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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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ENTITLED Affect-Dependent Recall

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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Affect-dependent Recall

The strength of a memory is influenced by the conditions in which it is formed and recalled. A special case of this situation is state-dependent memory. A state-dependent memory is one that is recalled better when the conditions at recall match those at memory formation. A state can be created by the immediate surroundings, drugs, alcohol, or mood. State-dependent recall is known by different names, describing the means of state induction.

Both context-dependent and state-dependent recall have been observed in humans and animals (Smith, Glenberg, and Bjork, 1978, Perkins and Weyant, 1958, Hill, Schwin, Powell, and Goodwin, 1973, Bliss, 1973). In addition affect- or mood-state-dependent recall has been observed in humans (Bower, 1981), but affect-dependent recall has yet to be observed in animals. If context-dependent, state-dependent, and affect-dependent recall are all manifestations of the same phenomenon, then affect-dependent recall should be observable in animals.

The question of affect dependent memory in animals was addressed in the context of a social memory situation. Adult male rats are placed in an arena with juvenile male rats in a first exposure, during which the adult's investigation of the juvenile is recorded. The rat's mood or affect was manipulated through associations to two different arenas, one which was safe and one unsafe.

A high level of training or overtraining has been observed to influence state-dependent memory (Bliss 1972). Therefore, when attempting to observe a state-dependent memory of any kind, the level of "training" or the amount of practice the subject is allowed is very important, because there must be sufficient variability in the measure (e.g. no ceiling or floor effect) such that it would be possible to measure a change if it exists. The two empirical questions addressed in this paper are: 1) At what first exposure length is there sufficient variability in the social memory task to be able to observe any later change? 2) Given this variability observed with a particular exposure, is it possible to observe affect-dependent recall in rats with this social memory task?

Varying first exposure length has a significant effect on investigation in the second exposure in test trials, where the same juvenile is used as in the first exposure, but not in control trials, where a different juvenile is used in the two exposures. The amount of investigation in the second exposure was not significantly influenced by the matching or non-matching of the arenas between the first and second exposures.

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INTRODUCTION

The strength of a memory is influenced by the conditions in which it is formed and recalled. An example of this effect is state-dependent memory, a kind of memory that is recalled better when the conditions at recall match those at memory formation. A state can be created by the immediate surroundings, various drugs, or the subject's mood. State-dependent memory or recall is known by different names, which are descriptive of the agents of state induction (Eich, 1980).

In this paper I will make a distinction between state-dependent memory, drug-state-dependent memory, context-dependent memory, and affect-dependent memory. These four categories will be designated as follows: "state-dependent refers to the general phenomenon, with no emphasis placed on the specific kind of state being discussed; "drug-state-dependent" refers to the state-dependent effect observed when a drug's dose is varied; "context-dependent" refers to the state-dependent effect observed when environmental stimuli are manipulated; "affect-dependent" refers to the state-dependent effect observed when the subject's mood or affect is varied.

Context-dependent memory, drug-state-dependent memory, and affect-dependent memory, while all caused by different agents, could be considered different facets of the same phenomenon. The three phenomenon react in the same manner to a number of different manipulations. The features of state-dependent memory suggest that the states are used as retrieval cues only after several other possible types of retrieval cues have been discarded as useless in that situation.

In this paper I will examine the principle features of context-dependent memory and drug-state-dependent memory. The features of affect-dependent memory will be reviewed in greater depth, and an experiment examining the possible existence of affect-dependent recall in animals will be reported.

Context-Dependent Recall

If recall in a memory test is poorer when the testing environment differs from the training environment, the memory is context-dependent. In this paper "context" is a class of stimuli whose properties do not change the overt qualities of the test, the task requirements, but the changing of which alters the testing environment. Changing the testing environment frequently influences the subject's performance. Whether changing the context influences just performance or the actual recall of information is an important distinction.

