REACTIVATING PRESCHOOL CHILDREN'S MEMORY FOR THE LOCATION OF HIDDEN OBJECTS

ROBERT B. GAUTHIER

Reactivating Preschool Children's Memory for the Location of Hidden Objects

by

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Abstract

There is little research regarding the amount of information that three-year-old children can retain and the length of time that they can retain it. In a task in which three-year-olds retained the locations of hidden objects, subjects were given a reactivation treatment to determine if the reminder would facilitate recall. An additional question was whether having input into where objects were hidden would facilitate recall. Ninety children learned the location of 16 objects hidden in a room. One-half of the children determined which object to hide in each of the pre-selected locations (self-generated condition), and the experimenter determined which object to hide at each location for the remaining children (experimenter-generated condition). For both the self- and experimenter-generated conditions, one-third of the children were visited three weeks after acquisition at which time they saw the 16 objects (reactivation treatment). Another one-third were returned to the experimental room but did not see the objects (partial-reactivation treatment). The remaining one-third of the children were visited again only at final testing (control treatment). All subjects were tested

for recall of the 16 object-location pairings 4 weeks after initial learning. Results showed no significant differences due to reactivation or generation conditions.

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Reactivating Preschool Children's Memory for the Location of Hidden Objects

Research has grown in the area of long-term retention of information by infants, school-age children and adults (e.g., Brainerd, Kingma, & Howe, 1985; DeLoache, 1986; Howe & Brainerd, 1989; Rovee-Collier & Hayne, 1987). However, there is little evidence regarding the amount of information that preschoolers can retain and the length of time that they can retain it In tests of long-term retention, researchers have found that reactivating information during a retention interval is effective in facilitating recall in infants (e.g., Rovee-Collier & Hayne, 1987) and school age children (e.g., Hoving & Choi, 1972; Hoving, Coates, Bertucci, & Riccio, 1972). One issue in tests of long-term retention is whether reactivation of the information learned in the acquisition stage will facilitate recall in preschool children. As well, it is not known whether a full reactivation treatment, such as reshowing all the material learned at acquisition, would facilitate better recall with preschool children than a partial reactivation treatment, such as re-showing a smaller amount of the learning material.

Another issue in the study of long-term retention is the effect of source of control at the learning stage on facilitating recall in preschoolers. Source of control is defined as subjects having some input into the learning material versus them not having input. In the present study, source of control was operationalized by varying whether the child or the experimenter chose a hiding place for each object. It can also be termed self- versus experimenter-generated learning, as in the present study. When subjects have input into the learning material, it facilitates recall in tests of school-age children and adults.

Researchers (e.g., Bjorklund, 1987, 1988) have argued that when school-age children and adults have input into the learning material of a long-term retention test, they make use of their prior knowledge of the material. Research in this area leads to the question of whether merely observing at the acquisition stage, compared with actually performing at the acquisition stage in a long-term retention test, will result in different recall performance. Performing could positively affect the knowledge a subject has of the learning material, thus facilitating recall. There is little evidence regarding the importance of source of control and of observing versus performing an action for preschoolers in tests of long-term retention, however.

The effects of reactivation and the effects of source of control in relation to preschoolers need to be examined. When researchers learn more about preschoolers' cognitive abilities, they gain more knowledge about the adaptive nature of cognitive ability. As Bjorklund and Green (1992) argued, a better understanding cognitive ability in older children and adults requires an understanding of it in preschoolers.

The goal of this thesis was to examine whether reactivation during the retention interval and/or input into learning at the acquisition stage of a long-term retention test would facilitate recall of information from long-term memory for three-year-old children. Three-year-olds have the cognitive abilities to complete memory tasks, but as yet have not been studied extensively. Much about memories of older children and adults is known, and there is some knowledge about memory in infancy. However, very little is known about preschoolers' memory.

Reactivation

Reactivation is defined as the reintroduction of a portion of an original event at a time after which the event may have been forgotten. In a typical test of reactivation, the subject first learns material to a criterion. Then, at some point during the retention interval, the subject is given a reminder of the learned material. Finally, the subject is tested for long-term retention of the event. Testing may involve single or multiple tests of recall or recognition. The purpose of reactivation is to reinstate (i.e., reconstruct) the memory trace. For example, showing a subject a list of stimulus words from a paired-associates list that he or she learned previously may reactivate the memory of the stimulus-response pairs. In infant-memory and animal-memory paradigms, subjects are trained in a highly distinctive setting. At some point during the retention interval, the reactivation treatment is given in the same setting that the initial acquisition took place. Subjects are subsequently asked to reproduce the acquired response in that setting. Researchers have found that reactivating memory is effective in strengthening the memory trace, thereby facilitating recall, for both human and animal subjects (Campbell & Jaynes, 1966, 1969; Rovee-Collier & Hayne, 1987).

Campbell and Jaynes (1966) defined reinstatement, another term for reactivation, as a small amount of partial practice or repetition of a learning experience over a period during which some aspect of behaviour is learned for life. This partial practice is enough to maintain a response for those subjects who had the experience at the acquisition stage, but not enough to produce any learning in those who did not have the experience. Campbell and Jaynes (1969) demonstrated the effects of reinstatement with rats in a study where they explored the retention of a visual discrimination task learned in infancy. The amount of partial practice affected the retention of the learned behaviour. Longer durations of reinstatement resulted in greater retention of the learned behavior. Thus, occasional reminders of the original learning experience may reinstate the memory of that experience.

