Integration and memory in very young children.

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INTEGRATION AND MEMORY IN VERY YOUNG CHILDREN

A Dissertation Presented

By

Danuta Bukatko

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Department of Psychology

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Abstract

Integration and Memory in Very Young Children

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Several recent studies have isolated integration skills - that is, the ability to co-ordinate separate pieces of information into a cohesive unit - as being important to semantic memory functioning. This study was designed to investigate whether very young children, 2½ and 3½ years of age, possess the ability to integrate various pieces of verbal information and to see if it has any effect on memory for that information.

In Experiment I, children were presented with a search task which was divided into two phases. In the acquisition portion, children learned to find toy containers hidden in particular locations to a criterion of three successive correct responses. Following acquisition, children were given information concerning the relationship between toy objects and the containers, and were asked to locate the hidden objects. In this task, where successful performance required subjects to co-ordinate object-container relations with previously learned container-location relations to derive the location of the object, it was found that both 2½ and 3½ year olds responded correctly at levels which were dramatically above chance. Furthermore, 3½ year olds made more correct integration responses than 2½ year olds. How-

ever, the results of a test for initial container-location relations following a failure to locate an object indicated that the poorer performance of 2½ year olds could be attributed to their higher rate of forgetting of initial container-location relationships.

Experiment II tested the hypothesis that having to perform an integrative operation on verbal material might facilitate memory for that material. A task similar to the one described above was used with the exception that on half the trials, information about the location of the object was given to subjects directly, while on the other half, locating the objects required an integration of information. Also, a delay of 30 seconds was introduced on half the trials prior to allowing the subjects to search for the designated objects; on the other half of the trials children were permitted to search for objects immediately. In general, performance between direct and integration trials did not differ in either delay or immediate conditions for either age group. Although these findings do not provide strong support for the hypothesis being tested, it was felt that the introduction of an integration pre-test on delayed integration trials to insure that integration did in fact occur might yield clear results.

Both experiments demonstrated clearly that integration is a skill which even very young children possess, and that when they fail to integrate it is usually because they have forgotten initial information. The present findings were contrasted to earlier studies which found that integration was not in the cognitive repertoire of younger children. The discrepancy in the findings was discussed in terms of differences in the meaningfulness of the materials used and variations in task demands.

Integration and Memory in Very Young Children

Introduction

Researchers concerned with the development of memory are taking an increasingly holistic orientation in their investigations, regarding memory as an integral and inseparable part of cognitive functioning in general, rather than as a phenomenon to be studied in isolation. More and more, levels of cognitive development, with their corresponding qualitative and quantitative characteristics, are being recognized as having great significance in the way in which memory processes develop. Certainly, this view of memory as an integral part of cognition is not a new one. Bartlett (1932), for example, in his treatment of memory, warned tha t it was impossible to study any higher level process in isolation from other mental processes. Piaget's theory of intellectual growth has also consistently retained the flavor of regarding changes in cognitive stages as influencing all aspects of knowing, of which memory is but one. This approach has been revitalized more recently, however, by a growing number of cognitive psychologists, including those interested in developmental change (Brown, 1975a; Cofer, 1973; Flavell, 1971; Jenkins, 1973; Meacham, 1972; Paris, 1975; Piaget and Inhelder, 1973).

Perhaps the most influential force in the trend toward a holistic, organismic psychology of memory development has been the work of Piaget and his colleagues. In their most recent treatment of this subject, Piaget and Inhelder (1973) have explicitly applied the general principles of Piaget's theory of intellectual development to the specific case of memory. As in other aspects of knowing activity, changes in memory processes are seen as being reflective of changes in cognitive structures and modes of operative thinking at various developmental stages. A child who is functioning at a particular stage (e.g., pre-operational) will incorporate information into his existing schemes, and memory for that information will also necessarily be a function of those schemes. Thus, a child who does not have the logico-mathematical structures for ordering objects in serial order will not be able to reconstruct a seriated array of sticks after a delay period. Memory for the display improves, however, as the child acquires the appropriate logical structures. Similarly, memory for other causal or spatial relationships changes as the corresponding logical schemes for these relationships become organized. Central to this theory, also, is the conceptualization of the child as an active participant in the building of his knowledge (and memory) store. Through the processes of assimilation and accommodation reorganization of cognitive schemes, which in turn interact with memory, constantly takes place. In contrast to more mechanistic, passive theories, where memory development is regarded as the gradual accumulation of associations or bits of information, Piagetian theory emphasizes the dynamic interplay between the child and external events. The child, in essence, operates on incoming information employing the cognitive schemes he possesses at a particular stage of development, and memory is a function of those operations.

Like Piaget, Soviet developmental psychologists (Smirnov and Zinchenko, 1969; Yendovitskaya, 1971) also believe that memory is a consequence of the activity of the individual, and understanding the nature of these activities is essential to the understanding of memory per se. Specifically, they maintain that material which is a central part of the activity of the subject will be remembered, while that which is peripheral to the activity will not be.

Even though the validity of some of the experimental findings upon which Piaget's theory is based has been questioned (see Liben, 1976, for example), there is no doubt that this dynamic and organismic view of memory espoused by both Piaget and the Soviets has influenced much of the research which is currently being conducted. The topic of the present study derives from this orientation, as well. The general themes of the importance of cognitive skills at a particular developmental level and the active interaction between subject and object provide the impetus to the research on integration and memory which follows. The major question being considered here is whether very young children possess a particular cognitive skill -- the ability to integrate verbal information, to co-ordinate two pieces of information in order to reach a conclusion. Because there is much ambiguity in the literature surrounding the use of the term "integration" (or alternatively, "inference"), the precise nature of the skill to be examined here is important to establish. "Integration" and "inference" have been used to describe a multitude of behaviors, ranging from the simple co-ordination of two pieces of information to the process involved in propositional logic. No attempt to distinguish or systematically categorize various types of "inference-making" will be made in the present discussion (although this is clearly an issue which need to be considered at greater length). For the purposes of this paper, only the term "integration" will be used to describe the cognitive skill being examined, and it will atheoretically simply refer to the ability of the child to combine two separate pieces of information with which he is presented in order to derive a conclusion.

A related question being examined in this study is whether the occurrence of integration has significant consequences for memory. Since the formulation of both problems addressed here was derived from experimental findings pertaining to semantic memory processing in children and the cognitive skills which affect this processing, the review of the literature which follows will develop the importance of integration skills in the context of semantic memory processing in children. First, some general aspects of semantic memory in children will be discussed, followed by evidence that integration has a key function in semantic memory. Finally, those studies which have specifically investigated integration and inference in children will be described.

Semantic Memory in Children

Interest in semantic aspects of memory has evolved quite recently, perhaps as a result of Piaget's influence, as well as some new developments in the adult cognitive literature. Research on semantic memory is concerned with how the organized knowledge a person has about concepts, rules, meanings, etc. affects memory for information, rather than with memory for specific, isolated, personal events (or episodic memory). The distinction between semantic and episodic memory was originally made by Tulving (1972), primarily to clarify and distinguish some problems in memory research, and is paralleled by Piaget and Inhelder's (1973) distinction between "memory in the strict sense" and "memory in the wider sense", the former being the analogue of episodic memory, and the latter semantic memory. Most developmental research to date has focused on children's episodic memory and how capacities and strategies for encoding and retrieving these episodic events change. If one inspects the literature, one would find that in most of these studies of memory, the experimental task is one where children are required to recall or recognize isolated strings of words, pictures, or objects which are completely devoid of context and which bear little relevance to real-world experiences. However, it has become obvious to many investigators that a theory of memory development must account not only for the increasing ability of the child to remember arbitrary lists of stimuli, but also for the remembering of more general, conceptual knowledge involved in such things as the comprehension of prose, the formulation and deployment of strategies in episodic tasks, and other sorts of situations where context and meaningfulness qualitatively change the nature of the task for the "rememberer". The result has been a growth of attention to semantic memory in children.

This interest has been enhanced by a framework for thinking about memory provided by Craik and Lockhart (1972) which places a great deal of emphasis on semantic processes. Instead of taking the traditional information-processing perspective of partitioning memory into a number of storage compartments regulated by control processes, Craik and Lockhart propose that memory be thought of as the product of a particular "depth of processing". That is, the greater the amount of semantic elaboration and extraction of meaning from a particular stimulus, the stronger the memory trace for that stimulus will be. Furthermore, a close correspondence between existing cognitive structures and stimulus materials facilitates a "deeper" level of processing. Thus, the cognitive skills that a child possesses at a particular developmental level take on considerable significance in light of this model and pose interesting questions for developmental research. For example, if memory is, in fact, a function of depth of processing, does depth of processing change in any systematic way with age? More significantly, what kinds of cognitive skills play a role at a particular level of processing and when do they become functional? These are some of the questions that research has begun to address, including the research to be presented in this paper.

Before considering this research in detail, however, another widely-held view of the nature of memory, especially the memory of very young children, should be presented, since it further emphasizes the need to understand semantic memory and the cognitive skills involved in that memory. Several investigators have described memory in young children as being largely involuntary (Flavell et al., 1970; Smirnov and Zinchenko, 1969; Yendovitskaya, 1971). Young children, when they remember things, seem to be operating on an automatic or spontaneous level, rather than deliberately acting on material with the intention to remember it. The determinants of memory involve the child's interest in and comprehension of an event (a semantic memory function) rather than the awareness and use of deliberate strategic memory skills. This notion was perhaps most concisely described by Brown (1975a):

> "... the child's level of intellectual development interacts with the material to determine what falls within the domain of semantic memory. If the material is congruent with the child's operational level, it will be perceived and retained as meaningful, i.e., the task is semantic. If, however, the child is insufficiently mature to perceive a logical or meaningful structure in the material, he will treat it as a meaningless situation and retention will demand the application of deliberate memorial skills." (p. 143)

The implication of Brown's statement is that a complete understanding of memory processes in very young children, presumably deficient in "deliberate memorial skills", (Flavell et al., 1970; Smirnov and Zinchenko, 1969; Yendovitskaya, 1971) would necessarily involve a description of semantic processes. That is, if the act of remembering can be characterized as involving one of two processes: 1) either an extraction of meaning from the materials to be remembered (which would be a semantic operation), or 2) the deployment of strategies, mnemonics, etc., to insure memory in less meaningful situations (as in episodic tasks), and very young children are deficient in the latter, then their memory functioning <u>must</u> be seen as being largely of a semantic nature. If a meaningful structure is not extracted from the material, and deliberate strategies for remembering are absent, then the material will not be well remembered. In order to understand how very young children do remember, then, it would appear to be essential to understand semantic processing and more specifically, to pinpoint the kinds of relationships and meanings they are capable of extracting and what kinds of operational abilities are tied to them.

This last issue leads directly to the central focus of this paper and will be discussed in greater depth in the sections which follow. However, since the importance of understanding semantic memory in children has been established, it would be useful, at this point, to assess some of the more general features of children's semantic memory processing. Several initial studies have clearly demonstrated that children, like adults, do in fact extract meaningful relationships from material to which they have been exposed. Paris and Carter (1973), for example, presented second and fifth graders with a series of stories each of which contained sentences upon which inferential judgments could be made. For example, one story contained the following sentences:

1. The bird is in the cage.
2. The cage is under the table.

Following story presentations, a recognition memory task was presented in which some of the sentences incorporated information from the initially presented sentences. In the above example, one such test item was, "The bird is under the table." In the recognition task, it was found that both groups of children made a large number of false alarm responses to new sentences which contained the true inference based on initial premises. That is, children recognized as "old" new sentences which had the same semantic content as the original sentences. This finding suggests that children encode the meaning of, rather than the direct lexical features of prose materials, a finding which has already been established for adults (Bransford and Franks, 1971; Bransford, Barclay, and Franks, 1972; Kintsch and Monk, 1972, for example). What is stored, then, is not the discrete stimulus units which were presented, but integrated units containing the stimulus information. A similar finding is reported by Moeser (1976). In one portion of her experiment, children ranging in age from 5 to 14 years were presented with sentences upon which inferences could be made. Again, a great number of false recognition responses were made to test sentences which were true inference statements.

Not only does semantic processing occur with respect to verbal materials, it seems to be a viable phenomenon in memory for visual materials, as well. Using a paradigm similar to the Paris and Carter (1973) study, Paris and Mahoney (1974) demonstrated that semantic operations were being performed by children when pictures were used where there was a potential for making an inference. Subjects responded to pictures which depicted true inference information based on initial premises as if they had already been seen. They were apparently incorporating the original information into meaningful, cohesive units, rather than storing separate bits of static information.

Further evidence that children are sensitive to the meaningful features of stimuli is provided by a series of studies by Brown and her associates. In one task (Brown, 1975b), kindergarten and second grade children were told to listen to a series of stories about a number of objects. When these stories consisted of logical sequences of events, verbal recall and reconstruction of the order of the narratives (measured by the ordering of pictures for these events) was consistently higher for both age groups than was memory for unconnected events. In a similar study, Brown and Murphy (1975) showed 4 year olds four pictures which depicted either a logical or random sequence of events. Again, reconstruction of logical sequences was far superior to that of random sequences, especially as a function of lag. That is, even when five intervening sets of sequences were involved, memory for logical sequences remained at a high level, while memory for random sequences declined. Even more dramatic was another finding in a second portion of this same study. When random sequences of pictures were accompanied by a unifying story, memory for those sequences was far superior to a similar set of random pictures which were unaccompanied by a connective narrative. Brown (1975a) maintains that subjects in these experiments were relying on processing via the semantic memory system in those cases where connected series of events (either logical or random) were involved, whereas episodic memory was being tapped when random pictures without a narrative were used. Her conclusion is that even children who are at the preoperational stage of development are capable of semantically integrating separate pieces of information into meaningful, cohesive units which are relatively resistant to decay.