One example of a context-dependent memory in animals is the straight alley performance of rats. Changing the color of a straight alley in which rats have been trained to run to obtain food increases running time (Perkins and Weyant, 1958). In this experiment the animal's running time is indicative of its memory for the task, because as an animal gains more experience with the task, latency to run to the end of the alley decreases. An increased running time in comparison to previous trials is interpreted as a decreased memory for the task (Perkins and Weyant, 1958). The color of the alley is contextual information and not part of the nominal task requirements. Where is the line drawn between requirements of the task and the context of the testing situation? These are not easy questions to answer. To the rat the color of the alley is apparently of some importance. One possible interpretation is that when the color of the alley is changed, the rat does not seem to remember the task as well. An alternative explanation is the rat remembers the behavior required to obtain the food, but the changing of the color of the alley reduces his level of performance, not the accuracy of his recall.

Two important experiments that examine the context-dependent effect in humans are : 1) a word list learning task where the two environments are under water and on dry land (Godden and Baddeley, 1975); 2) a word list learning task where the two environments or contexts were two different rooms in the same building (Smith, Glenberg, and Bjork, 1978). In the first experiment the subjects were deep sea divers who were asked to learn a word list either while on dry land or while under water. The subjects were later tested for their recall of the word lists either in the same environment where they learned the lists, or in the other environment. When the testing and training context were the same, recall was better than when the contexts were different. This effect was observed regardless of which environment was the training environment (Godden and Baddeley, 1975). In the experiment by Smith, Glenberg, and Bjork (1978), the different contexts were much more commonplace; they were two different rooms in the same building. Despite these more common environments, the results were comparable to those obtained by Godden and Baddeley (1975). When the rooms for testing and training were the same, the subject's recall was better than when the rooms were different. This is the context-dependent effect.

Elements of the training situation that are not directly relevant to the task are being remembered, and changing these elements influences the subject sufficiently to impair performance. One question that could be asked is whether the subjects, humans and animals, are remembering all the elements of the training situation. If this were the case it would seem to be a very inefficient way of learning. If every detail is not being stored, then what makes a detail important enough to be stored in any given situation and later used as a retrieval cue?

Drug-State-Dependent Recall

The design for an experiment to test the state-dependent manipulation generally involves five stages: 1) state induction, 2)training, 3)retention interval, 4)state induction and 5)testing. The state is created in the subject. While in this state the subject is trained on some sort of task or given a list of items to learn. Following an intervening period either the same state or a different state is induced in the subject, after which he or she is tested on the task he or she learned in the training stage. A comparison of the subject's memory between matched and unmatched states is made to see if the methods influenced memory in a state-dependent manner.

Various substances (e.g. alcohol and pentobarbital) induce drug-state-dependent effects on memory in various animals. The test subjects have included people, monkeys and rats.

A drug-state-dependent effect with alcohol was observed by Overton (1972), Miller, Adesso, Fleming, Gino, and Lauerman (1978), and Peterson (1977), among others. In each of these studies, the state-dependent effect was observed in non-cued recall tasks, but not in cued recall tasks, either with alcohol (Peterson, 1977) or with marijuana (Eich, Weingartner, Stillman, and Gillin, 1975). In a cued recall task the experimenter provides the subject with a "cue" or hint as to what the subject is to recall. For example, if the subject learned 3 lists of words, one which was of inanimate objects, one which was of state capitals, and one which was of famous people, and when he or she is asked to recall the lists the experimenter would prompt the subject with which noun class they are to recall. In a non-cued recall task the subject would just be asked to recall as many of the items from the lists as possible.

In these studies the greatest impairment to memory occurred when the training states did not match testing states. A matching of intoxicated states or sober states at training and testing results in better recall than if the subject is either sober at training and intoxicated at testing or vice versa. In addition to these drugs, pentobarbital administration influences memory in a state-dependent manner (Bliss, 1973). Drug-state-dependent recall is not observed each time the drug is administered. The disruption of recall is inversely related to how well drug dosage levels match between testing and training states (Bliss, 1973).

Not every attempt to reproduce this effect of state-dependent recall has met with success. One instance in which no evidence of the effect was observed was in a study by Bliss in 1973 with pentobarbital in monkeys. He attributes his failure in replication to an overtraining effect. Bliss used a color discrimination task in monkeys. In an experiment in which the state-dependent effect was observed, the monkeys were never exposed to the same discrimination twice. In the experiment in which no state-dependent effect was observed, the monkeys were exposed to the individual discrimination pairs more than once in training. As a result, the animals that did not show a state-dependent effect had more experience or training with the material to be remembered than the animals that did show the state-dependent effect (Bliss, 1972). A high level of training will cause a memory to be impervious to the effects of a change in states (Bliss, 1972).