Although the research on rat populations provides evidence for the benefits of reactivation, studies on humans are more relevant to the present research. Results of a number of studies on infants which used a conjugate reinforcement paradigm with a suspended mobile (e.g., Boller, Rovee-Collier, Borovsky, O'Connor, & Shyi, 1990; Fagen & Rovee-Collier, 1983; Hayne, 1990; Hill, Borovsky, & Rovee-Collier, 1988; Rovee & Rovee, 1969; Rovee-Collier & Hayne, 1987; Rovee-Collier & Sullivan, 1980) have led to the conclusion that it is possible for infants to remember for long periods of time. In the paradigm, the infant learns that kicking its foot causes an overhead mobile to move. At some point during a retention interval, the infant is placed in the same setting but cannot move the mobile: this is the reactivation treatment. At final testing, the infant is again returned to the distinct setting and can kick to move the mobile again. Kicking rate is used as the measure of long-term retention. Infants who were not given a reactivation treatment forgot that kicking caused the mobile to move, as evidenced by low kicking rates. However, at final recall, after the reactivation treatment, the kicking rate was at or near the same rate as at initial acquisition. This finding was obtained for two-month-olds (Greco, Rovee-Collier, Hayne, Griesler, & Earley, 1986), three-month-olds (Rovee-Collier & Hayne, 1987), and six-month-olds (Boller et al., 1990; Hill et al., 1988). Although this recall is cued, being elicited only by the re-presentation of a specific environmental context, it is similar in character to the more complex and symbolic recall responses shown by older children.

Rovee-Collier, Sullivan, Enright, Lucas, and Fagen (1980) stated that reactivation is an important mechanism through which behaviour can be influenced. Reactivation can provide the opportunity for the cumulative effects of early experiences to develop over long periods of time. The authors concluded that the results of reactivation studies provide evidence for the theoretical distinction between availability (i.e., storage) and accessibility (i.e., retrieval) of information in memory. The learned material may be stored in long-term memory, but without frequent reminders of the material individuals are unable to retrieve the stored information. Since reactivation does not affect recall, however, this may indicate an inability to access available information.

Although researchers have not studied the effects of reactivation on preschoolers' memory, there is research on the role of reactivation in the memory performance of school-aged children. Hoving et al. (1972) asked children (2 groups with mean ages of 6.7 and 10.1 years) to learn pairs of object names by showing them 20 black and white line drawings (10 pairs) of objects on cards. After being shown the pairs, the children were shown a stimulus card and asked to name the paired object. All subjects were trained to the criterion of one perfect recall trial of all 12 pairs. In the reactivation condition, children were exposed to the word pairs embedded in a story four weeks after acquisition. Children in the control group were not re-exposed to the words. At final testing, eight weeks after acquisition, the initial learning procedure was duplicated. Children given the reactivation treatment performed better at final testing than did children who received no reactivation treatment. As did Rovee-Collier et al. (1980), Hoving et al. speculated that reactivation may be involved in the persistence and incorporation of early childhood experiences into adult behaviour patterns. They argued that occasional reminders of stimuli, identical or similar enough to stimuli which were present and noticed at acquisition, are effective in maintaining conditioned responding. With reactivation, the responding is maintained at a high level after a time period during which the response would otherwise have been forgotten. This allows for future behaviour to build on past experiences.

Hoving and Choi (1972) examined whether the improved memory in the reactivation condition was due to the stimulus-objects or the response-objects in the pairs. Using the same stimulus materials as Hoving et al., Hoving and Choi examined five groups of 6- and 8-year-olds, varying reactivation treatments, showing stimulus-only cards or response-only cards. They found that the presentation of the response-card was the necessary and sufficient reactivator to increase the retention of paired-associates learning in young children.

Hoving and Choi (1972) looked at processes involved in paired-associates learning to determine why the response-only, and not the stimulus-only, condition increased retention in school-age children. They differentiated the learning of the response and the learning of the association between stimulus and response as two separate processes. Hoving and Choi argued that when only the stimulus is given as a reactivator, a child of six years would not spontaneously produce the response and hence would not reexperience the pairings. When the response is given as the reactivation treatment, the pairs are reexperienced, which facilitates recall. Not all researchers agree. For example, Silvestri, Rohrbaugh, and Riccio (1970) stated that the stimulus was the necessary and sufficient reactivator. Regardless of the specific influences of stimulus and response, it remains that generally the process of reactivation was effective.

There is inconsistency between the paradigms of reactivation studies with infants versus school-aged children. In the infant's situation, reactivation consists of putting the infant back into the experimental setting but the kicking produces no consequence. Operant analysis would call this extinction. In the school-age paradigm, reactivation consists of showing the word pairs embedded in a story. The procedure provides an additional learning opportunity; in fact, it may be considered over-learning. Although the research done in both paradigms has shown that reactivation facilitates recall, neither of the paradigms used to operationalize reactivation uses a true reactivation treatment. In studies of the effects of reactivation, it is necessary to have a treatment that does not operantly extinguish learning but also does not provide too much learning opportunity.

In summary, research on the effects of reactivation indicates that even a single reactivation experience at some point during a retention interval will improve subsequent recall. This is true for infants (e.g., Rovee-Collier & Hayne, 1987) and for school-age children (e.g., Hoving & Choi, 1972; Hoving et al., 1972). There is no evidence to support whether reactivation is an effective means of facilitating recall of information from long-term memory with preschool children.

Self- versus Experimenter-Generated Learning

In the present study, a design was employed to examine effects of reactivation; however, the design also allows for examination of whether or not having prior knowledge of or input into the learning material affects long-term retention of that material. Preschool children were given the opportunity to choose which objects are hidden in given locations. They may associate that cars are hidden behind chairs and, when asked what to hide behind a chair, they have the opportunity to choose the car. This would enhance retention of the object-location pairing for that subject. In this research, I hypothesized that the effects of prior knowledge combined with the effects of reactivation would facilitate learning. This question is secondary to the primary investigation of the effects of reactivation.

The two groups in the design are referred to as self-generated learning, in which case the subject has input into determining the learning material, and experimenter-generated learning, in which case the subject observes the experimenter present the learning material. Self-generated learning involves having input into learning by choosing which objects are hidden in given locations. Experimenter-generated learning involves observing the experimenter choose which object goes in which location. The object-location pairings are later recalled.

Two areas of particular interest relevant to this issue of source of control are knowledge base, and subsequent behaviour of observers and performers. Knowledge base is a theoretical construct used to identify prior knowledge. The effects of prior knowledge can be examined by using the experimental manipulation of self- versus experimenter-generated learning; this study attempts to answer the question: "Does having prior knowledge of the learning material facilitate acquisition and recall of the material?"