There is also some initial evidence that children younger than 5 years of age make contact with a semantic memory system in an essentially episodic task. Perlmutter and Myers (1976) showed 4 year old children a series of slides of common objects, some of which were classified as color-specific and others which were non-color specific. A banana, for example, is considered to be a color-specific item, since a particular color is strongly associated with it. A mitten, on the other hand, could have any of a number of colors associated with it. On initial presentation trials, both classes of objects were shown either in black-and-white or in their associated color values. In the recognition portion of the task, children were asked to choose from among four alternatives the stimulus they had seen. Numerous errors were made in the forced choice task. In particular, children tended to choose color-specific items in their associated color values as those which had already been seen, even though those items had initially been presented in black-and-white. Thus, even very young children have a network of knowledge about particular objects which strongly influences their memory for those objects.

These initial studies have clearly shown that children, even as young as 4 years of age, <u>are</u> bringing to experimental situations some organized knowledge which has definite effects on their memory performance. Information which has meaning to the child is very likely to be retained, while information which is meaningless will not be.

The Role of Integration in Semantic Memory

Given that children are quite capable of semantic processing of stimulus materials and that this process is hypothesized to intersect with memory performance, it would be useful to return to the previously raised problem of more precisely delineating the kinds of operations children are performing in their extraction of meaning from a given set of information. That is, what are the specific component processes that are involved in the tasks described above, how do they interact with the stimulus materials, and how do they change with age? These questions are particularly important if one subscribes to some of the theoretical notions that have already been mentioned -- namely, that 1) the child actively operates on information as a function of his cognitive skills at a particular level of development (Piaget and Inhelder, 1973; Brown, 1975a) and 2) the nature of the activity of the child influences memory for an event (Craik and Lockhart, 1972; Smirnov and Zinchenko, 1969; Yendovitskaya, 1971).

One important function which is implicated by some of the above findings and which both Brown (1975a) and Paris (1975) have focused on is the ability to integrate a set of information into a meaningful cohesive unit. One way in which this integrative process has been described has been in terms of making "inferences". Children appear to extract logical relationships from stimulus events and use their inferential reasoning capacities to construct an integrated meaningful whole which is then the unit of storage. That such a process occurs has already been proposed in the Paris and Carter (1973), Paris and Mahoney (1974), and Moeser (1976) studies. The effect that inference-making has on memorial processes has been demonstrated even more explicitly in a study by Paris and Upton (1974). Kindergarten through fifth grade children listened to a series of stories, the substance of which contained information upon which inferences could be made. After listening to each story, subjects were asked a series of questions, some of which required the retention of verbatim information and some of which required the making of an inference in order to answer correctly. The following is a sample of a story and the questions asked about it:

> "Linda was playing with her new doll in front of her big red house. Suddenly she heard a strange sound coming from under the porch. It was the flapping of wings. Linda wanted to help so much, but she did not know what to do. She ran inside the house and grabbed a shoe box from the closet. Then Linda looked inside her desk until she found eight sheets of yellow paper. She cut up the paper into little pieces and put them in the bottom of the box. Linda gently picked up the helpless creature and took it with her. Her teacher knew what to do.
>
> 1. Was Linda's doll new?
> 2. Did Linda grab a match box?
> 3. Was the strange sound coming from under the porch?

4. Was Linda playing behind her house?
5. Did Linda like to take care of animals?
6. Did Linda take what she found to the police station?
7. Did Linda find a frog?
8. Did Linda use a pair of scissors?"

The first four questions require the retention of verbatim information, whereas the last four require the making of an inference. Interestingly, children made more correct responses to the inference than verbatim questions. Also, even though the tendency to make inferences improved steadily with age, even kindergarten children were responding correctly at a relatively high level. In a second portion of this task, children were asked to recall as much of the material from the original passages as they could, their recall being measured in terms of "idea units". The results showed that recall of "idea units" was significantly related to the tendency to make inferences, even when age was eliminated as a factor in analysis. That is, the tendency to make inferences was the single best predictor of recall within each age group. This finding fits in nicely with Craik and Lockhart's notion of depth of processing in that a particular cognitive skill, the tendency to make inferences, coincided with the strength of memory traces. Presumably, as the child grows older, her cognitive skills, in this case his ability to make inferences, more closely match stimulus information to facilitate a deeper level of processing, and hence, recall. Paris' (1975) position is that this operation of making inferences is one facet of semantic elaboration that is probably critical for the comprehension and retention of prose materials. Not only does it induce a deeper level of processing, but it provides the memorizer with a richer source of cues for retrieval.

In addition, inference-making connotes some active operation on the part of the subject in his intake of stimulus information. The fact that energy is expended somewhere in the encoding process may act to further insure the durability of memory for that information. Several studies of paired-associate learning in adults have demonstrated that when subjects actively supply either a mediator between stimulus and response items (Bobrow and Bower, 1969) or generate the response items themselves, recall is facilitated (Anderson, Goldberg and Hiddle, 1971). In this last study, for example, some subjects were required to fill in the blank to sentences such as "Elevators stop at every ______," while others simply read sentences where the blank was already filled in (i.e., "Elevators stop at every floor."). Subjects in the first group recalled many more S-R pairs in a subsequent test than did subjects in the second group. These findings are very much in line with the Piagetian and Soviet thinking that the activity of the subject is of prime importance in memory tasks, so that "involuntary remembering of objects occurs in cases where subjects have had to deal actively with them" (Smirnov and Zinchenko, 1969). Inference and integration may constitute just such an activity.

Here, then, is one cognitive operation which is strongly implicated as having effects on memory. Certainly, there are many others which have yet to be determined. Yet, this particular skill seems to be so potent and influential that it merits further attention.

Young Children's Integration Skills

The fact that children improve in their inference and integration skills as they grow older (Paris and Upton, 1974) does not mean that young children are incapable of semantic integration at all. Rather, integration skills seem to be a good candidate in a search for what operations very young "involuntary" rememberers use in their "activities" with stimulus information. If the ability to co-ordinate information is a basic cognitive mechanism, then it could also very well be an important factor in the comprehension and memory of very young children, too. Unfortunately, lengthy prose passages, such as those used in the Paris et al. studies probably exceed the processing capacity of young children, and do not give a fair assessment of their ability to integrate. Pascual-Leone (1970), for example, maintains that there is a limit to the number of pieces of information which can be operated on in a hypothesized central processing space at each developmental level. Also, another problem presents itself regarding what the nature of the integrative operation is in the different experiments described thusfar. Some of these tasks required distinctly different operations on the part of the child than others. In the Paris and Upton (1974) study, for example, the inference task demanded that the child co-ordinate information from stories with his broader knowledge of environmental relations (e.g., if the creature that Linda found was flapping its wings, it was not a frog). In this instance, to make the "inference", the child had to supply a component of the information to be co-ordinated from his knowledge of animals and their characteristics. In the Paris and Carver (1973) study, however, all of the information to be co-ordinated was *already* supplied. Both of these tasks required an integrative operation, but the second supplied more of the necessary information than the first. If one is going to describe integration as being an important cognitive mechanism, at some point, a decision has to be made as to the precise meaning of that term. The interest in the present study is specifically in the ability of the child to co-ordinate (or integrate two pieces of information which are already available to him. By simplifying task demands in terms of presenting all the necessary information to the child in passages that do not exceed processing capacity, it might be possible to demonstrate that even very young children have the ability to integrate, and that this ability has its concommitant effects on memory.

There are some studies in the developmental literature which have found that very young children cannot integrate. Actually, these studies have again used the term "inference" to describe the behaviors in question, but since they do deal with children's ability to co-ordinate information which is already available to them, they bear relevance to the present discussion. There have been two major lines of research here -- one dealing with "inferences" in a problem-solving situation and one pertaining to "inferences" in perceptual judgments. With respect to the first of these, there is a series of studies done by Kendler and Kendler (1961, 1963, 1967) which is pertinent. In the standard experiment, the Kendlers had children learn two response patterns to criterion. One was to press a red panel on one side of the apparatus to obtain a marble and a blue panel on the other side to get a ball bearing. The second response to be learned was to deposit one of these objects, the marble or ball bearing, into a center panel in order to obtain a small toy. After these response patterns were well-learned, children were simply told to obtain the toy, a response which required the integration of the two previously learned response patterns. Five year old children did very poorly in this task in that they were unable to co-ordinate the two appropriate response patterns they had initially learned in order to obtain the toy. The Kendlers concluded that "the capacity to combine independently acquired habit segments is present in very few youngsters below 6 years of age" (Kendler, 1963, p. 47). In other words, young children do not have the ability to integrate information in order to solve a problem.

The second line of research has been concerned with inferential reasoning in children's perceptual judgments. Most of this research has stemmed from Piaget's theoretical views, his major point being that children who have not reached the stage of concrete operations (around 7 to 8 years of age) do not have the logical structures that direct inferential reasoning. The typical task upon which this theoretical view is based involves showing the child two rods, one of which is longer than the other, i.e. $A > B$. Next, he is shown B along with another rod, D, where $B > C$. The child is then asked to describe the relationship between A and C, a judgment which involves the integration of two pieces of information already available to him. Almost always, children under the age of 7 years are not able to make this "transitive inference" (Piaget and Inhelder, 1969).

Another study, however, provides evidence that children can integrate information in perceptual tasks when memory for the initial relations is high. Bryant and Trabasso (1971) showed children five rods of varying lengths (A, B, C, D, and E) and had them learn the relationships between every two adjacent rods (i.e., $A > B$, $B > C$, etc.) during the training phase. This training to perfect responding insured that children would not fail in the integration task because they forgot the content of the original comparisons. Subjects were then asked to make comparisons among all ten possible combinations of pairs of rods, the critical comparison for integration being the B-D pair. Children at all three age levels (4, 5, and 6 years of age) made the "transitive inference" in the B versus D situation at levels significantly above chance. A second experiment was run to eliminate the possibility that children were simply remembering the absolute sizes of rods B and D when they were responding. Here, children learned the relationships between adjacent pairs of rods where only equal portions of the rods were visible, so that they could not be learning their absolute lengths. Once again, even 4 year olds made the transitive inference to the B-D pair 82% of the time, a level which is significantly above chance. These data suggest that even pre-operational children have the structures necessary to integrate information, and that previous failures to demonstrate this phenomenon may have been due to subjects' forgetting of the original relationships among the rods.

One aspect of these studies which should be noted is that they involve a deliberate, logical process of considering premise information and then operating on it in a rather formal manner in order to reach a conclusion. This kind of process seems to be less automatic and spontaneous than the integration involved in the comprehension of simple prose passages or even in the integration of two pieces of arbitrary information, as was required in the Kendler and Kendler (1961, 1963, 1967) studies. Ultimately, the specific components of integration of prose materials may be the same as those involved in more formal logical reasoning (that is, remembering initial premises and combining them to derive a conclusion), but the Kendler and perceptual judgment tasks seem to require an awareness on the part of the child that a particular strategy is necessary in order to solve the problem. Although a child may be quite capable of performing the strategy itself, he may not have the problem-solving orientation which would lead him to call forth that skill. That is, the information provided by the experimenter to the child is not sufficiently detailed or clear enough for him to produce the necessary integration response on cue. If so, deficits in performance in more formal reasoning tasks may reflect a production deficiency similar to that which is found in the memory literature (Flavell, Beach, and Chinsky, 1966), rather than an absence of integrative abilities.

One other body of literature is peripherally relevant to the question of children's integrative abilities, and should be mentioned at this point, since it strongly suggests that at least some rudimentary ability to co-ordinate information at the sensorimotor level does exist even under the age of two years. This literature is concerned with the Piatetian notion of invisible displacements in the development of the object concept. Piaget (1954) has traced the child's growing realization that objects continue to exist despite variations in location and time through the search behavior of the child when those objects are hidden. For instance, in Stages I and II of the development of the object concept, the child will not actively search for objects that disappear from his field of view. In Stage II, the child's emergent awareness of the permanence of objects is evidenced by the fact that he will search for objects that are partially hidden. If a cloth covers an object so that part of it is exposed, the child will lift the cloth to reveal the whole object. By Stage IV, in this same situation, the child lifts a cloth covering an object, even when the object was covered entirely. In Stage V, the child is able to follow visible displacements of an object, so that if it is first hidden in location 1 and then in location 2, he will search in location 2 for the object, provided he has seen the object's displacement. Finally, in Stage VI, the object concept has become so firmly established that the child can follow invisible displacements of the object. If the object is moved from location 1 to location 2, the child will search in location 2, even if he hasn't actually seen the displacement. Most research on object permanence has been concerned with the earlier stages and has generally verified Piaget's findings (Miller, Cohen, and Hill, 1970; Gratch and Landers, 1971; Harris, 1971, for example). It is the behavior in Stage VI which is pertinent to the present discussion of integration, however. The child's search behavior in Stage VI can be interpreted as involving the co-ordination of two pieces of information to derive a conclusion. The following example from Piaget's work serves to illustrate this point:

> "OBS. 64. I. At 1;7(20) Jacqueline watches me when I put a coin in my hand, then put my hand under a coverlet. I withdraw my hand closed; Jacqueline opens it, then searches under the coverlet until hse finds the object." (Piaget, 1954, p. 88)

The fact that the child searched for the coin under the coverlet implies that some form of integration occurred -- the information that the coin was no longer in the hand, and that it had also been under the coverlet was co-ordinated to derive the conclusion that the coin was still under the coverlet. Thus, even pre-verbal children may have some limited ability to integrate information that is nonverbal in nature.

