperational period), can successfully draw from memory a previously presented decanter of wine. If, however, the decanter was tilted at about forty-five degrees from the normal and the child is asked to draw this display after an interval of time equal to that following the former presentation, then the drawing is as good as those in the first case except that the level of wine in the decanter is drawn incorrectly, parallel to the decanter-top rather than parallel to the ground. However, if retested several months later (without subsequent experimental presentations of tilted wine decanters), many of these children now draw the level of wine correctly. This improvement in a memory over time, says Piaget, occurs because of an operative (scheme-level) advance that results in an improved ability to reconstruct the original situation. Thus Piaget holds that memory improvement in the child depends upon the operational intelligence and that figurative reconstructions (as evidence by the drawings in this case) are limited by the current level of operativity.[4] This relationship of figurative to operative thought is of central importance to the current discussion and will be further elaborated when Piaget's views on imagery are presented.

The dependence of memory upon the current level of operational thought can be particularly disruptive to the child say Piaget and Inhelder (1973)

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[4] Section E will provide some evidence suggesting certain well comprehended aspects of figurative reconstruction to be somewhat independent of operativity. For example, the decanter itself was correctly drawn.

"...if the memory is not bound up with a dominant scheme (such as seriation) but with two schemes which remain uncoordinated for a relatively long time (e.g., numerical correspondence which is grasped at the age of seven years) ... the resulting conflict tends to weaken the memory" (p. 20). That is, if a particular memory situation requires the operation of two as yet uncoordinated schemes, then prior to their coordination this type of situation will be particularly difficult to recall since different aspects of it will be assimilated to each scheme because a single coordinated scheme is not yet available.

Piaget and Inhelder (1973) make an important distinction between the "memory in the strict sense" and "memory in the wide sense". Memory in the wide sense refers to the memory of schemes. Piaget and Inhelder explain: "A scheme ... conserves itself by virtue of its own functioning, and does so in the psychological sense of the conservation of the past. This is because its own mode of composition involves logical conservation, i.e., the invariance of the overall system under all transformations. ... the memory of an operational scheme coincides with the scheme itself which having been constructed, is conserved throughout the life of an individual, except for pathological reasons" (p. 15). Thus memory in the wide sense refers to the memory of schemes and, as stated by Piaget and Inhelder, once achieved these schemes are never, in a normal life, lost. Memory in the wide sense plays the critical role in any memory act, since "... only the internal system in its entirety, rather than memory content, can furnish the small measure of control necessary for the localization and tracing of past experiences." (Furth, 1969, p. 161). Memory in the wide sense is therefore the memory of schemes which are applied during the fixation of particular memories and also during their recall. In Piaget's conception there is no such thing as independent raw memory. The schemes of the operational intelligence always guide (and occasionally by their inadequacies, distort) any particular act of memory. Piaget and Inhelder (1973) explain that "The simplest explanation of the relationship between memory in the strict sense and the schemes is, therefore, that the first is merely a translation or figurative aspect of the second" (pps. 20-21).

Memory in the strict sense refers more specifically to the memory act; Furth explains: "Memory in the strict sense implies an accommodative activity directed towards specific features of a singular event in the past." (p. 154). Thus memory in the strict sense refers to the application of memory in the wide sense to specifically desired memories which, with the aid of the figurative plane of thought, are recognized, reconstructed, or recalled. Piaget and Inhelder (1973) elaborate: "The conservation of a scheme is, in fact, the direct consequence of an act of generalization, while the conservation of a memory consists in its rediscovery" (p. 389). Generalization refers to the means by which schemes are formed and consists of the dissociation of general form from particular content, while conservation refers to the retention of these schemes. Conservation of particular memories is an act of rediscovery in the sense that particular memories are reconstructed under the direction of the operational intelligence.

There are in Piaget's model three types of memory in the strict sense: recognition, reconstruction, and recall. Each of these types of memory relies on one of the figurative instruments -- either perception, imitation, or images. These instruments provide the schemes of the intelligence (memory in the wide sense) with the means for remembering specific instances. It is in this context that Piaget and Inhelder (1973) stated that "Though the conservation of memories is based on that of schemes, it nevertheless remains a fact that memories are not schemes but consist of images whose importance varies from case to case" (p. 395). What these authors are intimating by this statement is that memories are not stored at all (only schemes are stored), however, when a particular memory is required it is reconstructed as an image, even though its actual mode of storage is operational. During an act of recognition this reconstruction (by means of real objects) or recall (by means of images) is not required since the reconstruction is already present. The memory, therefore, in an act of recognition consists merely in acting meaningfully to a particular item -- i.e., applying appropriate schemes of understanding to it. Memory improvement with age as stated earlier is a result of the increased structuring and coordination of the intelligence which, as a result of this development, is able to bring more control, power, and versatility to a particular memory act. As Furth says, "A memory act is described by

Piaget as a convergent activity of specialized accommodation" (p. 160). "Convergent" refers to the convergence of the schemes towards regenerating a specific memory and "accommodation" refers to the specific modifications of the schemes that must occur as the to-be-remembered item is reconstructed and represented by means of the symbolic instrument. Furth explains the symbolic-operative relationship as follows: "For Piaget the operative process by which we construct (and reconstruct) reality-as-known and the symbolic process by which we (present and) re-present known reality are functionally different and possess a different reality status" (p. 68, parentheses and underlining mine). Thus for Piaget the search for a memory is guided by operative thought and, as the correct convergence of schemes is being attained, the to-be-remembered item is constructed and projected on the plane of figurative representations.

Though all three forms of memory in the strict sense are proposed to rely on schemes the first, recognition, can function with the early sensori-motor schemes while reconstruction and especially recall do not become functional until later stages of development. In view of this effect of scheme development upon memory versatility it is necessary to more fully understand what Piaget means by "scheme". According to Piaget there are two basic types of schemes: sensori-motor schemes which in their more advanced form are still called schemes, and operational schemes which in their higher order form may be called structures or groups. Sensori-motor schemes are the only form of understanding that the child possesses during the first two years of life and are, in their simplest and earliest forms, merely innate reflexes such as sucking and grasping. Gradually, through the course of the first two years, these schemes broaden as they are applied to new objects and, at the same time, they subdivide and intercoordinate such that by two years of age the child has a wide variety of such schemes available. The distinguishing feature of these sensori-motor schemes is that the object of knowing is external to the child or, to paraphrase Furth, the "knowing circle" is closed only when there is both a scheme and an external object for the scheme to act upon. In other words, a sensori-motor scheme is functional when an external motor reaction to a real object occurs. For example, for the sensori-motor scheme of sucking to occur, the child must have something to suck. In contrast, at later stages of development the child now has operational schemes which do not require an external ("out there") object in order to become functional. Furth says, "...the object of thinking is not outside the thinking scheme, as is the case in sensori-motor actions, but remains within and can itself be called a product of thinking" (p. 60). That is, unlike sensori-motor schemes which require an external object to function, the operational schemes can generate (with the help of the figurative instrument) an internal representation and "complete their knowing circle" by means of this internal representation. Furthermore, at the highest plane of operative thought (the stage of formal operations) the self-produced internal representation is not mandatory for the functioning of operative schemes. As stated earlier the internal representations, though within the mind of the child, are on the lower figurative plane and therefore still remain external to operativity. Furth explains: "...while the object of knowing is internal to the operative field, the symbol in its totality is external to operativity. It can have an independent status of external reality as in symbolic play or gesture, an external ceremony, or it can remain within the person as an internal image" (p. 94).

The relationship between sensori-motor and operational schemes is very close since the early operative schemes derive directly from sensori-motor schemes through a process which Piaget calls interiorization. Furth (1969) explains this process saying, "As knowing becomes more interiorized, the general forms of sensori-motor coordinations in the nature of schemes become gradually dissociated from the sensori-motor content. Sensori-motor schemes are thus incorporated into a structure of what Piaget calls operations" (p. 51). In other words, the child's earliest intellectual accomplishment is the development of a highly refined system of sensori-motor schemes which can be applied in a great variety of situations. Operational schemes begin to develop at the end of the sensori-motor period and result from an abstraction of the general form of particular sensori-motor schemes and the representation of these general forms as (operational) schemes in and of themselves.

Having briefly outlined the two types of schemes available to the child at different stages of development, it is now possible to continue to discuss Piaget's model of memory. Since the aforementioned types of memory (r e c o g n i t i o n, r e c o n s t r u c t i o n and recall or evocation) refer to memory in the strict sense they are all dependent upon the figurative instrument. Piaget and Inhelder state "... the memory in the strict sense relies on figurative instruments -- perceptive in recognition and imaginal in recall" (p. 21). Recognition, state Piaget and Inhelder (1973) is "...a primitive process found even in lower vertebrates, occurs in the presence of the object and consists of perceiving the latter as something perceived in the past" (p. 13). This freedom of recognition from an internally generated representation allows it to function by means of the simplest sensori-motor schemes. In fact Piaget believes that because internal representations are unavailable to the less than two year old child he/she is strictly limited to recognition and is incapable of recall. Recognition can, of course, occur in the adult however in this case an operational scheme is employed, with the external object merely taking the place of an internal representation. Being able to recognize only currently available stimuli is of course, very limiting and "Nor would anyone deny that the organization of the memory of a subject incapable of recalling the past, and hence restricted to sensori-motor recognitions, is quite different from that of a subject who can conjure up the past by means of images or conceptualized language" (Piaget and Inhelder, 1973, p. 380).

The second type of memory in the strict sense, proposed by Piaget, is reconstructive memory. Reconstructive memory say Piaget and Inhelder (1973) is "Situated between recognition and recall; mnemonic reconstructions represent a form of recall by actions, and, as such, promote recall by images while remaining quite distinct from them" (p. 358). That is, the reconstructive memory does not require the presence of the original model (as does recognition), instead it recreates the original model from its parts which are still available to the child. For example, the child is presented with a model made of several cardboard pieces. These pieces are then mixed up and the child is asked to reconstruct the original model. Because the pieces are available to the child he/she is not required to form "images"of the original model but rather the images are supplied by the object pieces and therefore need only be rearranged physically by the child. Piaget and Inhelder (1973) found an interesting developmental sequence in which "...the reconstructions were clearly in advance of recall up to the age of seven-to-eight, while eight-to-nine year old subjects often produce drawings and reconstructions at the same level..." (p. 391). Thus recall, which depends upon the generation and manipulation of mental images is, in the case of the two-to-six year old child, more difficult than reconstruction which has the "images" already available "out there" and thus must merely apply the appropriate operational schemes to effect an accurate reconstruction. Therefore reconstructive memory is superior because the greater concreteness of the real objects allows the two-to-seven year old child to manipulate them more readily than he or she can as yet manipulate the rudimentary mental images. This manipulation is an operative achievement. Piaget and Inhelder (1973) explain: "If 'remembrance' were based exclusively on memory images that superiority (of reconstruction to recall) would be quite inexplicable.... It might, of course, be argued that the provision of cardboard figures and bars (the experimental materials used by Piaget and Inhelder) identical to those included in the original model creates more vivid associations than do the child's imperfect drawings. True enough but why does it? Precisely because the child manipulates such figures and bars much more actively than he does his drawings and thoughts, so that his so-called associations turn out to be assimilations to his action schemes. Hence the advantage of the reconstruction over pure recall" (p. 357). In other words the internal figurative representations which are constructed to support operative thought and to regenerate a particular desired-to-be-remembered event are less concrete in the two-to-seven year old than are the real object parts of the model. Therefore they cannot be as actively manipulated by the schemes or memory in the wide sense and thus do not, at this age, lead to as accurate a remembrance of the original model. After eight or nine years, the child can readily form concrete internal representations (a process resulting from earlier operative achievements) and thus can now manipulate these images as actively and therefore as accurately as real objects. Piaget and Inhelder (1973) state "Reconstruction, too, is a form of recall (since the model is no longer in sight) but by actions, instead of images ... whereas reconstructions restore the supposed genetic order of the formation of memories (action -- schemes -- images) simple recall reverses that order by starting from the images. This is precisely why the superiority of reconstruction as mnemonic instruments confirms our hypothesis that the conservation of memories rests on the conservation of schemes" (p. 391). Thus Piaget and Inhelder explain their finding that it is easier for children under eight to reconstruct a model from its parts than it is to recall and draw it, by proposing that recall requires that the child first reconstruct images of parts of the model and then reconstruct these parts to form the original model. In other words, because the semiotic or symbolic function is still not fully developed (because of a lack of prerequisite operative development), the under-eight-year-old can not yet form images that are as concrete as real objects. Consequently recall is less supported than physical reconstruction and therefore less likely to generate the to-be-remembered model. However, after age eight or nine, Piaget and Inhelder found recall to be as effective as reconstruction and concluded on this basis that at this age images are as supportive to remembering as are real objects.

Recall, then, is the third and highest level of memory in the strict sense and becomes fully effective, according to Piaget and Inhelder (1973) at about eight or nine years of age. The authors state that recall consists of "...both the conservation of schemes and figurative consolidation by means of the memory image" (p. 95). Piaget and Inhelder (1973) state "recall may be considered a product of the combination of a certain, more or less, inferential, reconstruction, with the use of 'memory traces' subject to subconscious conservation" (p. 21). Though existing as an image, the product of an act of recall is, to paraphrase Furth (1969) "surrounded by operativity on all sides". Furth illustrates this point by explaining that one's memory of Geneva is far more than an image of the city and its lake. Such an image is "surrounded by operativity on all sides" in the sense that what one "knows" of a scene or object is far more than can be represented in an image. This example demonstrates that the image is the servant of the operative intellect and capable of only relatively simple functions.

The operative-figurative distinction in Piaget's model of memory is not found in current information processing memory models. In these latter models memory is reconstructive in the sense that stored features are used to reconstruct a to-be-remembered item, whereas, in Piaget's model the features themselves must also be reconstructed prior to the reconstruction of the original model. That is, in Piaget's view there is no such thing as independent raw memory, all memories and parts of memories are reconstructed by the application of the operational intelligence and these initial and subsequent memories are projected onto the plane of figurative thought as visual images or internal words. In contrast, in the information-processing view, the features are stored in some "pure" form and then are "put together" under the direction of an executive function (this contrast is elaborated in detail in Section E).

(b) Imagery: The relationship of the image to the memory, state Piaget and Inhelder (1973) is such that "...the memory and the image supply the intelligence with useful representations, in the material sense of the term, i.e., with the particular and concrete models it needs in order to engage in constructive activities" (p. 390). Thus the image is supportive to the operational intelligence (and therefore to that aspect of the operational intelligence directed toward retrieval of the past) but remains distinct from the act of retrieval. Piaget and Inhelder (1973) explain that "...the image is a symbol and recall a mental act which includes (attributive, relational, and existential) judgements precisely because it is not exclusively an image but also comprises a schemetization"[5] (p. 395). It is this view of Piaget's (that the image is a symbol) which distinguishes his model from those of other image theorists. Paivio (1969, 1971), for example, views the image as a more or less accurate copy of the object which is imported to the system and stored in a relatively unaltered form. Piaget, on the other hand, refers to the image as a symbol because he does not believe the image to be an imported copy of

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[5] The original term was "schematism", however since recall consists of images (schemata) and schemes the translation was obviously incorrect.

reality. Since in Piaget's model, the accuracy of the image depends upon the schemes available to construct it, the child's memory is dependent upon his/her current repetoire of schemes or level of operative intelligence. The symbolic nature of the image is demonstrated says Piaget by the fact that the child's drawings reflect "...what he knows of an object rather than what he sees or has seen of it..." (Piaget and Inhelder, 1973, pps. 94-95). And "...the memory image is at first an imitative symbol and not an extension of perception, and being a symbol it merely represents the object as a concept" (ibid., p. 95). Thus, in Piaget's view the image is an internal symbol which comes to represent real objects only after considerable scheme-level development, and, even in the adult, because the image remains a construction not an importation, the image need not be bound by the properties of real objects. Piaget and Inhelder (1973) summarize their view as to the role the image explaining, "An image is only a symbol, and, as such, it can be employed in operational representations (i.e., in the solution of a problem and above all in the anticipation of that solution); in the reconstruction of past events; in recall of all sorts of objects; or in fantasies, dreams, play or artistic activities..." (p. 378). The distinction between images and perception is that "...the sensible nature of the image (i.e., its similarity to the sensation of seeing) does not result from a residual prolongation of perception but from an imitation of perception which is not the same thing..." (Piaget and Inhelder, 1971, pps. xviii-xvix, parentheses mine). By perception Piaget refers to an operative process through which the external stimulus is "known"; that is its relevance to the current scheme repetoire is established. By an imitation of perception Piaget refers to the pure accomodation (i.e., focusing and modification of schemes) to the particular features of a particular stimulus which results in the formation of a figurative representation. Such representations might be called perceptual images, in the loose (i.e., not strictly visual) sense. As was discussed earlier, figurative representations can also be generated at the time of recall, in the absence of an external stimulus, through a similar act of pure accomodation. These representations might be called memory images (also taking the loose definition of image). However since both perceptual and memory images result from an accomodation of schemes they are in fact the same, though one may be more accurate than the other. That is, although only the information assimilated at the time of presentation[6] is available for formation of the perceptual image, because the mode of storage is operational, a subsequent scheme-level advancement may occur which permits later figurative constructions to surpass earlier ones. An elaboration of the earlier example of the tilted wine decanter demonstrates this point. As stated earlier, Piaget and Inhelder found that the ability of late preoperational children to correctly draw the level of wine in the tilted decanter, improved rather than worsened over a long delay. They attributed the superiority of the one month to the one week delayed recall to the establishment of relevant schemes in the interim three weeks.

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[6] This discussion barely scratches the surface of Piaget's theory of encoding, however such an analysis of scheme repetoire is beyond the scope of this dissertation.

Thus though the accuracy of a memory (image) is largely limited by the assimilation made at the time of presentation, operative advances occurring after this time may improve the memory due to the operatively determined ability for "anticipatory imagery".[7] A second interesting aspect of these experiments was the finding that the younger children (about four years old) when asked to copy the tilted decanter also drew the level of liquid incorrectly. Slightly older children did copy the wine level correctly but then made the same mistake as the four year olds when asked to draw the tilted decanter from memory one week later. These two results suggest that perception too, is limited by the current level of scheme development but that if the child is close to developing an understanding about liquid surface in tilted vessels then in the concrete situation of a copying task he/she may make an accurate copy. But, after a short delay, faced with his/her own less concrete reconstructed images the child will make an incorrect drawing. These results support Piaget's hypothesis that perception is an accommodative (or imitative) process in which the object is assimilated to the current repetoire of schemes, just as the perceptual image results from an accommodation to (or imitation of) perception with the possibility of some improvement in the memory image given appropriate scheme-level advancement. In other words, in most cases the percept (and sometimes also the perceptual image) is superior to the (reconstructed) memory image (especially in younger children) due to its greater concreteness and consequent amenability to action schemes. However, in certain cases of relevant operative advancement the memory image may more closely

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[7] Anticipatory images are discussed in greater detail later in this section.

resemble the object than does the percept (or the perceptual image). This latter relationship is explained by the authors as follows: "If the image is merely a prolongation of perception it should be possible for any new perception ... to be translated into an image. If, on the other hand, the image is an internalized imitation, the subject will only imitate what he can comprehend (assimilate) or what he is near comprehending (accommodate to) -- which implies the subordination of imitation to the functioning of the intelligence" (p. 7, parentheses mine). The mental image is, then, to use Furth's (1969) notation a schema or a product of accommodation which is figural and particular. Accommodation in this sense refers not to the general modifications and inter-coordinations of assimilatory schemes (i.e., expansion of the scheme repetoire) but rather to the initiator of this more general process -- the particular modifications of each of the schemes applied to the particular object or event. Accommodation, therefore, has two consequences, one of which is an expanded and more powerful repetoire of assimilatory schemes; while the second is a constructed perceptual or reconstructed memory image produced as a consequence of the accommodative-imitative process. This role of accommodation is termed imitation in as much as the child imitates or copies the object through currently available schemes and can modify these schemes (slightly) as required by the features of the object. As the scheme repetoire increases, imitation is able to be more exact and thus an image closely resembling the original model results. This is how an act of memory in the strict sense can lead to operational advances; by accommodating to a particular object the schemes are modified (though Piaget states only minor modifications are possible) and this modification results in advance on the operative plane as well as producing an imaginal product.

The image is said to fall midway on the continuum of figurative elements. This is so because it is neither a pure sign nor a pure symbol. Piaget and Inhelder (1973) state "There are first of all those figurative elements that do not participate in the semiotic function, among them perception, which, though representing a system of signifiers, does so by means of signs that are not differentiated from the perceptive data. Next there are the figurative cum semiotic mechanisms, for instance mental images, symbolic games, deferred imitation, gestural language, etcetera. Lastly, there are the semiotic instruments which are not figurative in themselves, namely, the system of signs. Natural languages belong to this category. However, a subject's use of this system is not necessarily deviod of all figurative aspects"[8] (p. 12).

Images derive from imitation which has its beginning in the sensori-motor period, prior to the appearance of images. Sensori-motor imitation consists of the modifications in schemes as they are applied to objects in the infant's environment. For example, the rudimentary sucking scheme must accommodate to (i.e., imitate) the shape of each thing which the child sucks. Sensori-motor schemes, as stated earlier, require the presence of an external object in order to become functional and the accomodations of this period do not give rise to images. However, during the preoperational period, as the sensori-motor schemes are being interiorized[9]

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[8] The semiotic and symbolic function are synonomous terms.

[9] Piaget uses these two specific terms to refer to the origin of operative schemes (interiorization) and schemas (internalization).

at the level of the operations, the imitations or accommodations to objects become internalized and give rise to mental images. Sensori-motor imitations are, therefore, the forerunner of the operative imitations which lead to images. Piaget and Inhelder (1973) explain the origin of images as follows: "...every scheme must accommodate itself to a given situation, and its application therefore involves balancing assimilation with accommodation. Now the latter when it predominates and becomes an end in itself lead to imitation, i.e., to the more or less pure accommodation to an object or process considered as the external model of an action, and imitation itself, once it has been internalized becomes the source of the image" (p. 403). This is how Piaget believes images to result from imitation. As the external imitations of the sensori-motor period are reformulated and expanded on the plane of preoperational thought they become internalized and imitation now leads to images. Reconstructive memory and recall can now be added to the earlier recognitive memory.

Furth (1969) elaborates on this internalization process remarking "The external movements of the hand muscles that overtly imitate the shape of a ball are similar in nature to the covert muscle movements that we may experience invoking the image of a ball" (p. 90). This statement of Furth's coupled with another in which he says, "...deferred imitation that is internalized and reduced in its overt activity is for Piaget what we commonly experience as images" (p. 90), could be misinterpreted to suggest that the external muscle movements are the source and substance of the image (rather like the Watsonian notion of thought as internalized speech). However, such a conclusion would run contrary to Piaget's previous insistence that the image is a symbol and not an imported copy of reality.

Furthermore, Piaget and Inhelder (1973) state that "It follows that, in his attempt to reconstruct what he has seen but no longer perceives, the S is reduced to symbolizing as faithfully as he can what assimilations to his schemes he made in the presence of the model: he will accordingly produce the most faithful image possible of what he has seen, but an image that is more faithful to his thought than his percepts simply because his thought persists while the perception is gone and can not be replaced by the image..." (p. 95). Given this clear statement that the image is constructed (at the time of perception) or reconstructed (at the time of recall), by the operative intellect (or memory in the wide sense) it is obvious that Piaget does not believe the image to be merely constructed of residual muscle movements (of either hand or eye). Rather Piaget insists that the image exists on the plane of figurative thought and is sensible (i.e., similar to sensory information) in nature. The key, then, to avoiding misinterpreting Furth (and Piaget) and concluding the image to be composed of covert muscle movements (e.g., perception of a color does not involve muscle movements except in a very peripheral sense) is to focus upon his two phrases "similar in nature to the covert muscle movements" and "deferred imitation". By saying that the act of imaging is "similar in nature to ... covert muscle movements" Furth means that the accommodation of schemes which leads to image formation is analagous to the sensori-motor accomodations. It is Piaget's intention in saying that covert muscle movements accompany imaging (rather like rapid eye movements accompany dreaming) to illustrate that the image, in his view, "feels" like the act of perceiving the original object even though the relationship between original and image is only symbolic. This point is further illustrated in Furth's choice of the words "deferred" and "experience" in his remark "...deferred imitation that is internalized and reduced in its overt activity is for Piaget what we commonly experience as images" (p. 90). By including the word "deferred" Furth is not referring to the imitation or accommodation that occurs in the presence of the object,[10] (e.g., the accommodation of the shape of the hand to pick up a ball), but rather to the accommodation or imitation which leads to (the perceptual image or) the memory image as the subject applies his repetoire of schemes in order to (construct or) reconstruct the object. The occurrence or sensation of covert muscle movements at this time is only a by-product of the accommodative activity and is not in any way useful to the formation of the image.

Having outlined the general status of the image in Piaget's theory, as well as the means by which images are formed (and reformed), it now becomes possible to more closely examine exactly what Piaget has concluded on the basis of his research into the problem of imagery. Since, however, the majority of this work refers to images that are primarily visual in nature, first it is necessary to understand more fully what Piaget and Inhelder consider to be the nature of images in general. In their book Mental Imagery in the Child (1971) these authors state "Images may be classified in terms of their content (i.e., they are visual, auditory, etc.), or according to their structure" (p. 91). For Piaget and Inhelder the latter is the only reasonable approach, however, most other cognitive

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[10] Though in this case also the image is not produced by the muscle movements.

psychologists (e.g., Neisser, 1967; Paivio,1969, 1971), have taken the former approach. Rohwer (1973), as will be seen later, agrees with Piaget on this point in the sense that he feels the mode of representation to be relatively unimportant. Despite Piaget's and Inhelder's focus on image structure rather than modality these authors do intimate that images have modal-like properties and, depending on the to-be-imaged event, a (re)construction may be quasi-visual (in the case of an object) and/or verbal (in the case of a sentence or name) or possibly possess some other modal-like "feel" (e.g., kinesthetic). Such modal-like content of internal representations is clearly true in percepts (and perceptual images of all modal types) and since memory images are also produced by a similar process, namely an accomodation of schemes, such substance is also suggested for memory images themselves. It is important, however, to remember that the image is a symbol and as such bears only partial correspondence to the original instance. According to Piaget, in terms of resemblance to the original event, the visual image comes to outstrip all other internal representations. Piaget and Inhelder (1971) state that "...the spatial image is the only image in which there is a tendency towards a real isomorphism between the symbolizing form amd the symbolized content" (p. 347). Whether, by this remark the authors mean the spatial image to be a subbranch of visual images or whether the two terms are synonomous is unclear. However, they are clear in stating the superiority of visual images to language and internalized speech (verbal images). They stress that "The image is not actually an element of thought, but like language, and at least in spatial spheres, with more evident success than language, it does serve as a symbolic instrument signifying the content of cognitive significations"

(p. 379). Thus the advantage of the image over language is due to the symbolic nature of the image -- its resemblance to the thing symbolized. Language, on the other hand is an arbitrary sign system and does not possess the ability to resemble the thing represented. It appears from the previous quotation that while there are definitely visual images, the term verbal image is a misnomer. Instead these "verbal images" are, in fact, language. However since language is a semiotic instrument (i.e., it functions on the figurative plane), it is probably correct to infer that, for example, in the act of recalling a word(s) or sentence(s), a figurative level reconstruction (in language rather than images) does occur. Such an idea might be used to explain the synonym errors made by children (and adults) when asked to recall previously presented written material. Each of these types of reconstructive *instruments* clearly has different advantages accruing to it. As Piaget and Inhelder state "... there are two fundamental reasons why the collective sign system, or language ... needs to be *complemented* by a system of imaginal symbols... The first reason is ... the signs of language are always social. Now there are a great many forms of experience which language conveys badly. Because it is the common property of all individuals it is necessarily too abstract. That is why, even when he is talking an individual will concretize the words he uses by means of personal images ... The second reason why imaginal symbols as distinct from verbal signs should be necessary is ... (because) there is a vast field which language cannot describe unless it uses endless complicated circumlocutions. This field comprises everything perceived in the ongoing present but also and more important everything perceived in the past in the external environment or in personal actions which it is important to retain... It is clear, therefore, that if one wishes to evoke in thought some past perception, it is necessary to supplement the verbal sign system with a system of imaginal symbols" (p. 350). Thus in Piaget's and Inhelder's view both image[11] and verbal signs are supportive but not constitutive elements of operational thought and each of these two figurative systems support this operational thought in a different way. Piaget and Inhelder believe the two systems to be distinct from each other but to function together (but independently) in certain situations. This dual representational system is very close to Paivio's dual (imaginal and verbal) coding hypothesis except that Paivio believes the duality to exist at the time of encoding and storage while Piaget and Inhelder believe all encoding to be operational and that the duality occurs only at the time of re-presentation when one or both of the semiotic instruments are used to support reconstruction (or reasoning). In Piaget's and Inhelder's view "The image's function is to designate not to interpret" (p. 383). "The image ensures a finer analysis of 'states', and even aids figural anticipation of 'transformations', in spite of the irreducibly static character of such a figuration. This makes the image an indispensible auxilary in the very dynamism of thought -- <u>but only as long as it remains constantly subordinate to such an operational dynamism, which it can not replace, and which it can only express symbolically with degrees of distortion or</u>

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[11] Which will continue to be used in the visual sense only.

fidelity varying according to circumstances" (p. 390, underlining mine). Paivio (1975) agrees with the hypothesis of Piaget and Inhelder[12] that image is superior to language, however, he believes this advantage reflects the greater "simultaneity of storage" capacity and unit-information strength of images (versus words) rather than Piaget's and Inhelder's belief, that the image is merely a more efficient crutch to thinking due to its ability to resemble the original material. Rohwer (also discussed in detail later) disagrees with Paivio's idea of modal-specific storage (as do Piaget and Inhelder) but does not seem to concur with Piaget's and Inhelder's stress upon modal-specific representation.

Piaget and Inhelder are the only one of the three research groups to be discussed in detail in this dissertation that have examined the specific types of images that are experienced.[13] Prior to their experimental investigation into this question, Piaget and Inhelder hypothesized that there would be two main types of images. The first of these types, the reproductive images, were thought to be images of things or situations already seen; while the second, anticipatory images, were thought to represent things or situations not previously encountered. Three types of reproductive images were proposed: reproductive static (RS) images which are images of familiar objects, reproductive kinetic (RK) images which are images of familiar movements, and reproductive transformation (RT) images which are images of familiar transformations. In addition, these authors believed there to be two types of anticipatory images: anticipatory

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[12] Though he doesn't mention them in this article the similarity in the two positions is clearly apparent.

[13] Such a task would not be relevant to Rohwer's position at any rate.

kinetic (AK) images which are images of unfamiliar movements and AT or anticipatory transformation images which are images of unfamiliar transformations. As is the case with most apriori hypotheses the results of their subsequent experimental investigations did not entirely bear out their original conception. From a developmental perspective their experiments showed only two significant stages with regard to image ontogenesis. The first of these occurred about two years of age and was simply the development of the symbolic function and hence the ability to form images of familiar objects. As stated earlier these early images bear only slight resemblance to their referents due to the paucity of schemes of assimilation available in the early preoperational period. Nonetheless, as discussed in the section on memory this new ability of the two-year-old to form images is a major achievement, since recall-type memory can now function. Having internalized the accommodation-imitation process the result is an imaginal product that can act as the display screen for consolidating to-be-recalled objects. The second decisive moment, according to Piaget and Inhelder (1971), occurs at the end of the preoperational and beginning of the concrete operational period. With the arrival and development of this period, and hence a greatly expanded repetoire of schemes (including some higher order schemes or structures), Piaget and Inhelder (1971) now found the child to be capable of anticipatory images. That is, in addition to being capable of forming a simple image of a familiar object, the child was now capable (or becoming capable) of forming images of an object at various stages of an anticipated motion (e.g., a pencil falling off a desk) and of an anticipated transformation (e.g., of a curved line changing to a straight line). The authors state

"...the images of the first period remain essentially static and consequently unable to represent even the results of movements or transformations and <u>a fortiriori</u> unable to anticipate processes not yet known. But at about 7 to 8 years a capacity for imaginal anticipation makes its appearance enabling the subject to reconstitute kinetic or transformation processes and even forsee other simple consequences" (p. 358). Though no different in substance than the images of the preoperational period (all images are static reproductions) the concrete operational images were able to be formed in the absence of an actual model merely by anticipating what the product and/or interim states of an object's movements or transformation would "look like". Thus this increase in the power of imagery occurring at concrete operations is a direct consequence of operative gains. The image itself has not changed (except for probably more closely resembling its referent), rather the realm of imagable things has increased since the child is now capable of anticipating how unfamiliar outcomes will appear.

Although the static reproductive images of the preoperational period are merely attempts by the child to re-present familiar objects they are, stress Piaget and Inhelder (1971), just as dependent upon the current level of operativity as are concrete operational images. The authors state "...the static character of the images before 7 to 8 years is due to the preoperational thought which ignores transformations in favour of configurations or states, with the result that the images of this level latch on to the simplest elements available within such a context" (p. 359). An interesting example of the dependence of the image upon the child's thought was found by Piaget and Inhelder (1971) through studying children's copies and reproductions of straight lines. Rather than the drawing errors being evenly distributed between over- and under-estimation of the original line length, instead it was found that the children's reproductions of the line were far more often shorter as opposed to longer than the original. This result further weakens the idea that images derive directly from perception since were this the case a random distribution of errors would be expected. Say the authors "They (errors) are in fact determined by the desire to avoid going beyond the end boundary point of the line. This concern is not far removed from those lying behind the preoperational concepts found in the ordinal estimation of lengths" (p. 219). Though the origin of this "concern" is unclear, it clearly results in a distortion of the image. Again stressing the role of the schemes (rudimentary though they may be) as superior to the image, Piaget and Inhelder (1971) state "It seems, therefore, that an operational framework of a logico-mathematical kind is necessary, not only as one would expect, for notional interpretation of <u>perceptual</u> data but also -- and this is more surprising -- for the <u>imaginal evocation</u> of such data" (p. 389, underlining mine). Clearly again, the authors are stressing the subordination of perceptual and memory images (the former being only slightly more accurate than the latter) to the rudimentary operations of "notions" of the preoperational period. It is easy to misinterpret Piaget and Inhelder's position on this point. Some authors (e.g., Ginsberg, 1969) have intimated preoperational thought to be governed by images rather than by schemes. Such a conclusion is easy to draw from remarks of Piaget's and Inhelder's (1971) like "...at this level (preoperational) images govern thought while the situation is reversed at the operational level" (p. 197, parentheses mine) and "...imaginal representation is a predominant characteristic of preoperational thought" (p. 258). However, what Piaget and Inhelder mean by these statements is, indeed that much of the preoperational child's cognition does consist of images, however, despite the plethora of images, they are, in every case, subordinate to operational thinking. This is clear in their declaration that "If the anticipatory images are formed and oriented with the aid of external contributory factors, and if they depend in consequence more or less directly on the progress of the operations, then will not the static reproductive images also be actuated by some earlier dynamism anterior to the operations, but genetically equivalent" (p. 257). That is, just as concrete operational images are subordinate to the operations, so are preoperational images subordinate to the anterior dynamism of the operations -- the interiorized sensori-motor schemes. Preoperational thought then, is governed by images only in the sense that it is concerned more with states than transformations. As Piaget and Inhelder (1971) explain: "Generally speaking, preoperational thought may be thought of as a system of notions within which figurative treatment of states takes precedence over comprehension of transformations" (p. 197).

At the start of concrete operations, images, under the influence of the operations, begin to be capable of representing the predicted outcome of movements and transformations and therefore can now support deduction. Thus though prior to this period the image was formed by schemes and served to consolidate a memory, the image can now be used to represent stages in a transformation and therefore supports operational thinking in an additional manner to memory consolidation.

Though in their original, pre-experimental formulation Piaget and Inhelder saw images of familiar movements (Reproductive Kinetic images) to be more closely related to Reproductive Static than Anticipatory Images their experimental investigations showed this not to be the case. They state: "However familiar the movements in question may be ... the kinetic reproductive image can be formed only by virtue of a reconstruction involving anticipation" (p. 97). In fact, despite their remarks suggesting the Static Reproductive images to stand apart from other types by virtue of this non-anticipatory nature, these authors also feel a degree of anticipation to be required even in forming an image of a simple object. They say "...even reproductive images in a direct copy (RSI), and even images as static as copies of a segment of a straight line, presupposes the intervention of anticipatory execution schemes, or 'fore-images'. ...(Also), deferred static reproductive images (RSII) are themselves improved if the models are assimilated into the Ss own action schemes. Once again this underlines the importance of the anticipatory process" (p. 353). This point makes good sense since formation of an image in the presence of an object and a fortiriori of an image without an immediate referent would seem to require anticipation of at least some features of the item. That is, the "filling in" of the image may come from anticipation guided by prior knowledge and may, with regard to certain features, dominate or embellish perceptual assimilations. Thus anticipation is a factor in the formation of all images but plays a minor role in Reproductive Static images (though not so minor when the image is evocative) and a relatively major role in kinetic and transformation images. The ease with which the latter images are formed depends less on how familiar the movement or transformation is to the child than it does upon the complexity of the action. It is, therefore, the advances on the operative plane that allow the more advanced forms of images to occur. As Piaget and Inhelder (1971) explain "...the image becomes anticipatory under the influence of the operations and then serves them as a supportive base" (p. 379). An example of the importance of operations or schemes of understanding is provided in a demonstration showing the length of an arc transformed to a line to remain the same (rather than being shortened to the length of the chord) only when operational conservation can be applied in such an instance. The development of conservation, say the authors (1971) "... proceeds by an interplay of inferences rather than by imaginal representation" (p. 190).