According to Bjorklund (1988), a person's prior knowledge is the conceptual information he or she has about the definition of and the relations among common language terms. A well-elaborated knowledge base may facilitate memory performance on long-term retention tests (a) by facilitating deliberate use of memory strategies, (b) through relatively automatic activation of relations among items, and/or (c) by increasing the activation of individual items (Bjorklund, 1987). Children who make greater use of their knowledge base have more features in long-term memory associated with the items. Therefore, at the time of recall the activated features should be more accessible for children involved in determining the learning material than for children who simply observed at the acquisition stage. Memory representations for children who use their knowledge base while involved in determining hidden object location pairings, for example, should be better able to readily activate these representations than those children who have no opportunity to use their knowledge base.

Bjorklund (1987) stated that the more knowledge a child has about a set of items and the more encounters with the items, such as through reactivation treatments, the less mental effort is required to activate the items. If this is so, then the use of knowledge base in acquiring information to-be-learned, should leave more of one's limited processing capacity for other cognitive activities.

The work of Bjorklund (1987, 1988) and Howe (1985) indicated that prior knowledge is an important explanatory component of memory performance. The prior knowledge strengthens the memory trace and facilitates recall. For example, in a paired-associates task the subject's knowledge base may include that two words are frequently encountered together. When given a stimulus word and asked to choose another word to pair it with, their choices are based on their prior knowledge. This makes learning easier and strengthens the memory trace because the subjects start out with a non-zero trace.

Many other researchers have added to this debate (e.g., Baker-Ward, Hess, & Flannagan, 1990; Feldman & Acredolo, 1979; Rudy & Goodman, 1991). Enhanced recall of learned material may occur for children as young as four years of age (e.g., Feldman & Acredolo, 1979). These results illustrate the importance of manipulating self-generated versus experimenter-generated conditions of recall when studying early memory development. When subjects have input into the learning material, they have the opportunity to use prior knowledge. Whether or not learning and recall are facilitated is important for practical and empirical reasons. Practically, it is important to know the benefits of involvement in learning for such purposes as designing education programs. Empirically, it is important for researchers to know when designing studies of memory that the mode of involvement (i.e., actively involved, as in self-generated learning, vs. passively involved, as in experimenter-generated learning) will affect the performance of young children.

In order to examine the importance of a knowledge base, Bjorklund and Bernholtz (1986) and Bjorklund (1988) used the paradigm of recalling self- versus experimenter-generated word lists. Bjorklund and Bernholtz manipulated the typicality of words with groups of good and poor 13-year-old readers. For the self-generated list, the typicality of the items was determined based on rating data obtained from the children in a previous session. For the experimenter-generated list, typicality was based on norms obtained from a sample of college students. During the learning stage of the study, subjects received two lists consisting of sets of typical and atypical items for recall. At recall, performance was better for the typical than for the atypical items for each group of children with both the self-generated and experimenter-generated lists. Good readers recalled more for the experimenter-generated lists than did poor readers. When the lists were devised by the subjects, however, there were no recall differences between the good and poor readers. Bjorklund and Bernholtz argued that the differences in knowledge base between the good and poor readers were responsible for the differences in recall found with the experimenter-generated lists rather than differences in strategy use. They stated that performance was influenced by nonstrategic, organizational processes associated with the relatively effortless activation of well-established semantic memory relations.

Bjorklund (1988), in examining how knowledge base is affected by age, studied children's strategies for remembering word lists (subjects were from grade 4 and grade 7). The typicality of the words was judged either by the subjects or by adult raters. Bjorklund referred to research on children's free recall (Bjorklund & Bernholtz, 1986; Rabinowitz, 1984) and cued recall (Ackerman, 1986; Bjorklund & Thompson, 1983; Whitney & Kunen, 1983) in which performance was higher for sets of typical than atypical category exemplars. In the procedure, subjects learned a word list, and at final testing they were given four recall tests. Older children recalled more words than younger children, and recall was greater for typical than for atypical category items for both self-generated and adult-generated lists. Recall of the atypical items for both older and younger children was greater for subjects receiving self-generated lists than for those receiving adult-generated lists. With more knowledge, processing becomes more efficient, thereby enabling easier access to entries in semantic memory.

In summary, Bjorklund and his colleagues (Bjorklund, 1987, 1988; Bjorklund & Bernholtz, 1986; Bjorklund & Bjorklund, 1985) found that knowledge base is an important explanatory component of memory performance. In their studies, recall was better in self-generated conditions than in experimenter-generated conditions. This learning condition variable interacted, however, with age (older vs. younger), reading ability (good vs. poor) and typicality.

The second area to consider in examining the effects of source of control is the difference in subsequent behaviour of observers (experimenter-generated learning) and performers (self-generated learning). The question in this area of observers versus performers is whether observing an action to be later recalled will affect recall differently than performing the action. For the purposes of the present research, this question is asked regarding three-year-olds. Following the logic of his theory, Bjorklund might argue that performing a task would strengthen the features in memory associated with the task. At time of final recall, the features would be more accessible for performers of the task thereby making recall less effortful. A child who interacts with objects to-be-hidden at their hiding location may have representations of movement and events that are linked to locations (e.g., Cohen & Cohen, 1982). It is also possible that the motor activity involved in performing the task may interfere with establishing the memory representations, although this possibility is not empirically supported. Baker-Ward et al. (1990) found that performed actions were retained better than observed actions when the to-be-recalled events were familiar and meaningful. They also argued, alternatively, that passive observation of another's activities may direct the subject's choice at recall, a possible support to the speculation that performing may cause interference.

Cornell and Heth (1986) examined observers and performers in a task of hiding and later finding 20 marbles in a room. The subjects, in kindergarten and grade two, either hid the marbles themselves, chose the locations but observed the experimenter hide the marbles, or observed the experimenter choose the locations and hide the marbles. The subjects immediately were required to find the marbles. Generally, although children who chose the locations used some form of strategy in their choices, there was no difference in recall between the groups. Children used memories of hiding places to direct their search. The information obtained from observation was sufficient to establish these memories.