To summarize thusfar, a number of studies have already shown that even 4 year olds extract meaningful relationships from stimulus materials (Brown and Murphy, 1975; Perlmutter and Myers, 1976), and that memory in those cases where they do may even exceed memory for more episodic events (Paris and Upton, 1974). The focus of subsequent research has been on delineating those cognitive activities and operations which the child uses to extract those meaningful relationships. One skill which appears to be important is the ability to make inferences, an integrative activity which serves an elaborative function in encoding and retrieval of information. Although the use of the term "inference" has been ambiguous, one could define the cognitive skill in question as the ability to co-ordinate two pieces of information which are already available. Using this definition, it is reasonable to suppose that the cognitive skill of integration is an important aspect of cognitive functioning, even in children who are much younger than 4 years of age. The Piagetian literature on transitivity and the Kendler experiments would lead one to believe that this is not the case. However, failure to control for memory for initial relations in the former situation and possible production deficiencies in calling forth problem-solving strategies in both situations might result in misleading conclusions. The child's performance in Stage VI of object permanence suggests that some basic ability to integrate is present even under the age of two years. Weighing all the evidence, there is good reason to believe that integration of verbal materials is a cognitive skill which even very young children possess and that it may be an important skill in influencing memory.

The Present Study

The purpose of the research presented here is to investigate the operation of integration of verbal materials and its relationship to memory in a group of children substantially younger than those used in previous experiments. If young children's memory is largely semantic in nature and the ability to semantically integrate information is as fundamental to the constructive processes of memory as Paris (1975) and Brown (1975a) believe, then integration skills should be present, at least in rudimentary form, at the point where children are becoming relatively facile with language -- at the age of 2½ years or so. Even though Paris and Upton (1974) found that kindergarten children made fewer inferences than older subjects, it could be that they were still capable of integrating information. As was previously mentioned, the task in that experiment placed greater demands on the child in that he had to supply some of the information which had to be co-ordinated from his knowledge of world events and relations. Also, rather long stories were used in this study, and it is possible that this much information exceeded the processing capacity of their younger subjects. It might very well be the case that if the task is modified in a few ways, even 2½ year olds might demonstrate the ability to integrate. These modifications would include: 1) presenting a task where all of the information to be integrated is already present so that the child's experience with rather sophisticated relations would not have to be drawn upon; 2) reducing the length of the prose material used to present the information to be integrated, so that limits in processing space would not be a factor; and 3) supplementing the verbal materials with interesting objects illustrating those materials, so that interest in and attention to the task would be more likely. This last modification is especially important for very young children, who tend to become disinterested in tasks where solely verbal materials are used. By instituting these modifications, it might be possible to get a more accurate assessment of children's integrative skills at a very young age, thereby adding valuable information to our knowledge of what cognitive skills children this age are able to use when dealing with simple prose materials. Therefore, the first question to be addressed in the present study is whether 2½ year old children are capable of integrating information presented in simple prose passages.

A second area of interest is in examining how the ability to integrate information develops. Perhaps the structures which direct integration are shaped and solidified by the child's having had a great deal of experience with certain premises and their conclusions in day to day events until the structures themselves gradually become useable independent of specific contents. The growing ability to apply those structures may be tied to repeated experiences with implied relationships in concrete, everyday situations.

Such a notion of structures becoming "content-free" can be traced back to William James' (1890) "law of dissociation by varying concommitants". James describes the process as follows:

> "What is now associated with one thing and now with another tends to become dissociated from either, and to grow into an object of abstract contemplation by the mind... The practical result of it will be to allow the mind which has thus dissociated and abstracted a character to analyze it out of a total whenever it meets with it again." (p. 506)

Applying this line of thinking to the development of integration structures, one could hypothesize that the way in which integrative capacities develop is through varying experience with antecedent-consequent events which involve combining information. For example, a young child may have had a great deal of experience with finding milk in a carton and seeing the carton in the refrigerator, so that an intention to find milk would lead him to look in the refrigerator. Similarly, he may have seen cookies in a box, and the box in the cupboard, so his search for cookies would lead him to the cupboard. In other words, to find the designated objects, he has to co-ordinate two separate pieces of information which are already available to him. Actually finding the objects in their hypothesized locations serves to solidify the appropriateness of using the integrative operation in those types of situations. By noticing the contiguous relationships between separate bits of information and finding their consistent conclusions, the child may be building the basic skills involved in integrative reasoning. As these cognitive structures become more and more consolidated from additional use, they might then become functional regardless of the specific contents of the information, so that they could be applied to relationships which have never been experienced before. The second purpose of this study, then, is to determine whether 2½ year old children are more likely to make integrative responses to situations congruent with everyday experiences than those that are not. Additionally, it would be interesting to see if a group of older children (3½ years of age) are less tied to the congruent situations than are younger children when they are required to integrate. Such a finding would be expected if it is true that the cognitive structures for integration are becoming more "content-free" with development.

Finally, the question of whether having to make an integrative response induces a deeper level of processing to facilitate memory will be considered. If Craik and Lockhart (1972) and the Soviet psychologists are correct, children who have had to actively operate on material in terms of integrating information should have better memory for that information. Such a finding would be consistent with the results of the Paris and Upton (1974) study, where memory was closely tied to an integrative operation. Here, the consideration is whether the integrative operation on material has this effect on memory in very young children, as well.

Experiment I

The major questions that were examined in Experiment I and the preductions associated with them are as follows:

1) Are 2½ year old children who are operating on a verbal level of capable of integrating two pieces of information presented in simple prose passages? By simplifying the task demands so that capacity of memory or processing space were minimized as factors, and by using interesting stimuli to maintain children's interest, it was hoped that this data could be obtained. The prediction was that 2½ year old children do have the ability to co-ordinate verbal information since this skill may be a part of even very basic day to day experiences.

2) Is the ability to integrate information dependent on that information being congruent with usual expectations or everyday experiences, especially for younger children? In this study, the hypothesis was that 2½ year olds would be more likely to integrate material that was compatible with their experience than material where the relationships among items were arbitrary. Older children, however, should perform equally well in either case, as they have had a greater amount of practice with this cognitive operation, making it relatively independent of contents.

Preliminary Experiment

Prior to conducting Experiment I, it was necessary to construct the congruent and noncongruent stimulus materials and to establish how appropriate they were for testing the second hypothesis described above. The general nature of the task in Experiment I was to have children play a search game where they first learned to find six containers in each of six buildings, after which they were to find six more objects in the same buildings. In this second phase, however, children were not told directly the buildings in which the objects were hidden; rather they were told the locations of the objects relative to the containers. In order to respond successfully, children had to integrate the object-container relation with the container-location relation. Some of these relations were congruent; that is, the object-container and container-location items corresponded to real-world relations with which children should be familiar. Others were non-congruent -- the object-container and container-location items were paired arbitrarily. However, it was important that the congruent relations not be so highly associated that children would search for objects in particular locations without using the container-location information. Therefore, the purpose of this preliminary study was to make sure that congruent items were not so strongly related that children would look for objects without using any mediating information.

Subjects. Five 2½ year old and 10 3½ year old children participated in this study, with 2 boys and 3 girls in the first group and 5 boys and 5 girls in the second group. Younger subject ranged in age from 2 years, 4 months to 2 years, 6 months ($\overline{X}$ = 2 years, 5 months), which older subjects ranged in age from 3 years, 4 months to 3 years, 6 months ($\overline{X}$ = 3 years, 5 months). Subjects came from middle to upper-middle class families residing in the Amherst, Massachusetts area who had already participated in other experiments as part of a project on early cognitive development at the University of Massachusetts.

Apparatus and stimuli. The apparatus consisted of two sets of six plastic buildings constructed to scale as part of railroad modeling kits. These buildings were approximately 6" x 4" x 4" in size and had a space in the center in which objects could be hidden. Buildings were arranged linearly on a child-size table so that they were all visible and within easy reach of the subjects.

In addition, 24 small plastic toys representing common objects were used. Twelve of these were items which were containers (e.g., pail, cup, plate) and 12 were objects which could be placed in those containers (e.g., key, flower, book). These toys were sufficiently small so that their placement under a building could not be detected without lifting the building. The small toys were kept out of the view of the child until it was time to use them in the experimental task.

Design and procedure. Each child received two blocks of trials, with six locations being used in each block. Within each block, there were two subsets of trials -- the first six trials tested for preferences in locating containers, and the second six tested for preferences in locating the remaining six objects. Table 1 shows the sets of items used in the two blocks of trials. Within the subsets of trials, containers and objects were presented randomly to subjects. Order of presentation of the sets was also randomized across subjects.

Children were brought individually into the experimental room where they were shown the six buildings from the first set arranged linearly on a table. The experimenter named each building for the subject and then asked the child to point to each building as it was named. If the child made an error, he was shown the correct building and was asked to locate it once more after all the other buildings had been named. The six small toys which were containers were then

Table 1

Stimuli for Congruent Relations

	Object	Container	Location
Set I:	key	car	gas station
	hamburger	plate	restaurant
	letter	mailbox	post office
	candy	shelf	store
	corn	pail	barn
	baby	crib	house
Set II:	book	desk	school
	money	table	bank
	dessert	cup	ice cream stand
	pants	suitcase	railroad station
	flower	pot	greenhouse
	ladder	truck	firehouse

put on the table, and again, the child was asked to point to each one as it was named. The containers were then hidden in their designated locations while the child was busy playing with a puzzle. Subjects were then asked to guess the location of each container. If the subject made an error (or noncongruent choice) he was not permitted to see the object; otherwise, he was. Following these trials, the six remaining objects for a set were placed on the table and identified by the child. Again, children were distracted while these objects were hidden in their designated locations and were then asked to guess the location of each object. This entire procedure was repeated for the second set of locations, containers, and objects.

Results. The dependent measure used to analyze these data was the number of responses children made where the location chosen was the congruent location for the items. Table 2 shows the mean number of congruent choices for container-location and object-location trials. It should be noted that the data of major interest is for object-location trials, since it was desirable to not have objects so highly associated with particular locations that the child could find the object by looking directly under the related location. Older children did make more congruent choices than younger children, the means for these groups being 1.58 and 1.05 for older and younger children, respectively. Also, slightly more congruent choices were made on container-location trials

Table 2

Mean Number of Congruent Choices as a Function

of Age, Set, and Trial Type

Age	2½			3½			
Set Trial Type	Set I	Set II	Over sets	Set I	Set II	Over sets	Over sets and ages
Container-location	1.60	1.20	1.40	1.60	1.70	1.65	1.57
Object-location	1.00	0.40	0.70	1.70	1.30	1.50	1.02
Over trial types	1.30	0.80	1.05	1.65	1.50	1.58	1.40

($\overline{X}$ = 1.57) than on object-location trials ($\overline{X}$ = 1.02). Furthermore, slightly more correct responses were made to Set I items ($\overline{X}$ = 1.53) than to Set II items ($\overline{X}$ = 1.03). However, a 2 (age) x 2 (sex) x 2 (set) analysis of variance (where set was a repeated measure) performed on each of the trial types indicated that no factor was significant. Table 3 illustrates the results of these analyses.