Though Piaget and Inhelder believe the image to play a vital supportive role in cognition during the preoperational and concrete operational periods, they do admit that it is possible that certain individuals (presumably at formal operations) may be able to anticipate the outcome of a series of transformations or movements without employing any figurative support simply through pure operative deduction. However such instances are presumed to be rare and in general images play an important role in thinking and, more certainly, memory, even during formal operations.

d) Summary: Within the broad field of cognitive psychology the theory of Jean Piaget clearly stands out as a well reasoned, well tested, and popular theory of cognition. The major thrust within this theory is the careful formulation of the intellectual development of the child through the first sensori-motor reflexes all the way up to logical structures such as the INRC group. It is the schemes, be they sensori-motor or operatory, that Piaget believes to embody the essence of thinking at all stages of development. The operational (in the literal sense) construct of the scheme derives great explanatory power due to its freedom from specific situations. However, this very strength of the scheme -- its freedom from the particular -- is precisely why Piaget has proposed and studied the image, for it is the image that provides the much needed particularity required in specific acts of cognition. By serving as a screen of projection, Piaget believes the image plays an almost vital role in terms of consolidating and displaying pertinent instances of objects and situations. Nonetheless despite this important supportive role the image is outside of the processes of thinking and, of more concern to the current discussion, memory. Piaget and Inhelder do not believe storage of information to depend upon or, in any way employ, images. Rather, in their view, storage is synonymous with schemes or memory in the wide sense. The image only comes to play a role in the actual process of remembering and it is here that its support is so helpful. This image support is proposed to occur at two times, in the act of remembering. First, at the time of fixation or encoding, the subject, by forming an image of the item, is able to apply a wider selection of schemes of assimilation to the concrete image than if an image were not formed, and, as a consequence, more of these schemes are available at the time of reconstruction or recall. Secondly, at the time of recall (or reconstruction) the image serves as a concrete display screen upon which the scheme-level reconstructions can be displayed and manipulated. Thus, for Piaget and Inhelder, the image facilitates both more effective encoding and, accurate decoding of the remembrance, but is uninvolved in the actual storage of information. Schemes are the mode of information storage and since they are "stored" by means of logical conservation in which any one part can reconstruct any other, they are not normally forgotten.

There is no doubt that Piaget's and Inhelder's views on imagery and its relationship to memory are sufficiently intriguing to warrant further experimental inquiry. However, for the purposes of the current research, Piaget's model was outlined not so that it can be tested in and of itself but rather so that an accurate application of Piagetian ideas to the current experiments may be permitted, in the hope of shedding new light upon the (semantic versus imagery) associative learning controversy. Following presentation of the interacting imagery and semantic elaboration models the results of the current experiments are provided.

C. Paivio

The second major point of view as to the role of imagery in children's memory is that of Paivio and his associates. In contrast to Piaget, Paivio's early training was in the S-R tradition, and it was to this school of thought that he felt most responsible to justify his subsequent research into mental imagery. In defiance of his early training which had labelled such areas as imagery "mentalistic" and therefore unworthy of scientific consideration, Paivio (1970) stated that "The charge of mentalism, or subjectivity, has little force because implicit verbal responses are every bit as inferential as mental images," (p. 386).

As mentioned earlier Paivio believes that imagery plays a central role in memory -- a role more important than the peripheral supportive role that Piaget believes it to play. Piaget does not believe in pure information storage but rather proposes that specific items of information are reconstructed by the schemes of understanding, and, that this reconstruction is facilitated by and projected upon the figurative instrument (which is generally an image). In contrast, Paivio (1975) proposed that "Thinking ... (is) characterized as a process that involves taking in or encoding stimulus information, organizing and storing it in memory, and retrieving that information according to the requirements of the task" (p. 161). Thus Paivio's is a storage and retrieval model whereas Piaget believes that only schemes are stored[14] and all other information is reconstructed. This basic difference between the two aforementioned models of thinking results in Paivio and Piaget attributing different status to the image. For Piaget the image is a tool for reconstruction and is never a prolongation of perception (but rather an active imitation of it). On the other hand, Paivio does believe images to arise from perception and also hypothesizes that information can be stored directly in image form. He says: "The imagery system is assumed to be specialized for processing non-verbal information stored in the form of images ... Images, in short are analog representations of perceptual information" (1975, p. 148).

In Paivio's model imagery is one of two major encoding and storage systems available to the child from a very early age. The second is the verbal system and when added to imagery comprises the other major infor-

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[14]Since the mode of storage of schemes (logical conservation) is such that any one part of a scheme logically leads to any other, schemes too, in this sense, are reconstructed.

mation processing, storage, and retrieval mode available to the child (and adult). While the image is specialized for the processing of non-verbal information, the verbal system performs the complementary function of "...dealing with abstract linguistic units that are only indirectly and arbitrarily related to things, according to the conventions of a given language. Such functions distinguish the verbal system as an abstract, logical mode of thinking as compared to the concrete, analogical mode that apparently characterizes imagery" (p. 145). In Paivio's formulation of this so-called dual coding hypothesis the two processing systems are considered as independent modes of thinking, each specialized for recording different aspects of a stimulus situation. The two systems are, however, interrelated in that a given object may arouse a verbal label or on the other hand a word may evoke an imaginal referent. Paivio believes that items that do evoke both imaginal and verbal codes will be better remembered simply on the basis that two codes are better than one. He says in his book Imagery and Verbal Processes (1971) that "The problem of remembering an item would thus be a direct function of the availability of both codes. In effect, this is a coding redundancy hypothesis: memory increases directly with the number of alternative memory codes available for an item" (p. 181). Thus "...images and verbal processes are viewed as alternative coding systems, or modes of symbolic representation, which are developmentally linked to experiences with concrete objects and events as well as with language" (1971, p. 8). Each of the two codes, in Paivio's view, is available at an early age (with imagery slightly preceding verbal processing) and both are potentially available for any stimulus situation. Whether one or both will be employed is dependent upon the amenability of the stimulus to each type of processing (although later in this section techniques for increasing mode-specific coding will be discussed).

The major support for Paivio's dual coding hypothesis comes from a number of studies which have shown adults' memory for concrete nouns to exceed their memory for abstract nouns (e.g., Gorman, 1961; Paivio, 1965, 1969). Paivio's explanation for these findings was that nouns rated high in imagery (e.g., house, kettle, star) are better recalled or recognized that are words with low imagery (e.g., liberty, peace, history) because concrete words can be stored in both the imaginal and verbal systems while abstract words can only receive verbal coding. The dual coding of concrete words, contends Paivio, explains their greater retrievability as compared to abstract words. He says: "In the case of concreteness, the increase in the number of items remembered as we go from abstract words to concrete words, to pictures would thus be interpreted as reflecting the differential availability of concrete imagery as a supplementary coding system, since the availability of the verbal code does not increase with concreteness" (1971, p. 181). That is, in Paivio's view, while the verbal system is equally available for all written and spoken information and also for all aspects of visual information that can be represented in words, the availability of the imagery system is directly dependent upon the concreteness of the to-be-learned material such that the more concrete this material is, the more likely it is to be represented in imaginal as well as verbal form. Support for the proposal that pictures are more concrete than high imagery nouns was obtained in a study by Paivio and Csapo (1969). These authors found that remembrance of a mixed list of items presented at the rate of 5.3 seconds per item was such that pictures were best recalled, followed by concrete words, followed by abstract words. However, at a fast presentation rate (two items per second), no differences in recall were found among the three types of items. This equal recall despite differential concreteness of the three types of items was interpreted by the authors to reflect a lack of sufficient time for dual coding. Though all items were processed in the verbal system (pictures were labelled) the presentation time was insufficient for the pictures and concrete nouns to elicit images. Thus all three types of items received only verbal processing and therefore were equal in terms of recall. In support of Paivio's hypothesis that the likelihood of image generation is dependent upon an item's concreteness, the latency of image formation was found to be somewhat longer for concrete words than pictures and considerable longer for abstract than concrete words (e.g., Ernst and Paivio, 1971; Paivio, 1966), whereas verbal codes were found to be aroused with equal facility at all levels of concreteness (Yuille and Paivio, 1967). Paivio (1966) also found latency of image arousal to be highly correlated with subjects' concreteness ratings of nouns (Paivio, Yuille, and Madigan, 1967). Other support for Paivio's dual coding hypothesis comes from studies designed to increase the application of imaginal or verbal coding or both. Bransford and Johnson (1972) found that college students' recall for connected discourse was greater if they were shown a drawing depicting the information contained in a paragraph prior to reading it than if no such drawing was presented. Furthermore, Wollen (1968), found that pictures accompanying abstract nouns facilitated recall, suggesting that even low concreteness items can benefit from dual coding if appropriate concrete referents for the abstract words are provided.

Aside from the dual (imaginal and verbal) coding advantage that accrues to single concrete nouns relative to the mono- (verbal) coded abstract nouns, Paivio (e.g., 1970) has also proposed that in a paired associate task those pairs that can be processed imaginally receive an additional advantage over abstract pairs. This advantage of imaginally codable items results from the ability of images to serve as what Paivio calls "conceptual pegs" - pegs from which the second item of a pair can be "hung". Paivio (1970) says "...high imagery or concrete, stimulus terms such as house function as efficient stimulus 'pegs' from which associates can be 'hung' and retrieved by means of mediating images" (pps. 397-398). The conceptual peg hypothesis is used to explain a finding by Paivio (1965) in which concrete-concrete pairs were better recalled than concrete-abstract pairs which were better recalled than abstract-concrete pairs which in turn were superior to abstract-abstract pairs. Paivio proposed that the C-A pairs were superior to the A-C pairs since, in the former case, the stimulus word is concrete (and therefore imagable), and thus can serve as a "peg" from which to "hang" the second item, whereas such an advantage cannot occur for A-C pairs since an image of the stimulus item generally is not formed and, thus, with no possibility of "hanging" the response word on the stimulus the two must be linked by some type of sentential verbal coding. In a study conducted with four-to-six year old children, Dilley and Paivio (1968) found children's recall of picture-word pairs to be superior to their recall of picture-picture pairs. Since "conceptual pegging" is hypothesized to occur for both types of pairs, and if anything picture-picture pairs should result in more effective imagery coding, this result appears inconsistent with other work. However, the proposal was advanced that children may have trouble decoding the second item in the image (due to insufficient language development) if it is coded in a primarily imaginal form whereas if it is a concrete noun it will still receive sufficient imagery coding but, in addition, the word will be coded verbally as well and this label will be available for recall. In other words, items that are stored primarily in the imaginal mode of young children's memory may, if required to be recalled verbally, be difficult to translate into verbal form due to insufficient familiarity with names of objects.

The proposal that images can serve as conceptual pegs expands the dual coding hypothesis as a theoretical construct and allows that, for certain types of stimulus situations, imagery coding is superior to verbal coding in and of itself. The notion that images can serve as conceptual pegs while verbal codes (e.g., words) can not was the forerunner of subsequent work by Paivio and his associates showing that imaginal and verbal modes are not only independent but also possess different properties. Support for the independence of imaginal and verbal coding comes from several sources. For example, Segal and Fusella (1970) obtained evidence for mode-specific interference in a study which found visual signal detection to be more disrupted by imaging pictures than imaging sounds, while acoustic signal detection suffered more during auditory imaging. Evidence for greater intramodal than cross-modal interference has also been found in studies by Atwood (1969, 1971) who found visual but not auditory interference to be disruptive to memory for concrete phrases while for abstract phrases auditory but not visual interference was detrimental to recall; and also by Powell, Hammon and Young (1975) who found a concurrent task, involving reporting whether a fifth shape (or word) has been previously in the first, second, third, or fourth position, to be detrimental to paired associate performance such that the shapes task was more interfering for adults instructed to use an interactive imagery strategy while the words task was more interfering to those adults in a verbal mediation instructional condition. Considering only the dual coding hypothesis, interfering with verbal processing, by either auditory or verbal means would be expected to block the verbal coding of concrete items and thus impair their recall since only the imaginal mode would be available. While the word task did impair memory for concrete items somewhat, no such interference was found in the Atwood (1969) experiment. Thus dual coding can not adequately explain the results of these experiments. Paivio (1975) expanded his model to account for results of recent experiments, such as those mentioned above which involve instructional manipulations and/or memory for phrases rather than single items or noun pairs. He stated: "Dual coding per se can explain the general superiority of concrete over abstract items in recall simply on the basis of increased probability of recall when two independent codes (image and word) are available for each item... However, dual coding alone would not explain the total pattern of results, especially the observation that _S_s recalled twice as many words from concrete phrase lists than from concrete word lists, but only the same number of words from abstract phrases and word lists. All of the results are, however, explained by a combination of dual coding and the assumption that the two codes can have different organizational properties" (1975, p. 158). Thus Paivio has recently expanded his original hypothesis that two codes are better than one to propose that the two codes also differ in their internal structure.

Paivio (1975) believes that a critical distinction between the two coding modalities is that the imagery system possesses the property of synchronous organization which "...involves integration of complex information in memory and redintegration of that information by a portion of the complex" (1975, p. 149). In the simplest case of a pair of concrete nouns this would mean that a person, if appropriately prompted, would form a single internal imaginal representation of the two items such that cueing with either part of the image would result in its complete recovery. Paivio (1975) stated, "The synchronous processes of imagery imply simultaneity in the availability of integrated spatial information, the possibility of redintegration of that information by one component, and freedom from sequential constraints in access to or retrieval of component information" (p. 151). This additional advantage of imaginal processing occurs only if an integrated image of the to-be-remembered items is formed. Paivio (1975) explains that "... dual coding can account for much of the s u p e r i o r i t y of concrete over abstract words or of imaged over v e r b a l i z e d words in free recall. Dual coding cannot account for the further increment that results under integrated imagery conditions" (p. 159). In support of this he cites a study by Begg (1973) which found that when the first and second members of a pair were to be imaged separately cued recall was no better than free recall. Under integrated imagery conditions, however, cued recall, which would provide "half" of every image and should result in redintegration of the whole image and thus the second item, was indeed superior to free recall. Thus while generating both imaginal and verbal referents to to-be-remembered items is useful, information that is to be stored as a unit can receive an extra benefit from imagery coding if an integrated image, which takes advantage of a property of the imagery mode, is formed. Paivio (1975) does not believe these integrated images to be limited to containing two items, rather, he says: "Multiple units of information, up to some limited number that has yet to be accurately determined, ... apparently can be combined quickly and efficiently into synchronously organized, integrated visual compounds that function essentially as units in memory storage" (p. 161). Only when integrated images are formed[15] at the time of storage can the presence of one item of an original compound facilitate recall of another group member. Paivio, therefore, limits this imagery advantage to only those situations which require associative recall. The verbal system, on the other hand, does not possess a potential for synchronous organization that is available for items coded imaginally. The main recall advantage that Paivio believes the verbal system has is a propensity to retrieve the original sequence in which items were encoded to memory. He states that "Groups of words apparently can not be similarly integrated into memory; instead, the units appear to be sequentially combined or concatenated into linear informational structures

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[15] Though Paivio does not speculate as to how this compound image formation comes about, Piaget might suggest that the assimilation of the group members results in an accommodation of schemes that has, as a supportive element and product, a kinetic-transformational image.

that take up more storage space and are subject to sequential constraints to a degree not characteristic of images" (1975, p. 161). Thus the verbal mode, proposes Paivio, is inferior to the imaginal in terms of retrieving information not required to be in the original order, providing that at the time of storage, that information was represented in a single interacting image and that, at the time of recall one or more parts of that image are available as retrieval cues. The verbal coding of information, on the other hand, results in a memory which, though lacking in the one-leading-to-all redintegrative potential of imagery, does contain information as to the sequential order of input, which can not be retained by means of images alone. For example, explains Paivio (1975) "... the verbal system presumably controls the sequential generation of visual images of the letters of the alphabet, but does not determine the shape of the imaged letters nor the order which one draws or describes the visual features of a given letter" (p. 150). In other words, each letter is stored as one visual image which can be regenerated by beginning at any point on the letter, whereas the verbal system, which functions in terms of item-to-item associations, is the means by which the order of the letters of the alphabet is retained.[16]

In summary, there are two critical aspects of Paivio's theory; first of all, humans possess two main information processing modalities which function independently such that information that is represented in both modes (i.e., dually coded) is more likely to be retrievable than information

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[16] Perhaps an integrated image can be formed of shorter words too, such that if the word, when written down, is spelled incorrectly it may be perceived as "looking wrong".

only stored in one system; secondly, these two processing systems possess different qualities such that in the imagery system information which is formed into a compound image can generally lead to recovery of any other item in the compound, whereas the verbal system, though incapable of this synchronous storage, is specialized for retrieving the original sequential order of information input. The dual coding hypothesis of Paivio's plus the idea that each processing mode is qualitatively different is very close to Piaget's proposal that images and language function as two major cognitive supports. Since Paivio believes information in one modality to be recodable into the other (e.g., an object may also be represented as a word, or a word also as an imaginal referent of an object) it seems that some additional processes must allow such translation to occur. Though Piaget would say the scheme performs this function, Paivio has not yet proposed a mechanism in his model designed to accomplish such a task. Rohwer's model, like Piaget's does not propose modal-specific storage. Nonetheless, as will be seen in the section dealing with this third model, Rohwer's notions of encoding and storage also are different from those of Piaget and Inhelder.

The majority of Paivio's experimental investigations have been conducted with college-age Ss, however he and, more particularly, his associates have also performed numerous experiments with children. Paivio (1970) believes that "imagery appears to be a useful mode of learning and remembering at all ages"[17] (p. 391). Verbal processing, too, is presumed to

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[17] A remark Piaget would not concur with since he does not believe the symbolic function to develop until the end of the sensori-motor period (2 years).

become functional at a very early age, though not as early as imagery.[18] Since the bulk of research on children's learning has been conducted with concrete noun pairs and short sentence or paragraph material rather than abstract nouns there is little evidence in this literature to support the hypothesis that two codes are better than one. One study that does offer support for the dual coding aspect of Paivio's theory among children was performed by Bird and Bennett (1974). As would be predicted from Paivio's model, and consistent with previous findings with adults, these authors found children's recognition memory for pictures to exceed that of concrete words which, in turn surpassed abstract word recognition. Such a result clearly could be attributed to the greater likelihood of dual coding of the more concrete items. Other support for a positive effect of dual coding comes from a study by Paivio and Yuille (1966) which replicated an effect previously obtained with adults (i.e., CC > CA > AC > AA). However, as is the case with all noun pair studies it is impossible to determine how much of the concrete-concrete pair superiority was due to the advantage of synchronous storage or "conceptual pegging" that Paivio believes is potentially available for imagable items.

Considerably greater support is available to support the application of Paivio's synchronous storage hypothesis to children's learning. As is predicted by Paivio's proposal that items stored as interacting images are exceptionally easy to retrieve if part of the compound image is provided, numerous researchers have found children's recall of pictured (or

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[18] This notion of iconic preceding verbal representation was previously proposed by Bruner (1966).

line drawn) object pairs that are presented in some interaction to be superior to their recall of these same pairs presented in a side-by-side fashion (Danner and Taylor, 1973; Davidson, 1964; Davidson and Adams, 1970; Holyoak, Hogeterp, and Yuille, 1972). A similar effect has been found with object pairs (Yuille and Catchpole, 1973) and with object pairs plus labels (Yuille and Catchpole, 1974). In addition, Holyoak et al. (1972), Kee and Rohwer (1974) and Reese (1965) not only found recall for conjoined pictures to exceed that of separated pictures but also reported that presenting the separated picture pairs within a verb or preposition linked phrase gave equal recall to the pure conjoined picture presentation. From the point of view of Paivio's synchronous storage proposal this latter result suggests that sentence frames can prompt synchronous storage to a degree equal to that of an interacting visual presentation.[19]

A second body of research which supports Paivio's proposal that interacting images are an especially efficient manner of storage involves a number of studies designed to train children to generate such interactions on their own. Danner and Taylor (1973) had children draw interacting pictures for a set of training pairs and then presented the learning set pairs and encouraged the children to think of interacting pictures for each pair. The improvement equalled the provided interactions. For children in upper elementary grades, Levin and Kaplan (1972), found instructions to mentally interact object pair members presented in a side-by-side manner resulted

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[19] Rohwer's interpretation of this effect is contrary to Paivio's synchronous visual storage proposal and instead proposes association to be facilitated by establishing a semantic overlap.

in better memory for these pairs than no such training. Yuille and Catchpole (1974), using a sample of grade one and three children, found interacting imagery training to result in superior immediate and delayed recall (and recognition) of object pairs relative to no training. Furthermore those children in the training condition performed significantly better than untrained children in a subsequent object pair task (one week later) in spite of not being reminded of the interacting imagery strategy. Catchpole and Yuille (1977) tested the effectiveness of imagery training with grades two and five children using a nouns, nouns plus object referents, or nouns plus interacting objects paired associate task. In the case of noun pairs and noun pairs plus their object referents, imagery training was found to significantly improve recall relative to no training in both age groups. In addition, the grade two children also benefitted from the training in the nouns plus interacting object referents condition while the children in grade five did not, suggesting that an interacting object presentation does not create maximally efficient synchronous storage in younger children but that imagery training can prompt such storage. As expected, within the no training condition, noun plus interacting objects were better recalled than either nouns alone or nouns plus side-by-side referents. However these latter two conditions gave equal recall, a result which suggests that imaginal coding of concrete nouns is already being maximized since providing object referents did not improve recall. Imagery training has been found effective in children as young as five (Yuille and Catchpole, 1973) although Rohwer, Ammon and Levin (1971) did not find dynamic imagery instructions to benefit children's learning.

A more consistently successful mnemonic training procedure has been developed by Wolff (e.g., Wolff and Levin, 1972; Wolff, Levin and Longobardi, 1972). Based on an interpretation of Piaget's proposal that visual imagery results from play and imitation, Wolff combined imagery training with an opportunity to physically manipulate the objects in each pair. Consistent with Wolff's extrapolation of Piaget's theory such training plus manual involvement was found to be effective in five year olds while simple imagery training was not. However, Wolff's interpretation that Piaget believes manual imitation to be the sole source of visual image formation is clearly incorrect since grasping and looking schemes must accomodate to, and thus produce imaginal representations of, the objects. Yuille and Catchpole (1973) found no mnemonic benefit from physical contact with object (or picture) pairs and also found recall of objects to be no greater than picture recall -- a result clearly contrary to Wolff's interpretation of imitation, since how else could a picture be imitated but visually. An alternative explanation for the effectiveness of Wolff's training procedure may be derived from the results of a study by Varley, Severenson, Levin, and Wolff (1974). These researchers found imagery training and motor-involvement prior to learning set presentation improved preschoolers' memory for object pairs even though no motor involvement with the learning items was permitted. This result may have occurred, not because motor involvement aids image formation (as Varley et al. suggested), but because it clarifies the task. This conclusion coincides with Paivio's idea that images are formed and stored as a result of visual (or visualized) experience and is not inconsistent with Piaget's ideas of imagery despite the failure of manual involvement to improve memory. In fact if learning were closely tied to physical manipulation the high rate of informational acquisition achieved by young children would be inexplicable. Nonetheless, the intermittent success of imagery induction procedures as applied to young children does seem inconsistent with Piaget's and Inhelder's insistence that kinetic and transformational images are not available to the young (preoperational) child. That is, if the formation of an interacting image is the key to the mnemonic effect then an inability to perform such cognitive manipulations could be expected to impair memory. An experimental investigation of this question is presented in Chapter Two.

The third body of research which lends support to Paivio's proposals of dual coding and synchronous imaginal storage consists of a number of experiments that have examined the effects of various connectives as facilitators for noun pair learning.[20] Paivio (1975) believes that "... a significant part of the informational substrate for descriptive sentences is to be found in the imagery system" (p. 156). That is, in accord with his concept of dual coding Paivio believes imaginal coding to occur for concrete aspects of sentences, and, when such imaginal coding occurs the potential to take advantage of the synchronous storage capabilities of the imaginal processor is available. Based on these two assumptions of Paivio's, Yuille (1973, 1974) proposed that the recall improvement which results from linking noun pairs with a verb as opposed to a conjunction or no link at all (Holyoak et al., 1972; Rohwer, 1966; Rohwer, 1967; Rohwer, Shuell and Levin, 1967) reflects the fact that though dual coding occurs in all three instances, only the verb-linked pairs receive the

[20] Most of these experiments were condicted by Rohwer and his colleagues and consequently are interpreted very differently by him as is seen in the next section (D).

additional recall advantage of synchronous storage. The verb, said Yuille, serves to prompt the child to form a single interacting image while a conjunction, or no link at all, does not prompt this process. Thus in Yuille's (1973, 1974) proposal, the verb-linked noun pair has the same recall advantage over an unlinked or conjunction-linked noun pair that an interacting presentation of objects has over a side-by-side object presentation. In support of this latter point Holyoak et al. (1972) found children's recall of verb-linked object pairs to be equal to their recall of interacting object pairs and superior to side-by-side object pair recall. Yuille (1973, 1974) further expanded his idea that verb facilitation reflects the operation of imaginal codes to suggest that the verb, rather than prompting a specific interacting representation, instead merely prompts the child to form his/her own idiosyncratic synchronous image. This proposal was based on data showing trial-to-trial changes in the linking verb to be just as facilitative as using the same verb over trials (Yuille, 1973), and also on a result from Yuille (1974) that showed correct second noun recall to be unrelated to the probability of recalling the linking verb. Combining these findings with a result obtained by Levin (1970a) that showed cueing second noun recall with the first noun plus verb was no more beneficial than cueing with the first noun only, supports Yuille's contention that the verb serves only to prompt interacting image formation and does not decree the nature of this interaction.

Other support for the notion that sentence facilitation results from an advantage which accrues to imaginal coding comes from experiments designed to ensure that the two nouns are imaged with maximal effectiveness. Consistent with Paivio's contention that imaginal coding must occur before advantage can be taken of the synchronous storage capacity of the visual system, Cooper (1968) and Jensen and Rohwer (1963, 1965) found that the positive effect of verbs relative to conjunctions as links in noun pair learning was even greater if the referents of the nouns were provided during learning relative to a purely verbal presentation. Also, Catchpole (1974) employed an imagery prompting instructional procedure which rather than prompting subjects to form interacting images (as does imagery training) instead is designed to merely ensure that the child forms images of both members of each noun pair. Catchpole's results showed this type of instruction to result in a significantly stronger verb over conjunction facilitation effect than was found with a group of unprompted children. In fact, as has been the case in some other experiments using a purely printed presentation of materials (e.g., Davidson, Schwenn, and Adams, 1970; Levin, Kaplan, and Horvitz, 1971; Yuille and Pritchard, 1969), the verb over conjunction linked pair recall superiority failed to achieve significance. A second outcome of the Catchpole (1974) study which supports Paivio (1975) and Yuille (1973, 1974) was the finding that among preposition-linked pairs, those pairs linked by prepositions which suggest a physical interaction of the two items were significantly better recalled under imagery prompting instructions than were pairs linked by prepositions which imply distanced spatial relationships. In light of previous work showing prepositional links to result in performance intermediate to verbs and conjunctions (Rohwer, Lynch, Levin, and Suzuki, 1967), Catchpole (1974) concluded that such a result may have reflected the presence of both interaction-suggesting (e.g., "in" or "on") and non-interaction suggesting (e.g., "beside" or "near") prepositions within the Rohwer et al (1967) materials. Regardless, these results do suggest that unlike verbs which, as far as is known, prompt interacting image formation more or less automatically, prepositions may fall into two classes one of which aids children's learning of noun pairs and one which does not. In support of this conclusion, Catchpole (1974) found no difference between children's recall of conjunction and non-interacting preposition linked pairs while interacting prepositions and verbs gave better recall than these former two connective classes and did not differ significantly from each other. The effect of preposition and verb type with regard to degree of implied interaction was examined through experiments reported in Chapter Two.

D. Rohwer

Although Paivio's dual coding hypothesis and proposal that synchronous storage is available to all information processed in the imagery system seem to provide a consistent interpretation of much of the research into children's learning; a second, alternative, explanation of these same data has been forwarded by Rohwer (e.g., 1970b, 1973).

While Paivio attributes the mnemonic effect of interacting object pairs, verb and preposition links, and instructions to form mental interactions to the formation of easy-to-reconstruct compound images, Rohwer, on the other hand, believes these manipulations to benefit memory due to their capacity for prompting the child to form semantic elaborations. Semantic elaboration, says Rohwer, is a process in which a shared meaning is created for two previously unrelated items and such meaningful links or "semantic overlaps" help recall of one of the pair items upon presentation of the other. Rohwer (1973) believes that "...the critical determinant of performance levels in a noun pair learning task[21] is whether or not the S generates an event as a common referent for each pair of nouns" (p. 6). Thus while Paivio (1970) says formation of a compound visual image is the key to improving children's PAL, Rohwer (1973), instead, proposes that semantic coupling is the source of improved retrieval. He says "... the coupling that occurs in paired-associate learning is brought about by a process that creates a shared meaning for the items" (1973, p. 4). For example, Rohwer hypothesizes that the better recall of a phrase like "The dog chews the ball" relative to "The dog and the ball" results from the fact that the former sentence provides a semantic overlap for the two items while the latter does not. If both pair members can be integrated into a common event (for example the one who chews and the one who is chewed), then the two items will be more likely to be stored together in memory than will two items not possessing such a common event or referent. Thus elaboration in Rohwer's theory, refers to the process of generating common events for to-be-learned pairs and can be prompted by providing a visual interaction of real object items, by inserting a verb or preposition between printed noun pairs, or by supplying the pair alone and asking the child to think of his/her own common event or referent. Rohwer (1973) explains: "This shared portion is created by generating either directly from memory or by recombining memories, something that can serve as a referent for both items ... in the case of

[21] And also object pair learning.

virtually unrelated nouns or objects ... it is hypothesized that the common referent will typically be an event or the product of an event involving the separate referents of the two items to be coupled" (1973, p. 5). Though such an "event" sounds very much like Paivio's compound image, Rohwer (1973), is careful to explain that "Vague as it is, the term meaning (i.e., semantic overlap) is intended as an abstraction not as an umbrella for words and images. Thus the content of learning in the paired associate task is regarded as the residuum of creating a shared meaning for items that are initially disparate" (p. 4-5, parentheses mine). He goes on to emphasize this point stating "...the present formulation disavows any notion that the contents of memory are words, pictures, or any other kind of copy of sensory or motor reality" (p. 4). The insistence of Rohwer upon an amodal memory structure is consistent with Piaget's and Inhelder's (1973) view that memory in the wide sense is amodal in nature. For these authors, however, the contents of memory are schemes rather than semantic elaborations. Also, Piaget and Inhelder (1973), while positing an amodal structure to memory do believe the "semiotic instruments"(e.g., images and words) to facilitate the reconstruction of particular individual pieces of previously encountered information. Hence it seems reasonable to conclude that Rohwer's is the most amodal of the three theories. In light of the similar mnemonic effects of the various methods of improving children's recall of noun or object pairs (i.e., experimenter- and child-supplied visual and verbal interactions or common events) Rohwer (1973) believes that "...with regard to prompt effects, the variation associated with modality differences is slight compared with variation attributable to prompt explicitness... Accordingly a single-process approach, as exemplified in the elaboration hypothesis, may be more heuristic than a multi-process approach for advancing toward an understanding of the major determinants of learning efficiency in childhood and adolescence" (p. 53). Although this statement is contrary to Paivio's (1969) dual coding hypothesis (i.e., dual coding, by definition, is not a single process model); Paivio's interpretation of the various methods for improving object, picture, and concrete noun pair learning is, in fact, also a single process model. The mnemonic benefit of experimenter- and child-supplied mediators is not a dual coding effect since the materials typically employed in children's PAL tasks are highly concrete and hence, according to dual coding, are automatically represented in both the verbal and visual processing modes. Rather, Paivio believes the greater ease of learning of experimenter- and child-linked pairs to be a result of a purely visual type of processing. Thus the only real distinction between the two theories is that while Paivio attributes improved PAL to synchronous visual storage of pair members, Rohwer feels the single process to be semantic rather than visual in nature. Hence though Rohwer (1973) says it is really a "...question of which prompt modality (i.e., verbal or visual) more effectively activates the underlying process" (p. 4, parentheses mine). Paivio would contend that, given concrete learning materials, the underlying process is visual in nature regardless of whether the learning materials are encoded by eye or ear.

Just as Rohwer's concept of semantic elaboration bears a distinct resemblence to Paivio's compound image hypothesis, it is also, in some sense, similar to Piaget's and Inhelder's (1973) explanation for successful informational encoding and reconstruction. The formation of a "semantic overlap" by integrating two items into a single event sounds very much like the Piagetian concept of assimilating two things to the same scheme. While Rowher attributed the superior recall of experimenter- or child-mediated, relative to unmediated, pairs to a semantic elaboration process, Piaget and Inhelder would probably attribute this effect to two features of assimilation. Firstly, mediated paired associates are more likely to be assimilated to the same scheme(s) than are their unmediated counterparts, and secondly, a mediated pair of items or an interactive event is a more meaningful piece of information that are two unrelated items and hence will be amenable to assimilation by a wider repetoire or greater number of schemes. According to Piaget's and Inhelder's (1973) conception of memory increasing the number of schemes to which two items are assimilated, and especially the number of common schemes, would be expected to increase the likelihood of recall by virtue of more reconstructive "power" being available as the schemes of the intelligence (i.e., memory in the wide sense) accommodate in an attempt to reconstruct the desired item. That is, from the Piagetian perspective formation of a semantic overlap should lead to better recall of the two items of information because the newly formed informational unit (or compound image), by virtue of a Gestalt-like effect in which the compound unit is more meaningful that the sum of the two parts, can be encoded to many more schemes of understanding than an unrelated pair of items. And, because a single event for two disparate items is provided the two members now have a much greater likelihood of being assimilated by the same schemes thus increasing the probability that, in the cued recall task, presentation of one pair member will call up schemes appropriate to the reconstruction of the second item. Though Rohwer's model depends upon storage of particular semantic overlaps (and Paivio's upon storage of particular compound images) while Piaget's and Inhelder's (1973) model eschews any notion that individual pieces of information are stored -- instead proposing only schemes to be stored and specific information to be reconstructed -- the Rohwer and Piaget (though not Paivio) models appear otherwise in agreement that it is generation of a "meaningful" or "semantic" overlap that is responsible for the various mnemonic effects of experimenter-supplied and child-generated mediators.

Unlike Paivio (1975) who implies that all compound images are equally effective, Rohwer (1973) has proposed that some PAL recall facilitating events will be more effective than others. That is, in Rohwer's view, given that an event incorporating the two items is formed, such an event can have greater or lesser mnemonic value depending upon whether it possesses two critical features: first, for an event to be maximally effective it must be assured that a "...balance (is) achieved between the two items to be coupled" (1973, p. 7, parentheses mine). That is, the event must be based upon relatively central properties of each of the two items. For example, says Rohwer (1973), "Given a pair of items like 'Man' and 'Book' ... an event designated by the sentence, 'The man sat on the book', should be less effective for retrieval than an event like: 'The man read the book'. It is only an incidental property of a book that it can be sat upon, whereas its readability is a central property" (p. 7). Rohwer's above specification as to the nature of a "successful" mediating event is contradictory to an interacting imagery interpretation of effective mediation since, from this latter perspective, as long as the compound image containing both members of a pair is formed, improved cued recall or recognition should occur regardless of how the items are interacted. This clear distinction between the predictions of Paivio and Rohwer is subjected to experimental analysis in Chapter Two.

Aside from the stipulation that effective units must be based upon central properties of the two items in a pair, Rohwer (1973) has further proposed that the mnemonic value of an event (be it experimenter- or child-generated) is also dependent upon "...the extent to which the event is uniquely defined by the objects it includes. The more critical the particular objects are for the identity of the event generated, the more resistant should the coupling be to interference from other items" (p. 7). Thus an event like "the man read the book" would, though facilitative since the "central property" requirement is met, not be maximally effective[22] since the "reading" event could as easily be applied to a boy and a newspaper or an engineer and a manual. On the dimension of event uniqueness an example of an effective event might be "the ax felled the tree" since felling is not an event that can link many other pairs of items. The more unique the event generated, says Rohwer, the less interference it will suffer from similar events and consequently the greater will be its retrievability.