In contrast, performing an activity may facilitate recall of the activity (Baker-Ward et al., 1990; Cohen & Cohen, 1982). There is also evidence that observing is sufficient to form representations in memory and that there is no difference in recall between observers and performers (Cornell & Heth, 1986). This lack of significant difference may be a result of the type of objects being hidden; the objects (marbles) were alike. Distinctive objects may have been more interesting, thereby increasing motivation of subjects to find the objects. To answer this question, further evidence using objects that would intrigue preschoolers is needed.

In the present study, the recall of observers versus performers was examined. The objects used were novel and age-appropriate toys. Involvement with hiding the objects (i.e., choosing which objects are hidden in given locations) is expected to facilitate acquisition and recall of the hiding locations. This expectation is based on the research which argues that prior knowledge facilitates learning and recall (e.g., Bjorklund & Bernholtz, 1986) and the research which supports that performing as opposed to observing an activity facilitates learning and recall (e.g., Cohen & Cohen, 1982).

In summary, whether or not knowledge base and subsequent behaviour of observers and performers facilitate learning and recall of material is unresolved. The inconsistency in research regards whether or not self-generated learning and/or performing a task in a test of long-term retention facilitates recall. Having prior knowledge of the learning material may give subjects the opportunity to use this knowledge to strengthen memory traces. This use of prior knowledge facilitates acquisition and recall of information, although there is no evidence that this is so for three-year-olds. The knowledge base literature includes a number of studies of self- versus experimenter-generated word lists, and studies of the effects of being permitted to use prior knowledge in paired-associates tasks. The results of the studies show that having input into determining the lists facilitates recall, at least for school-age children and adults. More features are encoded, which makes the lists more readily accessible at time of recall.

Regarding the controversy about the effects of observing versus performing a task, researchers argue that performers recall better than observers of events (Baker-Ward et al., 1990; Cohen & Cohen, 1982) and, alternately, that there is no difference between observers and performers (Cornell & Heth, 1986). As well, there is evidence in the two-choice alternation task literature that a task of hiding and seeking objects, a widely used task in this area, may be beyond the cognitive abilities of three-year-olds (Rabinowitz & DeMyer, 1971). These researchers would argue that examining the effects of observing versus performing by employing a paradigm of hiding and seeking objects would be inappropriate, although other researchers (e.g., DeLoache, 1986) would disagree.

Memory for Hidden Object Locations

In long-term retention studies of the effects of reactivation and source of control, appropriate methods of testing are necessary. Retention of word lists, such as used in Bjorklund (1987, 1988), Bjorklund and Bernholtz (1986), Hoving and Choi (1972), and Hoving et al. (1972) are appropriate in testing school-age children, but more innovative methods are needed when testing younger children. Lange, MacKinnon and Nida (1989) stated that the less cognitively demanding the task, and the more attractive the task, the more likely that preschoolers will tend to automatically respond with more effort. DeLoache (1986) successfully used a memory-for-hidden-objects paradigm to study two-year-old children's long-term retention. The subjects understood what was required of them and were capable of completing the task. The current research used a similar paradigm.

There are conflicting opinions in the literature as to whether preschoolers are cognitively capable of understanding the concept of "hiding". Flavell, Shipstead, and Croft (1978) examined whether or not young children between the ages of 29- and 48-months were able to hide objects from another person. They also examined whether the subjects were able to determine if the other person could see the hidden object(s). Even the youngest subjects knew how to hide an object from the experimenter by putting an object on the side of a panel opposite the experimenter. Only the older children were able to hide an object by placing a panel between the object and the experimenter. All children did well on determining whether a second experimenter could see an object when the first experimenter held a panel in a certain position and asked the child if the second experimenter could see the object. Thus, the results of Flavell et al. support the view that 2.5- to 3.5-year-old children understand the concept of hiding.

Lempers, Flavell, and Flavell (1977), in examining hiding behaviour, had young children aged 1- to 3-years hide an object from the experimenter. Either the child was to move the object to hide it behind a panel, or the child was to move the panel to hide the object. Three-year-olds performed at ceiling levels on almost all tasks used in the study. Lempers et al. concluded that by the age of three years children demonstrate the knowledge that objects can block the vision of other objects. They found that three-year-olds know that the experimenter's perception of an object is independent of their own. These young subjects do not exhibit much egocentric hiding.

In contrast, Rabinowitz and DeMyer (1971) found that three-year-olds do not have the cognitive ability to organize; they do not have the systematic cognitive abilities for hiding or searching. In the two-choice alternation tasks used by Rabinowitz and DeMyer, the children choose between two locations to find hidden objects; they may also hide the object. Their ability to hide in an unpredictable manner was examined and it was determined not to be present at age three years. The authors also found that the ability to search comes only about six months before the ability to hide. According to Rabinowitz and DeMyer, therefore, the subjects in the present research were only beginning to have the ability to search.

The alternation task of hiding is somewhat different from hiding objects as in the Lempers et al. (1977) study. The alternation task literature views hiding as a purposeful strategy rather than as an innate ability as described in the Lempers et al. study. Therefore, researchers such as Rabinowitz and DeMyer

(1971) who claim that three-year-olds cannot hide may be referring to strategic hiding.

In the present study, preliminary investigations indicated that three-year-olds did understand what was being expected of them when asked to hide an object. Based on the results of this test and on the research of both Flavell et al. (1978) and Lempers et al. (1977), I contend that preschool children understand the concept of hiding.

The memory-for-hidden-objects paradigm requires an ability to search as well as to hide. Searching for hidden objects is well within the capacity of infants and is useful in assessing the memory skills of toddlers and young children (Bjorklund & Muir, 1988). We know from the research of Heth and Cornell (1980) that children as young as one year of age can search effectively after observing models, their mothers, perform a search task. Children as young as three years of age can search effectively in a natural environment without observing a model. Searching seems to be a skill that develops early in life.