The major question, of course, was whether any of these levels of responding differed significantly from chance. First, the data were inspected to see if there were any trends of increased responses to congruent items toward the latter portions of presentation trials in all blocks and all trial types. An increase in responding could indicate that the level of chance responding was not equal for every trial, and that subjects were not sampling from the total set of locations with replacement on each presentation. Figure 1 shows the mean number of responses which were scored as congruent for each block and trial type. As can be seen, there was a slight tendency for 3½ year olds to improve in performance on later trials in Blocks I and II for container-location responses, and for 2½ year olds to improve in Block II for container-location responses and Block I for object-location responses. To see if there was any significant improvement in performance over trials, _t_-tests were performed on the data for the first three trials versus the second three trials for all blocks and all trial types. The

Table 3

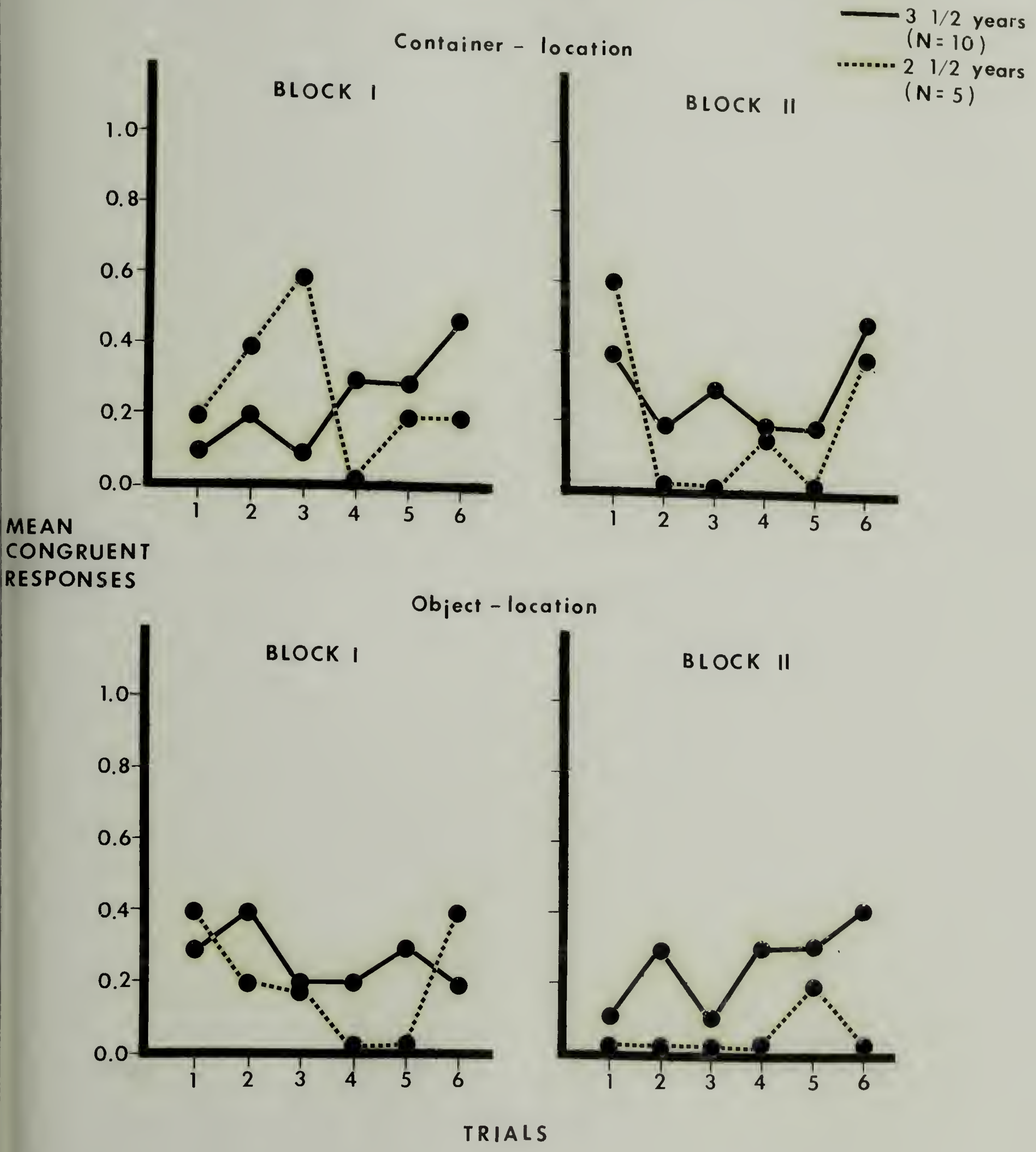
Summary of analysis of variance

for congruent choices

Source of variance	df	MS	F
I. Container-location responses			
Age (A)	1	0.47	0.22
Sex (X)	1	0.07	0.03
AX	1	6.14	2.82
S(AX)	11	2.18	
Set (T)	1	0.14	0.05
AT	1	0.47	0.17
TX	1	0.07	0.03
ATX	1	0.00	0.00
ST(AX)	11	2.72	
II. Object-location relations			
Age (A)	1	4.01	3.84
Sex (X)	1	0.01	0.01
AX	1	0.90	0.86
S(AX)	11	1.05	
Set (T)	1	0.54	3.27
AT	1	0.01	0.07
TX	1	0.54	3.27
ATX	1	0.01	0.06
ST(AX)	11	0.17	

FIGURE 1

Mean number of congruent responses as a function of age and trials



data for the first and second halves of trials are presented in Table 4. The only significant differences were for container-location trials, where 2½ year olds made more correct responses in the first half of the trials than the second half in Block I ($\underline{t} = 4.0$, $\underline{df} = 4$, $\underline{p} < .02$) and 3½ year olds made more correct responses in the second half than in the first half in Block I ($\underline{t} = 2.69$, $\underline{df} = 9$, $\underline{p} < .05$). However, these findings did not present problems in analyzing responses for object-location trials, where it could be assumed that chance level responding remained constant over trials. Since there were six possible chances for each set of six trials, chance level was assumed to equal .167. $\underline{t}$-tests on the means for each age group for object-location responses indicated that in no case did responding exceed chance level. Therefore, the results showed that the congruent relations were not so strongly associated that children would find objects in locations without considering intervening information. Experiment I was then carried out.

Method

Subjects

Subjects were 20 2½ year old and 20 3½ year old children, with equal numbers of boys and girls in each age group. Subjects in the younger group ranged in age from 2 years, 5 months to 2 years, 7 months, with a mean age of 2 years, 6 months. Older subjects ranged in age from 3 years, 5 months to 3 years, 6 months, their mean age being 3 years, 6 months.

Table 4

Mean number of congruent responses over trials

Container-location responses

Age	2½		3½	
	Trials 1-3	Trials 4-6	Trials 1-3	Trials 4-6
Block I	1.20	0.40	0.40	1.10
Block II	0.60	0.60	0.90	0.90

Object-location responses

Age	2½		3½	
	Trials 1-3	Trials 4-6	Trials 1-3	Trials 4-6
Block I	0.80	0.40	0.90	0.70
Block II	0.00	0.20	0.50	1.00

An additional 8 subjects were replaced, one 3½ year old boy because he did not talk yet, and 7 2½ year olds who either did not show any interest in the game (N = 2) or who did not complete the entire task (N = 5). There were 5 girls and 2 boys in this last group.

Children were drawn from a sample of middle class families in Springfield, Massachusetts, who expressed an interest in participating in the project. Many of these children had already participated in other experiments as part of an ongoing project in early cognitive development at the University of Massachusetts Child Study Center.

Apparatus and Stimuli

The same apparatus was used as in the preliminary experiment described above.

Design

The format of this experiment was that of a "finding game" consisting of two phases -- an acquisition portion and a set of integration trials. In acquisition, children learned to find six containers in each of six buildings. Once the locations of each of the containers were learned to criterion (acquisition), children were requested to find six other objects, each located in one of the containers (integration). On the six integration trials, the location of the objects was not directly told to the subject; rather, the child was only told in which container the object was hidden. To successfully locate the object, the child had to integrate the information about the object-container relationship with the location of the container that was learned during acquisition. For example, a child might have learned during acquisition that "the car is in the gas station". Later, during integration trials, he was told, "The key is in the car. Find the key". To find the object, the child had to combine these two pieces of information.

Acquisition and integration trials were presented for two blocks of trials. For 3½ year olds, six different locations were used in each block of trials -- those belonging to Set I and Set II described in Table 1. However, pilot testing had indicated that 2½ year olds would have trouble finishing a task this long. Therefore, this age group received a block of six trials followed by a block of four. Again, Sets I and II were used for each block, but two items were eliminated for the second block. Set I was presented first for half the subjects and second for the other half.

Within a block, the six container-location pairs used in acquisition and the six object-location pairs used in integration trials were such that half were congruent relations (see Table 1) and half were noncongruent. These last relations were constructed by randomly pairing items that remained in a set after the congruent relations were chosen. The assignment of items to the congruent condition was done so that particular congruent relations were presented equally often across subjects in each age group. One congruent and one noncongruent item were randomly eliminated for the $2\frac{1}{2}$ year olds, who received only four trials in Set II. The design of this experiment was a 2 (age) x 2 (sex) x 2 (congruency) model with congruency as a repeated measures factor.

Procedure

Each subject was tested individually in an experimental room located across the corridor from a playroom in which he awaited the experimenter. After the experimenter had familiarized herself with the child by playing with him for a short while, she invited him to play a "finding game" across the hall. Parents accompanied their children into the experimental room.

Acquisition trials. The child was shown the array of buildings in front of him and was asked to point to each building as the experimenter named it for him. If the subject made an error in finding the building, the experimenter corrected him and asked him to find it again both immediately and after all the other buildings had been named. The six containers for that set of trials were next brought out of a small box and placed on a small table directly behind the child. Once again, the subject was asked to point to each container as the experimenter named it. As before, if the subject made an error, he was corrected, asked to point to the item once more, and again after all the toys had been identified. The subject was told that each of these toys would be hidden in a particular building and was invited to help place the containers inside the buildings. The experimenter gave the child a container and told him to place it in the specified building until all the toys were hidden. As the subject placed a container in a building, the experimenter repeated verbally the location of the container (e.g., "See, the car is in the gas station.").

The child was then asked to find each of the hidden containers. For example, the experimenter would say "Where's the car?". A correct response required the subject to locate the building in which the container was located and lift it up to expose it. Every time a correct response was made, the subject received a small goldfish cracker which he could eat or deposit in a bag to take home. If an error was made, the subject was shown the correct location of the item.

The order of presentation of the learning trials was random with the constraint that each of the six containers be presented in a block of six trials. A dropout procedure was used in an attempt to equate levels of learning for the various container-location relations. Thus, after two successive correct responses were made in locating a particular item, that container was dropped from the presentation list. However, after all items were learned to criterion, all six containers were presented once again to make sure that all of the container-location relations had been learned. If the subject missed an item on this final presentation set, he was asked once again to locate that item. By using a rather stringent criterion for acquisition, it was felt that forgetting of initial container-location relations would be minimized in the test of integration performance.

Integration trials. Following the acquisition phase, the subject was shown six more objects on the table behind him. After he had correctly identified each of them, he was told that these toys, too, would be hidden in each of the buildings. The subject was given a number of beads to put on a string while the experimenter hid the items in the various containers. The six integration trials followed. The child was asked to find each object following a single verbal instruction that contained only information about the object's location relative to a container. For example, if he had learned that there was a car in the gas station, the instruction on the integration trial was, "The key is in the car. Find the key." The subject was to go to the correct building and lift it up to reveal the specified object. If, however, he approached and touched the wrong building, the experimenter prevented him from lifting it up to avoid his possibly seeing the location of an object yet to be tested. After the subject completed all six integration trials, he was asked to locate the containers for each object-container pair he had not successfully found. The purpose of this post-test was to determine if failure to locate objects on integration trials could in part be a function of memory loss for the locations of containers, that is, memory loss for one of the components required to produce an integrative response.

After completion of these trials, the first block of locations was replaced by the second, and the same procedure was followed once more for both acquisition and integration trials. Again, the only variation occurred for the 2½ year olds, for whom only four acquisition and integration trials were given.

Results

Acquisition Trials

The first question of interest was whether there were any differences in learning the initial container-location pairs. The dependent measure used in these analyses was the number of trials presented until criterion was reached for each item summed over congruent and noncongruent conditions. Thus, the minimum score to reach criterion would be nine trials for each condition when there were six locations in a block (three congruent and three noncongruent pairs, each with a minimum of three trials to reach criterion), and six trials for each condition when there were four locations in a block (two congruent and two noncongruent pairs, each with a minimum of three trials to reach criterion). A complete listing of the mean number of trials to criterion as a function of age, set, and congruency for each block of trials is shown in Table 5. It should be noted that the number of locations presented in Block II for 2½ year olds was four, rather than six, and there is, accordingly, a marked decline in the number of trials to criterion on Block II for 2½ year olds.

Table 5

Mean number of trials to criterion as a function of age, set, block and congruency

Age	2 1/2			3 1/2			
Condition	Congr.	Noncongr.	All cond.	Congr.	Noncongr.	All cond.	All cond. and ages
Block I							
Item set							
Set I	15.10	16.30	15.70	11.50	12.80	12.15	13.93
Set II	14.50	14.40	14.45	11.60	12.20	11.90	13.18
All sets	14.80	15.35	15.08	11.55	12.50	12.03	13.55
Block II							
Item set							
Set I	7.60	8.10	7.85	11.10	12.20	11.65	
Set II	7.80	8.60	8.20	11.80	11.40	11.60	
All sets	7.70	8.35	8.03	11.45	11.80	11.63	

To compare the number of learning trials to criterion for younger and older subjects, an analysis was performed on the data from the first block of locations. This restriction to the first block only was necessitated by the fact that the two age groups had unequal numbers of locations in the second block. Not surprisingly, 2½ year olds took more trials to reach criterion than 3½ year olds, the mean number of trials to criterion being 15.08 and 12.03, for younger and older children, respectively. However, since completely errorless responding would take nine trials in Block I, both groups of children were learning the locations of containers quite rapidly ($\overline{X}$ = 13.55). Learning took slightly longer for noncongruent items ($\overline{X}$ = 13.93) than congruent items ($\overline{X}$ =13.18). The particular set of items also did not make much difference in learning; the mean number of trials to criterion for Set I was 13.93 versus 13.18 for Set II. A 2 (age) x 2 (sex) x 2 (set) x 2 (congruency) repeated measures analysis of variance was computed on these data to test for significant effects of these factors. As Table 6 illustrates, the only significant factor to emerge was age, where F (1, 32) = 14.22, $p < .001$.

An analysis was also performed comparing learning in Blocks I and II for 3½ year olds to see if there were any fatigue or practice effects. A 2 (sex) x 2 (block) x 2 (congruency) repeated measures analysis of variance showed that block was not a significant factor and entered into no significant interactions.