[22] Though for this particular pair it may be the best possible.

Rohwer's two specifications of event quality (i.e., balance and uniqueness) are difficult to interpret from a Piagetian perspective since they are storage concepts and Piaget does not speak in terms of information storage but rather assimilation to schemes and subsequent reconstruction of information by means of these schemes. Nonetheless, just as an "eventful" pair would be more widely assimilated than an "uneventful" one, it might also be expected that certain types of events (e.g, balanced or unique ones) might be assimilated to a wider repetoire of schemes than other events. Beyond such a general idea, however, it is not possible to map Rohwer's notions of event quality further into Piaget's and Inhelder's theory of memory.

Though Rohwer (1973) believes different levels of event quality to exist, from a developmental perspective, he does not stipulate the capacity for generating more unique and balanced events (which can only occur in child-supplied mediation conditions anyway) to be a function of age. The central idea of Rohwer's position is that semantic elaborations are either formed or not formed and the likelihood that elaborations will be created is dependent upon the age of the child and the type of prompt-to-elaborate that is provided. Rohwer (1973) has outlined five classes of semantic elaboration-fostering prompts: (1) maximally explicit prompts -- which involves presenting the to-be-learned pair as an interaction of two objects and is the most powerful type of elaborative prompt; (2) augmented explicit prompts -- the second most powerful prompts, consisting of presenting the to-be-learned pair within a sentence frame or as photograph of interacting object referents; (3) explicit prompts -- the third most effective prompt to semantic elaboration, involving instructing children to think of their own sentence frame or interacting representation containing each pair; (4) minimally explicit prompts -- a considerably less powerful means of prompting semantic elaboration, consisting merely of instructing children to learn the pair; and (5) antagonistic prompts -- a type of prompt which requires semantic elaboration to be virtually "automatic" since antagonistic prompts involve having children do something to the pairs other than form a visual or verbal event (e.g., repeat the items out loud, attend to formal properties of the items, etc). According to Rohwer (1973), the older the learner, the less explicit need be the prompt in order for semantic elaboration (and hence improved learning) to occur. In the pre-school child, Rohwer contends that only the most powerful prompt -- maximally explicit -- is capable of successfully prompting semantic elaboration. No other prompt class can improve learning above that obtained in a simple noun-noun or side-by-side object pair task among children of this age. Experimental evidence as to the minimum age at which maximally explicit prompts can successfully foster semantic elaboration (i.e., improve learning) is somewhat contradictory. For example, Yuille and Catchpole (1973) found that in a paired associate recognition task, kindergarten children given an interacting object presentation (which Rohwer, 1973, defines as a maximally explicit prompt) correctly re-paired more items that did classmates who studied side-by-side pairs. On the other hand, Wolff and Levin (1972) found that although third grade children had higher recognition scores with maximally explicit versus minimal prompts, there were no differences in preschoolers' recognition scores with an interacting versus side-by-side presentation. One aspect of a Chapter Two experiment attempts to resolve this contradiction by comparing the effectiveness of maximally explicit versus minimal prompts with a pre-kindergarten sample.

Slightly after maximally explicit prompts become effective initiators of semantic elaboration, augmented explicit prompts also become potent. As stated above, in Rohwer's (1973) view there are two types of augmented explicit prompts -- embedding the pair items as nouns in a sentence frame or representing the two items as interacting in a single picture -- and both of these procedures are presumed to prompt children to form a semantic link between the two items. Though maximally explicit prompts are presumed to be the most effective means of fostering semantic elaboration, and one experiment (Wolff and Levin, 1972) found such prompts to be ineffective with five-year-olds, visual augmented explicit prompts have been consistently shown to improve five-year-olds' learning of picture pairs (e.g., Rohwer, 1967; Rohwer, Lynch, Levin, and Suzuki, 1967; Rossman, 1970; Yuille and Catchpole, 1973) relative to a minimal prompt. The young age at which augmented explicit prompts become effective, combined with the failure of Wolff and Levin (1972) to obtain improved learning with interacting versus side-by-side objects, plus the demonstration by Yuille and Catchpole (1973) that pictorial and real object pairs were equally well retrieved (by a first and third grade sample) whether interacting or not, and the fact that the degree of facilitation obtained in the interacting condition was equal for both types of items casts some doubt upon Rohwer's contention that maximally explicit and pictorial augmented explicit prompts are functionally different. Though the current research does not attempt to clarify this question, a comparison of pictorial and real object side-by-side and interacting presentations in a three- to four-year-old sample would help to resolve this issue.

Just as pictorial interactions improve the recognition and recall performance of elementary school children, representing to-be-learned pairs as nouns embedded in a sentence frame also has been demonstrated to improve children's memory for these items (e.g., Davidson and Adams, 1970; Holyoak et al. 1972; Rohwer, 1966). Furthermore, consistent with Rohwer's (1973) proposal that the mode of augmented prompts is irrelevant, such improvement is generally equal to that obtained with interacting pictorial referents (e.g., Holyoak et al, 1972; Kee and Rohwer, 1974; Reese, 1965). While pictorial interactions consistently result in improved learning relative to a minimal prompt, regardless of the nature of the interaction, the successful facilitation by sentence frames depends, somewhat, on the characteristics of these frames. For example, Rohwer (1966) found sentence frames to result in improved memory for noun pairs (i.e., prompt semantic elaboration) only when such frames consist of meaningful words. Thus while a sentence like "the Cow chases the Ball" improves recall of the noun pair relative to the "Cow and the Ball", embedding the pair in the phrase "the ludding Cow drases the spraking Ball" does not facilitate recall above that obtained with the minimal prompt. However, aside from this exception most other manipulations of the characteristics of the frame have little effect upon the facilitative effect of such prompts. Ehri (1970), for example, found active verbs to be just as facilitative as passive verbs and Rohwer and Levin (1968), who varied the degree of overt activity suggested by the verb, found memory for the second noun of each pair (upon presentation of the first) to be consistently improved relative to the conjunction-linked control condition regardless of the level of the activity variable. One attribute of the sentence frame that Rohwer (Rohwer and Levin, 1968) does believe can cancel the facilitative effect of sentence frames is the "semantic appropriateness" of the prompting sentence. Rohwer and Levin (1968), for example, found that although a sentence like "Cats jump Gates" resulted in better recall than "Cats and Gates", the semantically inappropriate sentence "Cats jump Songs" is no better recalled than "Cats and Songs". Rohwer and Levin attributed this result to the failure of sentences like "Cats jump Songs" to generate a meaningful link, or semantic overlap between the pair members (i.e., failure to prompt semantic elaboration). Piaget and Inhelder (1973) would, presumably, evoke a similar explanation such that information which does not make sense is not widely assimilable and hence little power is available to reconstruct the pair at recall. From an imagery perspective the low recallability of "Cats jump Songs" would be explained not in terms of the low meaning of such a sentence but rather by the type of imagery it evokes. By virtue of being an abstract noun "Songs" is relatively unlikely to evoke an imaginal referent within the span of time that each pair is displayed. Consequently, the pair will not be stored as a compound of the two imaginal referents of the two nouns and recall will be poor. Reese (1965, 1969) obtained support for the imagery interpretation of sentence facilitation in two studies which found bizarre links to be as effective as semantically appropriate ones. For example, Reese (1965) found the sentence "The Chicken is carrying the Flag" to have the same likelihood of recall as a pictorial interaction of the two items and both these former groups gave higher recall than "The Chicken and the Flag". Also Reese (1969) using a sample of pre-schoolers, found a bizarre link like "The Fish is talking on the Telephone" to be significantly better recalled than "Fish-Telephone". Though bizarre and semantically anomalous links are not exactly the same, an interpretational controversy between imaginal and semantic hypotheses exists nonetheless.

Taken together, maximally explicit and augmented prompts, in Rohwer's opinion, form the first of three stages of semantic elaboration which children pass through. This first stage extends up to seven years[23] and reflects the incapability of children to think up their own semantic overlaps during these years. The first major shift in children's employment of semantic elaboration as a strategy for improving PAL comes, says Rohwer (1973), at about seven years of age (which Rohwer notes corresponds with the onset of Piaget's concrete operational stage). Only upon entering this stage, says Rohwer, do explicit prompts (instructions to form linking sentences or interacting images) lead to successful semantic elaboration. Rohwer (1973) explains that "The early shift (i.e., when explicit prompts become effective) appears to come with a capacity for locating -- or 'thinking of' -- an appropriate event. Prior to this conceptual development even explicit instructions to generate events are ineffective; the child's problem may relate to other characteristics of conceptual processes: in Piagetian terms, he has not yet achieved concrete operations; and in terms proposed by Pascual-Leone (1970), the mental processing space available may be insufficient. In any case the fact is that a reduction of the task, by providing a referential event,

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[23] Rohwer is unclear as to the minimum age at which maximal and augmented prompts are effective though to date, research suggests a minimum of four years.

as is done when either augmented or maximal prompts are given, results in effective elaboration" (p. 43-44). The success of explicit prompts with children over the age of seven has been widely demonstrated. For example, Bean and Rohwer (1970) found school children given instructions to form covert sentences to presented noun pairs performed better than peers given only a minimal prompt. Similarly, Yuille and Catchpole (1974) trained grades one and three children to form interacting images for presented object pairs and found these children's recognition performance to significantly surpass that of a control (i.e., minimally prompted) group. More recently, Catchpole and Yuille (1977) have shown such training to be effective for noun pair learning in a paired associate recall task conducted with grade two and five children. Comparisons of verbal and imagery explicit prompts (e.g., Dempster and Rohwer, 1974; Yuille and Catchpole, 1977) have yielded similar positive effects leading the former authors to conclude that "...it is highly likely that the effects of instructions share a common property such as that of prompting item encoding in terms of semantic attributes" (p. 408). While Yuille and Catchpole (1977) instead interpreted their obtained equivalence in facilitation of verbal and imaginal explicit prompts to an underlying visual imagery commonality, the conclusion is still warranted that explicit prompts, regardless of whether fostering semantic or imaginal overlap (or some other process) are consistently effective among elementary school children. However, the evidence for Rohwer's (1973) contention that explicit prompts become effective only after seven years of age is mixed. For example, consistent with his theoretical formulation, Rohwer (1967) found that while grade three children performed equally well with augmented (experimenter-supplied sentence frames) and explicit (child-generated sentences) prompts, kindergarten children performed significantly better with augmented prompts. Also, Jensen and Rohwer (1965) found instructions to generate covert sentences containing both nouns of each pair to facilitate PA performance of grades two and four but not kindergarten children. On the other hand, Levin, McCabe, and Bender (1975) found that their sample of four-year-olds could benefit from explicit prompts (which in this case were instructions to form a story relating the pair of nouns). Furthermore, Rohwer, Irwin and Gerdes (cited by Rohwer, 1973) found serial learning of a 25 picture set to be significantly improved by an explicit prompt to form a story containing each subset of five items in a sample of high and low SES kindergarten and grade five children. Similar contradictory results have been obtained in studies using visual explicit prompts (i.e., instructions to form interacting visual images). Consistent with Rohwer's (1973) contention that explicit prompts are not effective until seven years of age, Rohwer, Ammon and Levin (1971) found five-year-olds to perform better in an augmented (interacting pictures) than visual explicit prompt condition. Similarly Wolff and Levin (1972) using pictorial materials and visual imagery instructions, found maximal and explicit prompts to be equally facilitative and to result in superior memory relative to minimal prompts in a third grade sample; whereas kindergarten children, while showing recall improvement when provided with already interacting pictures, performed no better in the explicit than minimal prompt condition. Contrary to these results, Varley, Levin Severson, and Wolff (1974) and Yuille and Catchpole (1973), have found visual explicit prompts to facilitate PAL in five year old children. Again a controversy exists between semantic and imagery (see Section C) interpretations of memory facilitation. While Rohwer attributes the positive effect of explicit prompts to semantic elaboration, Paivio believes interactive imagery to be responsible for the observed effect. Regardless whether the positive effect of explicit prompts reflects semantic or imagery processes it is of interest to further examine Rohwer's contention that they can not foster learning before seven years of age. This question is examined experimentally in Chapter Two through an attempt to teach pre-kindergarten children to use explicit visual prompts.

By about eight years of age maximally explicit, augmented explicit, and explicit prompts are, according to Rohwer, all capable of improving children's performance in paired associate tasks, however, it is not until early adolescence that, in Rohwer's view, minimally explicit prompts (i.e., instructions to learn the pair) and subsequently antagonistic prompts also come to encourage, or at least not interfere with, what has by this age become an almost automatic tendency to form semantic overlaps for presented pairs of items. Rohwer (1973) says: "...in adolescence the principal locus of shift (in terms of type of prompt required to elicit elaboration or event formation) appears to be in the growing sufficiency of minimal prompts -- and perhaps even of mildly antagonistic prompts" (p. 43). With the exception of a study by Bransford and Johnson (1970) who found college students' recall of connected discourse to be better if a picture representing the to-be-learned material was presented immediately prior to learning (a type of augmented prompt) experimental evidence largely supports Rohwer's (1973) contention that semantic elaboration comes to be "automatically" evoked during the period of adolescence. Bugelski (1962), for example, obtained evidence that college students routinely engage in generating events as common referents for word pairs. Also, Martin (1967), using a postlearning interview method found the frequency of reported elaborative activity to increase significantly with grade level among a fourth, sixth, and eighth grade sample. More direct evidence for the shift to spontaneous elaboration has come from a series of experiments by Rohwer and his associates. For example, Suzuki and Rohwer (1969) found that while grade five children performed better in an augmented (verb-linked noun pair) than a minimal (conjunction link) condition, performance of college students did not differ as a function of prompt type. Also, Rohwer and Bean (cited by Rohwer, 1973) found that high IQ grades one, three, and six children received equal facilitation from augmented and explicit prompts and that performance in these two conditions was significantly superior to that of children in a minimal and an antagonistic condition, performance in the latter two conditions also being equal. These results are entirely consistent with Rohwer's position since, among children of this age, both explicit and augmented prompts are postulated to prompt semantic elaboration while minimal (and antagonistic) prompts do not, thus explaining the poorer recall under the latter two conditions and also their equivalent recall results relative to each other. Grade eleven, high IQ students, on the other hand, performed equally well under augmented, explicit, and minimal prompting conditions and performance in these three groups significantly surpassed that of antagonistically prompted students. This result suggests that by age fifteen or sixteen, semantic elaboration is a virtually spontaneous process that fails to occur only when attention is occupied with other tasks. Interestingly, a sample of Grade 11, normal IQ, students showed the same pattern of prompt effectiveness as the high IQ grade ones, threes and sixes. Apparently the ease with which semantic elaboration can be prompted depends upon the intelligence as well as age of the child. The final prompt category in Rohwer's formulation are the antagonistic prompts which, says Rohwer (1973), "...consist of directing the learner to engage in an activity that precludes efforts to generate an event that can serve as a common referent for the items to be associated" (p. 10). Prompts such as "3 Rock 8 2 Bottle" or explicit instructions to perform some cognitive act upon the pair members other than form a referential event are examples of what Rohwer calls antagonistic prompts. The degree to which a particular antagonistic prompt precludes semantic elaboration is considered to be a function of its non-elaborative attention-getting properties plus the age and intelligence of the child.

In summary, Rohwer proposes that the key to improved performance in paired associate tasks is the activation of a cognitive process which he calls semantic elaboration. Semantic elaboration involves forming a referential event, containing both members of a pair, and results in improved recall for that pair due to the establishment of a meaning-based link between the items. While some events may be more effective in terms of recall facilitation than others, the major construct in Rohwer's theory is a delineation of the conditions under which the event formation process is likely to occur. According to Rohwer (1973) "...the older the learner, the less explicit the prompt necessary to activate elaboration" (p. 38). In the pre-school child only an obvious suggestion to store a referential event (i.e., presentation of an interacting pair of objects) will result in semantic elaboration and hence improved paired associate recall. At a slightly older stage, verb-linked sentence frames or interacting photographs can also effectively prompt semantic elaboration. Once the child enters the concrete operational period, Rohwer contends, simple instructions to form referential events will also suffice to prompt semantic elaboration. Finally, later in adolescence, simply instructing the child to learn the pairs will result in recall as good as that obtained with more explicit prompts though directing the learner's attention away from event formation may still impair elaborative encoding.

E. Additional Considerations

Although the theories and research of Piaget and Inhelder, Rohwer, and Paivio differ with respect to a multiplicity of issues, ranging from personal areas of special interest to epistemological perspective, within the field of children's associative learning their differences may be characterized in terms of three critical issues: (1) What is the nature of information retention -- does it consist of stored verbal representations and imaginal referents? A network of overlapping stored semantic features? Or, perhaps, an expanding repetoire of schemes or understandings. (2) What is the role of imagery, if any, in information recovery -- do images provide direct access to previously stored concrete information because much of memory is images? Are images irrelevant to information recovery, playing a role only in peripheral stages of encoding? Or do images serve to support the recovery of information by acting as a "display screen" upon which the particular information can be reconstructed by the schemes?

And (3) Why are interacting object and photograph pairs so much easier to remember than comparable side-by-side pairs, and is the explanation for this the same as for the sentence facilitation effect -- are interacting presentations and sentence-embedded noun pairs readily recovered in cued recognition or recall tasks because they are stored as interacting images? Because they facilitate formation of easily retrieved semantic overlaps? Or because such presentations are more meaningful than simple noun or side-by-side object pair materials and hence are more widely assimilated?

While Paivio's (1969, 1971, 1975), Piaget's and Inhelder's (1971, 1973), and Rohwer's (1970b, 1973) and each of their respective colleagues' hypotheses represent three dominant positions with respect to the aforementioned issues of current relevance, other researchers, not falling into one of these camps, have also formulated ideas relating to one or more of these topics. Concerning the question of the nature of storage (1) and the role of imagery in information recovery (2), Kosslyn (1975; Kosslyn and Bower, 1974) has recently formulated a hypothesis not unlike that of Piaget, though Kosslyn states his ideas in information processing rather than Piagetian language. Contrary to Paivio (e.g., 1971), and in agreement with several other cognitive psychologists (e.g., Pylyshyn, 1973), Kosslyn (1975) does not believe images to be photograph-like perceptions which are "stored in the head". Rather he (like Piaget and Inhelder, 1971) believes images to be internal constructions generated from an abstract amodal memory code and limited in their accuracy by the information extracted at initial presentation.[24] He says: "The hypothesis favored here

[24] Piaget believes that in some cases the subsequent image can be more accurate than the initial perception due to developmental advances in the abstract code (i.e., schemes).

is that the experience of an image itself arises out of 'constructive' processes (cf. Neisser, 1967). The notion is that the units abstracted and interpreted during perception are stored in long term memory in some abstract format, and must be acted upon by processes that serve to generate or to produce an experience of an image" (1975, p. 242). If Kosslyn's term "units" is replaced by "information relevant to one scheme" and if "abstract format" is renamed "scheme network" then the similarity of Kosslyn's (1975) hypothesis to that of Piaget and Inhelder (1973) becomes immediately obvious. Furthermore, just as Piaget and Inhelder (1971) believe images to be constructed by means of the operational plane schemes and projected onto the "lower" figurative plane, Kosslyn (1975) says: "A visual image is considered here to bear the same relationship to the underlying structure as a pictorial display on a cathode ray tube does to a computer program that generates it. The underlying 'deep' structure is abstract and not experienced directly, whereas the image itself seems pictorial in nature"(p. 342). Kosslyn further extends this analogy by suggesting that the image generation process is not like a normal program-to-cathode ray tube type of projection in which the electron beam scans the tube in a serial fashion, but rather is more accurately analogous to "the display mechanism reported by Perry and Aho ... (in which) the electron beam that excites the phosphor may plot patterns as single units" (p. 369, parentheses mine).

While Piaget and Inhelder (1971) discuss image formation upon the figurative plane, by means of the operational schemes, in only a general way, Kosslyn (1975) conducted some experiments to test for possible limitations upon this display mechanism. He employed a task in which college students were first instructed to form visual images of pairs of animals the first of which was an elephant or a fly. Possible properties of the second animal were then presented (e.g., claws) and subjects were timed as they determined if their image of the second animal contained this attribute. Thus the task involved calling up stored information as to the properties of the animals in question, representing these properties in image form, and then inspecting these images for the relevant attribute once it was supplied. This task is based on Kosslyn's (and Piaget's and Inhelder's) belief that constructing an image is an effective aid to memory and problem solving since the simultaneous display can be inspected by the "mind's eye" and embellished if necessary. What Kosslyn found was that animals paired with an elephant took significantly longer to evaluate than animals paired with the fly, while a second experiment, in which the students were to image the second animal next to a "giant fly" or a "minute elephant", gave the opposite results. In other words the second animal took less time to evaluate when it was paired with a small (i.e., normal fly or minute elephant) than large (i.e., normal elephant or giant fly) animal. Kosslyn (1975) also found that the second animal took longer to evaluate if paired with an imaged complex as opposed to simple matrix. Kosslyn's conclusion based on these results was that the "display screen" is limited by both size and complexity factors. He said "Human imagery may operate such that the capacity limitation is not a simple matter of how much area is displayed, but some joint function of area and number of parts (represented by a single underlying unit) depicted (1975, p. 319). He goes on to speculate that the display mechanism may possess a "grain" such that subparts of small images may not be observable, while large images potentially may be broken down into several sections for easy inspection. In Kosslyn's view the image requires frequent rejuvenation in order to be maintained otherwise it will fade. Rejuvenation of the image is proposed to require energy and the speed of this rejuvenation is fixed such that if too large or detailed an image is attempted it will not be maintainable in synchronous (see also Paivio, 1975) or simultaneous form.

Though Piaget and Inhelder (1971, 1973) and Kosslyn (1975) are largely in agreement regarding the nature and function of imagery in the retrieval (or reconstruction) of information from the abstract code, they differ both with respect to their conception of this code and also the role which imagery plays in its formation. Piaget and Inhelder (1973) conceive of the abstract code as consisting of a network of schemes or understandings which is entirely amodal in nature and which increases in terms of breadth, refinement, and interscheme coordination throughout the course of development. This development of the abstract code is brought about through the reciprocal processes of assimilation (representing new information by means of existing schemes) and accomodation (making minor modifications in existing schemes such that they can represent novel material without distortion). Imagery, according to Piaget and Inhelder (1971, 1973) is not only peripheral to this abstract code or memory in the wide sense but also plays no direct, but rather a supportive, role in the assimilation of information to existing schemes. While images can be assimilated they must be converted to the "scheme language" or operational plane of thought before becoming part of the abstract code, and hence recoverable. Images can facilitate the decoding of the abstract code

(Kosslyn agrees with this point) and can serve as fodder for assimilation in the same way as does perceptual data, but the abstract code itself is, according to Piaget and Inhelder, in no way image-like.

Kosslyn (1975; Kosslyn and Bower, 1974), as stated earlier, agrees with Piaget and Inhelder that images play an important role in the recovery of information (for purposes of memory, problem solving, or reasoning) from the abstract code. However, he also postulated the abstract code itself to possess some image-like features, and, he believes images to play a role in the formation of this code. Rather than conceiving of the abstract code for a particular information as consisting of the representation, in the scheme repetoire, of what is understood (assimilated) or close to being understood (accomodated to) of the material, Kosslyn (Kosslyn and Bower, 1974), using sentence learning as an example, believes that "when S studies and comprehends a particular sentence, he sets up an internal representation of the information he has extracted from it. Although Ss' immediate memory may include aspects of the sentence's exact phonetic (or literal) representation, these 'surface features' presumably decay from short term memory, leaving as the residue something like the conceptual or imaginal representation of the sentence studied" (pp. 30-31). Kosslyn and Bower (1974) studied memory confusions in children and adults and found that adults could successfully distinguish between sentences conceptually similar to, versus conceptually different from, the test sentences even when both "lures" evoked the same image as the study sentence; children on the other hand, could not. Based on these results they concluded that the adults' memory or abstract code contained conceptual as well as imaginal information about the original sentence, while the children, though shown to be aware of the conceptual meaning of the sentence at the time of presentation, rapidly lost this information leaving only image-derived abstract codes. Kosslyn and Bower (1974) believe "A sentence is initially encoded along several dimensions including its surface phonological form, its semantic (conceptual) relations, and the referential imagery it arouses. For simplicity these may be thought of as distinct memory codes closely tied together. In our comprehension tasks involving only very short-term memory, the codes from the two sentences of a pair were readily available, and the two sentences could be discriminated at that time on the basis of their surface phonology, their conceptual semantics, or their aroused imagery, depending on Ss'judgement task .... The data suggest that the forgetting rate of the semantic-conceptual code is much faster for children than for adults. Since children later have available in memory only the 'imagery codes' to compare with the test sentence, they make many false alarms to imaginally similar lures, and these are not distinguished (as they are for adults) between conceptually similar and conceptually different lures" (p. 37).

This notion that phonological, semantic-conceptual and imagery features are represented separately in the abstract code and have individual loss rates that are a function of age, is similar in some respects to a levels of processing model proposed by Craik and Lockhart (1972). According to these authors "...the memory trace can be understood as a byproduct of perceptual analysis ... (Also that) trace persistence is a positive function of the depth to which the stimulus has been analysed. Stimuli may also be retained over short intervals by continued processing at constant depth" (p. 671, parentheses mine). In the Craik and Lockhart (1972) model the "depth" to which a stimulus is encoded (and hence the likelihood of its subsequent recovery) is a function of both its "... familiarity, compatability, and meaningfulness" (1972, p. 624) such that highly familiar material will pass to "deeper" levels more rapidly, plus the amount of time devoted to studying it. Seen from the perspective of Craik's and Lockhart's model the suggestion of Kosslyn and Bower (1974), that multiple codes (e.g., phonetic, semantic-conceptual, and imaginal) with different decay rates are set up as a result of studying a stimulus, can be seen as reflecting the residue (memory traces) left at each processing level. The more closely that recall follows the offset of presentation, the greater will be the likelihood that all level-specific information (up to the deepest level to which the stimulus has been processed) will be available. As the time between stimulus offset and recall increases the information extracted at lower levels (e.g., phonetic features) will become unavailable leaving only the deeper codes. Presumably, if a stimulus is highly unfamiliar (and consequently only reaches shallow levels of processing) then a recall delay greater than the decay time for the deepest code formed will result in complete retrieval failure. Thus, from the levels of processing perspective, ensuring a deep level of encoding is especially vital to long-term recall since only the very deepest codes will persist over protracted time intervals. Both Rohwer's (1970, 1973) semantic elaboration and Paivio's (1969, 1975) interactive strategies can be seen from this perspective to be procedures designed to foster "deeper" coding, although whether the two procedures produce feature-specific (i.e., semantic versus imaginal) codes in the sense proposed by Kosslyn and Bower (1974), is not clear, though the generally equal recall-facilitating effects of these two experimenter-supplied or child-generated strategies either suggests that both procedures (or prompts) foster same-depth coding (be it imaginal, semantic, or abstract) or that one code is deeper than the other but that both are salient within the recall delay parameters employed in most studies. One piece of evidence in support of the latter alternative comes from a study by Yuille and Catchpole (1977) which found imagery (form an interacting image) and verbal (form a sentence containing both items) training to be equally effective at immediate recall, but after a one week delay imagery trained children surpassed their verbally trained classmates. Kosslyn's and Bower's (1974) result showing that children (but not adults) tend to lose conceptual but not imaginal information also lends support to a kind of multi-coding (as opposed to Paivio's, 1969, dual coding) hypothesis in which two of the deeper-level subcodes contain conceptual and imagery features. In other words, the levels of processing model offers an alternative conception of information retention (to the models of Rohwer -- storage is strictly meaning based, and of Paivio -- storage is verbally and/or image based) in which all information extracted from a stimulus must be "written into" an abstract code (i.e., translated into brain language) in order to be stored, but that at recall, what remains of this code can be reconstructed into the type of information it represents. For example, if at presentation, phonetic, conceptual-semantic, and imagery features of the stimulus are presented in the abstract code and, if prior to recall, the phonetic and imaginal part of the code is lost, then only conceptual-semantic features of the original stimulus will be recoverable. Why "shallower" information is lost more rapidly from the abstract code than "deeper" information is not specified by Craik and Lockhart (1972), however, since they stress that "elaborative processing" generates deeper codes, one possibility is that deeper coding levels are more closely in contact with previously acquired knowledge and that this knowledge may differentially facilitate reconstruction of deeper level information.

The conceptualizations of the abstract code forwarded by Kosslyn and Bower (1974), (and Craik and Lockhart, 1972) and by Piaget and Inhelder (1973) are, by virtue of their common belief that the retention of information is based on an abstract amodal code, very similar. The main distinctions between their respective views lie in how they "cut" this code, and as a consequence of these "cuts", how they conceive of information redintegration from the code. Kosslyn and Bower (1974) have divided the code into various levels of information abstraction ranging from acoustic down to deep-level (in the adult) conceptual information. In their view information is reconstructed only in the sense that it is translated from the abstract code into an internal and subsequently external output mode (e.g., images to speech, images to drawings, internalized speech to writing, etc.). Piaget and Inhelder, on the other hand, cut the code from the point of view of the individual such that the informational attributes which are encoded are those which can be represented in terms of what has already been understood (i.e., for which schemes are available) about similar stimuli. While it is possible that some information may be understood by schemes designed to understand phonetic information, while "imagery" or visual feature schemes may represent other aspects of the material, Piaget and Inhelder divide the code into "units of understanding" which may or may not be synonymous with the types of features (or coding levels) suggested by Kosslyn and Bower. Reconstruction of internally represented information in their view, is consequently different from the decoding proposal of Kosslyn and Bower (in which the level-specific features represented in the abstract code that have not decayed can be decoded at recall), such that schemes or understandings must reconstruct the original item from the scheme-specific informations incorporated during learning. In other words, for Piaget and Inhelder, all which is understood is represented by means of separate understandings (i.e., schemes) and it is these understandings that provide the power and the components for recall. Put another way, Kosslyn's and Bower's proposals about the abstract code can be seen as a trace model in which a stimulus leaves a residue[25] at certain coding levels; this residue being represented in the language (or a language) of the abstract code. Piaget's and Inhelder's model on the other hand, is not a residue model since nothing specific is left behind. Rather the schemes (which can also be seen as subcodes or, alternatively coding dialects) of assimilation applied to the stimulus change (e.g., differentiate, broaden, develop new inter-scheme connections) as a consequence of this application and as a result of this change become potentially capable of reconstructing assimilated aspects of the stimulus.

While the information processing (e.g., Kosslyn and Bower, 1974;

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25 The decay rate of these level-specific residues is probably best described as a half-life since from this point of view small amounts of shallow-level residues seem to persist over fairly long time intervals.

Craik and Lockhart, 1972) and Piagetian (e.g., Piaget and Inhelder, 1973), conceptions of the abstract code appear, from the above discussion, to be very different, certain weakensses in each of these models suggest a greater similarity between them than previously indicated. For example, in discussing their finding that conceptual (but not imaginal) features of the stimulus are rapidly lost by children, Kosslyn and Bower (1974) noted that "...the conceptual distinctions that the child forgets would appear to be those which he learns late and finds somewhat hard to comprehend -- dimensions such as causal attribution, intentionality, appearance versus reality, knowledge versus belief, etc...." (p. 37). While a levels of processing model is hard-pressed to account for this result (granted the conceptual processing level may not be fully developed in the child but what factors determine the development order in which specific conceptual residues may accumulate?) Piaget's explanation for this phenomenon is the key to his theory. That is, in Piaget's view, the ability to retain conceptual information develops through the assimilation and accomodation of the schemes. Children, according to Piaget, cannot recall certain conceptual features of information until certain ages because they have not yet developed the schemes to assimilate this knowledge and hence it does not become part of their memory in the wide sense. Thus Piaget and Inhelder might presumably explain Kosslyn's and Bower's finding, that imaginal stimulus information persists longer in memory than does conceptual information, in terms of the types of assimilatory schemes that are available to the preoperational child; such that the scheme repetoire of the young child is to a great extent developed in the direction of acquiring knowledge about how things look, with schemes for assimilating higher order abstract relations emerging later in development.

Although the levels of processing model has considerably less heuristic value for explaining the deep levels of processing and long-term retention, than does Piaget's model, the latter has some admitted weakness in the areas of shallow processing levels and short term retention. Within the levels of processing perspective there is strong support for some type of "raw" memory which may persist over time without necessarily being processed to "deeper levels". Craik and Lockhart (1972) believe that "Given that we recognize pictures, faces, tunes and voices after long periods of time, it is clear that we have long term memory for relatively literal non-verbal information" (p. 674). While Piaget is generally opposed to the concept of "raw" memory, preferring instead to attribute all "memory in the strict sense" to reconstructive scheme-based processes, he and Inhelder (1973) do hint that the figurative plane of knowledge may possess some functional autonomy. For example, Piaget and Inhelder (1973) state that "...we know of the existence of purely mnemonic schemata[26] (as investigated by F. Bartlett), some of which are spontaneous mnemo-technical procedures. Their relationship with the cognitive schemes still has to be determined by a study on the genetic plane or the plane of mental development in general" (p. 17). In addition, Piaget and Inhelder (1973) state that "Recall in its superior forms relies on memory images

[26] The failure of the translator (or authors) of Memory and Intelligence (1970) to distinguish between schemata (figurative plane representations) and schemes is especially frustrating in this case since the existence of mnemonic schemes have very different implications than mnemonic schemata. Though I have changed schemata to schemes in all other 1973 quotations, I believe that "schemata" does refer to schemata in this one case.

which have a greater mobility and independence and whose links with the schemes of the intelligence continue to pose a problem" (p. 358). Taken together the above two quotations suggest that Piaget and Inhelder are not totally committed to a solely reconstructive model of memory. The existence of "purely mnemonic schemata" which are distinct from "cognitive schemes", for example, suggests some type of information retention to be possible upon the figurative plane (of schemata) without, or perhaps only slightly supported by, operational schemes. Similarly, Piaget's and Inhelder's (1973) statement concerning the reliance of "superior" forms of recall upon "memory images" of great "mobility and independence" again suggests that these authors believe certain memory acts to benefit from "raw"[27] retained schemata[28] or images.

Furth (Furth, Ross, and Youniss, 1974) believes this persistence of "raw" memory to be particularly noticeable in short-term recall situations. Furth et al (1974), in a study which largely verified the results of Piaget's tilted wine decanter experiments, concluded that "...the observed deterioration as well as the improvement in long-term memory can be attributed to ... the interaction between a weakening figurative content -- the traditional memory traces -- and a fluctuating operative understanding in a transitional stage that gradually improves over long time intervals" (p. 70). Furth et al (1974) probably overstated the importance which Piaget and Inhelder place upon "raw" memory traces when they said that

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[27] Two types of "raw" schemata may be the (visual) image and verbal (word) processes suggested by Paivio (1971).

[28] "schemata" are images of all types whereas "images" refers to visual-like images.

"When Piaget ... applied his developmental theory to memory, his intent was to point out that operative understanding frequently makes a contribution to memory performance" (p. 63). Nonetheless the two quotations from Piaget and Inhelder (1973) cited above, do suggest that Furth et al (1974) are at least partially correct in suggesting pure (i.e., nonreconstructive) retention to play a role in memory -- especially when retrieval closely follows presentation. This formulation of short-term (and some aspects of long-term) memory stands in direct contrast to the Piaget model of memory presented in Section B, in which the operative schemes or "memory in the wide sense" reconstruct specific "strict sense memories" with the support of the figurative "display screen". Furth et al (1974) suggest (and Piaget and Inhelder, 1973, hint) that the figurative plane may possess some autonomous (i.e., without operational support) information retention capacities. The lack of explanatory mechanisms for this phenomenon weakens Piaget's and Inhelder's model of memory.

When the inadequacies of information processing explanations for long-term memory and Piagetian explanations for short term memory are considered, these two dominant models of memory do not appear so different from each other. Rather than differing radically with respect to their formulations of information retention, the foregoing discussion instead suggests the difference between these two models to be largely a question of research focus. Piaget and his colleagues have been involved with investigating the build-up of knowledge in the broad sense and in their studies of memory were primarily concerned with the role that this knowledge plays in the reconstruction of information. They have, in other words, focused upon the deeper coding levels; that is the memory which develops and persists over the lifetime of the individual. Information (and more specifically, levels of processing) theorists, on the other hand, have studied (i.e., employed paradigms appropriate to) the ability to retain specific memories over short time intervals. As a consequence each research group has developed a model of informational retention based upon individuals' ability to retain very different types of information (e.g., unrelated word pairs versus understandings about liquid levels in tilted containers). If, however, the remarks of, for example, Kosslyn and Bower (1972), relating to the types of conceptual information that are lost are combined with those of Piaget and Inhelder (1973) and Furth et al (1974) concerning the possibility that specific information may persist in the figurative plane without necessarily being operatively encoded, then the work of these two research groups on memory seem complementary rather than contradictory.