Thus, in accord with the research of DeLoache (1986), DeLoache and Brown (1983), DeLoache, Cassidy, and Brown (1985), Flavell et al. (1978), and Lempers et al. (1977), preschool children have the ability to hide and to later search for hidden objects in a room. Therefore, a memory for hidden objects paradigm seems to be appropriate to test recall of information from long-term memory in three-year-old children.

Present Research

There are several hypotheses in this study. One hypothesis is that in a test of long-term retention with three-year-old subjects, reactivation of a portion of the original learning material during the retention interval will facilitate recall of that material. I postulate that the stronger the reactivation, the better will be the recall, tested by giving some subjects less information during reactivation. This hypothesis is based on analyses by researchers studying the impact of reactivation (e.g., Hayne, 1990; Hoving & Choi, 1972; Hoving et al., 1972; Rovee-Collier & Hayne, 1987) who argued that the amount of reactivation does facilitate recall.

I also hypothesized that three-year-old children who have some input into the material they learn in a long-term retention test will have better recall of that material than those who do not have input. "Input" was operationalized as performing versus observing the task. This hypothesis is based on the work of researchers (e.g., Baker-Ward et al. 1990; Bjorklund, 1987, 1988; Cohen & Cohen, 1982; Feldman & Acredolo, 1979; Rudy & Goodman, 1991) who argued that more knowledge about what is learned, and performing rather than observing a task improves recall of what is learned. I wanted to determine if having input into learning a task is effective in facilitating recall with preschoolers.

If reactivation facilitates recall in infants and school-age children, then it may also facilitate recall in preschoolers. Furthermore, if self-generated learning facilitates acquisition and recall with three-year-olds, then subjects in the self-generated condition given a reactivation treatment should have the best recall performance. This possibility of these effects is the reason why the two variables are examined in a task which required three-year-old children to remember the location of hidden objects.

Method

Subjects. The subjects were 90 three-year-old children ($M = 39$ months, $SD = 1.96$). The subjects were selected from 24 daycare centres in St. John's. Permission for each child's participation was obtained by a letter of parental consent.

Design. The design was a 2 (self- versus experimenter-generated learning) X 3 (reactivation, partial reactivation, control) X 4 (trial) design, where the first two factors were between-subjects and the last factor was within-subjects. The dependent variable was total number of errors on each of four long-term retention test trials.

Materials and Procedure. All children were tested at their daycare. During the acquisition phase, all subjects learned the hiding locations of 16 objects (ball, book, car, cards, cow, crayons, eraser, flower, harmonica, man, plane, scissors, spoon, sunglasses, watch, yo yo). A subject was first taken into a separate room that was approximately 3 meters X 3 meters. The criteria for choosing the room was that it be familiar to the child, that it be free from distractions, and that it have potential for 15 hiding locations (e.g., behind a chair, under a cushion). The child was then introduced to the experimenter by a daycare staff member, and after establishing rapport, the experimenter asked the child: "Would you like to play a game with me? I would like to show you some toys that I have in this bag, and then we can play a game with them." Children tested within each daycare were distributed as evenly as possible across the six between-subject cells.

The experimenter and the child sat in the middle of the room on the floor, and the experimenter took the items at random from a bag and placed them on the floor in front of the child. After being shown each item the child was asked, "What is this called?" If the child did not respond or did not know, the information was provided. Failure to name an object occurred in less than five percent of the cases. As long as the child used a name that was a synonym for the requested name, the child's object name was accepted and used throughout the study.

Then the child was told that he/she and the experimenter were going to play a game of "hide-and-seek" with the objects. The following instructions were used: "We are going to play a game of hide-and-seek, but instead of you and I hiding, we are going to hide these toys around this room. When we are finished hiding them, you are going to have to find them."

In all instances the child was shown the location for hiding the object. Within each daycare the locations for all children were held constant. The only factor that varied was which object was hidden at each location. Subjects in the self-generated condition were asked which object they would like to hide in each of the given locations. The following instructions were used: "Here is a good hiding place. Which of these things would you like me to hide here?" In the experimenter-generated condition, the experimenter used the following instructions: "Here is a good hiding place. I am going to hide the ____ here." This procedure was followed until all 16 objects were hidden, with the order of each object being chosen at random. In both conditions, the experimenter actually placed the object in its hiding location. This was the first study trial.

After the items were hidden, the experimenter asked the child the location of the objects in a pre-arranged random order. This was the first test trial. Cued recall was randomized, with the constraint that objects which were hidden last were not among the first to be asked for in order to avoid serial position effects. The child was asked to point to the object from where he/she was seated without revealing the object at the location he/she pointed. The experimenter said: "I am going to ask you to tell me where the toys are hidden one at a time. You are not allowed to look at the objects. You are only allowed to point to where you think the toy is hidden." If no response to the request to point to the object was given, the child was asked to stand next to where the object was hidden. If this was unsuccessful, he/she was asked to tell the experimenter where the object was hidden. As long as the child did not reveal the object, any response which indicated a definite choice was accepted as the answer. He/she was given 10 seconds to identify the location, and the first choice was taken as his/her answer.

After asking for the locations of the 16 objects, the experimenter again showed the child the objects and their locations in a pre-arranged random order (thus avoiding serial position and short-term-memory effects).

Once again a test trial was administered where the child was asked, in a pre-arranged random order, the location of the hidden objects. This study-test procedure was followed until the child reached a criterion of two consecutive perfect recall trials. At that time the child was returned to his/her normal activity with the other children at the daycare.

Three weeks after acquisition, one-third of the children returned to the testing room with the experimenter and were shown the objects (reactivation treatment condition). Upon returning to the room the experimenter said: "Do you remember being here with me, and playing a game of hide-and-seek? We used these toys. I'm going to show them to you again." All subjects stated they remembered the activity. After showing the subject the objects, the examiner said: "That's all we're going to do today. Let's go back and see what the other boys and girls are doing now." Another third of the children returned to the testing room with the experimenter three weeks after acquisition but were not shown the objects (partial reactivation treatment condition). These subjects were asked by the experimenter: "Do you remember being here with me and playing a game of hide-and-seek? I just wanted to see if you remembered. Let's go back and see what the other boys and girls are doing now." The remaining third of the children were in the control condition and were not seen again in the experimental context until final testing.