Table 6

Summary of analysis of variance for number of trials to criterion

Source of variance	df	MS	F
Age (A)	1	186.05	14.22 *
Sex (X)	1	18.05	1.38
Set (T)	1	11.25	
Congruency (C)	1	11.25	1.81
AX	1	7.20	
AT	1	5.00	
XT	1	1.80	
AC	1	0.80	
XC	1	0.20	
TC	1	5.00	
AXT	1	0.50	
AXC	1	2.45	
ATC	1	0.45	
XTC	1	0.05	
S(AXT)	32	13.08	
AXTC	1	5.00	
SC(AXT)	32	6.21	

*p .001.

Integration Trials

The data of major interest in this experiment, of course, were children's responses on the integration trials. If children correctly located objects at a level significantly above chance on these trials, they had to perform some integrative operation, since they were never directly given the location of objects. The object-container information given on a test trial had to be co-ordinated with the container-location information which had been learned in acquisition in order for a correct response to occur. Table 7 shows the mean proportion of integration responses as a function of age, set, and congruency. A proportion measure was chosen so that all the data could be incorporated in the analyses, despite the unequal number of test trials in the second block for the two age groups. A 2 (age) x 2 (sex) x 2 (block) analysis of variance indicated that performance on integration trials did not vary as a function of block, so that the proportion scores were not affected by set size differences for 2½ year olds and could be summed over blocks. In general, all subjects were responding at very high levels, with older children performing somewhat better than younger children (mean proportion correct = .77 and .67, respectively). In fact 10 subjects, 5 in each age group, made no errors at all in integration trials for a particular block of trials. Both groups of children made slightly more integration responses in Set I (mean proportion = .75) than Set II (mean proportion =

Table 7

Mean proportion of integration responses as a function of age, block, set, and congruency

Age	2 1/2			3 1/2			
Condition	Congr.	Noncongr.	All cond.	Congr.	Noncongr.	All cond.	All cond. and ages
Block I							
Set I	.70	.64	.67	.80	.83	.81	.74
Set II	.74	.57	.66	.70	.77	.74	.70
Over sets	.72	.61	.67	.75	.80	.78	.72
Block II							
Set I	.65	.75	.70	.84	.77	.81	.76
Set II	.85	.45	.65	.64	.77	.71	.68
Over sets	.75	.60	.67	.74	.77	.76	.72
Over blocks							
Set I	.68	.69	.68	.82	.80	.81	.75
Set II	.79	.51	.65	.67	.77	.73	.69
Over blocks and sets	.73	.60	.67	.75	.79	.77	.72

.69). Furthermore, younger children made more integrations to congruent items (mean proportion = .73) than to noncongruent items (mean proportion = .60), while older children responded at approximately equal levels in both conditions (mean proportion = .75 for congruent items and .79 for noncongruent items).

A major concern in analyzing these data was determining if the proportion of integration responses exceeded chance levels. Since the data from the preliminary experiment indicated that performance would be at essentially the level of chance when children were simply guessing the locations of objects, any deviation from chance in the present study could be interpreted as evidence for integration. First, though, it was necessary to establish that children were sampling from the set of locations with replacement on each integration trial -- that they were not using a problem-solving strategy of ruling out locations already chosen in their responding on earlier trials. If subjects were using such a strategy, one would expect to see a gradual increase in correct responding over trials. Figure 2, illustrating the mean number of integration responses over trials, indicates that this is not the case. Levels of responding remained fairly constant over trials. To verify this impression, the total number of integration responses was summed over the first and second halves of each block for each age group and _t_-tests were performed on the means to test for significant differences.

FIGURE 2

Mean number of correct responses on integration trials as a function of age, block, and trials

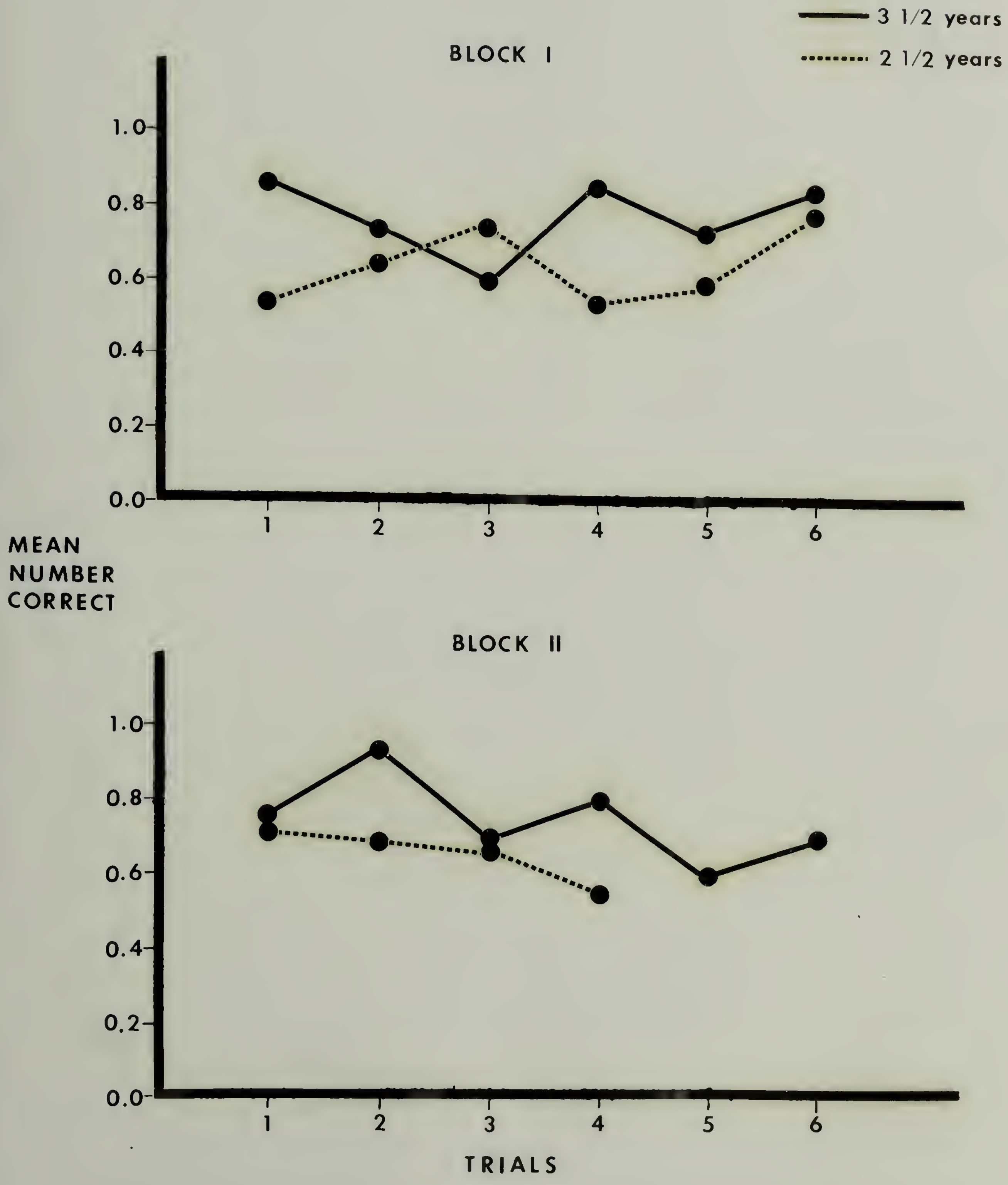


Table 8 shows the mean number of integration responses for each half of the total trials within a block. For 2½ year olds, the number of correct responses did not vary from the first half of the trials to the second for either Block I or Block II, _t_ = 0.00, _df_ = 19 and _t_ = 0.74, _df_ = 19, respectively - for Blocks I and II. For 3 ½ year olds, responding between the first and second halves of the trials was also not significantly different for Block I, _t_ = 1.63, _df_ = 19. This difference was significant, however, for Block II, _t_ = 2.29, _df_ = 19, $p < .02$. But this difference lies in the fact that responding _decreased_ over trials, a phenomenon which could be attributed to fatigue effects (these children had two blocks of six locations and consequently more trials in the entire task than 2½ year olds). Thus, there was no evidence that children were using a problem-solving strategy of ruling out previously chosen locations, and it could be assumed that chance remained at a fairly constant level over trials.

Since there were six possible response alternatives and six test trials in each block of locations for 3½ year olds, chance was assumed to be .16. For 2½ year olds, there were six alternatives and six test trials in the first block, and four alternatives and four test trials in the second block , so that chance would be .16 and .25 for the first and second blocks, respectively. However, for the purposes of simplifying analysis, the more conservative level of chance (.25) was used for the data from 2½ year olds. One-

Table 8

Mean number of integration responses as a function of age, block, and trials

Age	2½		3½	
	Trials 1-3	Trials 4-6	Trials 1-3	Trials 4-6
Block I	1.95	1.95	2.20	2.45
	Trials 1-3	Trials 4-6	Trials 1-3	Trials 4-6
Block II	1.40	1.30	2.45	2.10

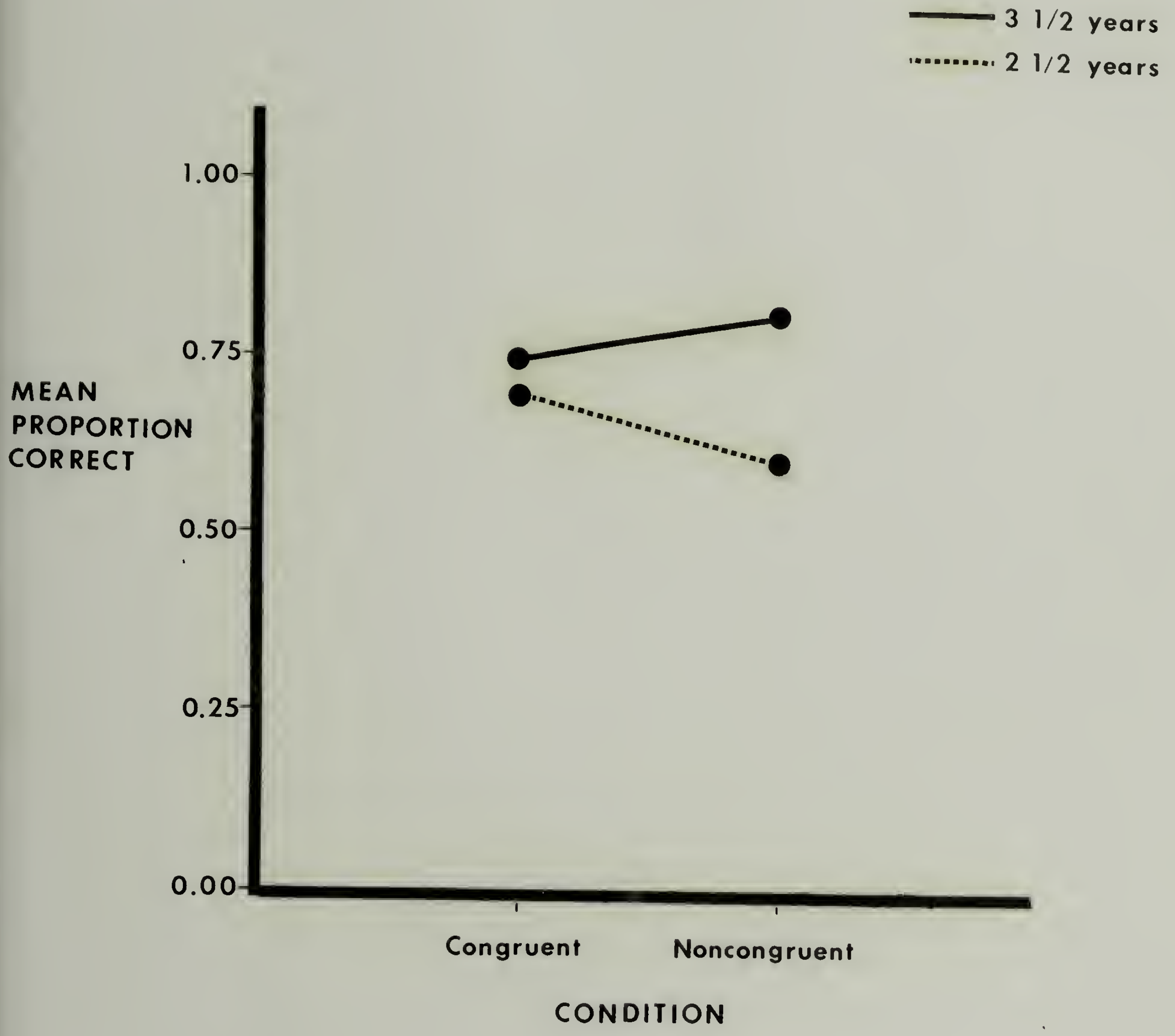
tailed *t*-tests were performed on the integration responses for both age groups for each condition and showed that children were responding well above chance in both congruency conditions. The t values for 2½ year olds were 11.23 (congruent), $df = 39$, $p < .001$, and 7.11 (noncongruent), $df = 39$, $p < .001$. For 3½ year olds, these values were 16.75 (congruent), $df = 39$, $p < .001$, and 14.13 (noncongruent), $df = 39$, $p < .001$. Thus, the major prediction of this experiment was strongly supported -- children did display the ability to integrate information.