Just as the information-processing perspective provides a fourth, alternative conception to those of Rohwer, Paivio, and Piaget and Inhelder, concerning the nature of memory and the role which images play in information recovery, it also would explain the recall facilitation effect of sentence frames and interacting, as opposed to side-by-side object presentations, in a unique way. The essence of the interaction effect would presumably result from neither interacting images nor semantic overlaps exclusively but rather a combination of these and other coding advantages which, according to the model, accrue to more elaborated (in a visual and semantic sense at a minimum) materials. Interacting objects (versus side-by-side objects) and sentence embedded noun pairs (as opposed to non-embedded pairs) are more "meaningful" in a more than semantic overlap sense and are thus processed to "deeper" levels more rapidly and consequently are better recalled.

CHAPTER 2

Experiments

The primary purpose of Chapter 1 was to outline, in detail, the semantic overlap (e.g. , Rohwer, 1973) and interacting imagery (e.g., Paivio, 1970) interpretations of mnemonic effects in children's associative learning. In addition, the model of memory proposed by Piaget and Inhelder (1973; see also Furth et al., 1974), as well as these authors' ideas about imagery (e.g., Piaget and Inhelder, 1971), were discussed and an attempt was made to relate these views to the semantic overlap versus interacting imagery controversy. Through the course of this presentation, several specific points of conflicting predictions between the semantic and imagery models were highlighted, as well as some Piagetian and other (e.g., Craik and Lockhart, 1972; Kosslyn, 1975; Kosslyn and Bower, 1974) ideas relating to these issues. While an exhaustive examination of all points of conflict between the interactive imagery and semantic elaboration hypotheses was beyond the scope of this dissertation, an experimental analysis of three such points was conducted, and is presented in this chapter. The intent of these experiments was to permit some resolution of conflicting views as to the nature of children's memory.

In Experiment 1 the ability of pre-kindergarten children to benefit from interacting imagery instructions, in a side-by-side object pair learning task, was examined. As outlined in Chapter 1 Paivio contends such training will be of benefit to children of this age while Rohwer has indicated that it will not. Piaget and Inhelder (1971) do not believe the scheme repetoire of the preoperational child to be sufficiently developed to permit the generation of anticipatory images of the type requested by interactive imagery instructions. Wolff and his associates (e.g., Wolff et al., 1972, 1974) have obtained a positive effect of interactive imagery instructions among five year olds if, and only if, in addition to the instructions the children are permitted to hold the two objects of each pair and interact them behind a screen. Wolff interpreted this effect as consistent with an interpretation of Piagetian theory in which motor involvement is seen as a support to image formation. To examine the conflicting predictions of Rohwer and Paivio, as well as Piaget's proposal regarding imagery development and Wolff's extrapolation thereof, Experiment 1 tested the efficacy of a non-motor imagery training procedure with a sample of pre-kindergarten children. Since age is not an entirely reliable indicator of developmental stage, the trained children were subsequently tested with standardized Piagetian tasks in order to determine if, in fact, these children were preoperational.

Experiment 2 (and Experiment 3 which was a partial replication of Experiment 2) examined Rohwer's (1973) claim that linking a noun pair with a verb which implies a central or highly familiar relationship between two items will result in a greater recall improvement relative to no link (among elementary school children) than if the pair is linked by a verb which implies a non-central or less familiar relationship. Such an effect, says Rohwer, will occur because the former case will lead to more effective semantic elaboration than the latter. In contrast, those who attribute the facilitative effect of verb links to interactive imaginal storage (e.g., Paivio, 1970, 1975; Yuille, 1973, 1974) would not anticipate a central link to lead to more effective recall than a non-central link since the former does not surpass the latter as a prompt to imaginal coding. From a Piagetian perspective central links rather than non-central links might be predicted to be more effective since, by virtue of their greater familiarity, they may lead to more effective or full assimilation of the noun pair. If Furth's (i.e., Furth et al., 1974; see also Piaget and Inhelder, 1973, as outlined in Section E of Chapter 1) claim -- that the relative contributions to memory of figurative and operative codes change over time such that the figurative code formed at presentation becomes increasingly unavailable with the passing of time -- is correct then it might also be expected that any central over non-central effect would increase as the retention interval increased since any aid to memory from the figurative code (which should favour neither type of linked pair, according to Piaget) would lessen over time. The above questions were investigated in Experiments 2 and 3 through an examination of cued recall for central versus non-central linked pairs at two different retention intervals.

Experiment 4, using a sample of elementary school children, made a direct examination of Paivio's (e.g., 1970, 1971, 1975) claim that pairs stored as interacting images are more readily recalled than pairs stored as side-by-side images. Noun pairs were linked by prepositions which either described a physical interaction of the two referents or indicated that they were spatially separated. If the implied spatial relationship is manipulated independently of the semantic relationship then no effect of preposition type would be anticipated from Rohwer's (1973) perspective.

An instructional condition which prompted half of the children to "picture" what each sentence described also was included to examine whether mode-specific coding, as reflected in a greater differential effect of preposition type, could be increased. Because assimilation should not be differentially affected by preposition type no changes in link effect as a function of the length of the retention interval would be anticipated from Piagetian theory. These conflicting predictions were examined in Experiment 4 through an examination of cued recall for pairs linked by interaction-suggesting versus non-interaction-suggesting prepositions at two post-presentation intervals.

Experiment 1

The purpose of Experiment 1 was to see if children demonstrated to be in the preoperational stage of development (according to Piagetian theory) could benefit from instructions and (non-motor) training in the formation of interacting images. A positive training effect among such children would be inconsistent with the claims of Rohwer and also Wolff, though not with Paivio, and also might contradict Piaget's claim that preoperational children are incapable of generating anticipatory images. A negative training effect, on the other hand, would support the aforementioned theories and require a modification of Paivio's view concerning the age at which imagery instructions will be effective.

The children selected for study were three to five year olds enrolled in daycare centers. To ensure that they were still at the preoperational level of cognitive development, the children given imagery training were administered standard tests employed by Piaget. The effects of the imagery training were evaluated by including two comparison groups, one which learned object pairs presented in a side-by-side fashion and a second group that were shown pairs in some interaction. The side-by-side uninstructed group was expected to show a relatively poor level of performance while the uninstructed group receiving interacting pairs should have performed better reflecting the facilitating effect of interactions (e.g., Danner and Taylor, 1973; Rohwer, 1967; Rohwer et al., 1967; Yuille and Catchpole, 1973, 1974). A comparison of the instructed group, who received pairs in a side-by-side arrangement, with these two groups should reveal whether instructions are ineffective with preoperational children (i.e., their performance would equal the side-by-side uninstructed children) or if instructions and training are as effective as presenting interacting pairs. In order to enhance the sensitivity of the design, the comparison of trained with untrained side-by-side presentation was conducted both within and between subjects. That is, two groups received side-by-side uninstructed presentation of pairs. One week later, one group received imagery training before learning the pairs. A third group was given an interacting presentation during both testing sessions.

Method

Subjects

Twenty- four boys and twenty-four girls were recruited from five Vancouver day-care centers to serve in the experiment. These children ranged in age from three years and three months (3-3) to five years and one month (5-1). The mean age was 4-3. Approximately equal numbers of boys and girls were tested in each condition and children from a particular center were distributed as evenly as possible among the three groups. Otherwise assignment of the children was randomly determined, using center records, prior to meeting the children.

Design

Each child was presented with a set of object pairs and administered a cued recognition test for these items (Test 1). One week later he/she was presented with a new set of object pairs and tested for cued recognition of these items (Test 2). Roughly one-half of the children were presented with one set of pairs (e.g., Set 1) at Test 1 and the other (i.e., Set 2) at Test 2; the remaining children studied Set 2 at Test 1 and Set 1 at Test 2. The three experimental conditions were as follows: for approximately one-third of the children (Group 1) each of the object pairs was presented in a side-by-side fashion for both Test 1 and Test 2; for the second one-third (Group 2) the two items of each pair were physically interacting at both Test 1 and Test 2; the remaining children (Group 3) were given a side-by-side type of presentation at Tests 1 and 2 (as was Group 1) as well as imagery training (i.e., instruction and practice in the generation of mental interactions) immediately prior to the Test 2 presentation. This design permitted a comparison of side-by-side and interacting presentations at Test 1 and a comparison of side-by-side, interacting, and side-by-side plus imagery training presentations at Test 2. The design also allowed a comparison of potential memory improvement as a result of the training since each child was used as his/her own control. The design for Experiment 1 is provided in Table 1.

As many Group 3 children as were available two weeks following the completion of the Test 2 session were included in a follow-up study

Table 1

Design of Experiment 1

	Test 1 (Week 1)	Test 2 (Week 2)
Group 1	side-by-side presentation of each pair (no special instruction) and cued recognition	side-by-side presentation of each pair (no special instruction) and cued recognition
Group 2	interacting presentation of each pair (no special instruction) and cued recognition	interacting presentation of each pair (no special instruction) and cued recognition
Group 3	side-by-side presentation of each pair (no special instruction) and cued recognition	side-by-side presentation of each pair (imagery training) and cued recognition

* Roughly one-quarter of the children in each Group at Test 1 studied under each combination of the Experimenter and Set variables. At Week 2 the children were tested by the other Experimenter who used the opposite set.

** As many Group 3 children as were available two weeks following Test 2 were administered the Piagetian tasks.

designed to determine their stage of development according to standard Piagetian tasks.

Materials

The names of the experimental materials are provided in Appendix A, Table 1. The materials consisted of 68 small objects and toys familiar to children. These objects were randomly arranged to form 34 pairs with the restriction that closely related items (e.g., Pencil-Eraser) were not accepted. From these 34 pairs two separate sets of 17 pairs each were generated. Two pairs of each set were used in the explanation of the paired associate procedure, five were used as practice (Groups 1 and 2 -- Test 1 and 2, Group 3 -- Test 1) or training (Group 3 -- Test 2) pairs, while the remaining ten pairs served as the learning set materials.

The materials used for the follow-up study (see also Inhelder, Sinclair, and Bovet, 1974) consisted of ten red and ten blue counting chips (used in the elementary number conservation task) and 24 geometrical shapes cut out of cardboard. The shapes were as follows: three red and three blue small circles (diameter, 25 mm.), three red and three blue large circles (diameter, 50 mm.), and three red and three blue small squares (25 mm. sides), and three red and three blue large squares (50 mm. sides). Two small flat boxes were used to store the sorted items.

Procedure

Each child was tested individually in a small room or quiet area of the daycare center. Each testing session involved five stages. First, the experimenter introduced him/herself to the child, asked the child his/her name and age (names and age were checked in the centers' files), and engaged the child in a short conversation in order to generate a relaxed testing atmosphere. This familiarization period helped to establish a rapport with each child, though at the experimenter's discretion several children were excluded at this stage of the experiment due to sleepiness, emotional upset, etcetera. Next the children were shown the two paired associate practice pairs (one at a time in a side-by-side fashion) and were instructed to remember that the two pair members "go together". For all pairs presented in the experiment the child was told that "the ______ goes with the ______". Following presentation of the two practice pairs, the second item from each pair (which was on the child's left) was placed in front of each child to form a recognition set. The other objects from each pair were then displayed, one at a time, and the child indicated the object from the recognition set that went with each one. Those who failed to correctly re-pair these items were given additional presentations and testings to a maximum of three trials. Children who were unable to perform the practice cued recognition correctly after three trials were dropped from the experiment. Stage 3 of a testing session involved presenting the five practice (training) pairs one at a time in a side-by-side manner. Each practice pair was presented for approximately 15 seconds, and the children were told that these practice pairs were similar to the types of pairs to follow in the actual learning set presentation. However, in addition, those children in Group 3, during Test 2, were instructed in the formation of interacting images as follows: a training pair was placed in front of the child and he/she was asked to "think of a picture of the two things playing together; think of how they would go together; how could these two things play together -- think of a picture of that". If the child stated an interaction of the items the experimenter performed it, if not then the experimenter stated and performed a simple interaction. For the last three training pairs the children were strongly encouraged to name an interaction of pair members. All interactions were performed by the experimenter and at no time was a child allowed to touch the toys. Because of the unrelatedness of the two members of each pair the child-suggested and/or experimenter-performed interactions of the training pairs were such that one item was either on top of, around, or partially inside the other item, with "on" being the most frequent relationship (e.g., "The Bell could go on the Matches, The Dice could go on the Penny, The Stapler could go on the T.V."). The lack of motor involvement with the instructional pairs, on the part of the children, made the current imagery training procedure distinct from four motor imagery training procedures found successful by Varley et al., (1974) (with six year olds),however, the current encouragement to the children to think of an interaction for all pairs, plus the providing of an interaction for every pair, made the current procedure somewhat more explicit than the imagery (training) control procedure of Varley et al. (1974), which was not as successful as motor imagery (training)among six year olds. However, since Varley et al.(1974) did not include a no training control condition it is impossible to determine if their non-motor control condition was a failure or only less successful than the more explicit motor imagery training procedures. Upon completing the practice pairs, each child received ten learning set pairs for 15 seconds each. Groups 1 and 3 children saw each pair in a side-by-side fashion while Group 2 studied interacting pairs. Finally, following the learning set presentation, the second object from each pair was displayed in a ten item recognition set in front of the child. The remaining items were then presented to the child one at a time for a maximum of 20 seconds and he/she was asked to place that item with its partner. The order of items presented for cued recognition was randomized relative to presentation order with the restriction that the first and last items in the presentation set appeared in neither of these positions in the cued recognition test.

The procedure for the follow-up study of the Group 3 children was taken directly from Inhelder et al. (1974, pp. 275-277, 290-291). Each child was tested on two Piagetian tasks: elementary number conservation and a different criteria sorting task. All follow-up testing was conducted by the original female experimenter. The specifics of the Piagetian tasks are provided in Appendix A, Table 2.

Results

An initial analysis of variance (see Appendix B, Table 1) including Set Order (Set 1 then Set 2 *vs* Set 2 then 1) and Experimenter Order (Experimenter 1 then 2 *vs* Experimenter 2 then 1) as independent variables revealed no significant main effects to be associated with these factors, nor were they involved in any significant interaction involving the Group variable. Therefore the results were collapsed over Set Order and Experimenter Order resulting in a 3x2 (Group x Test) between-within factorial containing a minimum of 14 children per Group. The results of the analysis of variance performed with this design are provided in Appendix B, Table 2, and the mean performance and standard deviation in each condition is presented in Table 2.

Both Group, $F(2,45) = 11.05$, $p < .001$, and Test, $F(1,45) = 8.37$, $p < .01$, were associated with significant main effects. Of greater

Table 2

Mean Number of Items Correctly Recognized

(max. = 10) in Each Group x Time Cell

of Experiment 1

	Test 1 (Week 1)			Test 2 (Week 2)		
	Condition	Mean	S.D.	Condition	Mean	S.D.
Group 1 (n = 15)	side-by-side (no training)	3.07	(2.55)	side-by-side (no training)	3.27	(2.05)
Group 2 (n = 14)	interacting (no training)	6.86	(2.21)	interacting (no training)	6.79	(2.19)
Group 3 (n = 19)	side-by-side (no training)	3.05	(2.30)	side-by-side (imagery training)	6.26	(3.19)

interest, however, was a significant interaction, $F(2,45) = 8.14$, $p < .01$, of Group and Test. Post hoc tests for simple main effects (see Appendix B, Table 3) showed that only the performance of the Group 3 children changed from Test 1 to Test 2, $F(1,45) = 22.33$, $p < .01$. No practice effect for the paired associate task was found for either Group 1, $F(1,45) = 0.09$, $p > .10$, or Group 2, $F(1,45) = 0.01$, $p > .10$, such that these children's performance remained unchanged over the two sessions. The significant improvement as a result of imagery instructions in Group 3 represented the first demonstration of the effects of mnemonic instruction in children as a within subject variable.

The comparisons among groups at Test 1 indicated the facilitating effect of presenting pairs in an interaction, $F(2,45) = 11.61$, $p < .01$. Pair-wise comparisons using the Tukey procedure (see Appendix B, Table 4) showed that Group 2 children (interactive presentation) performed better than Group 1 children ($p < .01$) and Group 3 ($p < .01$). The latter two side-by-side conditions did not differ significantly. At Test 2, the performance of Group 3 children had improved to the extent that they equalled the recognition performance of Group 2. Both Groups 2 and 3 significantly exceeded Group 1 ($p < .01$). This latter outcome is the same as that reported by Yuille and Catchpole (1973). That is, the effect of imagery training was found to be equal to the effect of presenting pairs in interactions. Obtaining this same pattern with the present young sample of children extends the generality of the finding, and places in doubt the assertions of: (1) Rohwer (1973), that preoperational children are too static in their thinking to generate (memory facilitating) semantic overlaps, and (2) Wolff et al. (e.g., 1974), that preoperational children lack anticipatory and/or active imagery abilities and therefore can not benefit from imagery training, unless motor support is provided. More directly, these results also appear contradictory with the delineation of the imagery abilities of the preoperational child outlined by Piaget and Inhelder (1971). That is, if the observed high performance of Group 3 children at Test 2 does indeed depend upon the formation of a mental image of the two items interacting in some fashion (similar to the interaction provided to Group 2) then such a cognitive act would at the least involve the anticipation of the end-state of an interactive process and perhaps also some type of kinetic-transformational imagery. Piaget and Inhelder (1971) are clear in their assertion that the degree of anticipation involved in the latter two types of imaging makes them unavailable to the preoperational child.

The final aspect of the analysis was the examination of the relationship of performance to the developmental level of the children. First a median split with respect to age was made and the Group x Time analysis was repeated with age as a factor (see Appendix B, Table 5). The mean age of the below median age children was 3-10, and the mean age of the above median children was 4-10. Neither the main effect of age, $\underline{F}(1,42) = 2.07$, $\underline{p} > .10$, nor any interactions involving age, $\underline{F}$'s < 1.68, $\underline{p} > .10$ were significant.

More directly to the issue of developmental level were the results of the Piagetian classification tasks given to the Group 3 children. These results were based on only eight of the nineteen children originally tested in this group. The Piagetian tasks were given two weeks after completion of the original testing, and illness, combined with the transient nature of day-care populations, substantially reduced the sample. However, an analysis of variance comparing the recognition scores of those Group 3 children given the Piagetian tasks with those who did not receive the subsequent testing revealed no significant differences (see Appendix B, Table 6). That is, the main effect of inclusion versus non-inclusion was not significant, $F(1,17) = 0.88$, $p > .10$, nor did this factor interact with time of test, $F(1,17) = 1.10$, $p > .10$. The results for the eight children are summarized in Table 3.

Five of the eight children were categorized at an intermediate or transitional stage of Conservation on the basis of the Elementary Number Conservation Task (Task 1). One child was clearly displaying Conservation, and two were functioning at a Non-Conservation level. For the Different Criteria Sorting Task (Task 2), the youngest child was found to be functioning at the earliest level (figural collections level), showing haphazard sorting and lack of knowledge of the names of the shapes. Four of the remaining children showed simple attempts at sorting, while the other three spontaneously used criteria. Thus one child (age 4-9) was clearly at the level of concrete operations, and this child showed <u>no</u> benefit of imagery training. Two children (ages 4-5 and 4-6) appeared to be in the late stage of transition, and they both showed improvement from instructions. The remaining five children were preoperational: two of them showed improvement after imagery training, and three showed no effect. No systematic relationships between level of development and benefit from imagery training appeared in these findings.

Table 3

Age, Piagetian Task Performance, and Cued Recognition Scores for the Follow-up Children

Subject	Age	Piagetian Task: Task 1	Piagetian Task: Task 2	Cued Recognition: Test 1 side-by-side	Cued Recognition: Test 2 side-by-side plus training
1	4-9	At conservation level	Sorting according to several criteria	4	4
2	4-5	Intermediate	Sorting according to several criteria	3	10
3	4-6	Intermediate	Sorting according to several criteria	8	10
4	5-1	Intermediate	First attempts at sorting, early level	3	3
5	3-9	Nonconservation level	First attempts at sorting, early level	0	7
6	3-10	Early Intermediate level	First attempts at sorting	3	1
7	3-9	Intermediate	First attempts at sorting	1	6
8	3-3	Nonconservation level	Figural collections	1	1

Discussion

The positive effect of an interaction presentation among preschool children supported the results of previous research (e.g., Danner and Taylor, 1973; Rohwer, 1967; Rohwer et al., 1967; Yuille and Catchpole, 1973, 1974) and was consistent with the expectations derived from the theoretical approaches outlined in the Introduction. That is, this effect was consistent with Rohwer's (e.g., 1973) claim that experimenter-supplied interactions, by virtue of their maximal explictness, can prompt semantic elaboration even among preschool children, and also with Paivio's (e.g., 1970) contention that such children can store provided interactions as (memory facilitating) interacting images. Furthermore, this result was consistent with the two Piagetian-based compromise positions outlined in Sections B and E of Chapter 1 in which either: (1) interacting pairs, by virtue of their richer meaning relative to side-by-side pairs (in a Gestalt-like sense where the whole is greater than the sum of the parts) are more widely assimilated to schemes and hence can be more readily reconstructed from the operative code; or (2) because the interacting pairs are more widely assimilated (due to their greater meaning or relevance to the child's schemes of understanding) the child-generated image of an interacting pair is more "supported" and hence persists longer as an image than does a less operationally supported image of a side-by-side pair. In either case, from the Piagetian perspective, the positive effect of the experimenter-supplied interactions must be attributed to the operative code since Piaget makes no predictions regarding the superiority of one figurative construction (i.e., an interacting image) over another (i.e., a side-by-side image). In other words, the superior memory for the interacting relative to the side-by-side pairs argues against the existence of a "figurative only" type of memory which mediates short term retrieval since no interacting over side-by-side effect would be anticipated were this the case.

While the positive effect of interactions was consistent with all theoretical positions, the success of the imagery training procedure was not. First, this effect contradicts Rohwer's (1973) statement that explicit prompts to semantic elaboration (e.g., imagery training) will not become effective until age seven, or specifically at the onset of the concrete operational period. The obtained positive effect of training offers evidence against this feature of the semantic elaboration hypothesis. Second, since the current training procedure afforded no opportunity for motor involvement, Wolff's (e.g., Wolff and Levin, 1972; Wolff et al., 1972, 1974) assertion that such involvement is necessary for imagery training to be effective, and the interpretation of Piagetian theory upon which this assertion is based, was not supported.

Wolff and his associates have failed to obtain a positive effect of imagery training among preschool children unless, in addition to the instruction, the children were allowed to hold the two objects of each learning set pair and interact them behind a screen while attempting to image the interaction. Wolff interpreted these results as being consistent with his interpretation of remarks by Piaget (1962) concerning the sensori-motor roots of the image. That is, Wolff believes motor involvement is prerequisite to successful imagery training among preoperational children. While the aforementioned studies support Wolff's view, the current experiment, as well as two others, do not.

Danner and Taylor (1973) obtained a positive effect of imagery training among six year olds if the children were given the pretraining in the drawing of interacting pictures of separated objects. Since the drawing was merely part of the imagery training instructions, and no drawing of the learning set items was permitted, it seems questionable to cite a motor involvement as the key to the improved memory for the learning set pairs. A second study which also seems inconsistent with a motor prerequisite position was conducted by Varley et al. (1974) though, in fact, these authors interpreted their results as supporting Wolff's position. Varley et al. (1974) found that allowing five year olds to hold and interact the imagery training practice pairs (or to draw interactions) gave better memory for the learning set items than imagery training with no motor involvement (no untrained control condition, with which to compare the non-motor imagery training, was included). As was the case in the Danner and Taylor (1973) study, the fact that no motor support was provided to the formation of interacting images of the learning set items places in doubt Wolff's claim that motor support is prerequisite to effective imagery training among preoperational children.

Aside from the inconsistency of the current and other (i.e., Danner and Taylor, 1973 and Varley et al., 1974) studies with the motor support interpretation, this idea also seems weak on purely theoretical grounds. As was outlined in Chapter 1 (pps. 26-28) Piaget and Inhelder (1971, 1973) believe the image to arise from an act of pure accomodation, or imitation, which has its beginning in the sensori-motor period. However, sensori-motor imitations (i.e., the application of sensori-motor schemes to particular objects) do not lead to images -- imitation leads to images and it is in this sense that Piaget believes images to have their roots in the sensori-motor period. The imitations (i.e., accomodations to a particular object) of the preoperational child do not require or benefit from an external sensori-motor action, rather the preoperational imitations are an internal abstract cognitive process in which the act of applying relevant schemes to (i.e., thinking about) a particular object leads to the generation of a particular schema or image. Thus sensori-motor imitations lead to image formation only in the indirect sense that the accomodations of the interiorized schemes (some of which were previously sensori-motor) of the preoperational child are supposed to be analogous to the external accomodations of the sensori-motor schemes. Since sensori-motor accomodations do not lead to images Wolff's belief that Piaget says they support image formation seems inappropriate. In fact, Piaget and Inhelder (1971) state that anticipatory imagery of a static, kinetic, or transformational type is unavailable to the preoperational child and these authors make no mention of motor involvement as a means of overcoming this cognitive limitation.

The aforementioned theoretical and experimentally-based problems with Wolff's position, plus the currently obtained positive imagery training effect -- in the absence of motor involvement with either the learning set or training pairs -- suggests that motor involvement is not the critical feature of successful imagery training among preoperational children. A more parsimonious interpretation of these effects would be simply that the key to successful imagery training among young children is a particularly clear explanation of what the child is supposed to do, through examples as well as instruction. In the Danner and Taylor (1973) and Varley et al. (1974) studies, for example, the various training conditions may have been effective because of the explicitness of the instructions -- ensured by having the children physically interact, or draw interactions of, the training pairs. The positive training effect obtained in the current study can also be seen as reflecting the effects of particularly clear instructions, possibly because of the employment of a within subject design. That is, Test 1 for the imagery training group may have served to clarify the paired associate procedure for these children such that at Test 2 they were able to concentrate upon the imagery training instructions without also having to learn how to perform a paired associate task. Thus it is proposed that an especially clear explanation of the process of interacting image formation, rather than motor involvement, is the key to successful imagery training among pre-kindergarten children. Whether these children are preoperational or concrete operational bears little or no relation to the potential success of such training.

The problem with abandoning Wolff's motor support interpretation of the successes of imagery training among preschool (and currently preoperational) children is that these results apparently now are placed more squarely in opposition to Piagetian theory. That is, contrary to the conclusions of Piaget and Inhelder (1971), preoperational children appear to possess the skills necessary to generate a compound visual image representing anticipated and generally unfamiliar interactions of objects. The present results do not reveal whether the image anticipates just the end-product of the interaction or if a more kinetic variety of image is involved in which the two objects are "moved" together. However, Marmor

(1975), using a mental rotation task, has found evidence of kinetic imagery among preoperational children. Whether the images are kinetic or static, according to Piaget and Inhelder (1971), any type of image which involves more than a slight degree of anticipation is unavailable to the preoperational child, and the current image generation demands placed upon the training subjects clearly fall outside of this category. Indeed Piaget and Inhelder (1971) contend that even the formation of images of not-currently-visible familiar objects (i.e., the so-called Reproductive Static II images) is, by virtue of the ancitipation involved, difficult for the preoperational child. Thus the currently obtained results contradict the expectations of Piaget's and Inhelder's (1971) model and instead suggest, in agreement with Paivio (e.g., 1970), that a quite flexible imagery system is available in service of the memory of the young child.

One interpretation of the consequences of these findings is that Piaget had been incorrect concerning the ontogeny of cognitive development from the preoperational to concrete operational period. Thus, in spite of a child displaying a lack of concrete operations with respect to classification and conservation tasks, he/she does have the requisite organization of operative schemes to permit the generation of figurative representations (i.e., interacting visual images) of anticipated interactions of objects through anticipatory static and possibly kinetic imagery. While there exists no finding in the current experiment to contradict this conclusion, it appears highly tenuous in relation to the volume of evidence from which Piaget's theory emerged. That is, it appears most premature to propose a major modification in the process of cognitive development, proposed by Piaget, on the basis of a few experiments. Consequently, this possibility is explored no further pending subsequent research and instead an interpretation of Piagetian theory which can be seen as consistent with the current experimental results is discussed.

As was noted earlier (see the interpretation of Piaget's theory of memory as outlined in Section E of Chapter 1), Furth et al. (1974) obtained evidence that late preoperational children were capable of accurately drawing a tilted glass of water (and particularly the slanting top of the liquid for which relevant assimilatory schemes were not thought to be available) a few minutes after removal of the stimulus. A week later, however, the top of the liquid was drawn incorrectly, parallel to the top of the decanter. Furth et al. (1974) attributed this effect to "...the interaction between a weakening figurative content -- the traditional memory trace -- and a fluctuating operative understanding in a transient stage..." (p. 70). Thus, according to the interpretation of Piaget offered by Furth et al. (1974) figurative constructions can occur given some relevant rudimentary operative understanding, though such constructions (e.g., images) will not persist. Nonetheless, during the period of image persistence, an accurate memory is available. Though it also could be argued that this result reflects a total figurative autonomy (i.e., image formation independent of operative support) in certain types of situations, an additional result of Furth et al. (1974) in which it was found that younger children could not even copy the tilted decanter correctly suggests, consistent with Piaget's ideas, that a certain limited level of operative development is prerequisite for figurative constructions, such as a perception or image. In other words, in the Furth et al. (1974) experiment, though the application of the rudimentary fluctuating schemes relevant to the assimilation of the display was sufficient to result in the generation of an accurate image, these schemes were unable to fully assimilate the stimulus to the operative code, hence when the perceptual image faded the assimilations which had been made to the operative schemes in the presence of the stimulus were insufficient to permit subsequent accurate reconstruction of this display as either a memory image or drawing.

Just as memory for static scenes over the short term may depend heavily upon a figurative image, Furth et al. (1974) also proposed figurative-in-advance-of-operative development to be relevant to memory for movement: "...a child can conceivably copy from a picture and even draw from memory the somersault of a falling stick without the corresponding understanding of the spatial transformation. In this case we speak of figurative knowledge that goes beyond operative understanding" (p. 63, see also Furth, 1969, pp. 149-154). Though the current experiment deals not so much with the reproductive static and reproductive kinetic types of imagery investigated by Furth et al. (1974) the interpretational precedent set by these authors seems directly applicable to the current experiment in as much as the otherwise anomalous (in terms of Piagetian theory) obtained success of imagery training may reflect a similar figurative-in-advance-of-operative effect within an anticipatory imagery situation. That is, though operational structures relevant to anticipatory figurative constructions are not fully realized until the attainment of concrete operations, sufficient rudiments of such structures are available to allow the generation of anticipated interacting images upon the figurative plane. Since, in the current case, the operative weakness lies in the formation of the image, not in the assimilation of its features, as was the case with the tilted decanter, there is no reason why the image, once formed, should not then be widely assimilable (as were the interacting pairs) and hence more readily remembered than a side-by-side pair.

Experiment 2

The primary purpose of Experiment 2 was to compare elementary school children's memory for noun pairs linked by verbs which suggest a central relation (i.e., highly familiar) with memory for non-centrally (i.e., less familiar) linked pairs. Rohwer (1973) contends that the former will lead to more effective semantic elaboration (and hence improved memory) relative to the latter. However, from an interacting imagery perspective (e.g., Paivio, 1970, 1975; Yuille, 1973, 1974), no difference is anticipated. The possibility that the facilitation of central over non-central links would be relatively greater when recall is delayed -- which would be supportive of the current extrapolation of Furth's (i.e., Furth et al., 1974) interpretation of Piaget's and Inhelder's (1973) model of memory -- also was examined, through a manipulation of the retention interval.

The children who participated in the experiment were from Grades Two and Four. Two age groups were selected in order to test for possible developmental interactions with the variables of current interest. To examine the effects of link centrality upon second noun recall, children were presented with a list of twelve noun pairs linked by verbs. Six pairs were linked by verbs which implied a central relationship between pair members and six were connected by non-central verb links. A second version of this list, studied by a second group of children, contained the same set of noun pairs (in the same order), however those pairs linked by central verbs in the first list were now non-centrally linked, while previously non-centrally linked pairs were linked by verbs which implied a central relationship between the two items. By controlling for list, any differential effects of link centrality upon second noun recall could be determined.

While children's memory for verb-linked noun pairs generally has been found to surpass their recall for unlinked pairs (e.g., Davidson and Adams, 1970; Holyoak et al., 1972; Rohwer, 1966; Rohwer et al., 1967) some researchers have obtained equal performance in these two conditions (e.g., Davidson et al, 1970; Levin, 1970a; Levin et al., 1971; Yuille and Pritchard, 1969). To examine whether linking verbs were facilitative in the current instance a control group, who studied the same set of pairs minus the links, also was included.

The test for centrality effects at different retention intervals was examined by having one-half of the children in each of the above conditions recall immediately following presentation, while the remaining children recalled the pairs for the first time two days later. A stronger centrality effect in postponed than in immediate recall would reflect the relatively greater dependence of long term retention on operative reconstructions. Since it was possible that the long term effect of centrality might be affected by an immediate recall test, it was decided to retest the children in the immediate recall condition, two days later. Inclusion of this condition also permitted a within subject investigation of potential changes in second noun recall, as a function of retention interval.

Following the two day delayed recall test, all children who studied linked pairs were presented with the two nouns of each pair, one pair at a time, and were asked to recall the original verb. This test provided some evidence concerning the relationship between noun and link retention.

Finally, all of the Grade Four children were retested for their memory of the original pairs two weeks following the two days delayed test. The Grade Twos were excluded from this condition since a "floor effect" was anticipated. Though confounded by differences in initial learning and number of previous recall tests, as well as the test for verb recall, these data may bear on the question of centrality effects over time.

Method

Subjects

Fifty-six Grade Two and 49 Grade Four children from a Vancouver school serving a lower to lower-middle class neighbourhood participated in the experiment. Advance consultation with homeroom teachers pinpointed thirteen students who were deemed to have language and/or learning problems that would impair their performance on the task. The data of these children, as well as four others who failed to learn the practice pairs after four trials, were not included in the analysis of the results. This resulted in a reduction of the sample to 47 Grade Twos and 41 Grade Fours. The mean ages of the children in the two grades were 7-10 and

9-10. Approximately equal numbers of males and females were tested in each group. As is the case in most Vancouver schools, about one-half of the children spoke a language other than English when at home.

Materials

The names of 32 things or animals familiar to children were formed into 16 pairs. Two of these pairs (i.e., Button-Elastic and Ashtray-Magazine) were used as examples of and practice for the learning set items. For those children studying linked pairs these items were embedded in the sentences "The Knife cuts the Cheese" and "The Lamp holds down the Magazine". The first sentence was designed to represent a Central or familiar relation between the items, while the second sentence represented a less familiar or Non-Central relationship. These sentences were constructed so as to mirror the two types of learning set sentences to follow. The remaining 12 pairs were formed into three identical lists (see Appendix A, Table 3 for the learning set items). The pairs were in the same order in each list. Those pairs in one list (Unlinked list) remained in unlinked form while the pairs in the other two lists (1 and 2) were embedded in short verb-linked sentence frames. For these sentences the first noun became the subject of the sentence and the second noun the object. The two linked lists were constructed such that half of the pairs were linked by a verb which suggested the first item to be performing some highly familiar or common action upon the second item (condition Central) while for the remaining six pairs the verb link suggested that the first item was performing a relatively less common or less familiar action upon the second item (condition Non-Central).

Lists 1 and 2 were arranged so that pairs linked by a Central relationship in List 1 were Non-Centrally linked in List 2, and vice versa. Only one presentation order was employed in the experiment and it was randomly generated with the restriction that the centrality of the relationship in List 1, and hence in List 2, was changed at least every two pairs (see Appendix A, Table 3). Two recall orders were generated, randomly, with two restrictions: the first two and last two items in the presentation order did not appear in any of these four positions in either recall order; and one level of the Centrality variable did not occur more than twice in a row. A random order of the pairs for testing link recall as well as a third cued recall order for the Two Week test, also were generated.