Four weeks after acquisition each child returned to the testing room with the experimenter. Each was told that he/she was going to again play the game of "hide-and-seek." The following instructions were given: "We are going to play that game of hide-and-seek again. I already have the toys hidden where they were hidden before. I want to see if you remember where they are. Where did we hide the ____? Point to where we hid it." There were four test trials with no further study opportunities. Howe and Brainerd (1989) recommended four trial designs. They stated that it is profitable to examine changes in performance between two or more tests of retention. Retention performance tends to improve across test trials; single test trials might not reveal all that a subject actually recalls.

The children were asked in a pre-arranged random order where the items were hidden. As at acquisition, they were first asked to point to the objects. If they did not respond, they were asked to stand next to the object. If they again did not respond, they were asked to tell the experimenter where the object was hidden. Any response which indicated a definite choice was accepted. At this time the objects were not actually hidden, since there would be no study trials and the test trials did not require retrieval of the physical object. This also ensured that the child would not reveal the object during a test trial. Ten seconds were allowed for a response and the first answer was scored.

Results

Analysis of Acquisition Data

An analysis of variance was conducted on the acquisition data for the 90 subjects in the six groups. The design was a 2 (self-generated versus experimenter-generated) X 3 (reactivation, partial-reactivation, control) between-subjects design. The dependent variable was total number of errors. The analysis of variance showed no significant main effects or interactions (see Table 1). Subjects in each of the six groups learned to criterion within approximately five study-test trials; there was no significant difference between groups in how many study trials it took to reach the criterion of two consecutive perfect recalls of 16 object-location pairings.

Insert Table 1 about here

Analysis of Long-term Retention Data

Although the initial ANOVA on the acquisition data showed no main effects or interactions, an ANCOVA was conducted on the retention data. This was done to ensure that the results observed will be attributed within limits of error to the treatment variable. The use of ANCOVA helps to eliminate spurious causes of effects, such as rate of learning at the acquisition stage of a two-stage experiment (Underwood, 1964). The design was 2 (self-generated versus experimenter-generated) X 3 (reactivation, partial-reactivation, control) X 4 (trial), where the first two factors were between-subjects and the last factor was within-subject. The dependent variable was total errors on each of the four long-term retention test trials, and the covariate was total errors at acquisition.

The covariate was significant [$F(1,83) = 24.21$, $p < 0.01$], and the interaction between source of control (self- versus experimenter-generated learning) and trial approached significance, [$F(3,252) = 2.62$, $p = 0.0517$] (see Table 2). Approximately 50 percent of the acquisition material was recalled by subjects in all six groups. The fact that three-year-olds were able to remember with 50 percent accuracy the location of 16 hidden objects is interesting and should encourage further research.

Insert Table 2 about here

Since the covariate was significant (i.e., those who made fewer learning errors made fewer recall errors), the estimated population parameter (adjusted mean) for each level of the independent variable was calculated. The adjusted mean error rate for each test trial are listed in Table 3. In the self-generated condition, there were few differences between the total number of errors in each of the three treatment conditions (reactivation, partial-reactivation, and control). In the experimenter-generated condition, subjects receiving the control treatment tended to have slightly more errors than those receiving the two reactivation treatments. There was very little difference between performance for subjects receiving the reactivation or partial-reactivation treatment.

Insert Table 3 about here

In order to interpret the interaction between source of control and trial that approached significance, the adjusted mean errors calculated on the self- and experimenter-generated conditions were analyzed using a Newman-Keuls test. The relevant trial mean number of errors are listed in Table 4.

Insert Table 4 about here

The Newman-Keuls test ($p < .01$) indicated that the interaction was due to performance being poorer on subsequent long-term retention tests within the self-generated condition relative to the experimenter-generated condition.

In summary, an ANOVA was conducted on the acquisition data, which indicated no main effects or interactions. An ANCOVA was then conducted, with the dependent variable being total errors on each of the four long term retention test trials and the covariate being total errors at acquisition. The only significant effect was for the covariate. The interaction between source of control and trial approached significance. A Newman-Keuls test conducted on the adjusted mean errors of the long-term retention data reflected that the interaction approached significance because there was a slight decrease in errors over the four long-term test trials for the experimenter-generated condition and a slight increase for the self-generated condition.

Discussion

In the present experiment, three-year-old children were clearly able to learn and recall information after a four-week interval: The subjects recalled approximately 50 percent of the hidden object-location pairs. However, the hypothesis that a reactivation treatment during a retention interval would facilitate recall from long-term memory for three-year-old children was not supported.

In answer to the question of whether or not having input into learning facilitated acquisition and recall of the hidden object-location pairings, the interaction between source of control and trial approached significance. Input into the learning material, and possibly the opportunity for use of prior knowledge to elaborate the learning material, were ineffective, and perhaps even detrimental, with this age group.

The effects of both reactivation and source of control were examined to determine whether there would be an interaction between the two variables. Bjorklund (1987, 1988) argued that both prior knowledge and repeated exposures to the learning material strengthen the links between features in memory traces. The implication is that input into learning and reactivation should have worked together to facilitate recall. This clearly was not the case.

Reactivation did not facilitate recall of information from long-term memory. Results showed no significant difference between the three treatment conditions (i.e., reactivation, partial-reactivation, and control). There are several ways to interpret this finding. First, the experimenter's presence outside of the experimental context may have acted as a reactivator for all subjects. It may also have interfered with the original memory trace of the acquisition material.