The second hypothesis was that there would be an interaction between age and congruency condition in that 2½ year olds would be more likely to integrate congruent than noncongruent relations, while 3½ year olds would do equally well in both conditions. Figure 3 shows that the proportion of integrative responses did fit this pattern. A two-tailed planned comparison on the difference between congruent and noncongruent means for 3½ year olds showed that they did not differ, $t = 0.368$, $df = 38$. A one-tailed planned comparison between these same means for 2½ year olds was only marginally significant, however, $t = 1.53$, $df = 38$, $p < .10$. Thus, the predicted differential effect of congruency on the two age groups did appear, but not as strongly as hypothesized. In fact, the effect appears only for the data for Set II, as Table 7 indicates.

A 4-way repeated measures analysis (age x sex x set x

FIGURE 3

Mean proportion correct responses on integration trials as a function of age and condition



congruency) was also done on integration responses to determine whether age, set, and congruency had significant effects on performance. The results of this analysis (Table 9) indicated that age had a significant main effect, F (1,36) = 5.02, $p < .05$., and that its interaction with congruency was only marginal, F (1, 36) = 3.63, $p < .10$. (This marginal interaction has already been discussed in terms of planned comparisons carried out on the hypothesized interaction between age and congruency described on p. 59.) Also, there was a significant interaction between age, set, and congruency, F (1,36) = 7.88, $p < .01$. This interaction seemed to stem from the fact that younger children made more integration responses to congruent items on Set II, while older children made more integration responses to noncongruent items in that set (see Table 7). One reason this may have occurred is because a particular item (or items) in the Set II congruent condition was causing problems for the 3½ year olds. Consequently the number of errors made for each individual congruent item by subjects in both age groups was examined and the results are shown in Table 10. It seems as though two items, in particular, were responsible for most of the errors made by 3½ year olds -- the "books-desk" relation and the "money-table" relation. For some reason, those relations were especially difficult for 3½ year olds. For 2½ year olds, on the other hand, the distribution of errors seems to fairly equal across individual items.

Table 9

Summary of analysis of variance for integration responses

Source of variance	df	MS	F	
Age (A)	1	0.40	5.02	**
Sex (X)	1	0.06		
Set (T)	1	0.13	1.49	
Congruency (C)	1	0.10	1.34	
AX	1	0.06		
AT	1	0.02		
XT	1	0.01		
AC	1	0.27	3.63	*
XC	1	0.06		
TC	1	0.10		
S(AX)	36	0.08		
AXT	1	0.00		
AXC	1	0.00		
ATC	1	0.40	7.88	***
XTC	1	0.01		
ST(AX)	36	0.09		
SC(AX)	36	0.08		
AXTC	1	0.16	3.07	
STC(AX)	36	0.05		

*p .10.
**p .05.
***p .01.

Table 10

Errors for congruent items in set II

Items	money-table		dessert-cup		pants-suitcase		ladder-truck		books-desk		flower-pot	
Age	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.
2 1/2	1	.13	3	.33	2	.25	1	.13	3	.38	2	.22
3 1/2	7	.70	2	.20	0	.00	1	.10	5	.50	2	.20

Memory Loss

In this experiment, children could fail to make an integration response for two reasons -- 1) either they did not co-ordinate the required information, or 2) they forgot the relevant container-location relation for a particular object-container pair. The success with which subjects correctly located the containers on post-test trials after missing an integration pair could give at least some indication of how important this second factor was. The proportion of correct and incorrect container-location responses following an error on the integration trials is shown in Table 11. 2½ year olds were more likely to make a memory error following failure to integrate than were 3½ year olds (60% versus 36%). This difference in proportion of memory errors following an integration error was found to be significant using a z-test on differences between proportions, $z = 2.22$, $p < .02$. Thus, one reason that younger children were responding at lower levels on integration trials could be because they were more likely to forget the initial locations of the containers.

Table 11

Proportion of container-location errors following object-container errors

	Proportion correct container-location responses	Proportion incorrect container-location responses
Age		
2½	.40	.60
3½	.64	.36

Discussion

The major focus of this first experiment was to determine the extent to which very young children possess a fundamental cognitive skill which has been implicated as having importance in memory -- namely, the ability to integrate two pieces of verbal information in order to reach a conclusion. The major prediction was that even 2½ year old children have this ability since it may be an important operation involved in the comprehension of everyday events. A related problem studied here was whether this ability to integrate might develop as a function of having had repeated and varied experiences with premise-like information and its conclusions in real-life situations. If this were the case, one could hypothesize that younger children could integrate information, but only when that information is congruent with their experience. For older children, on the other hand, these integrative skills might be so well-practiced that they could be applied to even arbitrary sets of information.

The main prediction in this study was overwhelmingly confirmed. When 2½ and 3½ year old children were given a task which required the location of objects on the basis of combining verbal information, they performed at levels which were well above chance. In fact, 25% of the subjects made no errors at all in a particular set. Clearly, these high levels of responding indicate that young children do have in their repertoire some mechanism for integrating information.

The idea that the cognitive structure involved in integration becomes content-free with development, in the sense that its application is less reliant on the situation being congruent with experience, was the second issue explored by this experiment. The prediction was that 2½ year old children would be more likely to integrate information that was within the realm of their experience. Older children, however, would perform equally well in congruent and non-congruent situations, since their ability would be less content-dependent. The findings of the present study do not provide strong support for this hypothesis, although there was a trend in the postulated direction. Younger children did make more integration responses to congruent than non-congruent items, although this difference was only marginally significant and approved in only one item set.

Several possibilities exist in terms of explaining this finding. One is that the hypothesis concerning how integrative skills develop is erroneous -- that the operation of integrating information is entirely independent of experiences the child may have had. Another is that the wrong age groups were isolated to demonstrate the possible interaction between congruency factors and the development of integration. It could be that 2½ year olds have already had a vast amount of practice using integrative skills, so that already, their structures have become "content-free". Still another possibility is that items in the noncongruent condition were not so noncongruent after all. In the construction of the noncongruent relations, all items that remained out of the total set of stimuli after congruent items had been selected were randomly paired. Thus, some noncongruent items were quite obviously not relations the child could have experienced, e.g., ladder-desk-greenhouse. Others, however, could have made sense to the child, e.g., letter-shelf-gas station. Although this last relationship is probably not as salient as "baby-crib-house", for example, it is certainly a relationship which is possible, if not probable. The fact that noncongruent items may not have been so different from congruent items overall is substantiated by the finding that in acquisition, there was no difference in learning congruent versus noncongruent relations. Alternatively, one could talk about the fact that congruent items were not as congruent as initially supposed. In either case, however, it may be that poor choice of items for congruent and noncongruent conditions was responsible for the relative weakness of the findings, rather than the formulation of an erroneous hypothesis.

The last aspect of the data which was considered dealt with why failures to integrate occurred. On those integration trials where subjects made errors, a post-test was given to detemine if loss of memory for initial container-location relationships was contributing to those errors. An inspection of the data showed that 48% of the subjects made errors on container-location relationships on these trials, implying that memory and not any lack of integration ability was accounting for integration errors. Moreover, younger children were more likely than older children to make memory errors, a factor which is probably accounting for their lower levels of integration responses. Bryant and Trabasso (1971) have already established the importance of memory factors in inference-making. Memory seems to be an important component of integration performance in the present task, as well.

Experiment II

The second experiment was designed to explore the consequences of the child's ability to integrate information on his memory for that information. The importance of the activity of the child in determining what will be remembered, especially for "involuntary rememberers" has already been discussed. If integration can be termed an "activity", then it should play a role in the memory functioning of this young age group. A depth of processing model would predict a similar result, since integration involves an operation on information which goes beyond the passive recording of static, separate units. If the child's cognitive skills match the task demands, the likelihood that a deeper level of processing ensues is increased, thereby facilitating memory. Experiment I has already demonstrated that integration is a cognitive skill that very young children do possess. Since their cognitive skills match the task demands, their memory should be affected. In order to test this hypothesis, Experiment II was carried out, using a "finding game" similar to that of Experiment I. Here, though, on some trials a delay was introduced before the child was permitted to search for designated objects. Also, there were two types of presentation conditions, one where the child had to integrate information to find objects, and one where he was given the location of the object directly. If integration affects memory, children should be more likely to find objects after a delay in the first condition than in the second.

Method

Subjects

Twenty-four children who were 2½ years of age and 24 who were 3½ years of age participated in this study. There were equal numbers of boys and girls in each age group. Once again, children were recruited from a sample of middle class families in Springfield, Massachusetts, many of whom had already participated in other projects on early cognitive development at the University of Massachusetts Child Study Center. None of these subjects, however, had participated in Experiment I.

Six 2½ year old children, 3 boys and 3 girls, were replaced, either because they did not show any interest in the task initially or because they did not complete the entire task. Furthermore, seven other children in the initial sample of 48 were not included in data analysis because they failed to reach acquisition on all acquisition trials. These subjects included one 3½ year old girl, 4 2½ year old boys, and 2 2½ year old girls. Thus, the final sample consisted of 23 3½ year old children ranging in age from 3 years, 5 months to 3 years, 7 months ($\overline{X}$ = 3 years, 6 months) and 18 2½ year old children, ranging in age from 2 years, 5 months to 2 years, 6 months ($\overline{X}$ = 2 years, 5 months).

Apparatus and Stimuli

The stimuli used were identical to those used in Experiment I. However, in the present study, buildings, containers, and objects were presented in three sets of four instead of two sets of six.

Design

As in Experiment I, the task was divided into two phases -- acquisition and test trials. Once again, acquisition involved the subject learning the locations of containers, with the difference that only four locations were used for a particular block of trials. Each subject received three blocks of four locations in the entire task.

Test trials differed slightly from those in the first experiment. Since the purpose of this study was to see if there would be differences in memory for integrated information as opposed to direct information, test trials were of four types. On half of the four test trials in each block, subjects were instructed to find objects on the basis of co-ordinating information. Thus, as in the first experiment, if children had learned that a mailbox was in the store, the test trial would consist of the following: "The key is in the mailbox. Find the key." On remaining trials, information about the location of the object was presented directly. Using the above example, a sample trial would be, "The key is in the store. Find the key." Within each of these conditions, half the responses were delayed and half were tested immediately. Therefore, there were four different types of test trials in each block -- delayed integration (DI), delayed direct (DD), immediate integration (II), and immediate direct (ID). The purpose of including these last two types of trials was to obtain some baseline measures for performance independent of the delay interval.

Because congruency of object-container-location relations was not a significant factor in Experiment I, all relations used in the present experiment were noncongruent. Container-location, object-container, and object-location relations were randomly selected from the entire set of stimuli, with the restrictions that the congruent relations in Experiment I not be used and that each item appear once in the entire task. Particular sets of relations were randomly assigned to each of the three blocks of trials for each subject. Also, the order of presentation of acquisition and test trials within a block was random for each subject. The design of this experiment was therefore a 2 (age) x 2 (sex) x 4 (trial type) model where trial type was a within subjects variable.

Procedure

The procedure essentially followed the same format as the previous experiment with some minor modifications.

In order to insure that children knew the names of locations, preliminary training trials on the names of locations were conducted. The experimenter first named each building in the array for the child, and then asked him to point to each building as it was named. This was done until the child had correctly identified each building twice in succession.

Acquisition trials followed the same presentation method described in Experiment I.

Test trials consisted of the ID, II, DD, and DI trial types described above. On DD and DI trials, the child was given one portion of the verbal instruction once (e.g., "The key is in the _____") and was then distracted for 30 seconds with the bead stringing toy. At the end of the delay period, he was instructed to find the object (e.g.,"Find the key"). As in the first experiment, if a subject approached and touched an incorrect location, he was prevented from lifting it. Following a set of test trials, he was given a post-test to assess memory loss for initial information. If an error was made on a DI trial, for example, the child was asked to locate the container for the missed item. If the trial was a DD trial, he was asked to identify the building for the missed item.

Results

Acquisition Trials

The mean number of trials to reach criterion in the acquisition of container-location relations for each block is shown in Table 12. In general, older children reached criterion faster than younger children ($\overline{X}$ = 14.72 and 16.35, for older and younger children, respectively). Completely errorless responding required 12 trials for each block (three trials for each of the four locations). Thus, it is clear that both groups of children were again learning the initial relationships quite rapidly. The mean number of trials to

Table 12

Mean number of trials to criterion as a function of age, sex, and block

Age	2 1/2			3 1/2			
Sex	Male (n=8)	Female (n=10)	Over sexes (n=18)	Male (n=12)	Female (n=11)	Over sexes (n=23)	Over all (n=41)
Block							
1	17.88	16.40	17.06	15.42	14.73	15.09	15.95
2	17.13	14.90	15.89	15.00	14.73	14.87	15.32
3	15.00	17.00	16.11	14.75	13.64	14.22	15.05
Over blocks	16.67	16.10	16.35	15.06	14.36	14.72	15.44

reach criterion for blocks 1, 2, and 3 were 15.95, 15.32, and 15.05, respectively. Thus, the amount of time it took subjects to learn the locations of containers remained fairly constant over blocks of trials. Table 13 illustrates the results of the 2 (age) x 2 (sex) x 3 (block) repeated measures analysis of variance which was performed on these data. Age was a significant main effect, F (1,37) = 14.87, $p < .001$. Younger children did require more trials to reach criterion than older children. The only other significant effect was an age x sex x block interaction, F (2, 74) = 3.82, $p < .03$, which appeared to be the result of 2½ year old boys requiring more learning trials in blocks 1 and 2 and 2½ year old girls requiring more learning trials in block 3 (see Table 12).