Design

Keeping in mind the experimental hypotheses, as well as the need for randomization and appropriate control groups, the following conditions were included in the experimental design. Approximately half of the sample was administered a cued recall test for the original pairs immediately following presentation (condition Immediate) and again two days later (condition Two Day Retest). The rest were tested for the first time after a two day delay (condition Two Day Postponed). Two recall orders were employed -- about half of the Immediate and half of the Two Day Postponed children were presented with one order and half with the other. In the Two Day Retest condition the children were presented with the opposite recall order to that with which they had been tested initially. Roughly half of the children in each of the Time of Recall x Order cells of the design were in Grade 2, the remainder were Grade 4 students. All Grade 4's were retested for their memory of the pairs two weeks following their two day delayed test (condition Two Week). While a majority of the children in each of the aforementioned conditions were presented with linked pairs at learning (condition Linked), approximately one-third studied the same pairs minus the links (condition Unlinked). Immediately following the two day delayed second noun recall test, all of the children in the Linked condition were tested for their recall of the original verbs (condition Verb recall). Among those children who studied linked pairs roughly one-half in each condition studied List 1, while the remainder studied List 2. In List 1 six pairs were linked by Central verbs and six pairs were linked by Non-Central verbs. The same was true for List 2 except that the centrality of the verb which linked each pair was reversed.

Procedure

All children were tested by a male experimenter and, with the exception of the Two Week test, all children were tested individually in a small storage room in the testing school. The Grade 2 students were drawn from five separate classes. One class was Grade 2 only and the rest also included children from Grades 1 and/or 3. The Grade 4 sample was drawn from a class of Grade 4's only, and from a class of Grades 4 and 5. Except for the Two Week test all Grade 4's were tested prior to the Grade 2 testing. All of the children within a single class were tested prior to the participation of another class. The children were tested roughly in an alphabetical order (some children were temporarily absent from their classroom but available later). One child was included in each presentation condition prior to the inclusion of a second child. An identical procedure was employed for the two day delayed test. All testing, with the exception of the Two Week recall (which due to group testing was accomplished in a single morning) was conducted Monday to Thursday over two weeks.

Seated across the table from each other in the testing room, the experimenter and child engaged in a brief conversation during which the child's name and age were determined. Then he/she was read the experimental instructions appropriate to his/her condition (see Appendix A, Table 4). These instructions began with a brief explanation of paired associate learning and cued recall and were followed by the presentation of two practice pairs. All instructions and materials were read aloud by the experimenter. Immediately following presentation of the practice pairs each child was tested for cued recall of these items. Children who made a mistake were given additional learning and recall trials to a maximum of four. Next, children in the Unlinked condition were presented with two more practice pairs and tested for cued recall. Children in the Linked condition were presented with these same pairs, embedded in sentence frames and were tested for their memory for the pairs. All 89 of those children who learned the first set of practice pairs within the four trial criterion, successfully learned the second set within the four trials.

The learning set instructions then were read to each child. In order to ensure that they would be unaware as to when they were to recall the learning set pairs, the children were informed only that recall would occur "some time later". The learning set pairs (or sentences) were presented at the rate of one pair every ten seconds. The children were requested not to speak during presentation. Reading of each pair was slow and distinct and occupied roughly four seconds of the ten second presentation interval. Following learning set presentation, the children in the Two Day Postponed condition were informed that recall testing would take place "in a couple of days" and were asked not to "think about or worry about" the pairs. The children also were instructed not to discuss the materials with their classmates.

The children in the Immediate condition were tested for cued recall beginning about 15 seconds after the final pair was presented. Roughly half of these children recalled the pairs in Order 1, the remainder in Order 2. Each child was provided with a maximum of 20 seconds to recall each second noun. If a response was made within this interval then the experimenter proceeded to the next item. After testing, the children were told that their memory for the pairs would be retested "in a couple of days".

Two days following the initial presentation, the children were recalled to the testing room one at a time. A cued recall test then was administered. Half of the Two Day Postponed children were presented with Order 1 and the remainder with Order 2. The Two Day Retest children received the opposite recall order to their original test. The procedure for these tests was the same as in the Immediate noun recall test.

Following this delayed test for noun recall, the children in the Unlinked condition were returned to their classroom. The children in the Linked condition were presented with the two nouns of each pair (in a random order) and asked to supply the original verb. The procedure for the Verb recall test was the same as for noun recall.

The Two Week recall scores were obtained in a single morning, 13 (or 14) days after the delayed recall test of the Grade Four children. None of the children, nor their teacher, had been forewarned of the experimenter's return. To prevent further disruption to the testing school, group testing, in each of the two Grade 4 homerooms, was used to gather the Two Week data. With the aid of the homeroom teacher, strict control was maintained during this test in order that the children not influence one another's performance. Each child was provided with an answer sheet which was numbered 1-12 with a blank beside each number. The first noun of each pair then was read aloud, by the experimenter, at the rate of one noun every 20 seconds. Several times the students were reminded of the appropriate number beside which to write their answer. The answer sheets then were collected.

Results

A. Scoring Citeria and Method of Analysis: In order to ensure a fine analysis of the data, both a loose and a strict criterion were employed to score the noun recall results. Only exactly correct responses, or a plural form, were accepted under the strict criterion. For the loose criterion, all reasonably close synonyms also were counted as correct providing that they did not appear elsewhere in the experiment. A list of synonyms accepted under the loose criterion, as well as their frequency of occurrence, is provided in Appendix A, Table 5. In only those few cases where the analyses of the two criteria did not yield an identical pattern of effects, are the results of the strict criterion presented. However, the outcome obtained with both criteria are provided in Appendix B.

The analysis of the data proceeded in four stages. First, the effects of Links versus No Links was examined at the various retention intervals. Second an examination of link Centrality, and potential interactions with Time of Recall, was conducted. Third, an analysis was made of the Verb recall results. The final analysis was of the Centrality effect among the Two Week scores.

B. Recall of Linked versus Unlinked Pairs at Various Retention Intervals: Second noun recall performance in the Linked versus Unlinked conditions was examined by collapsing the scores of the children in the former group over the within subject Centrality variable. List, therefore, was not a factor in this analysis. Three separate analyses were conducted. The first was a comparison of Links versus No Links in the Immediate versus Two Day Postponed conditions. Second, an analysis was made of percent loss from the Immediate condition to the Two Day Retest. Third, performance in the Linked versus Unlinked conditions was examined among the Two Week scores. These latter results are difficult to interpret because the different groups were not equated for initial learning and because only the children in the Linked condition were tested for Verb recall.

a) Linked versus Unlinked Recall in the Immediate versus Two Day Postponed Conditions.

The first analysis involved an examination of the effect of Linked versus Unlinked pairs in the Immediate versus Two Day Postponed conditions (see Table 4 for the mean recall and standard deviation in each of the conditions). Grade and Recall Order also were included as independent variables resulting in a 2x2x2x2 between subject factorial

Table 4

Mean Number Correct for Linked *vs* Unlinked Pairs at Immediate and Two Day Postponed Recall, Averaged Over Grade and Recall Order (Synonyms Included)

	Linked (SD)			Unlinked (SD)		
Immediate	7.35	(2.26)	n=34	7.14	(3.16)	n=14
Two Day Postponed	3.42	(2.29)	n=31	5.11	(1.69)	n=9

design. Results of the analysis of this design are presented in Appendix B, Tables 7 (loose criterion) and 8 (strict criterion).

Contrary to much, though not all, previous research the main effect of Link was not significant, $F(1,72) = 0.93$, $p > .10$. Overall, the children's memory for the second nouns of Linked pairs was no better than for Unlinked pairs. Furthermore none of the interactions involving Link emerged as a significant source of variation.

One potential reason for the failure to obtain greater recall with, than without, links might have been that the two nouns of each pair were more closely related to each other than those employed by other researchers; and, that as a consequence, the children in the Unlinked condition were prompted to form links spontaneously. In order to test for this possibility, the children's recall for the four learning set pairs judged lowest in terms of inter-item "relatedness" (namely Man-Book, Towel-Fork, Horse-Fence, and Tray-Glass) was analysed separately. The maximum possible score for each child thus was reduced from 12 to four. Since it was unlikely that guessing would affect recall for these items, only the loose scoring criterion was employed. The results of this analysis are provided in Appendix B, Table 9. Consistent with the results of the analysis of all 12 pairs, no significant main effect of Link, $F(1,72) = 0.01$, $p > .10$, nor any significant two-way interactions involving Link, were obtained. No other significant effects, based on a reliable number of children per cell were observed.

b) Linked versus Unlinked Recall in the Immediate versus Two Day Retest Conditions.

Percentage loss ($\frac{\text{Immediate-Retest}}{\text{Immediate}}$ X 100) scores were computed for the 48 children in the Immediate-Two Day Retest condition. Grade and Recall Order (Order 1 then 2 vs Order 2 then 1), as well as Link were included as variables resulting in a 2x2x2 factorial design. The results (see Appendix B, Tables 10 and 11) failed to reveal a main effect of Link, $F(1,40) = 0.03$, $p > .10$), nor was Link associated with any significant interactions.

c) Linked versus Unlinked Recall in the Two Week Condition.

A 2x2 analysis of variance (see Appendix B, Tables 12 and 13) comparing the scores of those children who had recalled the pairs once (Two Day Postponed) versus twice (Immediate and Two Day Retest) previously revealed no significant main effect of Link, $F(1,37) = 0.00$, $p > .10$. Also, the interaction was not significant, $F(1,37) = 0.03$, $p > .10$. The failure of a positive effect of Link to emerge in these scores was surprising, particularly because the children in the Linked condition had received an additional presentation of the pairs, relative to the Unlinked condition, during the Verb recall test. A separate analysis of the Non-Associated items only (see Appendix B, Table 14) also failed to reveal any significant effects involving Link.

d) Summary of the Analysis for Link Effects

Contrary to most, but not all, previous work the verb links were not facilitative to Immediate recall. The failure to find an effect of Link, in any of the delayed recall analyses, offered no support to the suggestion that facilitation might be stronger over longer relative to shorter retention intervals. In addition, interpretations of the results relating to link Centrality clearly are limited.

C. Second Noun Recall for Pairs Linked by Central versus Non-Central Verbs: These analyses, of course, involved only the children learning linked pairs, and permitted inclusion of the List variable.

a) Recall of Central versus Non-Central Linked Pairs in the Immediate versus Two Day Postponed Conditions.

This analysis included Grade, Recall Order, List, Link Centrality, and Time as factors, resulting in a 2x2x2x2x2 between-within factorial design. Centrality was the only within subject variable. Analysis of these data (see Appendix, Tables 15 and 16) revealed only one significant main effect, Time, $F(1,49) = 35.24$, $p < .01$. Not surprisingly, children who recalled the second nouns immediately following presentation had higher recall scores than those whose first recall attempt was postponed for two days. Centrality, contrary to the expectations of Rohwer (1973), was not a significant source of variation, $F(1,49) = 2.29$, $p > .10$. Nonetheless, three significant interactions emerged in the analysis, each of which involved Centrality. One of these was a Centrality x Time interaction, $F(1,49) = 4.96$, $p < .05$, and another was an interaction of Centrality x List, $F(1,49) = 12.46$, $p < .01$. However, both of these were qualified by a significant, three-way, Centrality x Time x List interaction, $F(1,49) = 6.27$, $p < .02$. This was the only significant effect to emerge in the strict criterion analysis, $F(1,49) = 4.49$, $p < .04$. The mean recall score and standard deviation in the six Centrality x Time x List conditions is provided in Table 5. The results of an analysis for simple, simple main effects (see Appendix B, Tables 17 and 18) revealed no significant effect of Centrality for either the List 1 or List 2 Immediate recall conditions. In the Two Day Postponed condition recall for

Table 5

Mean Number of Correct Responses in Each Time (Immediate _vs_ Two Day Postponed) x List (1 vs 2) x Centrality (Non-Central _vs_ Central) Condition Averaged Over Grade and Recall Order

a) Strict Criteria (no synonyms)

		Non-Central	(SD)	Central	(SD)	
Immediate	List 1	3.588	(1.770)	3.059	(1.478)	n=17
	List 2	3.294	(1.404)	3.529	(1.281)	n=17
Two Day Postponed	List 1	0.824	(1.015)	1.647	(1.272)	n=17
	List 2	1.500	(1.286)	1.571	(1.016)	n=14

b) Loose Criteria (synonyms included)

		Non-Central	(SD)	Central	(SD)	
Immediate	List 1	3.588	(1.770)	3.706	(1.263)	n=17
	List 2	3.882	(1.616)	3.529	(1.281)	n=17
Two Day Postponed	List 1	0.824	(1.015)	2.471	(1.807)	n=17
	List 2	2.000	(1.359)	1.571	(1.016)	n=14

Central pairs significantly surpassed Non-Central recall in List 1, $\underline{F}(1,49) = 24.79$, $\underline{p} < .01$ (for the strict criterion, $\underline{F}(1,49) = 5.53$, $\underline{p} < .05$). For List 2, however, no significant difference was obtained. One interpretation of these results is that the distinction between the six Central and six Non-Central links was greater in List 1 than in List 2. This is supported by the strict criterion scores (see Table 5) since, for List 2, performance with Central and Non-Central links simply was equal. A second interpretation, however, is suggested when the loose criterion scores are examined. In List 2 there is a trend for higher noun recall of Non-Centrally linked pairs than Centrally linked ones. Since the two lists were constructed such that the six pairs linked by Central verbs in List 1 were linked by Non-Central verbs in List 2 (hereafter these six pairs are called Pair Set 1), and since the six pairs linked by Non-Central verbs in the List 1 were linked by Central verbs in List 2 (Pair Set 2), it is possible that it was not the Centrality of the linking verb which resulted in the interaction involving List, but rather that it reflected something about the pairs themselves. That is, though Pair Sets 1 and 2 may have been equally easy to recall in the Immediate test, long term retention of the former six pairs may have been better for some reason not relating to the link. If indeed it was the pairs themselves that were responsible for the observed Centrality effect in the Two Day Postponed condition, then it stands to reason that a similar effect should have been observed in the Unlinked list. To examine for this possibility the recall scores of the 23 children in the Unlinked condition were scored as a function of Pair Set. A 2x2 (Time of Recall x Pair Set) between-within analysis of variance then was conducted (see Appendix B, Tables 19 and 20). No significant main effect of Pair Set was obtained, $F(1,21) = 3.68$, $p > .06$, nor was the critical Time x Pair Set interaction a significant source of variation, $F(1,21) = 0.45$, $p > .10$. These results do not support the suggestion that the pairs rather than the links were responsible for the observed Centrality effects at delayed recall.

In view of the confusing results with regard to potential link Centrality effects it was decided to replicate the Two Day Postponed condition with a new sample of children. Prior to the presentation of this experiment the remainder of the results of Experiment 2 are provided.

b) Recall of Central versus Non-Central Linked Pairs in the Immediate versus Two Day Retest Conditions

The percentage of Central and the percentage of Non-Central linked pairs forgotten over the two day interval between the Immediate and Two Day Retest conditions was calculated for each of the 34 children. An analysis of variance then was performed comparing the percent loss in these two conditions. Grade, Recall Order, and List also were included as factors resulting in a 2x2x2x2 between-within design. Results from the analysis of the strict criterion (see Appendix B, Table 21) scores failed to reveal a significant main effect of Centrality, $F(1,26) = 0.00$, $p > .10$, nor was Centrality associated with a significant interaction. The loose criterion analysis (see Appendix B, Table 22) also obtained no main effect of Centrality, $F(1,26) = 0.32$, $p > .10$. However, the Centrality x List, $F(1,26) = 9.46$, $p < .01$, and the Centrality x List x Order, $F(1,26) = 6.48$, $p < .02$, interactions were significant. Though the trends in the List x Centrality conditions (under both criteria) can be seen, in Table 6, to be consistent with the results obtained in the Immediate versus Two Day Postponed loose criterion analysis -- that is, more Non-Central than Central loss in List 1 and the opposite in List 2 -- an analysis for simple main effects in the significant List x Centrality interaction (see Appendix B, Table 23) found this trend to be significant for List 2 only. An analysis for simple, simple main effects in the significant Centrality x List x Order interaction (see Appendix B, Table 24) further qualified this latter result by obtaining significantly greater Central than Non-Central loss in List 2, under Order 1 only. Nonetheless the results of the percentage loss analysis largely were consistent with those effects obtained in the Two Day Postponed condition. In view of the observed cross-over in Centrality effects across the two lists, the percent loss analysis seems to support the idea that the pairs themselves (i.e., the Pair Sets) were of critical importance in the two day recall conditions.

D. Recall of Non-Central Verb Links: The Verb recall results were scored by a loose criterion only, in which any response which implied a similar relationship to that suggested by the original verb was counted as correct. Because the children almost always guessed a link, if they could not recall the original verb, the number of correctly recalled Central verbs far exceeded the number of correctly recalled Non-Central verbs. In fact, the children frequently responded with a Central link when the original link was Non-Central, while in no cases did the opposite occur. This pattern of guessing made any analysis comparing recall for Non-Central versus Central links meaningless. Thus the only analysis performed with these data was a comparison across conditions of the number

Table 6

Mean Percentage Loss in the List x Centrality

Conditions Averaged Over Grade and Recall Order

a) Loose Criterion

	Non-Central (SD)		Central (SD)		
List 1	25.69	(31.68)	8.72	(18.27)	n=17
List 2	-6.88	(51.56)	17.74	(34.28)	n=17

b) Strict Criteria

	Non-Central (SD)		Central (SD)		
List 1	25.69	(31.68)	16.27	(17.97)	n=17
List 2	9.51	(22.30)	17.74	(34.28)	n=17

of Non-Central verbs correctly recalled. Grade, Previous Noun Recall Test(s) (One vs Two), and List were factors in this 2x2x2 between subject factorial design. The results from this analysis (see Appendix B, Table 25) revealed only one significant source of variation: Previous Noun Recall Test(s), $F(1,57) = 16.64$, $p < .01$. The children having two previous noun recall tests retained more of the original Non-Central links than did the children who had only one. Apparently an opportunity to remember the nouns immediately following presentation improved the children's memory for both the nouns and the verb links (N.B., Separate analyses comparing the noun recall of children in the Two Day Postponed vs Two Day Retest conditions showed performance in the latter to reliably exceed that in the former; see Appendix B, Tables 26 and 27.) The results of the Verb recall analysis suggest that the nouns were stored together with their linking relationship (for at least two days). The demonstrated relationship between an opportunity to retrieve the nouns and memory for the verbs supports the conclusion that the links did mediate recall of the pairs. Additional support for this conclusion was obtained from an examination of the relationship between Link recall and performance in the Two Week condition. For those pairs for which the Non-Central link was recalled, 83.78 percent were remembered correctly (under the loose criterion) at Two Weeks (90.90% for the Immediate-Two Day Retest children and 66.66% for the Two Day Postponed condition). However, for those pairs for which the Non-Central link was not recalled, only 58.85 percent were recalled correctly at Two Weeks (71.96 % for the Immediate-Two Day Retest children and 45.75% for the Two Day Postponed condition). The higher recall at Two Weeks, when the verb was remembered supports the conclusion that the links mediated recall for the pairs and, therefore, that the equal performance in the Linked and Unlinked conditions reflects the spontaneous formation of links on the part of the Unlinked children. Nonetheless, the relatively high Two Week recall for those pairs for which the Non-Central links were not recalled indicates that remembering the linking verb is not prerequisite to successful noun recall.

E. Recall of Central versus Non-Central Linked Pairs in the Two Week Condition: Because only the Grade 4 students participated in the Two Week test, and since a single new recall order was employed, the design was a 2x2x2 mixed factorial. Previous Noun Recall Test(s) (One *vs* Two) and List were between subject factors and the within subject factor was Centrality. The mean performance in each of the Two Week conditions is presented in Table 7.

Results from the analysis of the loose criterion scores (see Appendix B, Table 28) revealed three significant sources of variation. The Previous Noun Recall Test(s) effect, $F(1,25) = 4.81$. $p < .04$, indicated that those children with two previous tests had higher recall after two weeks than those in the Two Day Postponed condition. However, this main effect was qualified by a significant interaction with Centrality, $F(1,25) = 11.66$, $p < .01$, and the latter variable also emerged in a significant interaction with List, $F(1,25) = 6.50$, $p < .02$. Unlike those analyses of noun recall presented earlier, the three-way interaction of Previous Test(s) x List x Centrality was not a significant source of variation. An analysis for simple main effects in the Previous Test(s) x Centrality interaction (see Appendix B, Table 29) revealed no significant

Table 7

Mean Recall Performance for the Two Week Condition

Under Both the Loose and Strict Scoring Criteria

a) Strict Criterion

		Non-Central (SD)		Central (SD)	
Immediate plus Two Day Retest	List 1	3.29 (2.43)	n=7	2.29 (1.80)	n=7
	List 2	3.88 (0.99)	n=8	3.63 (1.30)	n=8
		3.58	n=15	2.96	n=15
Two Day Postponed	List 1	1.88 (1.36)	n=8	2.88 (1.13)	n=8
	List 2	2.00 (1.41)	n=6	2.33 (1.51)	n=6
		1.94	n=14	2.60	n=14

b) Loose Criterion

		Non-Central (SD)		Central (SD)	
Immediate plus Two Day Retest	List 1	3.29 (2.43)	n=7	3.57 (2.15)	n=7
	List 2	4.75 (0.89)	n=8	3.75 (1.39)	n=8
		4.02	n=15	3.66	n=15
Two Day Postponed	List 1	1.88 (1.36)	n=8	3.50 (0.93)	n=8
	List 2	2.17 (1.33)	n=6	2.83 (2.13)	n=6
		2.02	n=14	3.16	n=14

effect of Centrality for those children who had recalled the pairs twice before, $F(1,25) = 1.73$, $p > .10$. However, for children who had recalled the pairs only once previously, a significant Central over Non-Central effect was obtained, $F(1,25) = 14.89$, $p < .01$. This same interaction when analyzed from the point of view of one versus two previous noun recall tests at each level of Centrality (see also Appendix B, Table 29) found no significant effect of Previous Test(s) for Centrally linked pairs, $F(1,25) = 0.55$, $p > .10$. However, for Non-Centrally linked pairs, the children who had recalled the pairs twice before (i.e., Immediate) had better memory for these items than those who had participated in the Two Day Postponed (i.e., No Immediate) condition only, $F(1,25) = 11.66$, $p < .01$. In other words, the two week retention of Centrally linked pairs did not suffer from a lack of an Immediate recall trial while the Non-Central pairs did. An analysis for simple main effects in the significant Centrality x List interaction (see Appendix B, Table 30), revealed that, for List 2, children's recall for Central and Non-Central pairs did not differ significantly, $F(1,25) = 0.82$, $p > .10$. However, for List 1, significantly more Central than Non-Central pairs were recalled, $F(1,25)=10.82$, $p < .01$. This pattern replicated that obtained in the analysis of the two day recall scores. The analysis of the strict criterion scores (see Appendix B, Table 31) revealed only the interaction of Centrality x Previous Noun Recall Test(s), $F(1,25) = 8.10$, $p < .01$ to emerge as a significant source of variation. A simple main effects breakdown of this interaction (see Appendix B, Table 32) replicated the pattern of results obtained under the loose criterion.

F. Summary of the Analysis for Centrality Effects: The failure to find a Central over Non-Central facilitation among the Immediate recall scores was contrary to Rohwer's (1973) predictions. The examination of Centrality effects among the Two Day Postponed scores was confounded by List effects and therefore this condition was replicated in Experiment 3. The examination of the Two Week scores showed no differential effect of Centrality when an Immediate recall test was administered. However, if the only previous noun recall test followed presentation by two days, then a significant Central over Non-Central effect was observed among the Two Week scores. Since the current extrapolation of Piaget's and Inhelder's model of memory did not qualify the time effect according to the number of previous recall opportunities, no direct support was obtained for this extrapolation.

Prior to a full discussion of those effects observed in Experiment 2, the results of Experiment 3 are presented.

Experiment 3

Because of the unanticipated List x Centrality interaction obtained in the Experiment 2 Two Day Postponed condition, in which those pairs linked by a Central relationship were better recalled than Non-Centrally linked pairs in List 1 only, it was decided to replicate these conditons with a new sample of children. To this end, half of the learning set sentences (three Central and three Non-Central) from each list in Experiment 2 were interchanged. The resultant lists served as Lists 1 and 2 in the current experiment. Half of the children studied one list and half studied the other. Both groups were tested for cued recall two days following presentation.

Method

Subjects

A total of 31 elementary school children (14 males) took part in the experiment. The testing school served a middle to lower-middle class neighbourhood and operated under a deliberately less formal structure than other Vancouver public schools. The children were drawn from two homerooms: a class of Grade 4's only and a mixed class of Grade 3 and 4. Since age had not interacted with the Two Day Postponed condition in Experiment 2, and because as large a sample as possible was desired, the third grade students in the mixed class also were included as subjects. The mean age of the children was 9-7. All children tested were designated by their homeroom teacher as fluent in English and five spoke Greek at home.

Materials

All the experimental materials were the same as those in Experiment 2 except that no Unlinked list was employed. Also, List 1 in the current experiment was made up of six linked pairs from List 1 in Experiment 2 (three Central and three Non-Central) and six linked pairs from the original List 2 (three Central and three Non-Central). List 2 in the current experiment consisted of the remaining linked pairs from Experiment 2. The same order of pair presentation was employed in each list. Each of the lists was arranged such that an original List 1 linked pair was followed by a List 2 linked pair, which was followed by a List 1 pair, and so on. Also, the sentences were arranged such that pairs linked by one type of verb did not appear more than twice in a row. Two recall orders were generated, randomly, with the same restrictions as those imposed in Experiment 2. The learning set materials are provided in Table 8.

Design

Since the intent of the current experiment was to clarify the List x Centrality interaction obtained in the Two Day Postponed condition in Experiment 2, only these variables were manipulated here. Because the experiment was conducted in the last week of school prior to summer vacation, two experimenters (one male and one female) were employed to reduce the testing time. Two recall orders were used, as well as the two word lists. For List 1, half of the pairs were linked by Central verbs and half by Non-Central verbs. For List 2, the Centrality of the verb which linked each List 1 pair was reversed.

Procedure

Sixteen of the 31 children were tested by the male experimenter. Presentation and recall testing of a single child was conducted by the same experimenter. Presentation occupied one entire school day as did the Two Day Postponed recall test. An entire class was tested prior to the testing of the second class. The experimental procedure was identical to that employed in Experiment 2.

Results

Both a strict and a loose scoring criteria were employed to score the data and two separate 2x2x2x2 analyses of variance were performed (see Appendix B, Table 33 and 34). A list of synonyms accepted under the loose criterion, and their frequency of occurence is provided in Appendix A, Table 6. Results from the analyses of the data revealed no significant sources of variation. That is, neither the minor variables,

Table 8

Learning Set Materials for Experiment 3

a) List 1

	Linked Pair	Centrality
1.	The Fish swims up the River.	C
2.	The Man sits on the Book.	NC
3.	The Tray carries the Glass.	C
4.	The Rabbit steps on the Plant.	NC
5.	The Rocket dents the Moon.	NC
6.	The Pole supports the Tent.	C
7.	The Axe chops down the Tree.	C
8.	The Stapler falls on the Papers.	NC
9.	The Horse jumps over the Fence.	C
10.	The Towel covers the Fork.	NC
11.	The Foot wears the Sock.	C
12.	The Dog pushes the Bone.	NC

b) List 2

	Linked Pair	Centrality
1.	The Fish drinks the River.	NC
2.	The Man reads the Book.	C
3.	The Tray smashes the Glasses.	NC
4.	The Rabbit eats the Plant.	C
5.	The Rocket lands on the Moon.	C
6.	The Pole rips the Tent.	NC
7.	The Axe leans against the Tree.	NC
8.	The Stapler fastens the Papers.	C
9.	The Horse licks the Fence.	NC

Table 8 continued

	Linked Pair	Centrality
10.	The <u>Towel</u> dries the <u>Fork</u>	C
11.	The <u>Foot</u> picks up the <u>Sock</u>.	NC
12.	The <u>Dog</u> chews the <u>Bone</u>.	C

Experimenter and Recall Order, nor those of major concern, Centrality and List were associated with any significant effects. The interaction of these latter two variables (for the strict criterion: $F(1,23) = 0.04$, $p > .10$; for the loose criterion: $F(1,23) = 1.04$, $p > .10$) did not emerge even as marginally significant. The mean recall scores and standard deviations in each List x Centrality condition, averaged over Experimenter and Recall Order, are provided in Table 9.

To examine the Pair Set interpretation of the List x Centrality interaction obtained in Experiment 2, the current data were scored for Pair Set (Pair Set 1 comprised the six Central List 1 pairs and Pair Set 2, the six Non-Central List 1 pairs, in Experiment 2) and reanalyzed. Consistent with the interpretation that Experiment 2 effects were due to specific pairs, the analyses for Pair Set revealed (under both criteria, see Appendix B, Tables 35 and 36) higher recall for those pairs in the first versus the second set of pairs, $F(1,27) = 23.99$, $p < .01$. Clearly, the Centrality x List interaction in Experiment 2 was due to specific pairs (i.e., it was an artifact) and did not reflect an effect of link centrality.

Table 9

Mean Number of Correct Responses in Each List x Centrality Condition Averaged Over Recall Order and Experimenter: All Recall Scores Obtained Two Days Following Presentation

a) Strict Criterion (no synonyms)

	Central (SD)	Non-Central (SD)
List 1	1.500 (1.592)	1.437 (1.209) n=16
List 2	2.067 (1.100)	2.000 (0.845) n=15

b) Loose Criterion (synonyms included)

	Central (SD)	Non-Central (SD)
List 1	2.063 (1.526)	1.625 (1.360) n=16
List 2	2.467 (1.246)	2.600 (1.183) n=15)

Discussion

Using an individual aural testing method, Experiment 2 obtained no evidence that either eight or ten year olds' cued recall memory can be improved by embedding noun pairs in verb-linked sentence frames. Since most, though not all, previous researchers have obtained superior recall in a Linked relative to an Unlinked condition, some discussion of the present result is required. Two interpretations appear possible: either (1) the children in the Linked condition received no mnemonic benefit from the verbs (e.g., the verbs were ignored); or (2) the children in the Unlinked condition spontaneously thought of links (i.e., linking relationships) which, roughly, were as facilitative to memory as those relationships suggested by the verbs in the Linked condition. Several pieces of evidence support the latter alternative. First, the individual aural testing procedure (which should maximize a child's attention to the task), plus the relatively long presentation time, would seem to make it unlikely that the children in the Linked condition would ignore the verb. Also, sufficient time would be provided for the children in the Unlinked condition to engage in spontaneous mediation. Second, if the links were not related to memory for the pairs then no effect of Centrality would be predicted. The significant Central over Non-Central effect in the Two Week scores of the Two Day Postponed children argues against this notion -- although, as is discussed later, the reliability of this effect is in question. Third, the finding that memory for the verbs was better if an Immediate noun recall test was conducted, further suggests that the children in the Linked condition stored the nouns and verbs together in memory, and hence indicates the occurrence of spontaneous mediation in the Unlinked condition. Finally, perhaps the strongest evidence that the verbs were facilitative in the Linked condition (and hence that spontaneous mediation occurred in the Unlinked condition), was the finding that Two Week recall memory for those pairs for which the link was remembered was better than recall for those pairs for which the link was forgotten. Nonetheless, despite the foregoing arguments, there was no direct evidence that the equal Linked and Unlinked performance reflects spontaneous mediation on the part of the children in the Unlinked condition; hence the possibility that the current verb links did not prompt mediation can not be ruled out.

Regardless of which interpretation of the equal Linked versus Unlinked performance is adopted, the results of this analysis are inconsistent with the semantic elaboration hypothesis as formulated by Rohwer (1973). That is, according to the elaboration viewpoint, spontaneous mediation does not occur among elementary school children, and the provision of verb links should improve memory for noun pairs. If the results were due to spontaneous mediation among the Unlinked children, it might be possible that the presence of the "high association" pairs within the Unlinked list prompted the children to elaborate the learning set pairs.

The relationship of these results to the interacting imagery proposal (e.g., Paivio, 1970; Yuille, 1973, 1974) is less clear. Since Paivio believes verb links to prompt effective (interacting image) mediation and also considers spontaneous mediation to be possible among elementary school children, the spontaneous mediation interpretation is consistent with his views (as would have been superior Linked relative to Unlinked recall). However the (less well supported) possibility that verb links for some reason did not prompt mediation would be inconsistent with the imagery hypothesis.

The results of the Linked versus Unlinked analysis also are unclear relative to the current extrapolation of Furth's interpretation of Piaget's and Inhelder's model of memory. Since the children were old enough to be free of the limited anticipation associated with the preoperational period the suggestion of equal Linked and Unlinked recall due to spontaneous mediation (or broad assimilation) of the Unlinked pairs would seem consistent with the Piagetian-based position. On the other hand, the possibility that the links were of no value to noun pair memory contradicts the current extrapolation in which links are assumed to lead to improved assimilation -- though whether this extrapolation is appropriate can not be determined. Regardless, if indeed the Linked and Unlinked pairs were assimilated in a similar fashion then, consistent with the current results, no differential link effect would be expected, no matter when recall was tested. The results of the analysis for Centrality effects upon second noun recall are discussed now.

If the less well supported suggestion that the equal Linked versus Unlinked recall resulted because the links failed to prompt mediation is accepted, then any discussion of the effects of link Centrality would be inappropriate. If, however, the spontaneous mediation interpretation is correct, then the following discussion is permitted. The Immediate recall results offered no support to Rohwer's

(1973) claim that Central links would lead to better memory for the pairs than Non-Central links, through prompting more effective semantic elaboration. The effect supports Yuille's (1973, 1974) claim that the particular linking verb is unimportant since it just prompts the child to form his/her own mediator. However Yuille's suggestion that this mediator is an interacting image is neither supported nor contradicted.

The examination of Centrality effects in second noun recall in the Two Day Postponed condition led to equivocal results in Experiment 2. However Experiment 3 clearly indicated that link Centrality did not affect memory for the pairs after two days. This result does not support the prediction that, by virtue of leading to more effective operative coding, Centrally linked pairs would be more readily recalled than Non-Centrally linked pairs after a two day delay.

The Two Week noun recall condition only was included to support the Two Day effects. It was not designed to serve as the sole basis for evaluating Centrality effects at delayed recall. Nonetheless, the Two Week scores of the Two Day Postponed children did reveal a clear Central over Non-Central effect. For the Immediate-Two Day Retest children, however, link Centrality was not a factor in Two Week recall. Since the current Piagetian-based prediction did not suggest that an Immediate recall test might ameliorate an effect of link Centrality at delay recall the current extrapolation of Piaget's and Inhelder's (1973) model was not supported.

Two post hoc interpretations of the Two Week results follow. First, if the Immediate recall test somehow resulted in a strengthening of the figurative codes of these children (figurative codes are assumed to favour neither type of linked pair) then these codes may (with the aid of the Two Day Retest) have remained salient for two weeks. Whereas, the figurative codes of the Two Day Postponed children, while still salient after two days, may have faded more rapidly. Thus these children's Two Week recall would be dependent upon a reconstruction from operative codes (which are presumed to favour Centrally linked pairs). The advantage of this interpretation is that unlike Rohwer's and Paivio's hypotheses it provides an explanation for changes in Centrailty effects over time. However, in light of the confounding of the Two Week scores by the Verb recall test, plus the unexpected Pair Set effect at Two Days, a second less speculative interpretation of the Two Week results simply would be that they are an artifact of one, or both, of these confounding factors.

The strongest effect to emerge in Experiment 2 -- and one which was not related to the experimental hypotheses -- was the powerful effect upon Two Day and Two Week recall of the Immediate versus No Immediate manipulation. Certainly, an opportunity to recall learning set materials shortly after presentation is a highly effective method for improving long term recall. Whether a similar effect would have been obtained had a second learning trial replaced the recall trial can not be determined from the current design. Nonetheless the obtained effect was a powerful one and deserves consideration vis-a-vis the models of current interest. Since a similar effect was obtained in the following experiment, discussion of this result will follow presentation of Experiment 4.

Experiment 4

A third experimental situation in which contrasting predictions may be derived from the semantic elaboration and interacting imagery hypotheses involves the improvement in children's noun pair learning which results when the pairs are linked by prepositions (e.g., Rohwer et al., 1967; see also Chapter 1, pps. 58-59). From the semantic elaboration perspective the particular linking preposition should be unimportant, providing that the suggested relationship is usual or familiar. For example, both of the sentences "The Duck is on the Lake" and "The Duck is near the Lake" can be seen as roughly equal in terms of the semantic overlap suggested by the link. However, from the interacting imagery perspective there is a critical difference between these two sentences -- the former describes a physical interaction, hence the two items may be stored as a single interacting image. The latter, on the other hand, describes a distanced spatial relationship, and thus, more likely, would lead to the formation of separate images of the two items. Relative to the situation with verbs, spontaneous interacting image formation, regardless of the particular link, would seem less likely since the sentences simply describe the types of situations actually provided (i.e., physically present) in Experiment 1. Thus the purpose of Experiment 4 was to contrast semantic and imagery predictions by manipulating the implied spatial relationship of the two items, independently of the suggested semantic overlap.