The reactivation treatment was given in the daycare centre, where the experimenter was often seen by all children. When he went to test subsequent subjects at the same daycare centre, his presence was a reminder of the initial learning for the subjects tested earlier, as evidenced by the many children who asked to play the game (the method was presented as a game of hide and seek). The learning material may have been reactivated for subjects in all conditions. Boller et al. (1990) stated that information acquired after initial training may become associated with the original memory trace. Such information may include seeing the experimenter in any context. As well as reactivating subjects in all conditions, this subsequent information could have altered the original trace and created interference between the new trace and the original trace. Boller et al. argued that the longer the retention interval, the more opportunities for this to occur. If this alteration happens, then an otherwise effective reactivator, such as showing the objects used in an object-location pairing task, might be unable to access the original trace. If the sight of the experimenter reactivated the original memory trace for all conditions, or if it altered the original trace for all conditions thereby reducing access to the trace, then the sight of the experimenter could account for there being no difference between the three treatment conditions. The information was available but not accessible, as Rovee-Collier and Fagen (1981) argued.

A second interpretation to account for why reactivation was not effective is that the experimental room was accessed by the subjects on a daily basis. A familiar room in the daycare was used to make the child feel more comfortable. DeLoache, Cassidy and Brown (1985) found no performance difference between conducting such tests in the home (familiar setting) and the lab (unfamiliar setting). The hiding locations, the response in the object-location pairings, may have been seen by the subjects regularly over the four week retention interval which reactivated the pairings. Hoving and Choi (1972) stated that the response was the necessary and sufficient reactivator. It may be that all subjects had this reactivation treatment, reducing any differences between treatment conditions. If this study had been done in a school, as was the Hoving et al. (1972) study, or in a lab setting, the subjects in the control condition would not have seen the experimenter until final testing. As well, in a school or lab the subjects would not have routinely been in the experimental room.

A third possible interpretation is based on the fact that the stimulus (objects) rather than the response (hiding locations) was used as the reactivation treatment. Although Hoving and Choi (1972) stated that response alone is the necessary and sufficient reactivator, in the present study the stimulus was used because the design is analogous to the infant research on reactivation. Rovee-Collier and Hayne (1987) used a complex stimulus and a single response. The response in the present study was complex and might have provided reactivation of the learning material.

A fourth interpretation of the ineffectiveness of reactivation regards the contextual cues at the acquisition stage. Rovee-Collier and Fagen (1981) argued that the fewer the number of contextual cues at acquisition, the smaller the possibility that the target attribute will be accessed at final testing. Maybe there were not enough contextual cues in the present study. Each room used had enough locations to hide the 16 objects. However, locations such as 'in a box with a brightly coloured clown on the top' rather than locations such as 'behind a chair' or 'under a cushion' might have increased the contextual cues. Also, Rovee-Collier and Hayne (1987) emphasized the importance of a distinctive setting for reactivation to be effective. It may be that a more distinctive setting is necessary. A reactivation treatment might then have more strongly reinforced the relationship between the object and the location.

Another factor that may have contributed to the null findings is the length of retention intervals. The retention intervals between acquisition and reactivation, and between reactivation and long-term retention, differ from those used in research on infants and school-age children. Infant researchers argue that three-month-old children forget after 9 - 13 days (Rovee-Collier & Hayne, 1987) and that six-month-old children forget after 14 - 20 days (Hill et al., 1988). A reactivation treatment within two weeks of forgetting, they stated, will allow full access to the original memory trace. Researchers who study school-age children (Hoving & Choi, 1972; Hoving et al., 1972) employ a longer time period between acquisition and reactivation and between reactivation and long-term retention.

The interval of three weeks between acquisition and reactivation may not have been long enough to ensure that there had been sufficient forgetting for reactivation to be effective. The time period between reactivation and final testing may also not have been optimal to see positive results. Further research is necessary to determine how long it takes preschoolers to forget and the optimal time for a reactivation treatment to be most effective.

Thus, there are several interpretations as to why reactivation was not effective in facilitating recall in three-year-old children. There seems to be significant evidence in the literature that reactivation is effective with infants (e.g., Rovee-Collier & Hayne, 1987; Rovee-Collier et al., 1980) and school-age children (e.g., Hoving & Choi, 1972; Hoving et al., 1972). Further research is needed before one can draw conclusions about the effects of reactivation with preschool children. Such research should determine if reactivation is effective in facilitating recall when the subjects are seen in a lab setting, accounting for continuous reactivation, and when a response rather than a stimulus is used as the reactivator, as suggested by Hoving and Choi (1972). These two factors seem most plausible in explaining why the present results were not significant.

The question of whether or not input into learning would facilitate recall of the learning material was also examined. The lack of significant differences in error between sources of control (i.e., self- vs. experimenter-generated conditions) possibly resulted from the tasks for each experimental condition being similar. The only methodological difference was that the children in the self-generated condition performed by choosing which object to hide in a given location, and this may not have been distinct enough from the experimenter-generated condition. If subjects in the self-generated condition were required to choose the objects and hiding locations rather than just objects, thus further distinguishing between the two conditions, the primary concern of reactivation would have been made redundant. Each child would have been reminded of different object-location pairings, and any differences found could not have conclusively been attributed to the effects of reactivation since the reactivation would not have been consistent across participants.

The question of whether or not performing a task results in greater recall of the learned material is still unresolved. Cornell and Heth (1983) argued that there is no benefit to being involved in learning the material. Boller et al. (1990) argued that passive observation may be sufficient to learn and recall actions. Rosenbaum (1967) argued that observing a task of finding the way through a multiple choice maze resulted in greater recall of the correct pattern of the maze than performing the task. To the best of my knowledge, no research has been conducted on preschoolers to determine if input into learning of hidden-object locations facilitates recall. The conflicting results in the research demand further research to determine if having input into the learning material is effective in facilitating recall of that material.

Some researchers may argue that three-year-old children do not have the cognitive ability to complete a task such as the one required in this study. However, based on the work of Flavell et al. (1978) and Lempers et al. (1977), three-year-olds should be able to perform the present task. It appeared during the present experiment that the subjects understood the requirements of the task. Their recall of about 50 percent of the material indicates that they understood. Therefore, the lack of difference may more likely be due to a lack of distinctiveness between the task demands than to a lack of understanding of the task.