Test Trials

Since all subjects received an equal number of test trials, the dependent measure used in analyzing performance was the number of correct responses in each of the trial-type conditions. These were summed over the three blocks of trials for each subject, so that for each trial type, the minimum score was 0 and the maximum score was 3. Figure 4 illustrates the result. Over all trials, 3½ year olds were responding at higher levels than 2½ year olds. Also, performance in both delay conditions was lower than in immediate conditions, a finding, which, of course, would be expected if decay from memory were operating here. The most relevant aspect of the data is the difference between the direct

Table 13

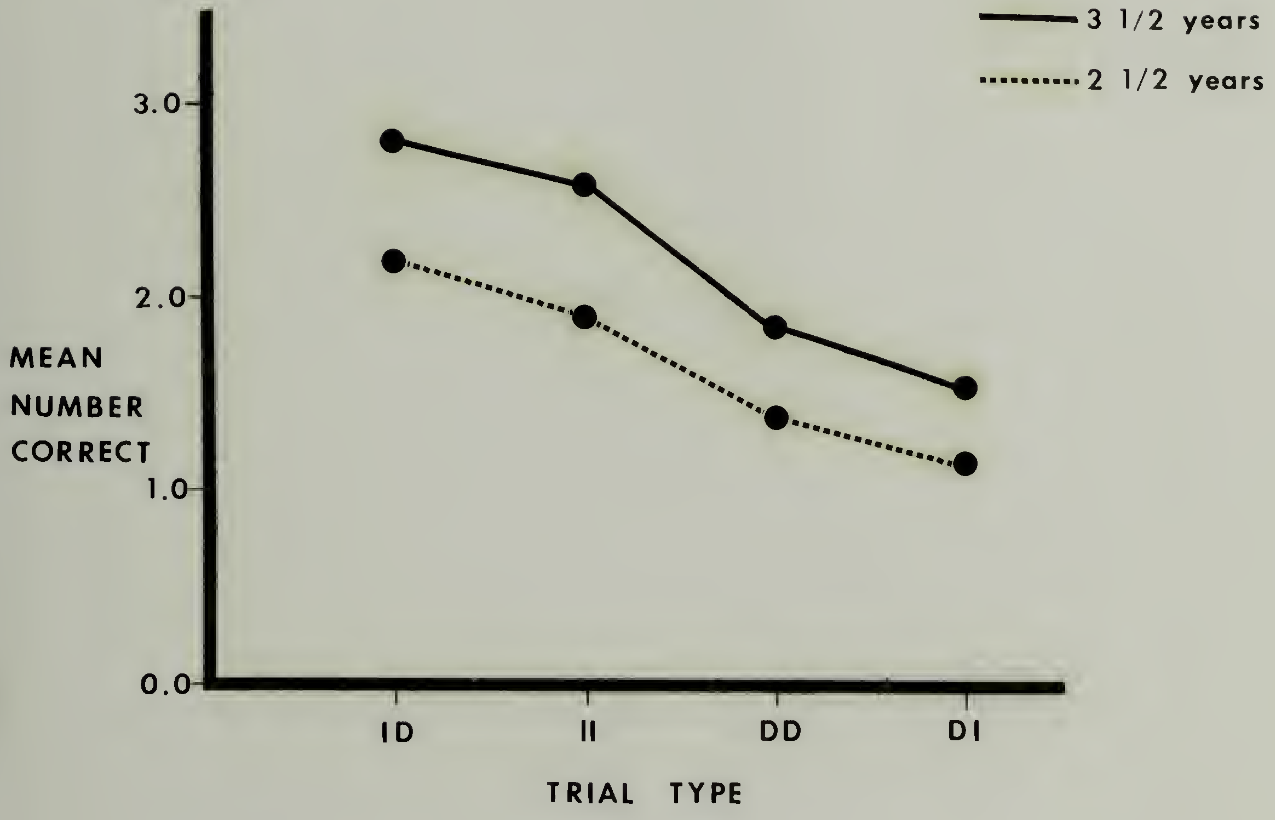
Summary of analysis of variance for number of trials to criterion

Source of variance	df	MS	F
Age (A)	1	84.20	14.87 **
Sex (X)	1	11.90	2.10
AX	1	0.12	0.02
S(AX)	37	5.66	
Block (B)	2	10.54	2.28
AB	2	2.24	0.48
XB	2	8.71	1.89
AXB	2	17.63	3.82 *
SB(AX)	74	4.62	

**p .001.
*p .03.

FIGURE 4

Mean number of correct responses on test trials as a function of age and trial type



and integration trials. Figure 4 indicates that performance for integration trials is at almost the same level as performance for the direct trials in both the immediate and delay situations.

A closer inspection of the means, shown in Table 14, confirms these initial impressions. Older children made an average of 2.27 correct responses over all trial-types, while younger children made 1.69 correct responses. Furthermore, the mean number of correct responses for the ID and II conditions was 2.59 and 2.37, respectively, while the means for the DD and DI trials were 1.68 and 1.44. There did not appear to be any major difference between integration and direct trials in either immediate or delayed conditions.

Before analyzing these results in more detail, it was necessary to determine if responding exceeded chance levels for the different test trial conditions. On any given trial within a block, there were four possible response alternatives. Since children received only three trials in each condition, and it could be assumed that they would be correct by chance on one-fourth of these trials, chance performance was considered to be .175. Two-tailed *t*-tests on the means for each condition for each age group showed that performance was reliably above chance for all conditions for each age group. The values of *t* for the ID, II, DD, and DI conditions for 3½ year olds were 29.52, 19.83, 6.58, and 5.70, *df* = 22, $p < .001$. The corresponding values for 2½ year olds were 8.53 (*df* = 17, $p < .001$),

Table 14

Mean number of correct responses on test trials as a function of age and trial-type

Age	2½ (N=18)	3½ (N=23)	Over ages (N=41)
Trial type			
ID	2.22	2.87	2.59
II	1.94	2.70	2.37
DD	1.38	1.91	1.68
DI	1.22	1.61	1.44
Over trial types	1.69	2.27	2.02

5.08 ($df = 17$, $p < .001$), 3.19 ($df = 17$, $p < .002$), and 3.65 ($df = 17$, $p < .005$).

A 3-way repeated measures analysis of variance (age x sex x trial type) of the mean number of correct responses confirmed that age was a significant factor, $F(1, 37) = 24.79$, $p < .001$ (see Table 15). Trial type was also significant, $F(3,111) = 22.43$, $p < .001$. Newman-Keuls comparisons among the means for trial type indicated that all means were significantly different from each other except for the ID versus II and DD versus DI comparisons. The values that these contrasts took are as follows: ID versus DI, $q = 1.146$, $p < .01$; ID versus DD, $q = .902$, $p < .01$; II versis DI, $q = .927$, $p < .01$; II versus DD, $q = .683$, $p < .01$. These analyses verify the notion that performance did not differ between direct and integration trials.

Memory Post-Test

Table 16 summarizes the propostion correct and incorrect responses on the post-test following an error on test trials. For direct conditions, these figures represent the extent to which the names of locations are remembered. For integration trials, they represent the extent to which the container-location relations are remembered for missed items. These data, to some degree, provide some insights into why errors occur for the different types of trials. As can be seen, for direct trials, very few errors were made because children forgot the names of locations; rather some attentional factor

Table 15

Summary of analysis of variance for correct responses on test trials

Source of variance	df	MS	F
Age (A)	1	13.10	24.79 *
Sex (X)	1	0.10	0.18
AX	1	0.10	0.20
S(AX)	37	0.53	
Trial-type (T)	3	11.57	22.43
AT	3	0.25	0.48
XT	3	0.32	0.62
AXT	3	0.12	0.23
ST(AX)	111	0.52	

*P .001.

Table 16

Proportion of correct and incorrect responses following an error on test trials

I. Direct trials

Age	2½		3½	
Condition	Proportion correct location responses	Proportion incorrect location responses	Proportion correct location responses	Proportion incorrect location responses
Immediate	.73	.27	.50	.50
Delay	.81	.19	.83	.17

II. Integration trials

Age	2½		3½	
Condition	Proportion correct container-location responses	Proportion incorrect container-location responses	Proportion correct container-location responses	Proportion incorrect container-location responses
Immediate	.52	.48	.29	.71
Delay	144	.56	.79	.21

may have been involved, at least in ID trials. For integration trials, a fair number of errors for container-location relations followed an error for locating the object, indicating once more that memory for initial relations plays a role in the process of integration.

Discussion

The major hypothesis of Experiment II was that integrating information would facilitate memory for that information. This prediction was derived from a number of theoretical perspectives which stress the importance of the activity of the child, especially the very young child, in influencing his memory. Integration is one activity which the very young child can and does perform. Therefore, in situations where he applies this operation, his memory for that information should be enhanced. The task in this experiment was designed so that on some trials, the child would be required to integrate information in order to find objects, while on other trials he had to register static cues as to their location. If integration affects memory function, the child should remember better the locations of objects which he had to deduce than those which involved a more passive or episodic registration of information.

The findings show that performance on DI trials did not exceed performance on DD trials for either age group. Thus, the prediction failed to be supported. However, performance in these two conditions did not differ, which suggests that integration might still be having some effects on memory. For one thing, more information had to be encoded and stored in the DI condition -- object-container-location relations comprised three bits of information the child had to process. In DD trials, only two bits of information were involved --

the object-location relation. If the functioning of memory is governed by static encoding and retrieval of stimuli, it would be expected that performance on test trials would <u>decrease</u> in the DI condition, since there was a greater likelihood that one of the bits would be lost somewhere in processing. The fact that performance did not differ between DD and DI trials suggests that some factor was responsible for maintaining memory on integration trials. Possibly, that factor is the activity of integration.

The other consideration in interpreting these findings is that although II trials were intended to provide some indication that integration was occurring even on DI trials, they did not <u>guarantee</u> that it did. There was some evidence that children were integrating on DI trials. Many children, when they heard the object-location relation, looked immediately to the correct location before they were distracted, indicating that integration was occurring at this point. Nevertheless, DI trials may have included cases where integration did not occur upon presentation of the verbal information. Thus, there are an unknown number of instances in the DI condition in which integration may not have occurred prior to the delay interval. The consequence could only be a deflation in the true value of the scores for DI trials. Unfortunately, given the design of this experiment, there is no systematic way to assess that portion of trials in which failure to integrate may have occurred. One way around this problem might be to repeat this experiment with the modification that children be required to locate objects before the delay without actually seeing them. Such a procedure would provide stronger evidence that DI trials did actually involve integrative processing on the part of the child, and the hypothesized superiority of performance in DI over DD trials might appear.

Conclusion

The most significant finding in the studies presented here was that very young children had the ability to coordinate two pieces of verbal information with which they were presented in order to derive a conclusion. The presence of this integrative ability was demonstrated quite clearly in both Experiments I and II, where levels of correct responding on integration trials were exceptionally high, even for 2½ year olds. Such a finding does run contrary to some of the experimental literature which was described in preceding sections. Specifically, these results directly conflict with the Kendler (1963) position that "inference... may be a process that is not readily available to lower phylogenetic species and perhaps not to young children." (p. 46). Both the Kendlers' task and the present one required the integration of two components of information in order that the problem be solved. Yet, while the problem was fairly easily solved by 2½ year olds in the present task, even 5 year olds could not solve the problem in the Kendler experiment. Several factors could be responsible for the divergent results. First, the stimuli used in the present experiment were colorful, interesting toys which were both familiar and attractive to children. The Kendlers, on the other hand used a large unfamiliar apparatus whose only function was to dispense marbles and ball-bearings. It could be, then, that more interesting nature of the stimuli used in the present experiment enhanced children's attention to and motivation to perform in the task. Secondly, if one analyses what was required of the child in these two experimental situations, there are some important differences. The Kendlers' inference task required the child to: 1) realize that a particular strategy was necessary to solve the problem, 2) remember two previously learned response components (push panel to get marble, drop marble in slot to get toy), and 3) integrate these two responses to solve the problem. Deficiencies in solving the problem could thus be a function of: 1) a production deficiency in terms of calling forth the appropriate strategy (as was previously discussed), 2) a failure to remember both response components, or 3) an absence of the ability to integrate the response components. In the present task, a correct solution of the problem required the child to: 1) realize that a particular strategy was required to solve the problem, 2) remember <u>one</u> response component (the container-location relation), and 3) integrate that response component with current information to solve the problem. The differences in these two tasks thus lie in two areas. In the first place, the present task required the child to remember only one response component as opposed to two. The importance of memory for initial relationships in determining whether or not integration takes place has been demonstrated in both this study (where it was found that if children did not integrate, very often it was because initial relations had been forgotten) and by Bryant and Trabasso (1971). Thus, failure to respond in the Kendlers' task could have been due to loss of memory for the original response components. This explanation, however, is not very satisfying in light of the fact that the response components were fairly well-learned in that task. The other possibility is that in the present task, the appropriate strategy to use was more obvious to subjects, since on a given trial, the verbal instruction provided some cues as to the appropriate steps to take. For example, a statement such as "The key is in the car" requires a progression from key to car to gas station. The initial step in that progression has already been provided in the present task, and as such may have alerted the child to the fact that it was necessary to link information about the object and container with information about the location of that container. In the Kendlers' task, the instruction was to "get a toy", a statement which provides the child only with the end point of the progression "press panel to get marble", "marble in slot to get toy". In this case, the child would have to work backwards through the progression in order to ascertain the starting point for solving the problem. His inability to find a starting point might thus be the production deficiency involved. Therefore, the differences in results between these two studies may lie in the fact that in the present study, the particular strategy necessary for correct solution was more apparent to the child by virtue of the fact that the starting point for problem solution was provided. Making the requirements of a problem clearer to the child to induce more solutions of the problem has been found to be significant in one other recently done study. Kopp, O'Connor, and Finger (1975) found that children were more likely to use a long stick to get a cookie out of a tube when that tube was transparent than when it was opaque. Presumably, this was because the demands of the problem were clearer when the child could see the relationships among the three items involved. The structure of the present task probably provides the child with these same kinds of cues.