Both Grades Three and Five children were tested in order to examine for possible interactions between age and the variables of current interest. To explore the effect of the link-implied relationship upon second noun recall, six of the 12 learning set pairs were linked by prepositions which suggested a physical interaction between the two items. The remaining six pairs were linked by prepositions which implied a distanced spatial relationship. A second list, in which the type of linking relationship was reversed, was studied by a second group of children. Thus the effects of the link-suggested relationship (i.e., Interacting vs Non-Interacting) could be examined by controlling for list. In order to check if, indeed, preposition links were facilitative in the current experiment, a third group of children studied the same 12 pairs minus the links.

From the imagery perspective, a differential effect of preposition type upon second noun recall would be expected to occur only if an imaginal code is formed for each pair. Therefore, an instructional condition, designed to encourage such coding was included in the experiment. Half of the children in each condition were trained to "think of a picture of what each sentence describes". The remainder received no special instructions.

From the point of view of the current extrapolation of Piaget's and Inhelder's (1973) model, no differences as a function of link type would be anticipated. Furthermore, long term retention should favour neither Interacting nor Non-Interacting linked pairs. However, any Linked over Unlinked effect might be expected to be greater when recall is delayed since memory should be dependent upon operative codes primarily. To examine for possible effects of the retention interval, half of the children were tested for second noun recall immediately following presentation and again two days later. The remaining children received the second test only.

Two random recall orders were employed and the testing was divided between a male and a female experimenter.

Method

Subjects

Permission was obtained to test the Grades Three and Five children from a Vancouver school serving a middle and upper middle class neighbourhood. Experimenter error and absenteeism at delayed recall reduced the initial sample of 95 children to 35 Grade 3's and 54 Grade 5's. The mean ages of the children were 8-11 and 11-0. All of the children were fluent in English and all but five spoke English at home. Approximately equal numbers of boys and girls were included in each condition.

Materials

The experimental materials consisted of the names of 32 things arranged into 16 pairs. Two pairs (i.e., Button-Shoelace and Ashtray-Matches) were used as examples for practicing the paired associate task. A further two pairs (i.e., Knife-Cheese and Lamp-Magazine) were used as examples of the learning set materials. These latter pairs also served as instructional items for the Imagery Prompting children. For the children who studied Linked pairs these latter two pairs were embedded in the sentences "The Knife is in the Cheese" and "The Lamp is beside the Magazine". These sentences served to introduce the children to the two types of linked learning set pairs. The remaining 12 pairs served as the learning set materials for the children who studied Unlinked pairs. For those children studying Linked pairs, two lists (both in the same order as the Unlinked list) were generated in which each pair was embedded in a preposition-linked sentence frame (see Table 10 for the learning items). Half of the pairs were linked by prepositions which implied a physical interaction between the two items (i.e., "in", "on", "around", "down", "against", and "across"). The remaining pairs were linked by prepositions which implied a distanced spatial relationship (i.e., "near", "beside", "in front of", "after", "above", and "behind"). The two lists were arranged so that one type of link did not appear more than twice in a row. Pairs linked by an interacting preposition in List 1 were linked by a non-interacting preposition in List 2, and vice versa. The assignment of the prepositions to the pairs was such that each of the resultant sentences was semantically appropriate (see Table 10). Only one presentation order was employed. Two recall orders were generated randomly with the restriction that the first two presentation items occupied neither of these positions in either recall order; nor did the last two presentation items appear in either of their original positions at recall.

Design

The following conditions made up the experimental design. Roughly half of the children were tested for recall immediately following presentation (condition Immediate) and again two days later (condition Two Day Retest). The remaining children received the second test only (condition Two Day Postponed). Half of the children in each of these conditions were given the Imagery Prompting instructions and the rest received No Prompting. Slightly less than half of the children in each Time of Recall x Prompting condition were in Grade 3. The remainder were Grade 5 students. About

Table 10

Learning Set Items for Experiment 4

List 1

The Whale is after the Octopus	(NI)
The Squirrel is behind the Pipe	(NI)
The Skateboard is against the Bus	(I)
The Sock in across the T.V.	(I)
The Snake is near the Rat	(NI)
The Man in down the Chimney	(I)
The Elastic is around the Book	(I)
The Tape is in front of the Stapler	(NI)
The Helicopter is above the Tree	(NI)
The Duck is on the Lake	(I)
The Car is in the Ditch	(I)
The Tomato is beside the Bowl	(NI)

List 2

The Whale is against the Octopus	(I)
The Squirrel is down the Pipe	(I)
The Skateboard is after the Bus	(NI)
The Sock is in front of the T.V.	(NI)
The Snake is around the Rat	(I)
The Man is behind the Chimney	(NI)
The Elastic is near the Book	(NI)
The Tape is across the Stapler	(I)
The Helicopter is on the Tree	(I)
The Duck is above the Lake	(NI)
The Car is beside the Ditch	(NI)
The Tomato is in the Bowl	(I)

NI = Non-Interacting; I = Interacting

Table 10 continued

Unlinked List

Whale - Octopus
Squirrel - Pipe
Skateboard - Bus
Sock - T.V.
Snake - Rat
Man - Chimney
Elastic - Book
Tape - Stapler
Helicopter - Tree
Duck - Lake
Car - Ditch
Tomato - Bowl

two-thirds of the children in each of the foregoing conditions studied Linked pairs, and the rest were presented with the Unlinked list. Among those children who studied Linked pairs, approximately half were presented with List 1. The remaining Linked children studied List 2.

Neither experimenter nor recall order were included within the factorial design. Experiments 1-3 offered no suggestion that these factors would qualify potential effects of current interest, and their inclusion would have resulted in some empty cells within the current factorial design. Each experimenter attempted to test at least one child, under each recall order, in every condition. The original recall order given to each of the Immediate children was reversed for the Two Day Retest. A single child always was tested by the same experimenter.

Procedure

The Grade 3 children were drawn from a class of Grade 3's only and from a mixed class of Grades 2 and 3. The Fifth Grade children came from two unmixed classes. The children were taken from their classrooms in an approximately alphabetical order. The first child went to the first experimenter's testing room, the second child to the second experimenter's room, and so on. The children were assigned to conditions in a prearranged random order. A different order of assignment was employed by each experimenter.

In the testing room the experimenter and child sat across from each other at a small table. The child's name, age, and language habits were determined after which he/she was presented the instructions appropriate to his/her condition (see Appendix A, Table 7 for the experimental instructions). All instructions and materials were read aloud to the child.

First, all children were given a brief explanation of a paired associate learning task. Then they were presented with the two practice pairs and tested for recall. All of the children learned these pairs within four presentation-testing trials. Next, the children in the Unlinked condition were presented with two more pairs. Roughly half of these children were instructed to think of a picture of each member of each pair. No special instruction was given to the remaining Unlinked children. One recall test for these pairs was conducted. The children in the Linked condition were presented with these same two pairs embedded in preposition-linked sentence frames. Roughly half of these children were instructed to think of a picture of what each sentence described. The remaining Linked children received no special instruction. A single test then was performed with these children.

Immediately prior to learning set presentation all Imagery Prompting children were reminded to form mental pictures of the items just as they had done with the practice materials. To ensure that they would be unaware as to when recall would occur all of the children simply were told that recall would take place "some time later". The presentation rate for the 12 learning set items was one item every ten seconds and the reading of each pair (or sentence) occupied about four seconds of this interval. Following the presentation of the learning set items the children in the Two Day Postponed condition were informed that recall would take place "in a couple of days". The children were asked not to practice, discuss, or worry about the items. The Immediate recall children were tested for cued recall approximately 15 seconds after presentation. About half of them were tested with Order 1 and the remainder with Order 2. Up to 20 seconds were allowed for each item. If the child responded prior to the elapse of this time, the experimenter proceeded to the next item. After testing, these children were informed that they would be retested in a couple of days and were cautioned not to discuss, practice, or worry about the items in the intervening period.

Two days following presentation all the children were recalled to their original testing room , one at a time, and tested for cued recall. The procedure for the Two Day Postponed and Two Day Retest conditions was identical to the Immediate recall test.

Results

A. Scoring Criterion and Method of Analysis

As was the case in Experiments 2 and 3, both a strict and a loose scoring criterion were employed. A list of synonyms accepted as correct under the loose criterion, and their frequency of occurrence, is provided in Appendix A, Table 8. The results obtained from the strict criterion analysis are reported only when they differ with the loose criterion effects. However, the results from both analyses are provided in Appendix B. Presentation of the results begins with the effects of Links versus No Links. Then the results of the analysis for Type of Preposition (i.e., Interacting versus Non-Interacting) are presented.

B. Recall of Preposition-Linked versus Unlinked Pairs

The Linked versus Unlinked analysis was performed by collapsing the former scores over the within subject Interaction variable. Thus List was not a factor in this analysis. Two separate analyses for Link effects were performed. First Linked versus Unlinked performance was examined in the Immediate versus Two Day Postponed conditions. Next an analysis of percent loss, from the Immediate to the Two Day Retest, was conducted. Only those effects involving Link are presented here.

a) Linked versus Unlinked Recall in the Immediate versus Two Day Postponed Conditions.

The following effects emerged from the analysis of the Grade x Prompting x Recall Time x Link design (see Appendix B, Tables 37 and 38). A significant Linked over Unlinked effect was obtained under the loose criterion only, $\underline{F}(1,73) = 5.06$, $\underline{p} < .05$. Of critical interest, however, was a Link x Recall Time interaction which was significant under both the loose, $\underline{F}(1,73) = 14.29$, $\underline{p} < .01$, and the strict ($\underline{p} < .01$) criterion. The mean recall performance and standard deviation in each of these four conditions is presented in Table 11. A breakdown of the Recall Time x Link interaction by an analysis for simple main effects (see Appendix B, Tables 39 and 40) revealed the following results. First, a significant Linked over Unlinked effect, $\underline{F}(1,73) = 24.72$, $\underline{p} < .01$, was found in the Immediate recall condition. However, at Two Day Postponed, Link was not a significant source of variation, $\underline{F}(1,73) = 0.47$, $\underline{p} > .10$. This same analysis for simple main effects showed performance in the Immediate condition to surpass Two Day Postponed recall for both Linked, $\underline{F}(1,73) = 177.29$, $\underline{p} < .01$, and Unlinked, $\underline{F}(1,73) = 14.92$, $\underline{p} < .01$ pairs. No other significant effects involving Link were observed.

b) Linked versus Unlinked Performance in the Immediate versus Two Day Retest Conditions

In order to examine further for possible changes in Link effects over time, percentage loss scores were calculated for the 45 children in the Immediate-Two Day Retest condition. No significant main effects or

Table 11

Linked Versus Unlinked Recall in the Immediate versus Two Day Postponed Conditions

a) Loose Criterion

	Immediate (SD)	Two Day Postponed (SD)
Linked	9.48 (1.57) n=31	2.78 (1.91) n=32
Unlinked	6.29 (3.29) n=14	3.25 (2.67) n=12

b) Strict Criterion

	Immediate (SD)	Two Day Postponed (SD)
Linked	8.81 (1.76) n=31	2.22 (1.84) n=32
Unlinked	6.21 (3.24) n=14	2.67 (2.42) n=12

interactions emerge in this analysis (see Appendix B, Tables 41 and 42). Contrary to the lack of a Link effect in the Two Day Postponed condition, no change in the effect of links was observed from the Immediate to the Two Day Retest, $\underline{F}(1,37) = 1.31$, $\underline{p} > .10$. Mean loss scores in the Linked and Unlinked conditions were 21.66% and 31.66% respectively. Apparently the facilitative effect of links remained two days later when an Immediate recall test was provided. This conclusion was supported by a separate analysis comparing Linked versus Unlinked performance in the Two Day Postponed versus the Two Day Retest condition (see Appendix B, Tables 43 and 44). Recall Time x Link, $\underline{F}(1,73) = 10.38$, $\underline{p} < .01$, was a significant source of variation in this analysis. A simple main effects breakdown of this interaction (see Appendix B, Tables 45 and 46) revealed a significant Linked (mean score, 7.77) over Unlinked (mean score, 4.50) effect, $\underline{F}(1,73) = 20.80$, $\underline{p} < .01$, for the Two Day Retest but not for the Two Day Postponed, $\underline{F}(1,73) = 0.38$, $\underline{p} > .10$, condition.

c) Summary of the Analysis for Link Effects

Preposition links were facilitative to children's memory for noun pairs if recall was tested shortly after presentation. Memory after two days showed no positive effect of links unless Immediate recall was tested.

C. Recall for Pairs Linked by Interacting versus Non-Interacting Prepositions

These analyses, of course, included only the scores of the children in the Linked condition. Two separate analyses were performed. First, second noun recall performance with Interacting versus Non-Interacting links was examined in the Immediate versus Two Day Postponed conditions. Second, an analysis of percent loss of Interacting versus Non-Interacting pairs, from the Immediate to the Two Day Retest, was conducted.

a) Recall of Interacting versus Non-Interacting Linked Pairs in the Immediate versus Two Day Postponed Conditions

Three significant main effects emerged from the analysis of variance of the Grade x Prompting x Recall Time x List x Interaction design (see Appendix B, Tables 47 and 48). List 2 was better recalled than List 1 under the strict criterion, $F(1,47) = 4.39$, $p < .05$ ($p < .055$ for the loose criterion). Grade 5's had better recall than Grade 3's, $F(1,47) = 4.68$, $p < .04$. And performance in the Immediate condition surpassed that at Two Day Postponed, $F(1,47) = 211.79$, $p < .01$. No significant interactions involving List were obtained in the current experiment, hence this variable is discussed no further. The Grade x Recall Time interaction was significant under the loose criterion, $F(1,47) = 4.23$, $p < .05$. A simple main effects analysis (see Appendix B, Table 49) revealed Grade 5 performance to surpass that of the Grade 3's in the Two Day Postponed, $F(1,47) = 21.25$, $p < .01$, but not the Immediate, $F(1,47) = 0.13$, $p > .10$ condition. The Grade x Recall Time interaction was not significant under the strict criterion. However, mean recall performance of the Grade 3's and 5's, roughly, was equal in the Immediate condition (8.70 _vs_ 8.86 respectively), while at Two Day Postponed the Grade 3's tended to perform more poorly than did the Grade 5's (1.15 _vs_ 2.95, respectively).

The only other effect to emerge from the analysis was an interaction of Recall Time x Interaction. The mean recall performance and standard deviation in each of these conditions is provided in Table 12. Though not reaching conventional levels of significance, $F(1,47) = 3.81$,

Table 12

Recall for Interacting versus Non-Interacting Items in the Immediate versus Two Day Postponed Conditions

a) Loose Criterion

	Interacting (SD)	Non-Interacting (SD)
Immediate	5.03 (1.05) n=31	4.45 (1.09) n=31
Two Day Postponed	1.34 (1.23) n=32	1.44 (1.11) n=32

b) Strict Criterion

	Interacting (SD)	Non-Interacting (SD)
Immediate	4.74 (1.18) n=31	4.06 (1.26) n=31
Two Day Postponed	1.06 (1.24) n=32	1.15 (0.99) n=32

$p < .057$ (for the strict criterion, $p < .065$) a simple main effects breakdown of this interaction (see Appendix B, Table 50) showed a significant Interacting over Non-Interacting effect, $F(1,47) = 5.12$, $p < .03$ (for the strict criterion, $p < .02$) among the Immediate scores. For the Two Day Postponed condition, Interaction was not a significant source of variation, $F(1,47) = 0.13$, $p > .10$. Prompting did not emerge as a significant effect, $F(1,47) = 1.84$, $p > .10$, nor was the Prompting x Interaction effect significant, $F(1,47) = 0.51$, $p > .10$.

b) Recall of Interacting versus Non-Interacting Linked Pairs in the Immediate versus Two Day Retest Conditions

As a further check for possible changes in the effects of preposition-suggested Interaction over time, percentage loss scores were calculated for the 31 children in the Immediate-Two Day Retest condition. An analysis of variance performed with these data (see Appendix B, Tables 51 and 52) revealed a significant main effect of Interaction, $F(1,23) = 6.05$, $p < .03$ under the loose criterion. For the strict criterion, however, the Interaction main effect did not attain a conventional level of significance, $F(1,23) = 2.99$, $p > .097$. Nonetheless, a strong trend showing greater Interacting (24.65%) than Non-Interacting (8.33%) loss was observed. These results indicate that the Interacting over Non-Interacting effect observed at Immediate recall did not hold up for the Two Day Retest. Consistent with this conclusion, a separate analysis comparing the Two Day Retest with the Two Day Postponed condition (see Appendix B, Tables 53 and 54) found no significant main effect of Interaction, nor was the critical Recall Time x Interaction effect significant, $F(1,47) = 0.35$, $p > .10$. Mean recall scores for the Interacting and Non-Interacting Retest conditions were 2.60 and 2.63 respectively. As was the case in Experiment 2, performance in the Two Day Retest condition (7.58) reliably surpassed that at Two Day Postponed (2.57), $F(1,47) = 79.61$, $p < .01$.

c) Summary of the Analysis for the Effects of Interaction

Interaction-suggesting prepositional links were found to result in superior second noun recall relative to Non-Interacting links when recall closely followed presentation. If, however, recall was postponed for two days, or retested two days following an Immediate test, then memory for Interacting and Non-Interacting linked pairs was equal. The latter effect contrasts with the results of the Linked versus Unlinked analysis where Links gave superior recall to No Links in the Two Day Retest as well as the Immediate condition.

Discussion

In contrast to Experiment 2, a clear Linked over Unlinked effect was obtained in the current Immediate recall condition. This result replicates the positive effect of preposition links -- relative to no links -- obtained by Rohwer et al. (1967). While memory for the pairs was better when links were provided, spontaneous link formation, on the part of the Unlinked children cannot be ruled out. The higher standard deviations in the Unlinked relative to the Linked conditions (see Table 12) may indicate that some of the Unlinked children spontaneously generated linking relationships, while the majority did not. That is, the relatively less variable performance (and superior recall) in the Linked versus Unlinked conditions would seem most appropriately attributed to more consistent mediation on the part of the Linked children. It is interesting also to note the equal Unlinked performance between the No Training and Imagery Prompting conditions. Since Imagery Training has been found to improve children's memory for Unlinked noun pairs (e.g., Yuille and Catchpole, 1977), while Imagery Prompting apparently does not, it seems clear that successful imagery instruction requires not that the child merely picture the pair but rather that he/she think of an interaction of the two items.

The failure of a positive Link effect to emerge in the Two Day Postponed condition indicates that linking prepositions have only a transitory mnemonic effect. Apparently a two day postponement in recall eliminates any benefit of experimenter-supplied links, unless an Immediate recall opportunity is provided. This result has both theoretical and practical implications. It is a more or less implicit assumption of both the semantic and imagery hypotheses that an initial coding advantage will persist over time. Rohwer, for example, has been interested in effecting a general improvement in school children's memory, through encouraging them to form semantic overlaps. Since the most typical "in-school" memory task involves postponed recall, it would appear essential that an Immediate recall test be provided in order that the mnemonic benefits of initial mediation remain for long term retention. The limitation of mnemonic effects to Immediate recall has little ecological validity. More theoretically, these results question the appropriateness of generalizing interacting imagery or semantic elaboration constructs to delayed recall situations. Also, the effects of Link over delay do not support the current extrapolation of Piaget's and Inhelder's (1973) model of memory. That is, if it is assumed that the

Immediate recall improvement results from broader assimilation of the pair, then according to the current view, an even stronger Linked over Unlinked effect should have emerged when recall is delayed (since only scheme-based reconstruction is available). Clearly the current results are exactly opposite to what would be expected from this perspective and may indicate, therefore, that the initial mnemonic effect of links is unrelated to operative (assimilatory) processes as described by Piaget. This point is considered further in the final, Concluding Remarks, section.

Though the positive effect of preposition links upon Immediate recall is anticipated from, and equally consistent with, both the semantic elaboration and interacting imagery perspectives, the effects of the Interaction variable are not. The key to improved noun pair memory, according to Rohwer (1973), is the generation of an "event" which can serve as a "shared meaning" for the two items. Alternatively, Paivio (1970, 1975) cites storage of the pair as a "spatially integrated, visual compound (image)" as the essential factor. Given these two definitions, and in light of the fact that all of the phrases imply a single shared event, the current Interacting over Non-Interacting result appears slightly more supportive of the interacting imagery proposal. That is, since the latter specifically mentions spatial integration as the key to improved recall, while the semantic elaboration hypothesis does not, the current results appear more consistent with the imagery position. Nonetheless, since interaction was manipulated independently of semantic overlap -- whereas semantic overlap was not manipulated directly -- it may be that Interacting events tend to imply greater shared meaning than do Non-Interacting events. Thus the effect of Interaction at Immediate recall, though somewhat more consistent with the imagery viewpoint, can not be taken as definitive evidence against a semantic elaboration interpretation of the mnemonic effect of links. Further support would have accrued to the imagery hypothesis if the Interacting over Non-Interacting effect had been even stronger when the children were instructed to picture each phrase. However, if maximal imagery coding occurred in the No Prompting condition then no greater difference would be expected as a consequence of Prompting.

The failure of a positive effect of Interaction to emerge in the Two Day Postponed condition was consistent with the results of the Link analysis. That is, since the links were of no benefit to Postponed recall, whether or not a particular link is Interacting or Non-Interacting should be unimportant. The failure of an Interaction effect to appear in the Two Day Retest, however, is more difficult to interpret since Link was significant in this condition. Apparently the Immediate recall test helped maintain the original positive effect of Links (versus No Links) but not of Interaction (versus No Interaction). It might be possible to explain this effect by postulating separate Interaction and Link codes each with a different decay rate following Immediate recall. However, pending further research, a more parsimonious interpretation would be that since the Immediate effect of the Link (versus No Link) variable was more pronounced that that of Interaction (versus No Interaction), that the latter effect levelled more quickly.

As was the case in Experiment 2, there was a powerful effect of an Immediate (versus No Immediate) recall test upon delayed recall. Although, currently, it can not be determined if a second presentation trial would have been as facilitative to delayed recall as was the Immediate test, it nonetheless remains clear that such a test is a highly effective means for improving long term retention. It would appear from the imagery and semantic perspectives that this effect should be attributed to the Immediate recall test increasing the likelihood (relative to a single presentation) of a mediator or being formed for each pair. However, the fact that the Two Day Retest condition surpassed Two Day Postponed performance for both Linked and Unlinked pairs (in both Experiment 2 where Links = No Links, as well as in Experiment 4 where Links > No Links), seems to indicate that the effect of the Immediate test is independent of the mnemonic effect of links. That is, the Immediate test seems to have a powerful "raw" or non-mediational mnemonic benefit for delayed remembering. Though not interpretable within the imagery or semantic frameworks, this result supports the suggestion advanced in Experiment 1 that a "raw" or figurative code of short duration may be strengthened by an initial recall test, making the code more readily available for delayed recall. Furthermore, the appearance of a Link effect in the Retest but not the Postponed condition of the current experiment suggests that formation of such a code is mandatory for the effect of links to persist over more than a short retention interval.

Concluding Remarks

The current research was designed to shed new light upon the controversy between semantic overlap (e.g., Rohwer, 1973) and interacting imagery (e.g., Paivio, 1970) interpretations of mnemonic effects in children's associative learning. Two approaches were taken to this task. First, several conflicting predictions of the semantic and imagery models were pinpointed and subjected to experimental analysis. Second, in an attempt to supercede the semantic versus imagery issue, the Piagetian (e.g., Piaget and Inhelder, 1973; also Furth, 1969; and Furth et al., 1974) conception of memory was considered and some predictions, derived from an extrapolation of this model to associative learning, were examined experimentally.

In terms of the first approach, the results were somewhat more consistent with the imagery than with the semantic position. However, no clear choice, in favour of the former, was warranted. In Experiment 1 imagery training was found to improve preoperational children's memory for object pairs. This result supported Paivio's ideas regarding the age at which interactive imagery strategies are potentially available. In contrast, Rohwer's (1973) claim that such training (which he calls an explicit prompt to semantic elaboration) will not be effective until the child enters the concrete operational period was not supported. Contrary to much, though not all, previous research Experiment 2 found that elementary school children's memory for noun pairs was unaffected by the presence of linking verbs. Some evidence was obtained to suggest that the children in the unlinked condition spontaneously generated linking relationships -- a result which would be consistent with the imagery but not the semantic hypothesis. Acceptance of the other alternative -- that the verbs were not effective for mediating noun pairs learning -- contradicts both the semantic and imagery models. If, indeed, the former, spontaneous mediation, interpretation is correct then the failure of verbs which imply a central or familiar relationship to lead to better memory relative to verbs which imply a non-central or less familiar relationship also was inconsistent with the semantic, but not the imagery, position. In Experiment 4, preposition links were found to give superior memory for noun pairs relative to no links. This result was consistent with both models. However, within the linked condition, those prepositions which implied physical contact between pair members led to better immediate recall than prepositions which implied a distanced spatial relationship. This result was somewhat more consistent with the interacting imagery than the semantic elaboration model. It is quite possible, however, that the degree of semantic overlap for interacting items is greater than if the items are spatially distanced. Thus the effect of interaction upon immediate recall provided no definitive evidence for accepting an imagery over a semantic interpretation.

Overall those effects which were inconsistent with the semantic model contradicted only its peripheral features. Hence the immediate recall results offered no clear resolution of the semantic versus imagery issue. However, inclusion of several measures of delayed recall (in order to pursue the second, Piagetian-based approach) did indicate a serious limitation of both hypotheses. Specifically, the effect in in Experiment 4 showing no positive effect of links in the two day postponed recall condition contrasted with the implicit assumption of the semantic and imagery models, that mediation leads to more effective storage and hence is of benefit to long as well as short term retention. The current results directly contradicted this notion. Instead they suggested the mnemonic effect of preposition links to be transitory, unless an immediate recall opportunity is provided. Thus evidence was obtained to suggest that the initial mnemonic effects of preposition links -- and perhaps, by virtue of their similarity, other mnemonic effects in children's associative learning -- are not associated with any "deep" or long-lasting memory superiority.

The value of the second, Piagetian-based approach also proved limited. Though the semantic and imagery models could not account for the delayed recall results, the current extrapolation of Piagetian theory also was contradicted by these data. The success of the imagery training procedure in Experiment 1 could be squared with the currently extrapolated Piagetian position if, as suggested by Furth et al. (1974), preoperational children are considered to be capable of forming temporary images (and hence underlying scheme-based anticipations) in the absence of full operative competence. That is, the current extrapolation requires the effect of the training to be scheme-based. However, improved delayed recall need not have occurred necessarily, since the anticipated interaction may well have been forgotten, by virtue of its dependence upon an unstable anticipatory process. Once leaving the preoperational stage, however, the formation of anticipated interactions (which is assumed to lead to improved assimilation) would be expected to result in improved delayed as well as immediate recall. While this possibility was not examined in Experiment 1, the results of the fourth experiment contradict this notion. In the latter, if the positive effect of links at immediate recall is assumed to reflect relatively superior operative coding then -- since delayed remembering is assumed to be particularly dependent upon scheme-based reconstructions -- a similar, or more likely stronger, effect of links should have emerged in the postponed condition. The failure of any link effect to appear in postponed recall, therefore, argues against attributing the immediate mnemonic effect to an operatively-based process. That is, the various mnemonic effects at immediate recall may be unrelated to improved assimilation. This conclusion is contrary to the remarks of Rohwer and Matz (1974) who stated that "Rohwer's assumption that the coupling that occurs in paired associate learning is brought about by a single process that creates a shared meaning despite the form of external representation is consonant with Piaget's idea that to know is to assimilate reality into systems of transformations" (p.2). Instead, the apparent evanescence of mnemonic effects in paired associate learning, suggests they might more appropriately be related to Piagetian theory in terms of "mnemonic schemata ... whose relationship to the cognitive schemes has yet to be determined" (Piaget and Inhelder, 1973; also Chapter 1, p. 89). In light of the current experimental effects and theoretical considerations it would, therefore, appear appropriate to conclude that memory over the short term can be mediated by codes which are more or less independent of operative functions. Whether these codes are best described by means of an interacting imagery, semantic overlap, or some other construct, remains to be determined.

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APPENDIX A

Table 1

Practice Training, and Learning Set Materials

Employed in Experiment 1

	Set 1	Set 2
a)	Paired Associate Practice Pairs	
	1. Fly-Paintbrush	1. Fish-Guitar
	2. Chair-Horse	2. Ruler-Pin
b)	Training (Group 3, Test 2) or Practice Pairs	
	1. Bell-Matches	1. Sweater-Crayon
	2. Turtle-Bracelet	2. Chain-Scissors
	3. Penny-Dice	3. Bear-Telephone
	4. Alligator-Clothespin	4. Coffeepot-Barrel
	5. Banana-Box	5. T.V.-Stapler
c)	Learning Set Pairs	
	1. Bird-Pencil	1. Airplane-Book
	2. Rat-Pipe	2. Lion-Hairclip
	3. Duck-Hat	3. Car-Whistle
	4. Highchair-Fish	4. Shell-Dog
	5. Bottle-Eraser	5. Doll-Ashtray
	6. Shovel-Mirror	6. Shoe-Flower
	7. Gun-Snake	7. Moose-Glove
	8. Truck-Plate	8. Purse-Lightbulb
	9. Rock-Button	9. Buggy-Key
	10. Comb-Jug	10. Bottle-Marble

Table 2

Piagetian Tasks Employed in Experiment 1

I. Elementary Number Conservation

See Piaget and Szeminska, 1941.

1. METHOD*

Materials: 10 red counters;
10 blue counters.

Task Description

First situation. The experimenter lays out one row of about seven blue counters and asks the child to put out the same number of red counters: "Put out as many of your red counters ... exactly the same number as I've put blue ones ... just as many, no more, no less."

The child's response is recorded in his protocol and then, if necessary, the experimenter pairs off the red and blue counters (one-to-one correspondence) and makes sure that the child appreciates the numerical equivalence of the two rows.

The experimenter then modifies the lay-out by spacing out the counters in one of the rows, or by moving them together, so that they form either a longer or a shorter row: "Are there as many ... the same number ... of blue ones as red ones or aren't there? Or are there more? How do you know?"

Counter-Arguments

If the child has given a correct conservation answer, the experimenter draws his attention to the lay-out: "Look how long this line is, aren't there more counters?" If the child's answer was wrong, the experimenter reminds him of the initial equivalence: "But don't you remember, before, we put one red counter in front of each blue one, and someone else said that there are the same number of red and blue ones now; what do you think?" In addition, the experimenter asks him a quotity question: "Count the blue ones (the experimenter hides the red ones). How many red ones are there, can you guess without counting them? How do you know?"

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*From the description in this appendix, the interviews might appear rather standardized. In fact, each is adapted to the particular subject, especially with regard to the latter's understanding of the terms used in quantification.

Second situation. Having collected all the counters, the experimenter takes about seven red ones and arranges them in a circle on the table, before proceeding as for the first situation. Having paired off the counters as before, the experimenter either makes one of the circles smaller by pushing the counters closer together or takes the counters from one of the circles and puts them into a heap before asking the same questions as in the first situation.

2. RESPONSES

Nonconservation (up to Four to Five Years)*

When they are asked to put out red counters on the table in the two situations, some children may try to count how many blue ones there are, some may just put some counters down in a haphazard way, while others roughly estimate the number required or pair off the blue and red counters.

In both situations, the conservation questions are answered incorrectly: "There are more red ones because the blue ones are all squashed together," etc.

Only some of the children give a correct answer to the quotity questions.

Intermediate

The children determine the right number of counters to put on the table by pairing off the blue and red counters (one-to-one correspondence).

The following responses are noted when the experimenter asks these children the conservation questions:

a. Some children give correct answers in only one of the situations.

b. Other children hesitate and/or keep changing their minds in both situations: "There are more blue ones ... no, red ones ... they're both the same ..." etc.

Even when these children give correct answers, they cannot explain and justify them adequately.

They give correct answers to the quotity problem, e.g.: "There are seven red ones ... so I should think there are seven blue ones as well."

Conservation (from Five Years)

These children give correct answers to all the questions, are not swayed by anything the experimenter says to try to make them change their minds and give one or several of the following arguments:

"There are just as many blue ones as red ones because it was right before and we haven't taken anything away. they've just been squashed

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* Ages mentioned indicate approximately the start of the corresponding stage, but these may vary with the cultural and educational setting of the subjects.

up" ("identity" argument).

"We could put the others in a heap as well, or put one by the other so there aren't more blue ones or red ones" ("reversibility" argument).

"Here the red ones are in a long row, but there's space in between the counters, so that makes it the same" ("compensation" argument).

II. Different Criteria Sorting Task

See Piaget and Inhelder, 1959.

1. METHOD

Materials: geometrical shapes cut out in cardboard:
five or six little round disks (diameter 25 mm), red ones and blue ones;
five or six large round diskc (diamtere 50 mm), red ones and blue ones;
five or six small squares (25 mm sides), red ones and blue ones;
five or six large squares (50 mm sides), red ones and blue ones;
two flat boxes.

Presentation: The experimenter puts all the shapes in a heap on the table and asks the child to describe them: "Tell me what's there."

Task Description

Situation 1. Spontaneous sorting: "Can you put in a pile all the ones that go together? ... Put those that are very like each other together."

When the child has finished, the experimenter asks him: "Why did you put them like that?"

Situation 2a. Dichotomy: "Now could you put them all in just two piles ('families') and put them into these two boxes?"

When the child has finished, the experimenter asks him: "Why did you put all these together? And all those? What could you call this pile? And that one?"

Situation 2b. First change of criterion: "Could you arrange them any other way in two piles?" If the child has repeated his first solutions, the experimenter says: "You've already done it like that. Can you find a different way of putting them together in two piles?" If necessary, the experimenter himself starts a new method of sorting and asks the child to continue. The interview continues as for 2a.

Situation 2c. Second change of criterion: "Can you find yet another way of putting them in two piles? ... Can you arrange them in a different way?" The interview continues as for 2a and 2b. Finally, the child is asked to recapitulate the first two ways of arranging the shapes: "The first time, how did you divide them? ... And then?"

2. RESPONSES

Figural Collections (from Four to Five Years)

Some children put some roughly similar shapes together, but keep changing the criterion and do not use all the shapes.

Others arrange the shapes in a complicated way, explaining that the result represents, e.g., a train or a house.

First Attempt at Sorting (from Five to Six Years)

The children manage to make up small collections according to various criteria, but cannot link these small collections, e.g., "This is the pile of big red squares, this is the pile of little red circles and this is the pile of big red circles ..." etc. The most advanced children at this level can, if helped, regroup the little collections into general classes, but cannot determine the main criteria before the collections have actually been established.

Sorting According to Several Criteria (from Six to Seven Years)

First of all, the children can announce the criteria, carry out the necessary action, and describe afterward two ways of dividing the shapes into two general classes. The third way has to be suggested by the experimenter. Subsequently, they spontaneously make use of all three criteria.

Table 3

Learning Set Items for Experiment 2

List 1	(Centrality)
The Man reads the Book	(Central)
The Pole rips the Tent	(NC)
The Stapler fastens the Papers	(C)
The Dog pushes the Bone	(NC)
The Tray carried the Glass	(C)
The Ax chops down the Tree	(C)
The Foot picks up the Sock	(NC)
The Horse licks the Fence	(NC)
The Fish swims up the River	(C)
The Rocket dents the Moon	(NC)
The Rabbit eats the Plant	(C)
The Towel covers the Fork	(NC)

List 2	(Centrality)
The Man sits on the Book	(Non-central)
The Pole supports the Tent	(C)
The Stapler falls on the Papers	(NC)
The Dog chews the Bone	(C)
The Tray smashes the Glass	(NC)
The Ax leans against the Tree	(NC)
The Foot wears the Sock	(C)
The Horse jumps over the Fence	(C)
The Fish drinks the River	(NC)
The Rocket lands on the Moon	(C)
The Rabbit steps on the Plant	(NC)
The Towel dries the Fork	(C)

Unlinked List

Man-Book
Pole-Tent
Stapler-Papers
Dog-Bone
Tray-Glass
Ax-Tree
Foot-Sock
Horse-Fence
Fish-River
Rocket-Moon
Rabbit-Plant
Towel-Fork

Table 4

Instructions for Experiment 2

General

Hello, my name is Mike Catchpole. I am a university student and I am doing a project to find out how children like you remember things.

Paired Associate Instructions and Practice

What I am going to do is to read you some pairs of words and then some time later I will read you the first word of each pair and you will have to tell me the word that went with it, you will have to tell me its partner. Let's practice a bit so you are sure that you understand what you are supposed to do. Listen carefully: Button-Elastic; Ashtray-Matches. Now what was the word that went with Button? And what was the word that went with Ashtray?

Example Presentation for Unlinked Condition

Let's practice again with two more pairs. Listen carefully: Knife-Cheese; Lamp-Magazine. Now what went with Knife? And what went with Lamp?

Now I am going to read you the real pairs. Listen carefully so that sometime later when I tell you the first word of a pair you will be able to tell me the second word.