Subjects in the self-generated condition had the opportunity to use prior knowledge learned through their involvement with their environment (e.g., a cat gets hidden behind a cushion.) It may be that the lack of significant results reflects that the children simply did not have this kind of prior knowledge available to help them learn and retain the information. They did not seem to automatically or deliberately use a strategy such as elaboration to help themselves acquire the learning material.

The interaction between source of control and trial approached significance, resulting from an apparent slight decrease in errors over the four test trials for the experimenter-generated condition, and a slight increase in errors for the self-generated condition. Although not too much can be made of this, the decrease in performance in the self-generated condition was surprising. Since this condition's knowledge base was supposedly elaborated, these children should have been able to retain the material over time. It could perhaps be that the children in the self-generated condition became bored with the task and put less effort into recalling the object-location pairings. It seems more possible that their knowledge base was not elaborated and the decrease in recall over test trials is related to some other factor.

Although the hypotheses of the present study were not supported, in this study one thing was reinforced and one thing was learned. First, as Howe and Brainerd (1989) argued, learning to criterion at acquisition and multiple testing at long-term retention are necessary components of a two-stage long-term retention test. When subjects learn the acquisition material to a stringent criterion, it ensures that all subjects learn the material. At long-term retention, as Hoving et al.

(1972), Howe and Brainerd (1989), and Bjorklund (1987, 1988) argued, multiple tests of long-term memory ensure recall of all that has actually been retained. Recall of some information may spark recall of additional information. Multiple test trials can result in no change, an increase in information recalled, or a decrease in information recalled. In this study, for three-year-olds there was a slight increase over test trials of information recalled for the experimenter-generated condition but there was a slight decrease for the self-generated condition. More long-term retention test trials might have led to a significant difference between the self- and experimenter-generated conditions. A single test would not have shown this approach to significant difference and is not necessarily indicative of what is remembered and how strong the memories are. The importance of learning to criterion and multiple test trials was therefore reinforced.

Second, it was learned that the use of a memory for hidden objects paradigm to examine long-term retention with three-year-old subjects was appropriate. Research with preschoolers has tended to rely on parent reports or episodic memories of events in which the subjects took part. The method used here was novel, motivating, and it empirically examined the effects of reactivation and source of control and can be replicated. Contrary to some researchers' beliefs, preschoolers, as Flavell et al. (1978) and Lempers et al. (1977) argued, are capable of hiding and seeking. They seem to be able to transfer their knowledge of the game of hide-and-seek to hiding and seeking objects. Subjects understood what it meant to hide the objects, to be required to remember the hiding locations, and to search for objects they previously observed being hidden.

The ramifications of the present findings are clear. First, three-year-old children are capable of acquiring information and retaining that information over long periods of time. Second, the lack of significant main effects or interactions may have been caused by a problem with the method, namely a lack of control over the experimental context and task differences between conditions not being distinct enough. This is new research and even with the above-mentioned methodological concerns there is enough empirical evidence to justify further research on the effects of reactivation and source of control in relation to long-term retention for preschoolers. To determine if reactivation and input into learning facilitate recall, researchers should differentiate between reactivation and control treatments and ensure that only the prescribed reactivation treatment is given. The task demands could also be increased by increasing the retention interval or the number of object-location pairings. Finally, to test theories of knowledge base rather than just use it as an additional question as in the present study, future researchers should clearly differentiate the task demands of self-generated and experimenter-generated learning conditions. Based on the findings of researchers in the areas of reactivation and self-generated learning and on the results of this study, future research should reveal more about the amount of information preschoolers can retain and the length of time they can retain it.

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Table 1. Analysis of variance on acquisition data.

Source	DF	Mean Square	F
Condition	1	0.4444	0.9885
Treatment	2	5.9111	0.1315
Condition/Treatment	2	43.2444	0.9618
Error	84	44.9619	

Condition - Experimenter/Self Generated Learning
Treatment - Reactivation/Partial Reactivation/Control

Table 2. Analysis of Covariance on long-term retention data.

Source	DF	Mean Square	F	p
Condition	1	130.4824	2.82	
Treatment	2	69.2984	1.48	
Cond./Treat.	2	86.5160	1.87	
1st covariate	1	1120.2919	24.21	0.0000
1 error	33	46.2704		
Trial	3	1.0556	0.33	
Trial/Condition	3	0.2593	2.62	0.0517
Trial/Treatment	6	5.2556	1.66	
Trial/Treatment/ Condition	6	6.2037	1.96	
2 error	252	3.1579		

Condition - Experimenter-/Self-Generated Learning
Treatment - Reactivation/Partial Reactivation/Control
Trial - Trial #1-4
Dependent Variable - Total errors on each test trial
Covariate - Total errors at acquisition

Table 3. Mean errors for each treatment condition.

Self-Generated Condition

Trial		Reactivation	Partial Reactivation	Control
1	Mean	8.62	9.31	8.27
	SD	3.7	3.9	5.1
2	Mean	9.30	9.51	8.27
	SD	4.5	4.6	4.9
3	Mean	9.42	9.98	9.54
	SD	3.5	4.2	5.6
4	Mean	8.69	8.91	10.41
	SD	3.7	3.5	5.2

Experimenter-Generated Condition

Trial		Reactivation	Partial Reactivation	Control
1	Mean	6.89	7.24	10.53
	SD	3.7	4.4	3.9
2	Mean	8.16	6.50	9.73
	SD	4.8	3.6	3.8
3	Mean	7.23	6.70	9.53
	SD	3.1	4.1	3.4
4	Mean	7.49	6.45	9.33
	SD	2.9	4.1	4.1

Table 4. Trial mean errors for Self- and Experimenter-Generated conditions employed in Newman-Keuls test.

	Condition			
	Self-Generated		Experimenter-Generated	
Trial	Mean	SD	Mean	SD
1	8.73	4.2	8.22	4.0
2	9.02	4.7	8.13	4.1
3	9.65	4.4	7.82	3.6
4	9.34	4.1	7.76	3.6