Still another factor might be responsible for these discripant findings. The Kendlers' task could be characterized as essentially an episodic one, that is, the material and apparatus used were not especially meaningful to the child. On the other hand, the materials used in the present experiments _were_ meaningful to the child in the sense that the objects and verbal materials used were familiar and the relationships among them were at least some of the time plausible ones. Besides facilitating attention to the task, this aspect of the present study essentially made the nature of the task a semantic one. Young children's difficulties with episodic tasks have already been discussed. Their performance is quite good, however, when they perceive a situation as meaningful, which involves a semantic operation. Thus, it could be that because this task may have tapped children's semantic processes, they performed quite well.

Furthermore, they might perform equally well in a task such as the Kendlers' if that problem were cast in a more meaningful context for children.

The finding that young children did integrate verbal information when the cues to perform that operation were clear does fit in with some of the other experimental findings presented earlier. If finding objects following their invisible displacement (Stage VI of sensorimotor development) can be conceptualized as an integrative operation, and that operation is within the grasp of pre-verbal children, then it is not too surprising that an analogous operation on verbal materials is within the grasp of children who are starting to deal with the world in more verbal terms.

Some added insights into the process of integration are provided by portions of the data in Experiment II. In particular, the finding that performance on ID and II trials or on DD and DI trials did not differ significantly implies that integrating information is almost as easy for the child as processing direct cues. This notion is strengthened by the general impression that during experimental sessions, children found objects on integration trials very quickly and without hesitation. As soon as the information was presented, children began their approach toward a location. In fact on DI trials, the experimenter had difficulty in preventing several children from searching immediately for designated objects because their reaction was so fast. The integration process seems to be a fairly rapid one, and most importantly, a fairly spontaneous one for very young children. Surprisingly, however, this ability has received little attention from developmental psychologists, despite its naturalness to young children.

Although younger children tend to do somewhat less well than older children on integrative trials, there is every reason to believe that at this point, such age differences are largely a function of lack of memory for the components of the task. In both Experiments I and II, the data on memory for initial container-location relations following a failure to integrate indicated that this was the case. Thus, developmental changes in integration performance may reflect changes in memory capacity, for example, rather than changes in the skill per se.

Throughout this paper, a very heavily "cognitive" orientation has been taken in discussions of integration abilities in children. Integration has been described as an _activity_ that requires _co-ordination_ of information. That activity derives from _cognitive structures_ which direct its _operations_. This dynamic, organismic perspective merely reflects a bias on the part of the author in interpreting the process which enables the child to successfully derive conclusions in the integration task. However, this is by no means the only perspective from which these data could be interpreted. The major purpose of this paper was to demonstrate that very young children have a particular ability and not to establish the precise character of the process from which this ability derives. However, an alternative position does exist to account for successful performance in this task, and should be mentioned briefly at this point.

The alternative point of view in describing performance in the present task is the traditional associationistic or S-R approach. If one analyzes the present problem for the child as one where he first learns a B-C relationship (container-location), and then is presented with an A-B relationship (object-container), the A-C response can be seen as a chaining event, where B acts as the link in the chain. The contiguity between stimulus and response components acts to strengthen their relationship and establishes a bond between them. If the B-C pair has a strong bond, B acquires secondary reinforcing value, which in turn strengthens the A-B bond. Therefore, an occurrence of A will elicit B, which will in turn elicit C because of the strong relationships among all the components (Skinner, 1938).

Alternatively, one could take Hull's (1952) perspective of how "habit segments" become connected. During acquisition of the B-C pair, subjects acquire, in addition, an anticipatory goal response, r_g, to C. The r_g operates backward until the stimulus which begins the habit segment also elicits it. Thus, r_g may also become tied to A-B such that $A \rightarrow r_g \rightarrow B \rightarrow r_g \rightarrow C$. Empirical data from the literature on paired associates learning in children does support both of these theoretical positions. For example, both of these theories predict that learning of B-C pairs in the paired associate task, followed by learning A-B pairs should facilitate the learning of A-C pairs. This does occur, according to a number of studies (Daehler and Wright, 1968; Flamer, 1965; Nikkel and Palermo, 1965; Odom, 1965). These theories could therefore also describe the process which occurs in the integration of object-container-location relations in the present study. Container-location bonds might generate either anticipatory goal responses, or containers could acquire secondary reinforcing value to facilitate the object-location connections. However, S-R theorists would have some trouble in explaining why children (and 3½ year olds, in particular) apparently integrated congruent and noncongruent items at approximately equal levels. Associationistic theories would predict that congruent items would be integrated more than noncongruent items for <u>all</u> ages, since the initial bonds among the items are presumably stronger in the first place. In particular, strong associations should affect the A-B relation, which is presented only once in this task for each item. In congruent conditions, the A-C relation should be attained faster because of the initial strength of A-B. Of course, since there may be some problems in this study in terms of the specific items used for noncongruent relations, this particular experiment is not a good test of the relative value of associationistic versus cognitive theories. However, the differential predictions of these theories in a task such as this one are important to consider. Furthermore, the terms "secondary reinforcer" and "anticipatory goal response" are descriptive and have little explanatory value in delineating the specific nature of what happens inside the child's head when he integrates. An "anticipatory goal response" in the S-R framework, could, in fact, be likened to "cognitive activity" in the organismic perspective. Both are necessary theoretical constructs which supply the missing link between A and C, and both are vague in terms of explaining precisely why and how the linkage occurs.

Regardless of what theoretical perspective one takes, however, in describing the process of integration, the fact remains that it is a skill which very young children possess. How it develops and how it might affect memory for information which has been integrated is still unclear. Nevertheless, integration appears to be so prevalent and so spontaneous in even very young children that it deserves even further attention.

References

Anderson, R.C., Goldberg, S.R., and Hidde, J.L. Meaningful processing of sentences. _Journal of Educational Psychology_, 1971, _62_, 395-399.

Bartlett, F.C. Remembering: A study in experimental and social psychology. Cambridge, Mass.: University Press, 1932.

Bobrow, S.A., and Bower, G.H. Comprehension and recall of sentences. _Journal of Experimental Psychology_, 1969, _80_, 455-461.

Bransford, J.D., Barclay, J.R., and Franks, J.J. Sentence memory: A constructive versus interpretive approach. _Cognitive Psychology_, 1972, _3_, 193-209.

Bransford, J.D., and Franks, J.J. The abstraction of linguistic ideas. _Cognitive Psychology_, 1971, _2_, 331-350.

Brown, A.L. The development of memory: Knowing, knowing about knowing, and knowing how to know. In H.W. Reese (Ed.), _Advances in child development and behavior_. Vol. 10. New York: Academic Press, 1975(a).

Brown, A.L. Recognition, reconstruction, and recall of narrative sequences by preoperational children. _Child Development_, 1975(b), _46_, 156-166.

Brown, A.L., and Murphy, M.D. Reconstruction of arbitrary versus logical sequences by preschool children. _Journal of Experimental Child Psychology_, 1975, _20_, 307-326.

Bryant, P.E., and Trabasso, T. Transitive inferences and memory in young children. _Nature_, 1971, _232_, 456-458.

Cofer, C. Constructive processes in memory. _American Scientist_, 1973, 537-543.

Craik, F.I.M., and Lockhart, R.S. Levels of processing: A framework for memory research. _Journal of Verbal Learning and Verbal Behavior_, 1972, _11_, 671-684.

Daehler, M.W., and Wright, J.C. Visual prompting in a paired-associates mediation paradigm. _Journal of Verbal Learning and Verbal Behavior_, 1968, _7_, 148-153.

Flamer, G.B. Conditions of positive and negative transfer in children's verbal learning. Unpublished doctoral dissertation, University of Minnesota, 1965.

Flavell, J.H. First discussant's comments: What is memory development the development of? _Human Development_, 1971, _14_, 272-278.

Flavell, J., Beach, D., and Chinsky, J. Spontaneous verbal rehearsal in a memory task as a function of age. _Child Development_, 1966, _37_, 283-299.

Flavell, J., Frederichs, A., and Hoyt, J.D. Developmental changes in memorization processes. _Cognitive Psychology_, 1970, _1_, 324-340.

Gratch, G., and Landers, W.F. Stage IV of Piaget's theory of infant's object concepts: A longitudinal study. _Child Development_, 1971, _42_, 359-372.

Ham's, P.L. Examination and search in infants. _British Journal of Psychology_, 1971, _62_, 469-473.

Hull, C.L. _A behavior system_. New Haven, Conn.: Yale University Press, 1952.

James, William. The Principles of Psychology, Vol. 1. N.Y.: Dover, 1890.

Jenkins, J. Remember that old theory of memory? Well, forget it! American Psychologist, 1974, 29, 785-795.

Kendler, T.S. Development of mediating responses in children. In J.C. Wright and J. Kagan (Eds.), Basic cognitive processes in children. Chicago: University of Chicago Press, 1963.

Kendler, H.H., and Kendler, T.S. Inferential bheavior in pre-school children. Journal of Experimental Psychology, 1961, 51, 311-314.

Kendler, H.H., and Kendler, T.S. Inferential behavior in young children. In L.P. Lipsitt and C.C. Spiker (Eds.), Advances in child development and behavior, Vol. 3. New York: Academic Press, 1967.

Kintsch, W., and Monk, D. Storage of complex information in memory: Some implications of the speed with which inferences can be made. Journal of Experimental Psychology, 1972, 94, 25-32.

Kopp, C., O'Connor, M., and Finger, I. Task characteristics and a Stage 6 sensorimotor problem. Child Development, 1975, 46, 569-573.

Kiben, L.S. Memory from a cognitive-developmental perspective: A theoretical and empirical review. In Furth, H., Overton, W., and Gallagher, J. (Eds.), Yearbook of Developmental Epistemology, Vol. 1. New York: Plenum.

Meacham, J.A. The development of memory abilities in the individual society. _Human Development_, 1972, _15_, 205-228.

Miller, D., Cohen, L., and Hill, K. A methodological investigation of Piaget's theory of object concept development in the sensory-motor period. _Journal of Experimental Child Psychology_, 1970, _9_, 59-85.

Moeser, S.D. Inferential reasoning in episodic memory. _Journal of Verbal Learning and Verbal Behavior_, 1976, _15_, 193-212.

Nikkel, N., and Palermo, D.S. Effects of mediated associations in paired-associate learning of children. _Journal of Experimental Child Psychology_, 1965, _2_, 92-102.

Odom, R.D. A method for studying the effects of mediated associations in the paired-associate learning of children. _Psychonomic Science_, 1965, _2_, 1-2.

Paris, Scott G. Integration and inference in children's comprehension and memory. In F. Restle, R. Sniffrin, J. Castellan, H. Lindman, and D. Pisoni (Eds.), _Cognitive Theory_, Vol. 1. Potomac, Md.: Earbaum and Associates, 1975.

Paris, G., and Carter, A.Y. Semantic and constructive aspects of sentence memory in children. _Developmental Psychology_ 1973, _9_, 109-113.

Paris, S.G., and Mahoney, G.J. Cognitive integration in children's memory for sentences and pictures. _Child Development_, 1974, _45_, 633-642.

Paris, S.G., and Upton, L.R. The construction and retention of linguistic inferences by children. Paper presented at the Western Psychological Association, San Francisco, April 1974.

Perlmutter, M., and Myers, N.A. A developmental study of semantic effects on recognition memory. *Journal of Experimental Child Psychology*, 1976, in press.

Piaget, J. *The construction of reality in the child*. New York: Basic Books, 1954.

Piaget, J. and Inhelder, B. *The psychology of the child.* New York: Basic Books, 1969.

Piaget, J. and Inhelder, B. *Memory and intelligence*. New York: Basic Books, 1973.

Skinner, B.F. *The behavior of organisms*. New York: Appleton-Century, 1938.

Smirnov, A.A., and Zinchenko, P.I. Problems in the psychology of memory. In M. Cole and I. Maltzman (Eds.), *A handbook of contemporary Soviet psychology*. New York: Basic Books, 1969.

Tulving, E. Episodic and semantic memory. In E. Tulving and S. Donaldson (Eds.), *Organization of memory*. New York: Academic Press, 1972.

Yendovitskay, T.V. Development of memory. In A.V. Zaporozhets and D.B. Elkonin (Eds.), *The psychology preschool children*. Cambridge, Mass.: MIT Press, 1971.