Example Presentation for Linked Condition

When I read you the real pairs that you have to remember they will each be in a short sentence. I want you to listen to the sentence and to try to remember the pair. Let's practice the sentences. Listen carefully: The Knife cuts the Cheese; The Lamp holds down the Magazine. What was the word that went with Knife? What was the word that went with Lamp? What was the last word in that sentence?

Now I am going to read you the real pairs. Each pair will be in a sentence. You must listen carefully so that some time later when I tell you the first word of a pair you will be able to tell me the other word.

Post Presentation Instructions to Delayed Recall Children

In a couple of days I will see if you can remember some of the pairs but I don't want you to worry about or think about the pairs at all until I ask you to remember them in a couple of days.

Immediate and Delayed Recall Instructions

Now let's see if you can remember some of the pairs. I'll tell you the first word of a pair and you try to tell me its partner.

Post Presentation-Testing Instructions to Immediate Recall Children

In a couple of days I'm going to ask you to remember these pairs again but I don't want you to worry about or think about the pairs at all until I ask you to remember them again in a couple of days.

Subsequent Recall Instructions

Now let's see if you can still remember some of the pairs. I'll tell you the first word and you try to tell me the other word.

Table 5

Scoring Criterion for Synonym Responses in Experiment 2

Responses Accepted as Synonyms

Correct Answer	Synonym	Frequency of Occurence	Number of Children Employed by
River	Water	24	18
River	Stream	6	3
River	Lake	6	5
River	Pond	4	4
River	Sea	2	2
River	Pond	1	1
River	Underwater	1	1
Plant	Carrot	17	14
Plant	Bushes	9	7
Plant	Grass	11	8
Plant	Flower	3	2
Plant	Leaf	3	2
Tree	Wood	31	20
Book	Newspaper	2	2
Glass	Cup	11	8
Fork	Spoon	1	1
Fence	Gate	1	1
Moon	Stars	1	1

Table 6

Scoring Criterion for Synonym Responses in Experiment 3

Correct Answer	Synonym	Frequency of Occurrence
Tree	Wood	9
River	Water	4
River	Pond	2
River	Lake	1
River	Brook	1
Plant	Carrot	6
Plant	Lettuce	2
Tray	Cup	3
Tray	Bottle	1
Moon	Planet	1

Table 7

Instructions for Experiment 4

General - (All children)

Hello my name is Mike Catchpole. I am a university student and I am doing a project to find out how children like you remember things. This is just for fun and doesn't count for your report card.

Practice - (All children)

What I am going to do is to read you some pairs of words and then some time later I will read you the first word of each pair and you will have to tell me its partner. Let's practice a bit so you are sure you understand what you are supposed to do. Listen carefully: Button-Shoelace; Ashtray-Matches. Now what was the word that went with Button? And what was the word that went with Ashtray?

Unlinked No Training Children

Let's practice again with two more pairs. Listen carefully: Knife-Cheese; Lamp-Magazine. Now what went with Knife? And what went with Lamp?

Now I am going to read you the real pairs. Listen carefully so that some time later when I tell you the first word of a pair you will be able to tell me the second word.

Unlinked Imagery Prompting Children

There is a special way I want you to learn the real pairs so we will practice this method for a while. What I want you to do is for each pair you hear try to think of a picture of the two things. For example for the pair Kinfe-Cheese think of a picture in your head of a Knife and of a piece of Cheese. Another example is Lamp-Magazine. Think of a picture of each of these things. Now what went with Knife? And what went with Lamp? Now I will read you the real pairs. Be sure that you think of a picture in your head of both things in each pair. Some time later I will tell you the first word of a pair and you will have to tell me its partner. Don't forget to think of the pictures.

Linked No Training Children

When I read you the real pairs that you will have to remember they will be in a short sentence. I want you to listen to the sentence and to try to remember the pair. Let's practice a couple of sentences. Listen carefully: The Knife is in the Cheese; The Lamp is beside the Magazine. What was the word that went with Knife? And what went with Lamp?

Now I am going to read you the real pairs. Each pair will be in a sentence. Listen carefully so that some time later when I tell you the first word of a pair you will be able to tell me the other word.

Linked Imagery Prompting Children

When I read you the real pairs that you will have to remember they will be in a short sentence. I want you to listen to the sentence and try to remember the pair. Now there is a special way that I want you to remember the pairs. When I read you a sentence I want you to think of a picture of what the sentence is saying in your mind. Think of a picture of what the sentence describes. Let's practice this with a couple of sentences. Think of a picture of what each of these sentences describes:

The Knife is in the Cheese. Think of a picture of that. The Lamp is beside the Magazine. Think of a picture of that. Now what went with Knife? And what went with Lamp?

Now I will read you the real pairs. Each pair will be in a sentence. For every sentence I want you to think up a picture of what the sentence describes. Then sometime later when I tell you the first word of a pair you will be able to tell me its partner. Don't forget to think of a picture of what the sentence describes.

After Presentation

Immediate Recall Children

Now we will see if you can remember some of the pairs. I will tell you the first word of a pair and you try to tell me its partner. (After testing tell them you will restes in a couple of days but don't think about or worry about the pairs.)

Postponed Children

In a couple of days I will see if you can remember some of the pairs. I don't want you to think or worry about the pairs during the next two days. Just put them out of your mind.

Table 8

Scoring Criterion for Synonym Responses in Experiment 4

Responses Accepted as Synonyms

Correct Answer	Synonym	Frequency of Occurrence	Number of Children Employing
Lake	Pond	37	25
Lake	Water	9	8
Lake	River	2	2
Lake	Swamp	1	1
Bowl	Dish	10	6
Bowl	Plate	2	2
Book	Paper	3	3
Octopus	Squid	3	2
Rat	Mouse	2	2
Tree	Pole	1	1
Bus	Truck	1	1

APPENDIX B

Table 1

Overall Analysis of Variance for Experiment 1

Group x Experimenter Order x Set Order x Time of Test

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Group	/175.732	2	87.866	10.369	0.000
Experimenter	1.409	1	1.409	0.166	0.686
Set	22.902	1	22.902	2.703	0.109
G x E	41.679	2	20.840	2.459	0.100
G x S	39.400	2	19.700	2.325	0.112
E x S	0.289	1	0.289	0.034	0.855
G x E x S	8.712	2	4.356	0.514	0.602
Error	305.048	36	8.474		
Time	24.360	1	24.360	9.384	0.004
T x G	41.203	2	20.601	7.936	0.001
T x E	39.816	1	39.816	15.338	0.000
T x S	16.087	1	16.087	6.197	0.018
T x G x E	8.001	2	4.001	1.541	0.228
T x G x S	3.821	2	1.911	0.736	0.486
T x E x S	2.286	1	2.286	0.881	0.354
T x G x E x S	0.963	2	0.481	0.185	0.832
Error	93.451	36	2.596		

Table 2

Analysis of Variance for Experiment 1

Collapsed Over Experimenter Order and Set Order -

Group x Time of Test

Source	Sum of Squares	*df*	*MS*	*F*	*p*
Group	195.163	2	97.581	11.052	0.000
Error	397.323	45	8.829		
Time of Test	29.229	1	29.229	8.365	0.001
Time x Group	56.912	2	28.456	8.144	0.006
Error	157.243	45	3.494		

Table 3

Analysis for Simple Main Effects of the Significant Group x Time Interaction in Experiment 1

	Time 1 (b_1) (Total)	(n)	Time 2 (b_2) (Total)	(n)	
Group 1 (a_1)	46	n=15	49	n=15	95
Group 2 (a_2)	96	n=14	95	n=14	191
Group 3 (a_3)	58	n=19	119	n=19	177
	200		263		

$3\ a_1 = 95^2/30 = 300.83$

$3\ a_2 = 191^2/28 = 1302.89$

$3\ a_3 = 177^2/38 = 844.45$

$5\ a_1 = 46^2/15 + 49^2/15 = 301.13$

$5\ a_2 = 96^2/14 + 95^2/14 = 1302.93$

$5\ a_3 = 58^2/19 + 119^2/19 = 922.37$

$4\ b_1 = 200^2/48 = 833.33$

$5\ b_1 = 58^2/19 + 46^2/15 + 96^2/14$

$= 976.41$

$4\ b_2 = 263^2/48 = 1441.02$

$5\ b_2 = 119^2/19 + 49^2/15 = 95^2/14$

$= 1550.02$

Simple Effects for A:

For b_1 - SSa for $b_1 = 5b_1 - 4b_1 = 143.08$

For b_2 - SSa for $b_2 = 5b_2 - 4b_2 = 109.00$

(continued)

Table 3 (continued)

Simple Effects for B:

For a_1 - SSb for $a_1 = 5a_1 - 3a_1 = 0.30$

SSb for $a_2 = 5a_2 - 3a_2 = 0.04$

SSb for $a_3 = 5a_3 - 3a_3 = 77.92$

Anova for Simple Effects

Source	SS	df	MS	F	p
Group for Time 1	143.08	2	71.54	11.61	0.01
Group for Time 2	109.00	2	54.50	8.85	0.01
Error		45	6.16*		
Time for Group 1	0.30	1	0.30	0.09	n.s.
Time for Group 2	0.04	1	0.04	0.01	n.s.
Time for Group 3	77.92	1	77.92	22.33	0.01
Error		45	3.49*		

* Winer (1962, p. 310) - for a within subject variable at one level of a between subject variable the original within subject error term is used (i.e., 3.49), however for a between subject variable at one level of a within subject variable the correct error term (Winer, 1962, p. 323) given a reasonably large number of degrees of freedom (over 30) is $(MS(e)A + (q-1)MS(e)B)/_q$ = (8.829 + (2-1)3.494)/2 = 6.16.

Table 4

Tukey Tests for the Significant Effect of Group at Time 1 and Group at Time 2

MS(e) = 6.16 (see Appendix Table 3)

n - a harmonic n must be employed (i.e., $\bar{n}_h$) since the group sizes are unequal. $\bar{n}_h$ = No. of levels of $A/(1/a_1 + 1/a_2 + 1/a_3)$

$= 3/(1/15 + 1/14 + 1/19)$

$= 15.79$ MS(e)/n = 6.16/15.79 = 0.62

Truncated Range r

$S\bar{x}$ g .95 (r,45)	= 3.43
$S\bar{x}$ g .99 (r,45)	= 4.35
r(MS(e)/n) .95	= 2.14
r(MS(e)/n) .99	= 2.72

a) For Group at Time 1 ($\underline{F}(2,45) = 11.61$, $\underline{p} < .01$)

Order	1	2	3
Trts. in Order of Position	Group 3	Group 1	Group 2
Tj	3.05	3.07	6.86

	Group 3	Group 1	Group 2
G3		$0.02^{n.s.}$	3.81^{**}
G1			3.79^{**}
G2			

G3 = G1 < G2

b) For Group at Time 2 ($\underline{F}(2,45) = 8.85$, $\underline{p} < .01$)

Order	1	2	3
Trts. in Order of Position	G1	G3	G2
Tj	3.27	6.26	6.79

	Group 1	Group 3	Group 2
G1		3.99^{**}	3.52^{**}
G3			$0.53^{n.s.}$
G2			

G1 < G2 = G3

Table 5

Analysis of Variance for Group x Time in Experiment 1 with Age (Above Median *vs* Below Median) as an Independent Variable

Source	SS	df	MS	F	p
Group	194.360	2	97.180	11.350	0.000
Age	17.737	1	17.737	2.071	0.157
Group x Age	15.620	2	7.815	0.913	0.409
Error	359.614	42	8.562		
Time	28.239	1	28.239	8.167	0.007
Time x Group	57.408	2	28.704	8.302	0.001
Time x Age	0.513	1	0.513	0.148	0.702
Time x Group x Age	11.651	2	5.825	1.685	0.198
Error	145.218	42	3.458		

Table 6

Analysis of Variance Comparing the Performance of the Piagetian Tested *vs* Non-Tested Group 3 Children Over Time - Inclusion x Time

Source	*SS*	*df*	*MS*	*F*	*p*
Inclusion	9.797	1	9.797	0.880	0.361
Error	189.256	17	11.133		
Time	88.823	1	88.823	20.199	0.000
Time x Inclusion	4.823	1	4.823	1.097	0.310
Error	74.756	17	4.397		

Table 7

Analysis of Variance for Second Noun Recall of Linked *vs* Unlinked Pairs: Grade (2 *vs* 4) x Time (Immediate *vs* Two Day Postponed) x Recall Order (1 *vs* 2) x Link (linked *vs* Unlinked) - Synonyms Included

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Grade	17.881	1	17.881	3.012	0.087
Time	146.615	1	146.615	24.695	0.001
Order	3.764	1	3.764	0.634	0.429
Link	5.490	1	5.490	0.925	0.339
G x T	0.258	1	0.258	0.043	0.836
G x O	24.572	1	24.572	4.139	0.046
T x O	0.071	1	0.071	0.012	0.913
G x L	0.241	1	0.241	0.041	0.841
T x L	7.558	1	7.558	1.273	0.263
O x L	4.578	1	4.578	0.771	0.383
G x T x O	3.658	1	3.658	0.616	0.435
G x T x L	2.729	1	2.729	0.460	0.500
G x O x L	46.269	1	46.269	7.793	0.007
T x O x L	0.000	1	0.000	0.000	0.993
G x T x O x L	4.696	1	4.696	0.791	0.377
Error	427.467	72	5.937		

Table 8

Analysis of Variance for Second Noun Recall of Linked *vs* Unlinked Pairs: Grade (2 *vs* 4) x Time (Immediate *vs* Two Day Postponed) x Recall Order (1 *vs* 2) x Link (Linked *vs* Unlinked) - No Synonyms

Source	Sum of Squares	*df*	Mean Squares	*F*	*p*
Grade	13.250	1	13.250	2.623	0.110
Time of Recall	165.478	1	165.478	32.762	0.000
Order	0.176	1	0.176	0.035	0.853
Link	4.256	1	4.256	0.843	0.362
G x T	2.321	1	2.322	0.450	0.500
G x O	21.917	1	21.917	4.339	0.041
T x O	2.933	1	2.933	0.581	0.449
G x L	0.078	1	0.078	0.015	0.901
T x L	5.686	1	5.686	1.126	0.292
O x L	0.885	1	0.885	0.175	0.677
G x T x O	2.236	1	2.236	0.443	0.508
G x T x L	0.634	1	0.634	0.125	0.724
G x O x L	47.853	1	47.853	9.474	0.003
T x O x L	1.556	1	1.556	0.308	0.581
G x T x O x L	7.350	1	7.530	1.491	0.270
Error	363.667	72	5.051		

Table 9

Analysis of Variance for Recall of Linked *vs* Unlinked Non-Associated Items: Grade (2 *vs* 4) x Time (Immediate *vs* Two Day Postponed) x Order (1 *vs* 2) x Link (Link *vs* Unlinked)

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Grade	1.037	1	1.037	0.965	0.329
Time	14.637	1	14.637	13.615	0.000
Order	0.002	1	0.002	0.002	0.968
Link	0.005	1	0.005	0.005	0.942
Grade x Time	1.222	1	1.222	1.136	0.290
Grade x Order	2.592	1	2.592	2.411	0.125
Time x Order	0.770	1	0.770	0.716	0.400
Grade x Link	0.382	1	0.382	0.356	0.553
Time x Link	1.812	1	1.812	1.685	0.198
Order x Link	0.362	1	0.362	0.336	0.564
Grade x Time x Order	0.004	1	0.004	0.003	0.954
Grade x Time x Link	0.800	1	0.800	0.744	0.391
Grade x Order x Link	4.621	1	4.621	4.298	0.042
Time x Order x Link	0.413	1	0.413	0.384	0.538
Grade x Time x Order x Link	0.672	1	0.672	0.625	0.432
Error	77.414	72	1.075		

Table 10

Analysis of Variance of Percentage Loss Scores for the Immediate-Two Day Retest Children for Linked versus Unlinked Pairs: Grade (2 _vs_ 4) x Recall Order (1 then 2 _vs_ 2 then 1) x Link (Linked _vs_ Unlinked) - Synonyms Included

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Grade	1182.633	1	1182.633	1.973	0.168
Order	49.267	1	49.267	0.082	0.776
Link	20.254	1	20.267	0.034	0.855
G x O	407.090	1	407.090	0.679	0.415
G x L	66.496	1	66.496	0.111	0.741
O x L	18.586	1	18.586	0.031	0.861
G x O x L	595.043	1	595.043	0.993	0.325
Error	23981.464	40	599.537		

Table 11

Analysis of Variance of Percentage Loss Scores for the Immediate-Two Day Retest Children for Linked versus Unlinked Pairs: Grade (2 _vs_ 4) x Recall Order (1 then 2 _vs_ 2 then 1) x Link (Linked _vs_ Unlinked)- No Synonyms

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Grade	1154.953	1	1154.953	3.187	0.082
Order	62.234	1	62.234	0.172	0.681
List	395.297	1	395.297	1.091	0.303
G x O	15.195	1	15.195	0.042	0.839
G x L	452.176	1	452.176	1.248	0.271
O x L	57.586	1	57.586	0.159	0.692
G x O x L	350.777	1	350.777	0.968	0.331
Error	14495.801	40	362.395		

Table 12

Analysis of Variance for Linked *vs* Unlinked Recall at Two Week: Previous Noun Recall Tests (1 *vs* 2) x Link (Linked *vs* Unlinked) - Grade 4's Only - Synonyms Included

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Previous Tests	46.573	1	46.573	5.704	0.022
Link	0.028	1	0.028	0.003	0.954
P x L	0.263	1	0.263	0.032	0.859
Error	302.122	37	8.165		

Table 13

Analysis of Variance for Linked *vs* Unlinked Recall at Two Week:
Previous Noun Recall Tests (1 *vs* 2) x Link (Linked *vs*
Unlinked) - Grade 4's Only - No Synonyms

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Previous Tests	50.141	1	50.141	6.996	0.012
Link	0.956	1	0.956	0.133	0.717
P x L	1.374	1	1.374	0.192	0.664
Error	265.194	37	7.167		

Table 14

Analysis of Variance for Link Effects Among the Non-Associated Items in the Two Week Condition: Previous Noun Recall Tests (1 _vs_ 2) x Link (Link _vs_ Unlinked)

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Previous Tests	9.482	1	9.482	6.214	0.017
Link	0.997	1	0.997	0.654	0.420
P x L	0.028	1	0.028	0.018	0.900
Error	56.457	37	1.526		

Table 15

Analysis of Variance for Centrally Linked versus Non-Centrally Linked Pairs: Non-Central vs Central x Immediate vs Two Day Postponed x Grade 2 vs Grade 4 x Recall Order 1 vs Recall Order 2 x List 1 vs List 2 - Synonyms Included

Source	Sum of Squares	df	Mean Square	F	p
Grade	7.903	1	7.903	2.285	0.137
Time of Recall	121.903	1	121.903	35.242	0.000
Order	0.001	1	0.001	0.000	0.988
List	0.095	1	0.095	0.028	0.869
G x T	0.636	1	0.636	0.184	0.670
G x O	1.566	1	1.566	0.453	0.504
T x O	0.007	1	0.008	0.002	0.963
G x L	6.351	1	6.531	1.836	0.182
T x L	0.256	1	0.256	0.074	0.787
O x L	0.069	1	0.069	0.020	0.889
G x T x O	0.008	1	0.008	0.002	0.963
G x T x L	0.037	1	0.037	0.011	0.918
G x O x L	4.764	1	4.764	1.377	0.246
T x O x L	0.041	1	0.041	0.012	0.913
G x T x O x L	0.529	1	0.529	0.153	0.697
Error	169.491	49	3.459		
Centrality	2.134	1	2.134	2.294	0.136
C x G	0.268	1	0.268	0.288	0.594
C x T	4.612	1	4.612	4.957	0.031
C x O	0.118	1	0.118	0.127	0.723
C x L	11.593	1	11.593	12.459	0.001
C x G x T	1.808	1	1.808	1.943	0.170
C x G x O	1.935	1	1.935	2.080	0.156
C x T x O	3.028	1	3.028	3.255	0.077
C x G x L	0.069	1	0.069	0.074	0.787
C x T x L	5.834	1	5.834	6.270	0.016
C x O x L	0.922	1	0.922	0.991	0.324
C x G x T x O	0.332	1	0.332	0.357	0.553
C x G x T x L	0.712	1	0.712	0.765	0.386
C x G x O x L	1.566	1	1.566	1.683	0.201
C x T x O x L	1.566	1	1.566	1.683	0.201
C x G x T x O x L	0.712	1	0.712	0.765	0.386
Error	45.592	49	0.930		

Table 16

Analysis of Variance for Centrally Linked versus Non-Centrally Linked Pairs: Non-Central vs Central x Immediate vs Two Day Postponed x Grade 2 vs Grade 4 x Recall Order 1 vs Recall Order 2 x List 1 vs List 2 - No Synonyms

Source	Sum of Squares	df	Mean Square	F	p
Grade	6.529	1	6.529	2.235	0.141
Time of Recall	127.624	1	127.624	43.693	0.000
Order	0.046	1	0.046	0.016	0.900
List	0.655	1	0.655	0.224	0.638
G x T	0.268	1	0.268	0.092	0.763
G x O	2.067	1	2.067	0.708	0.404
T x O	0.006	1	0.006	0.002	0.965
G x L	4.612	1	4.612	1.579	0.215
T x L	0.772	1	0.772	0.264	0.609
O x L	1.185	1	1.185	0.406	0.527
G x T x O	0.636	1	0.636	0.218	0.643
G x T x L	0.332	1	0.332	0.114	0.737
G x O x L	2.343	1	2.343	0.802	0.375
T x O x L	0.636	1	0.636	0.218	0.643
G x T x O x L	0.389	1	0.388	0.133	0.717
Error	143.124	49	2.921		
Centrality	0.922	1	0.922	0.888	0.351
C x G	0.021	1	0.021	0.020	0.887
C x T	3.151	1	3.151	3.304	0.088
C x O	0.233	1	0.233	0.225	0.638
C x L	0.015	1	0.015	0.014	0.905
C x G x T	0.922	1	0.922	0.888	0.351
C x G x O	0.546	1	0.546	0.526	0.472
C x T x O	0.546	1	0.546	0.526	0.472
C x G x L	0.268	1	0.268	0.258	0.614
C x T x L	4.663	1	4.663	4.489	0.039
C x O x L	0.512	1	0.512	0.493	0.486
C x G x T x O	0.464	1	0.464	0.446	0.507
C x G x T x L	0.222	1	0.222	0.214	0.646
C x G x O x L	2.067	1	2.067	1.990	0.165
C x T x O x L	1.185	1	1.185	1.141	0.291
C x G x T x O x L	0.018	1	0.018	0.017	0.896
Error	50.891	49	1.039		

Table 17

Analysis of Simple, Simple Main Effects for the Significant Time (Immediate vs Two Day Postponed) x List x Centrality Interaction Among the Linked Scores - Loose Criterion

		Non-Central (C_1)		Central (C_2)		
Immediate (a_1)	List 1 (b_1)	61	n=17	63	n=17	124
	List 2 (b_2)	66	n=17	60	n=17	126
Two Day Postponed (a_2)	List 1 (b_1)	14	n=17	42	n=17	56
	List 2 (b_2)	28	n=14	22	n=14	50

(total scores in each condition collapsed over Grade and Recall Order are provided)

* for C (within subject) at any between subject variable, MSw. error = 0.930 (1, 49), i.e., the within subject error term.

$9a_1b_1 = a_1b_1c_1^2/n + a_1b_1c_2^2/n = 452.353$ $\quad 6a_1b_1 = a_1b_1^2/n = 452.235$

$9a_1b_2 = a_1b_2c_1^2/n + a_1b_2c_2^2/n = 468.000$ $\quad 6a_1b_2 = a_1b_2^2/n = 466.941$

$9a_2b_1 = a_2b_1c_1^2/n + a_2b_1c_1^2/n = 115.294$ $\quad 6a_2b_1 = a_2b_1^2/n = 92.235$

$9a_2b_2 = a_2b_2c_1^2/n + a_2b_2c_2^2/n = 90.571$ $\quad 6a_2b_2 = a_2b_2^2/n = 89.286$

$9a_1b_1 - 6a_1b_1 = 0.118$

$9a_1b_2 - 6a_1b_2 = 1.059$

$9a_2b_1 - 6a_2b_1 = 23.059$

$9a_2b_2 - 6a_2b_2 = 1.285$

Table 17 continued

Source	SS	df	MS	F	p
C for a_1b_1 (Centrality for Imm. List 1)	0.118	1	0.118	0.12	n.s
C for a_1b_2 (Centrality for Imm. List 2)	1.059	1	1.059	1.13	n.s.
C for a_2b_1 (Centrality for Postponed List 1)	23.059	1	23.059	24.79	<.01
C for a_2b_2 (Centrality for Postponed List 2)	1.285	1	1.285	1.38	n.s.
Error (original MSw cell)		49	0.930		

Table 18

Analysis of Simple Main Effects for the Significant Time of Recall (Immediate vs Two Day Postponed) x List 1 vs 2) x Centrality (Non-Central vs Central) Interaction Among The Linked Pairs - Strict Criterion Scores Only

		Non-Central (c_1)		Central (c_2)		
Immediate (a_1)	List 1 (b_1)	61	n=17	52	n=17	113
	List 2 (b_2)	56	n=17	60	n=17	116
Postponed (a_2)	List 1 (b_1)	14	n=17	28	n=17	42
	List 2 (b_2)	21	n=14	22	n=14	43

(total scores collapsed over Grade and Recall Order are provided

* for C (within) at any between subject variable, MSw error = 1.039 (1,49), i.e., the within subject error term.

$9a_1b_1 = a_1b_1c_1^2/n + a_1b_1c_2^2/n = 377.93$ $\quad$ $6a_1b_1 = a_1b_1^2/n = 375.55$

$9a_1b_2 = a_1b_2c_1^2/n + a_1b_2c_2^2/n = 396.23$ $\quad$ $6a_1b_2 = a_1b_2^2/n = 395.76$

$9a_2b_1 = a_2b_1c_1^2/n + a_2b_1c_2^2/n = 57.63$ $\quad$ $6a_2b_1 = a_2b_1^2/n = 51.88$

$9a_2b_2 = a_2b_2c_1^2/n + a_2b_2c_2^2/n = 66.07$ $\quad$ $6a_2b_2 = a_2b_2^2/n = 66.03$

$$9a_1b_1 - 6a_1b_1 = 2.38$$

$$9a_1b_2 - 6a_1b_2 = 0.47$$

$$9a_2b_1 - 6a_2b_1 = 5.75$$

$$9a_2b_2 - 6a_2b_2 = 0.04$$

Table 18 continued

Source	SS	df	MS	F	p
C at a_1b_1 (Centrality at Immd. List 1)	2.38	1	2.38	2.29	n.s.
C at a_1b_2 (Centrality at Immd. List 2)	0.47	1	0.47	0.45	n.s.
C at a_2b_1 (Centrality at Postponed List 1)	5.75	1	5.75	5.53	$<.05$
C at a_2b_2 (Centrality at Postponed List 2)	0.04	1	0.04	0.03	n.s.
Error		49	1.04		

Table 19

Analysis of Variance for Pair Set 1 versus Pair Set 2 in the Unlinked Condition Only: Time of Recall (Immediate *vs* Two Day Postponed) x Pair Set (1 *vs* 2) - Loose Criterion Scores

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Time of Recall	9.773	1	9.773	2.794	0.109
Error	73.444	21	3.497		
Pair Set	4.754	1	4.754	3.676	0.069
P x T	0.580	1	0.580	0.449	0.510
Error	27.259	21	1.293		

Table 20

Analysis of Variance for Pair Set 1 versus Pair Set 2 in the Unlinked Condition Only: Time of Recall (Immediate *vs* Two Day Postponed x Pair Set (1 *vs* 2) - Strict Criterion Scores

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Time of Recall	15.631	1	15.631	4.485	0.046
Error	73.194	21	3.485		
Pair Set	0.091	1	0.091	0.066	0.799
P x T	0.004	1	0.004	0.003	0.956
Error	28.909	21	1.377		

Table 21

Analysis of Variance of Percentage Loss Scores for the Immediate Two Day Retest Children for the Linked Condition Only - Grade (2 vs 4) x Order (1 vs 2) x List (1 vs 2) x Centrality (Non-Central vs Central) - No Synonyms

Source	Sum of Squares	df	Mean Squares	F	p
Grade	53.348	1	53.348	0.060	0.808
Order	2.918	1	2.918	0.003	0.955
List	1020.039	1	1020.039	1.156	0.292
G x O	1475.441	1	1475.039	1.673	0.207
G x L	286.848	1	286.848	0.325	0.573
O x L	22.645	1	22.645	0.026	0.874
G x O x L	91.449	1	91.449	0.104	0.750
Error	22932.246	26	882.449		
Centrality	2.543	1	2.543	0.003	0.955
C x G	178.980	1	178.980	0.231	0.635
C x O	144.516	1	144.516	0.186	0.670
C x L	1552.098	1	1552.098	2.000	0.169
C x G x O	52.117	1	52.117	0.067	0.798
C x G x L	144.457	1	144.457	0.186	0.670
C x O x L	2034.641	1	2034.641	2.621	0.117
C x G x O x L	101.398	1	101.398	0.131	0.721
Error	20179.852	26	776.148		

Table 22

Analysis of Variance of Percentage Loss Scores for the Immediate-Two Day Retest Children for the Linked Condition Only - Grade (2 vs 4) x Order (1 vs 2) x List (1 vs 2) x Centrality (Non-Central vs Central) - Synonyms Included

Source	Sum of Squares	df	Mean Square	F	p
Grade	4.785	1	4.785	0.003	0.956
Order	844.211	1	844.211	0.536	0.471
List	2541.683	1	2541.683	1.612	0.215
G x O	3046.430	1	3046.430	1.933	0.176
G x L	76.473	1	76.473	0.049	0.827
O x L	1854.832	1	1854.832	1.177	0.288
G x O x L	879.258	1	879.258	0.558	0.462
Error	40983.391	26	1576.284		
Centrality	285.008	1	285.008	0.321	0.576
C x G	1525.680	1	1525.680	1.717	0.202
C x O	2533.145	1	2533.145	2.851	0.103
C x L	8407.323	1	8407.323	9.462	0.005
C x G x O	745.754	1	745.754	0.839	0.368
C x G x L	6.383	1	6.383	0.007	0.933
C x O x L	5756.488	1	5756.488	6.478	0.017
C x G x O x L	721.074	1	721.074	0.811	0.376
Error	23102.672	26	888.564		

Table 23

Simple Main Effects Analysis of the Significant List x Centrality Interaction in the Analysis of Percentage Loss Scores - Synonyms Included

	Non-Central (b_1)	Central (b_2)	
List 1 (a_1)	436.65	146.33	n=17
List 2 (a_2)	-116.67	301.66	n=17

* total scores collapsed over Grade

* for B (within subject at any between subject variable, MSw. error = 888.56 (1,26) - i.e., the original within subject error term)

$$SS\ b\ at\ a_1 = a_1b_1^2\ /17 + a_1b_2^2\ /17 - A_1^2/34 = 2444.95$$

$$SS\ b\ at\ a_2 = a_2b_1^2\ /17 + a_2b_2^2\ /17 - A_2^2/34 = 9699.22$$

Source	SS	df	MS	F	p
B for a_1 (Centrality for List 1)	2444.95	1	2444.95	2.75	n.s.
B for a_2 (Centrality for List 2)	9699.22	1	9699.22	10.91	<.01
Error		26	888.56		

Table 24

Simple Main Effects Analysis of the Significant List x Order x Centrality Interaction in the Analysis of Percentage Loss Scores - Synonyms Included

		Non-Central (c_1)	Central (c_2)	
List 1 (a_1)	Order 1 (b_1)	269.99	58.33	n=9
	Order 2 (b_2)	166.66	90.00	n=8
List 2 (a_2)	Order 1 (b_1)	-266.66	195.00	n=8
	Order 2 (b_2)	149.99	106.66	n=9

*Total scores collapsed over Grade

* for C (within subject) at any between subject variable, MSw. error = 888.56 (1,26) - i.e., the within subject error term

$SS\ c\ at\ a_1b_1 = a_1b_1c_1^2/9 + a_1b_1c_2^2/9 - A_1B_1^2/18 = 2488.88$

$SS\ c\ at\ a_1b_2 = a_1b_2c_1^2/8 + a_1b_2c_2^2/8 - A_1B_2^2/16 = 376.29$

$SS\ c\ at\ a_2b_1 = a_2b_1c_1^2/8 + a_2b_1c_2^2/8 - A_2B_1^2/16 = 13320.62$

$SS\ c\ at\ a_2b_2 = a_2b_2c_1^2/9 + a_2b_2c_2^2/9 - A_2B_2^2/18 = 104.30$

Source	SS	df	MS	F	p
C at a_1b_1 (Centrality for List 1, Order 1)	2488.88	1	2488.88	2.80	n.s.

continued

Table 24 continued

Source	SS	df	MS	F	p
C at a_1b_2 (Centrality for List 1, Order 2)	376.29	1	376.29	0.41	n.s.
C at a_2b_1 (Centrality for List 2, Order 1)	13320.62	1	13320.62	14.99	<.01
C at a_2b_2 (Centrality for List 2, Order 2)	104.30	1	104.30	0.11	n.s.
Error		26	888.56		

Table 25

Analysis of Variance for Recall of Non-Central Connectives Immediately Following the Two Day Postponed or Two Day Retest Recall: Grade (2 _vs_ 4) x List (1 _vs_ 2) x Time of Recall (Two Day Postponed _vs_ Two Day Retest)

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Grade	1.909	1	1.909	0.861	0.357
Time	36.931	1	36.931	16.645	0.000
List	1.953	1	1.953	0.880	0.352
G x T	0.246	1	0.246	0.111	0.740
G x L	0.989	1	0.989	0.446	0.507
T x L	2.195	1	2.195	0.989	0.324
G x T x L	0.597	1	0.597	0.269	0.606
Error	126.473	57	2.219		

Table 26

Analysis of Variance Comparing the Performance of Children in the Two Day Postponed vs Two Day Retest Conditions: Grade (2 vs 4) a Time of Recall (Two Day Postponed vs Two Day Retest) x Order of Recall (1 vs 2) x List (1 vs 2) x Centrality (Non-Central vs Central) - Loose Criterion

Source	Sum of Squares	df	Mean Square	F	p
Grade	12.033	1	12.033	3.556	0.065
Time of Recall	72.604	1	72.604	21.455	0.000
Order	0.230	1	0.230	0.088	0.767
List	0.590	1	0.590	0.174	0.678
G x T	0.020	1	0.020	0.006	0.940
G x O	1.275	1	1.275	0.377	0.542
T x O	0.440	1	0.440	0.130	0.720
G x L	6.322	1	6.322	1.868	0.178
T x L	0.002	1	0.002	0.001	0.980
O x L	0.274	1	0.274	0.081	0.777
G x T x O	0.001	1	0.001	0.000	0.985
G x T x L	0.035	1	0.035	0.010	0.920
G x O x L	2.649	1	2.469	0.730	0.397
T x O x L	0.979	1	0.979	0.289	0.593
G x T x O x L	1.792	1	1.792	0.530	0.470
Error	165.816	49	3.384		
Centrality	1.761	1	1.761	2.151	0.149
C x G	0.590	1	0.590	0.721	0.400
C x T	5.205	1	5.205	6.358	0.015
C x O	0.572	1	0.572	0.699	0.407
C x L	26.233	1	26.233	32.041	0.000
C x G x T	1.197	1	1.197	1.462	0.232
C x G x O	0.003	1	0.003	0.004	0.949
C x T x O	0.410	1	0.410	0.501	0.483
C x G x L	0.054	1	0.054	0.066	0.798
C x T x L	0.488	1	0.488	0.596	0.444
C x O x L	0.011	1	0.011	0.013	0.908
C x G x T x O	0.762	1	0.762	0.931	0.339
C x G x T x L	0.122	1	0.122	0.149	0.701
C x G x O x L	1.610	1	1.610	1.966	0.167
C x T x O x L	5.366	1	5.366	6.554	0.014
C x G x T x O x L	0.683	1	0.683	0.834	0.366
Error	40.117	49	0.891		

Table 27

Analysis of Variance Comparing the Performance of Children in the Two Day Postponed vs Two Day Retest Conditions: Grade (2 vs 4) x Time of Recall (Two Day Postponed vs Two Day Retest) x Order of Recall (1 vs 2) x List (1 vs 2)x Centrality (Non-Central vs Central) - Strict Criterion

Source	Sum of Squares	df	Mean Square	F	p
Grade	7.968	1	7.968	2.794	0.101
Time	61.282	1	61.282	21.468	0.000
Order	0.069	1	0.069	0.024	0.877
List	1.625	1	1.625	0.570	0.454
G x T	0.617	1	0.617	0.216	0.644
G x O	0.001	1	0.001	0.000	0.986
T x O	0.001	1	0.001	0.000	0.986
G x L	3.447	1	3.447	1.209	0.277
T x L	0.171	1	0.171	0.060	0.808
O x L	0.673	1	0.673	0.236	0.629
G x T x O	0.373	1	0.373	0.131	0.719
G x T x L	0.081	1	0.081	0.029	0.867
G x O x L	1.110	1	1.110	0.389	0.536
T x O x L	1.236	1	1.236	0.433	0.513
G x T x O x L	1.210	1	1.210	0.424	0.518
Error	139.758	49	2.852		
Centrality	0.673	1	0.673	0.675	0.415
C x G	0.012	1	0.012	0.012	0.912
C x T	3.667	1	3.667	3.675	0.061
C x O	0.211	1	0.211	0.212	0.647
C x L	0.417	1	0.417	0.418	0.521
C x G x T	0.991	1	0.991	0.993	0.324
C x G x O	0.332	1	0.332	0.333	0.567
C x T x O	0.581	1	0.581	0.593	0.449
C x G x L	0.171	1	0.171	0.171	0.681
C x T x L	1.935	1	1.935	1.939	0.170
C x O x L	0.033	1	0.033	0.033	0.857
C x G x T x O	0.402	1	0.402	0.403	0.528
C x G x T x L	0.332	1	0.332	0.333	0.567
C x G x O x L	0.028	1	0.028	0.029	0.867
C x T x O x L	2.637	1	2.637	2.643	0.110
C x G x T x O x L	1.968	1	1.968	1.972	0.167
Error	48.891	49	0.998		

Table 28

Analysis of Variance for the Two Week Loose Criterion Scores:
Previous Noun Recall Tests (1 _vs_ 2) x List (1 vs 2)
x Centrality (Non-Central _vs_ Central)

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Previous Tests	22.181	1	22.181	4.807	0.038
List	1.436	1	1.436	0.311	0.582
P x L	3.639	1	3.639	0.788	0.383
Error	115.366	25	4.615		
Centrality	2.223	1	2.223	3.210	0.085
C x P	8.074	1	8.074	11.656	0.002
C x L	4.500	1	4.500	6.496	0.017
C x L x P	0.096	1	0.096	0.138	0.713
Error	17.318	25	0.693		

Table 29

Analysis of Simple Main Effects for the Previous Noun Recall Tests (1 *vs* 2) x Centrality Interaction Within the Two Week Scores - Grade Four Loose Criterion

	Non-Central (b_1)	Central (b_2)		
Immediate + Retest (a_1)	61	55	n=15	116
Postponed (a_2)	28	45	n=14	7.3
	89	100		

* total scores in each condition collapsed over List

* for B (within subject) at A (between subject) the MSw. error = 0.693; i.e., the within subject error term.

$$SSb \text{ at } a_1 = a_1b_1^2/15 + a_1b_2^2/15 - A_1^2/30 = 1.200$$

$$SSb \text{ at } a_2 = a_2b_1^2/15 + a_2b_2^2/14 - A_2^2/28 = 10.322$$

Source	SS	df	MS	F	p
B for a_1 (Centrality at Two Previous Recalls)	1.200	1	1.200	1.732	n.s.
B for a_2 (Centrality at One Previous Recall)	10.322	1	10.322	14.895	<.01
Error (original MSw. cell)		25	0.693		

Table 29 continued

SSa at $b_1 = a_1 b_1^2/15 + a_2 b_1^2/14 - B_1^2/29 = 30.92$

SSa at $b_2 = a_1 b_2^2/15 + a_2 b_2^2/14 - B_2^2/29 = 1.48$

* for A (between subject) at B (within subject); Error = (MS(e) Between + (q-1)MS(e) within)/q = (4.62 + (2-1)0.69)/2 = 2.65

Source	SS	df	MS	F	p
A for B_1 (Previous Test at Non-Central)	30.92	1	30.92	11.66	<.01
A for B_2 (Previous Tests at Central)	1.48	1	1.48	0.55	n.s.
Error		25	2.65		

Table 30

Analysis of Simple Main Effects for the List x Centrality Interaction Within the Two Week Recall Scores - Grade Four Loose Criterion

	Non-Central (b_1)	Central (b_2)		
List 1 (a_1)	38	53	n=15	91
List 2 (a_2)	51	47	n=14	98
	89	100		

* total scores in each condition collapsed over Previous Tests

* for B (within subject) at A (between subject) the MSw. error = 0.693, i.e., the within subject error term.

$$SSb \text{ at } a_1 = a_1b_1^2/15 + a_1b_2^2/15 - A_1^2/30 = 7.500$$

$$SSb \text{ at } a_2 = a_2b_1^2/14 + a_2b_2^2/14 - A_2^2/28 = 0.571$$

Source	SS	df	MS	F	p
B for a_1 (Centrality at List 1)	7.500	1	7.500	10.823	<.01
B for a_2 (Centrality at List 2)	0.571	1	0.571	0.824	n.s.
Error (original MSw. cell)		25	0.693		

Table 30 continued

$$SSa \text{ at } b_1 = a_1b_1^2/15 + a_2b_1^2/14 - B_1^2/29 = 8.91$$

$$SSa \text{ at } b_2 = a_1b_2^2/15 + a_2b_2^2/14 - B_2^2/29 = 0.22$$

Source	SS	df	MS	F	p
A for b_1 (List at Non-Central)	8.91	1	8.91	3.36	n.s.
A for b_2 (List at Central)	0.22	1	0.22	-	n.s.
Error		25	2.65		

Table 31

Analysis of Variance for the Two Week Strict Criterion Scores: Previous Recall Tests (1 _vs_ 2) x List (1 _vs_ 2) x Centrality (Non-Central _vs_ Central)

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Previous Tests	14.213	1	14.213	3.616	0.069
List	2.043	1	2.043	0.520	0.478
P x L	4.915	1	4.915	1.250	0.274
Error	98.274	25	3.931		
Centrality	0.006	1	0.006	0.008	0.928
C x P	5.964	1	5.964	8.095	0.009
C x L	0.006	1	0.006	0.008	0.928
C x P x L	1.793	1	1.793	2.436	0.131
Error	18.417	25	0.737		

Table 32

Analysis of Simple Main Effects for the Significant Centrality x Previous Tests Interaction Among the Two Week Strict Criterion Scores

	Non-Central (b_1)	Central (b_2)		
Immediate Plus Two Day Retest (a_1)	54	45	99	n=15
Two Day Postponed (a_2)	27	37	64	n=14
	81	82		

(total scores in each condition collapsed over List)

* for B (within subject) at A (between subject) the MSw. error = 0.737 (1,25); i.e., the within subject error term.

$$SSb \text{ at } a_1 = a_1b_1^2/15 + a_1b_2^2/15 - A_1^2/30 = 2.70$$

$$SSb \text{ at } a_2 = a_2b_1^2/14 + a_2b_2^2/14 - A_2^2/28 = 3.57$$

Source	SS	df	MS	F	p
B at a_1 (Centrality at Immediate-Two Day Retest)	2.70	1	2.70	3.66	n.s.
B at a_2 (Centrality at Two Day Postponed)	3.57	1	3.57	4.85	<.05
Error		25	0.737		

Table 32 continued

SSa at $b_1 = a_1b_1^2/15 + a_2b_1^2/14 - B_1^2/29 = 20.23$

SSa at $b_2 = a_1b_2^2/15 + a_2b_2^2/14 - B_2^2/29 = 0.92$

* for A (between subject) at B (within subject); Error = (MS(e) Between + (q-1)MS(e) within)/(q = (3.93 + 0.74)/2 = 2.33

Source	SS	df	MS	F	p
A at b_1 (Previous Tests at Non-Central)	20.23	1	20.23	8.68	<.01
A at b_2 (Previous Tests at Central)	0.92	1	0.92	0.39	n.s.
Error		25	2.33		

Table 33

Analysis of Variance for Experiment 3 Loose Criterion Scores:

List (1 vs 2) x Order of Recall (1 vs 2) x Experimenter

(1 vs 2) x Centrality (Non-Central vs Central)

Two Day Postponed Only

Source	Sum of Squares	*df*	Mean Squares	*F*	*p*
List	4.157	1	4.157	1.361	0.255
Order	0.675	1	0.675	0.221	0.643
Experimenter	1.959	1	1.959	0.641	0.431
L x O	2.043	1	2.045	0.670	0.422
L x E	0.533	1	0.533	0.175	0.680
O x E	3.793	1	3.793	1.242	0.277
L x O x E	2.700	1	2.700	0.884	0.357
Error	70.250	23	3.054		
Centrality	0.334	1	0.334	0.390	0.538
C x L	0.890	1	0.890	1.038	0.319
C x O	0.890	1	0.890	1.038	0.319
C x E	0.370	1	0.370	0.432	0.518
C x L x O	0.334	1	0.334	0.390	0.538
C x L x E	0.370	1	0.370	0.432	0.518
C x O x E	0.370	1	0.370	0.432	0.518
C x L x O x E	0.370	1	0.370	0.432	0.518
Error	19.717	23	0.857		

Table 34

Analysis of Variance for Experiment 3 Strict Criterion Scores:

List (1 _vs_ 2) x Order of Recall (1 _vs_ 2) x Experimenter

(1 _vs_ 2) x Centrality (Non-Central _vs_ Central) -

Two Day Postponed Only

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
List	2.287	1	2.827	1.176	0.289
Order	0.000	1	0.000	0.000	0.997
Experimenter	1.390	1	1.390	0.579	0.455
L x O	2.576	1	2.567	1.072	0.311
L x E	0.175	1	0.175	0.073	0.790
O x O	4.376	1	4.376	1.822	0.190
L x O x E	0.244	1	0.245	0.102	0.753
Error	55.258	23	2.403		
Centrality	0.163	1	0.163	0.204	0.656
C x L	0.031	1	0.031	0.038	0.846
C x O	1.086	1	1.086	1.361	0.255
C x E	0.739	1	0.739	0.926	0.346
C x L x O	0.010	1	0.010	0.012	0.913
C x L x E	1.426	1	1.426	1.787	0.194
C x O x E	0.343	1	0.343	0.430	0.519
C x L x O x E	0.308	1	0.308	0.386	0.540
Error	18.358	23	0.798		

Table 35

Analysis for Pair Set in Experiment 3: Order (1 *vs* 2) x Experimenter (1 *vs* 2) x Pair Set - Loose Criterion Scores

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Order of Recall	2.568	1	2.567	0.882	0.356
Experimenter	0.583	1	0.583	0.200	0.658
O x E	6.905	1	6.905	2.373	0.135
Error	78.580	27	2.910		
Pair Set	35.343	1	35.343	23.999	0.000
P x O	4.556	1	4.556	3.084	0.090
P x E	0.031	1	0.031	0.021	0.885
P x O x E	3.062	1	3.062	2.079	0.161
Error	39.763	27	1.475		

Table 36

Analysis for Pair Set in Experiment 3: Order (1 *vs* 2) x Experimenter (1 *vs* 2) x Pair Set (1 *vs* 2) - Strict Criterion Scores

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Order	0.058	1	0.058	0.026	0.872
Experimenter	0.271	1	0.271	0.123	0.729
O x E	8.853	1	8.853	4.011	0.055
Error	59.587	27	2.207		
Pair Set	6.046	1	6.046	4.857	0.036
P x O	0.981	1	0.981	0.788	0.382
P x E	0.023	1	0.023	0.018	0.893
P x O x E	2.624	1	2.624	2.108	0.158
Error	33.607	27	1.245		

Table 37

Analysis of Variance for Link Effects Among the Loose Criterion Scores: Prompting (Imagery Prompting *vs* No Prompting) x Time of Recall (Immediate *vs* Two Day Postponed) x Link (Linked *vs* Unlinked) x Grade (3 *vs* 5)

Source	Sum of Squares	*df*	Mean Square	*F*	*P*
Grade	37.264	1	37.264	9.333	0.003
Prompting	30.055	1	30.055	7.528	0.008
Recall Time	421.942	1	421.942	105.056	0.000
Link	20.188	1	20.188	5.056	0.028
G x P	0.886	1	0.886	0.222	0.639
G x R	22.115	1	22.115	5.539	0.021
P x R	13.272	1	13.272	3.324	0.072
G x L	4.404	1	4.404	1.103	0.297
P x L	9.379	1	9.379	2.349	0.130
R x L	57.048	1	57.048	14.288	0.000
G x P x R	1.195	1	1.195	0.299	0.586
G x P x L	0.007	1	0.007	0.002	0.967
P x R x L	0.587	1	0.587	0.147	0.703
T x R x L	8.128	1	8.128	2.036	0.158
G x P x R x L	0.004	1	0.004	0.001	0.974
Error	291.467	73	3.993		

Table 38

Analysis of Variance for Link Effects Among the Strict Criterion Scores: Prompting (Imagery Prompting *vs* No Prompting) x Time of Recall (Immediate *vs* Two Day Postponed) x Link (Linked *vs* Unlinked) x Grade (3 *vs* 5)

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Grade	37.432	1	37.432	9.161	0.003
Prompting	31.037	1	31.037	7.596	0.007
Recall Time	440.526	1	440.526	107.808	0.000
Link	9.328	1	9.328	2.283	0.135
G x P	0.031	1	0.031	0.008	0.931
G x R	10.590	1	10.590	2.592	0.112
P x R	18.315	1	18.315	4.402	0.038
G x L	1.731	1	1.731	0.424	0.517
P x L	5.643	1	5.643	1.381	0.244
R x L	34.390	1	34.390	8.416	0.005
G x P x R	1.356	1	1.356	0.332	0.556
G x P x L	0.874	1	0.874	0.214	0.646
G x R x L	0.580	1	0.580	0.142	0.707
P x R x L	4.532	1	4.352	1.109	0.296
G x P x R x L	0.544	1	0.544	0.133	0.716
Error	298.293	73	4.086		

Table 39

Analysis of Simple Main Effects for the Significant Time of Recall (Immediate vs Two Day Postponed) x Link (Linked vs Unlinked) Interaction among the Loose Criterion Scores

	Immediate (b_1)	Postponed (b_2)
Linked (a_1)	294 (n=31)	89 (n=32)
Unlinked (a_2)	88 (n=14)	39 (n=12)

(total scores collapsed over Grade and Training)

$$SSa \text{ at } b_1 = a_1b_1^2/31 + a_2b_1^2/14 - B_1^2/45 = 3341.40 - 3242.75 = 98.64$$

$$SSa \text{ at } b_2 = a_1b_2^2/32 + a_2b_2^2/12 - B_2^2/44 = 374.28 - 372.36 = 1.91$$

$$SSb \text{ at } a_1 = a_1b_1^2/31 + a_1b_2^2/32 - A_1^2/63 = 3035.78 - 2328.39 = 707.39$$

$$SSb \text{ at } a_2 = a_2b_1^2/14 + a_2b_2^2/12 - A_2^2/26 = 679.89 - 620.34 = 59.54$$

Source	SS	df	MS	F	p
A at b_1 (Link at Immediate)	98.64	1	98.64	24.72	<.01
A at b_2 (Link at Postponed)	1.91	1	1.91	0.47	n.s.
B at a_1 (Time of Recall at Linked)	707.30	1	707.30	177.29	<.01
B at a_2 (Time of Recall at Unlinked)	59.54	1	59.54	14.92	<.01
Error		73	3.99		

Table 40

Analysis of Simple Main Effects for the Significant Time of Recall (Immediate vs Two Day Postponed) x Link (Linked vs Unlinked) Interaction Among the Strict Criterion Scores

	Immediate (b_1)	Postponed (b_2)
Linked (a_1)	273 (n=31)	71 (n=32)
Unlinked (a_2)	87 (n=14)	32 (n=12)

(total scores collapsed over Grade and Training)

$$SSa \text{ at } b_1 = a_1b_1^2/31 + a_2b_1^2/14 - B_1^2/45 = 2944.80 - 2880.00 = 64.80$$

$$SSa \text{ at } b_2 = a_1b_2^2/32 + a_2b_2^2/12 - B_2^2/44 = 242.86 - 241.11 = 1.75$$

$$SSb \text{ at } a_1 = a_1b_1^2/31 + a_1b_2^2/32 - A_1^2/63 = 2561.69 - 1878.34 = 683.34$$

$$SSb \text{ at } a_2 = a_2b_1^2/14 - a_2b_2^2/12 - A_2^2/26 = 625.97 - 544.65 = 81.32$$

Source	SS	df	MS	F	p
A at b_1 (Link at Immediate)	64.80	1	64.80	15.84	<.01
A at b_2 (Link at Postponed)	1.75	1	1.75	0.42	n.s.
B at a_1 (Time of Recall at Linked)	683.34	1	683.34	167.07	<.01
B at a_2 (Time of Recall at Unlinked)	81.32	1	81.32	19.88	<.01
Error		73	4.09		

Table 41

Analysis of Variance of Loss Scores in the Linked versus Unlinked Conditions: Grade (3 _vs_ 5) x Prompting (Imagery Prompting _vs_ No Prompting) x Link (Linked _vs_ Unlinked) - Synonyms Included

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Grade	1410.926	1	1410.926	2.150	0.151
Prompting	29.781	1	29.781	0.045	0.832
Link	859.879	1	859.879	1.310	0.260
G x P	91.086	1	91.086	0.139	0.712
G x L	375.086	1	375.086	0.571	0.454
P x L	30.605	1	30.605	0.047	0.830
G x P x L	41.176	1	41.176	0.063	0.804
Error	24286.320	37	656.387		

Table 42

Analysis of Variance of Loss Scores in the Linked versus Unlinked Conditions: Grade (3 _vs_ 5) x Prompting (Imagery Prompting _vs_ No Prompting) x Link (Linked _vs_ Unlinked) - No Synonyms

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Grade	1512.422	1	1512.422	2.06	0.159
Prompting	2.340	1	2.340	0.000	0.955
Link	1340.980	1	1340.980	1.829	0.184
G x P	321.738	1	321.748	0.439	0.512
G x L	1040.555	1	1040.555	1.420	0.241
P x L	509.164	1	509.164	0.695	0.410
G x P x L	4.504	1	4.504	0.006	0.938
Error	27121.844	37	733.024		

Table 43

Analysis of Variance for Link Effects in the Two Day Retest Noun versus Two Day Postponed Noun Conditions: Grade (3 _vs_ 5) x Prompting (Imagery Prompting _vs_ No Prompting) x Recall Time (Two Day Retest Noun _vs_ Two Day Postponed Noun) x Link (Linked _vs_ Unlinked) - Strict Criterion

Source	Sum of Sqaures	_df_	Mean Squares	_F_	_p_
Grade	54.752	1	54.752	10.549	0.002
Prompting	14.788	1	14.788	2.849	0.096
Recall Time	160.046	1	160.046	30.835	0.000
Link	10.195	1	10.195	1.964	0.165
G x P	0.302	1	0.302	0.058	0.810
G x R	3.893	1	3.893	0.750	0.389
P x R	6.523	1	6.523	1.257	0.266
G x L	0.851	1	0.851	0.164	0.687
P x L	0.074	1	0.074	0.014	0.905
R X L	36.036	1	36.036	6.943	0.010
G x P x R	0.625	1	0.625	0.120	0.730
G x P x L	2.305	1	2.305	0.444	0.507
G x R x L	9.000	1	9.000	1.734	0.192
P x R x L	0.000	1	0.000	0.000	0.992
G x P x R x L	1.743	1	1.743	0.336	0.564
Error	378.896	73	5.190		

Table 44

Analysis of Variance for Link Effects in the Two Day Retest Noun versus Two Day Postponed Noun Conditions: Grade (3 _vs_ 5) x Prompting (Imagery Prompting _vs_ No Prompting) x Retest Time (Two Day Retest Noun _vs_ Two Day Postponed Noun) x Link (Linked _vs_ Unlinked - Loose Criterion

Source	Sum of Squares	_df_	Mean Square	_F_	_p_
Grade	57.247	1	57.247	11.527	0.001
Prompting	16.165	1	16.165	3.255	0.075
Recall Time	158.236	1	158.236	31.862	0.000
Link	16.966	1	16.966	3.416	0.069
G x P	1.915	1	1.915	0.386	0.537
G x R	10.504	1	10.504	2.115	0.150
P x R	4.758	1	4.758	0.958	0.331
G x L	0.013	1	0.013	0.003	0.959
P x L	1.380	1	1.380	0.278	0.600
R x L	51.536	1	51.536	10.377	0.002
G x P x R	0.423	1	0.423	0.085	0.771
G x P x L	0.155	1	0.155	0.031	0.860
G x R x L	8.878	1	8.878	1.788	0.185
P x R x L	0.927	1	0.927	0.187	0.667
G x P x R x L	0.142	1	0.142	0.029	0.766
Error	362.537	73	4.967		

Table 45

Simple Main Effects Analysis for the Significant Recall Time (Two Day Retest vs Two Day Postponed) x Link (Linked vs Unlinked) Interaction in the Loose Criterion Scores

	Linked (b_1)	Unlinked (b_2)
Two Day Retest (a_1)	241 n=31	63 n=14
Two Days Postponed (a_2)	89 n=32	39 n=12

* Total scores collapsed over Grade and Training

$$SSa \text{ at } b_1 = a_1b_1^2/31 + a_2b_1^2/32 - B_1^2/63 = 392.54$$

$$SSa \text{ at } b_2 = a_1b_2^2/14 + a_2b_2^2/12 - B_2^2/26 = 10.09$$

$$SSb \text{ at } a_1 = a_1b_1^2/31 + a_1b_2^2/14 - A_1^2/45 = 103.39$$

$$SSb \text{ at } a_2 = a_2b_1^2/32 + a_2b_2^2/12 - A_2^2/44 = 1.91$$

Source	SS	df	MS	F	p
A at b_1 (Recall time at Linked)	392.43	1	392.54	78.98	<.01
A at b_2 (Recall time at Unlinked)	10.09	1	10.09	2.03	n.s.
B at a_1 (Link at Two Day Retest)	103.39	1	103.39	20.80	<.01
B at a_2 (Link at Two Day Postponed)	1.91	1	1.91	0.38	n.s.
Error		73	4.97		

Table 46

Simple Main Effects Analysis for the Significant Recall Time (Two Day Retest *vs* Two Day Postponed) x Link (Linked *vs* Unlinked) Interaction in the Strict Criterion Scores

	Linked (b_1)		Unlinked(b_2)	
Two Day Retest (a_1)	221	n=31	59	n=14
Two Day Postponed (a_2)	71	n=32	32	n=12

*Total scores collapsed over Grade and Training

$$SSa \text{ at } b_1 = a_1b_1^2/31 + a_2b_2^2/32 - B_1^2/63 = 379.65$$

$$SSa \text{ at } b_2 = a_1b_2^2/14 + a_2b_2^2/12 - B_2^2/26 = 15.47$$

$$SSb \text{ at } a_1 = a_1b_1^2/31 + a_1b_2^2/14 - A_1^2/45 = 81.93$$

$$SSb \text{ at } a_2 = a_2b_1^2/32 + a_2b_2^2/12 - A_2^2/44 = 1.75$$

Source	SS	df	MS	F	p
A at b_1 (Recall Time at Linked)	379.65	1	379.65	73.15	<.01
A at b_2 (Recall Time at Unlinked)	15.47	1	15.47	2.98	n.s.
B at a_1 (Link at Two Day Retest)	81.93	1	81.93	15.78	<.01
B at a_2 (Link at Two Day Postponed)	1.75	1	1.75	0.33	n.s.
Error		73	5.19		

Table 47

Analysis of Variance for the Effects of Preposition Type: Prompting (Imagery Prompting *vs* No Prompting) x Recall Time (Immediate *vs* Two Day Postponed) x Grade (3 *vs* 5) x List (1 *vs* 2) x Interaction (Interacting *vs* Non-Interacting) - Loose Criterion

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Grade	6.544	1	6.544	4.678	0.036
Prompting	2.567	1	2.567	1.835	0.182
Recall Time	296.319	1	296.319	211.794	0.000
List	5.415	1	5,415	3.871	0.055
G x P	0.199	1	0.199	0.143	0.708
G x R	5.915	1	5.915	4.228	0.045
P x R	0.083	1	0.083	0.060	0.808
G x L	0.008	1	0.008	0.006	0.940
P x L	0.944	1	0.944	0.675	0.415
R x L	0.003	1	0.003	0.002	0.961
G x P x R	0.199	1	0.199	0.142	0.708
G x P x L	0.034	1	0.034	0.024	0.877
G x R x L	0.219	1	0.219	0.156	0.694
P x R x L	0.027	1	0.027	0.019	0.891
G x P x R x L	0.328	1	0.328	0.234	0.631
Error	65.757	47	1.399		
Interaction	1.711	1	1.711	1.678	0.202
I x G	0.027	1	0.027	0.026	0.873
I x P	0.518	1	0.518	0.508	0.480
I x R	3.880	1	3.880	3.805	0.057
I x L	0.001	1	0.001	0.001	0.979
I x G x P	0.864	1	0.864	0.848	0.382
I x G x R	1.938	1	1.938	1.900	0.175
I x P x R	0.564	1	0.564	0.553	0.461
I x G x L	0.751	1	0.751	0.737	0.395
I x P x L	0.072	1	0.072	0.070	0.792
I x R x L	3.322	1	3.322	3.258	0.077
I x G x P x R	0.110	1	0.110	0.107	0.745
I x G x P x L	0.023	1	0.023	0.023	0.881
I x G x R x L	0.239	1	0.239	0.234	0.631
I x P x R x L	0.751	1	0.751	0.737	0.295
I x G x P x R x L	0.034	1	0.034	0.033	0.856
Error	47.925	47	1.020		

Table 48

Analysis of Variance for the Effects of Preposition Type: Prompting (Imagery Prompting *vs* No Prompting) x Recall Time (Immediate *vs* Two Day Postponed) x Grade (3 *vs* 5) x List (1 vs 2) x Interaction (Interacting *vs* Non-Interacting) - Strict Criterion

Source	Sum of Squares	df	Mean Square	F	p
Grade	8.934	1	8.934	5.847	0.020
Prompting	3.716	1	3.716	2.433	0.126
Recall Time	274.318	1	274.318	179.552	0.000
List	6.707	1	6.707	4.390	0.042
G x P	0.190	1	0.190	0.124	0.726
G x R	2.773	1	2.773	1.815	0.184
P x R	1.071	1	1.071	0.701	0.407
G x L	0.090	1	0.090	0.059	0.810
P x L	0.304	1	0.304	0.199	0.657
R x L	0.249	1	0.249	0.163	0.688
G x P x R	0.646	1	0.646	0.423	0.519
G x P x L	0.034	1	0.034	0.022	0.882
G x R x L	0.001	1	0.001	0.000	0.983
P x R x L	0.229	1	0.229	0.150	0.701
G x P x R x L	0.000	1	0.000	0.00	0.997
Error	71.806	47	1.528		
Interaction	1.422	1	1.422	1.297	0.260
I x G	0.038	1	0.038	0.034	0.854
I x P	0.003	1	0.003	0.003	0.956
I x R	3.922	1	3.922	3.579	0.065
I x L	1.938	1	1.938	1.768	0.190
I x G x P	0.884	1	0.884	0.807	0.374
I x G x R	1.498	1	1.498	1.367	0.248
I x P x R	0.083	1	0.083	0.076	0.784
I x G x L	3.097	1	3.097	2.826	0.099
I x P x L	0.404	1	0.404	0.369	0.547
I x R x L	0.733	1	0.733	0.669	0.418
I x G x P x R	0.944	1	0.944	0.862	0.358
I x G x P x L	0.066	1	0.066	0.060	0.807
I x G x R x L	0.124	1	0.124	0.113	0.738
I x P x R x L	1.524	1	1.524	1.390	0.244
I x G x P x R x L	1.524	1	1.524	1.390	0.244
Error	51.508	47	1.096		

Table 49

Analysis of Simple Main Effects for the Significant

Grade x Recall Time Interaction

a) Loose Criterion Scores

	Immediate (b_1)	Postponed (b_2)
Grade 3 (a_1)	96 n=10	21 n=13
Grade 5 (a_2)	198 n=21	68 n=19

* total scores collapsed over Training, List, and Interaction

SSa at b_1 = 0.19

SSa at b_2 = 29.76

SSb at a_1 = 360.34

SSb at a_2 = 341.32

Source	SS	df	MS	F	p
A at b_1 (Grade at Immediate)	0.19	1	0.19	0.13	n.s.
A at b_2 (Grade at Postponed)	29.76	1	29.76	21.25	<.01
B at a_1 (Recall Time at Grade 3)	360.34	1	360.34	257.38	<.01
B at a_2 (Recall Time at Grade 5)	341.32	1	341.32	243.80	<.01
Error		47	1.40		

Table 50

Analysis of Simple Main Effects for the Significant Interaction

Recall Time x Interaction

a) Loose Criterion

	Interacting (b_1)	Non-Interacting (b_2)
Immediate (a_1)	156 n=31	138 n=31
Two Day Postponed (a_2)	43 n=32	46 n=32

* total scores collapsed over Grade, Training and List

SSb at a_1 = 5.22

SSb at a_2 = 0.14

Source	*SS*	*df*	*MS*	*F*	*p*
B at a_1 (Interaction at Immediate)	5.22	1	5.22	5.12	<.03
B at a_2 (Interaction at Two Day Postponed)	0.14	1	0.14	0.13	n.s.
Error		47	1.02		

Table 50 continued

b) Strict Criterion

	Interacting (b_1)	Non-Interacting (b_2)
Immediate (a_1)	147 n=31	126 n=31
Two Day Postponed (a_2)	34 n=32	37 n=32

SSb at a_1 = 7.11

SSb at a_2 = 0.14

Source	SS	df	MS	F	p
B at a_1 (Interaction at Immediate)	7.11	1	7.11	6.46	<.02
B at a_2 (Interaction at Two Day Postponed)	0.14	1	0.14	0.12	n.s.
Error		47	1.10		

Table 51

Analysis of Variance of Loss Scores in the Loose Criterion Interacting versus Non-Interacting Conditions: Grade (3 vs 5) x Prompting (Imagery Prompting vs No Prompting) x List (1 vs 2) x Interaction (Interacting vs Non-Interacting)

Source	Sum of Squares	df	Mean Square	F	p
Grade	3900.531	1	3900.531	5.534	0.028
Prompting	446.426	1	446.426	0.633	0.434
List	9588.270	1	9588.270	13.604	0.001
G x P	6.789	1	6.789	0.010	0.923
G x L	3581.820	1	3581.820	5.082	0.034
P x L	2573.105	1	2573.820	3.651	0.069
G x P x L	541.316	1	541.316	0.768	0.390
Error	16211.020	23	704.827		
Interaction	2122.601	1	2122.601	6.083	0.022
I x G	7.781	1	7.781	0.022	0.883
I x P	2.797	1	2.797	0.008	0.929
I x L	1297.222	1	1297.222	3.718	0.066
I x G x P	3087.383	1	3087.383	8.848	0.007
I x G x L	339.609	1	339.609	0.973	0.334
I x P x L	299.691	1	299.691	0.859	0.364
I x G x P x L	674.445	1	674.445	1.933	0.178
Error	8025.844	23	348.950		

Table 52

Analysis of Variance of Loss Scores in the Strict Criterion

Interacting versus Non-Interacting Conditions:

Grade (3 vs 5) x Prompting (Imagery Prompting vs No

Prompting) x List (1 vs 2) x Interaction

(Interacting vs Non-Interacting)

Source	Sum of Squares	df	Mean Squares	F	p
Grade	4547.699	1	4547.699	4.146	0.053
Prompting	16.398	1	16.398	0.015	0.904
List	11708.375	1	11708.375	10.675	0.003
G x P	57.574	1	57.574	0.052	0.821
G x L	9057.500	1	9057.500	8.258	0.009
P x L	2447.328	1	2447.328	2.231	0.149
G x P x L	1628.102	1	1628.102	1.484	0.253
Error	25226.871	23	1096.820		
Interaction	2337.793	1	2337.793	2.994	0.097
I x G	26.688	1	26.688	0.034	0.855
I x P	851.934	1	951.934	1.219	0.281
I x L	569.840	1	569.840	0.730	0.402
I x G x P	4166.500	1	4166.500	5.336	0.030
I x G x L	1590.605	1	1590.605	2.037	0.167
I x P x L	96.504	1	96.504	0.124	0.728
I x G x P x L	2712.168	1	2712.168	3.473	0.075
Error	17959.469	23	780.846		

Table 53

Analysis of Variance for Interaction Effects in the Two Day Retest Versus Two Day Postponed Conditions: Grade (3 vs 5) x Prompting (Imagery Prompting vs No Prompting) x Recall Time (Two Day Retest vs Two Postponed) x List (1 vs 2) - Loose Criterion

Source	Sum of Squares	df	Mean Square	F	p
Grade	18.239	1	18.239	9.112	0.004
Prompting	1.323	1	1.323	0.661	0.420
Recall Time	159.335	1	159.335	79.605	0.000
List	25.483	1	25.483	12.732	0.001
G x P	1.576	1	1.576	0.787	0.379
G x R	0.518	1	0.518	0.259	0.613
P x R	0.027	1	0.027	0.013	0.909
G x L	5.813	1	5.813	2.904	0.095
P x L	0.056	1	0.056	0.028	0.868
R x L	7.093	1	7.093	3.544	0.066
G x P x R	0.131	1	0.121	0.066	0.799
G x P x L	1.275	1	1.275	0.637	0.429
G x R x L	3.438	1	3.438	1.718	0.196
P x R x L	1.093	1	1.093	0.546	0.464
G x P x R x L	0.549	1	0.549	0.274	0.603
Error	94.074	47	2.002		
Interaction	0.012	1	0.012	0.014	0.906
I x G	0.270	1	0.270	0.312	0.579
I x P	1.967	1	1.967	2.267	0.139
I x R	0.304	1	0.304	0.351	0.557
I x L	0.646	1	0.646	0.745	0.393
I x G x P	0.239	1	0.239	0.275	0.602
I x G x R	0.503	1	0.503	0.580	0.450
I x P x R	2.057	1	2.057	2.371	0.130
I x G x L	2.951	1	2.951	3.401	0.071
I x P x L	0.030	1	0.030	0.035	0.853
I x R x L	0.986	1	0.986	1.136	0.292
I x G x P x R	1.182	1	1.182	1.363	0.249
I x G x P x L	1.182	1	1.182	1.363	0.249
I x G x R x L	0.131	1	0.131	0.151	0.699
I x P x R x L	0.591	1	0.596	0.687	0.411
I x G x P x R x L	1.252	1	1.252	1.442	0.236
Error	40.774	47	0.868		

Table 54

Analysis of Variance for Interaction Effects in the Two Day Retest Versus Two Day Postponed Conditions: Grade (3 _vs_ 5) x Prompting (Imagery Prompting _vs_ No Prompting) x Recall Time (Two Day Retest _vs_ Two Day Postponed) x List (1 _vs_ 2) - Strict Criterion

Source	Sum of Squares	_df_	Mean Squares	_F_	_p_
Grade	21.272	1	21.272	10.526	0.002
Prompting	2.072	1	2.072	1.025	0.317
Recall Time	144.955	1	144.955	71.728	0.000
List	28.934	1	28.934	14.317	0.000
G x P	0.032	1	0.032	0.016	0.901
G x R	0.002	1	0.002	0.001	0.977
P x R	0.298	1	0.298	0.148	0.703
G x L	7.347	1	7.347	3.635	0.063
P x L	0.481	1	0.481	0.238	0.628
R x L	10.813	1	10.813	5.351	0.025
G x P x R	0.036	1	0.036	0.018	0.895
G x P x L	1.697	1	1.697	0.840	0.364
G x R x L	5.687	1	5.687	2.814	0.100
P x R x L	0.588	1	0.588	0.291	0.592
G x P x R x L	1.264	1	1.264	0.625	0.433
Error	94.982	47	2.021		
Interaction	0.424	1	0.424	0.526	0.472
I x G	1.060	1	1.060	1.315	0.257
I x P	1.336	1	1.336	1.657	0.204
I x R	0.019	1	0.019	0.023	0.880
I x L	0.654	1	0.654	0.812	0.372
I x G x P	0.276	1	0.276	0.342	0.561
I x G x R	0.151	1	0.151	0.187	0.667
I x P x R	2.257	1	2.257	2.800	0.101
I x G x L	6.734	1	6.734	8.354	0.006
I x P x L	0.466	1	0.466	0.579	0.451
I x R x L	0.075	1	0.075	0.093	0.762
I x G x P x R	0.244	1	0.244	0.303	0.585
I x G x P x L	1.725	1	1.725	2.140	0.150
I x G x R x L	0.234	1	0.234	0.290	0.593
I x P x R x L	1.642	1	1.643	2.088	0.160
I x G x P x R x L	5.245	1	5.245	6.508	0.014
Error	37.883	47	0.806		