Another failure to produce the effect was by Miller, Adesso, Fleming, Gino and Lauerman (1978). In this exp-riment word lists were learned by subjects while in either an intoxicated or sober condition. No state-dependent effect was observed. The failure at replication could also be attributed to an overtraining effect. The design of the experiment called for an immediate test of free recall after the training session.
This testing of knowledge of the word list may have strengthened the memory of the subjects, making it more resistant to any impediment that a change in drug state can cause.

State-dependent memory is observed with various drugs, but only under certain conditions. Memories of a non-cued variety are subject to the state-dependent effect, while cued recall does not show the effects of these drugs. A high level of training or overtraining will also mask the drug-state-dependent effect, because the context of the memory task for an overtrained memory may act as the necessary retrieval cues.

One possible explanation for the existence of the state-dependent effect is: in the absence of either retrieval cues or a memory for an overtrained task, which requires no augmentation to be retrieved, the brain must rely on what information is at hand to choose the appropriate information for retrieval. The surrounding and/or drug effects could be "drafted into service" as retrieval cues in the absence of any other cues.

Affect-Dependent Recall

Mood or affect has effects similar to various drugs or context on memory. The same mood at training and testing sometimes results in better recall than a different mood at training and testing (e.g. Bower, 1981, Bartlett and Santrock, 1977, Leight and Ellis, 1981). There have, however, been failures to replicate some of these findings (e.g. Bower and Mayer, 1985).

The range of subjects who have shown affect-dependent memory includes preschool children, college students, the easily hypnotized, and diagnosed affective disorder patients. In most subjects, the mood or affect must be induced. No mood induction is used in victims of affective disorders; instead, the naturally occurring mood shifts are utilized to compare mood state effects.

A mood induction procedure is analogous to the administration of a drug. There are a number of different types of mood induction procedures. The means of induction include the reading of self-referent phrases, e.g. the Velten Induction procedure (Velten, 1968), the reading of affectively biased prose passages (e.g. Bartlett and Santrock, 1977), and hypnosis (Bower, 1981).

Affect-Dependent Memory in Children

Two studies have examined affect-dependent memory in children. They are not the earliest studies to examine the phenomenon, but they are among the first to study the effect in an "ordinary population" (Bartlett, Burleson, and Santrock, 1982). Both studies found an affect-dependent effect in free recall tasks, but not in cued recall (Bartlett and Santrock, 1979; Bartlett, Burleson, and Santrock, 1982). (That affect-dependent recall is observed in free recall situations and not cued recall situations is not surprising if affect-dependent memory is a "subclass" of state-dependent memory.) Moods were induced in both studies through the reading of affectively valenced prose passages to children by experimenters. These two studies provide strong evidence for the existence of affect-dependence. Part of the strength of this evidence stems from the failure of the mood induction technique to produce the state when it was preceded by a relaxation process (Bartlett, Burleson, and Santrock, 1982). The authors explained this failure to show affect-dependence through an application of the two factor theory of emotion. In agreement with Mandler (1975), they argued that the perception of an emotion is possible only if there is the appropriate autonomic arousal. The cognitive component of the emotion was not enough, by itself, to influence memory in their test. When the cognitive state set up by the induction was accompanied by the corresponding induced autonomic arousal, there was an effect in the memory test. Arousal cues and arousal state significantly influence affect-dependent recall (Clark, Milberg, and Ross, 1983). These two studies, one showing that blocking autonomic arousal cues masks or eliminates affect-dependent memory (Bartlett, Burleson, and

Santrock, 1983), and the other showing that an arousal-state-dependent effect is observable (Clark, Milberg, and Ross, 1983), suggest that the distinctive states necessary for the manifestation of state-dependent recall must have components that are not just cognitive in nature.

Affect-Dependent Memory in Clinical Populations

Affective disorder patients are good subjects for the study of affect-dependent memory because their "natural" mood swings can be used to test across affective states. Calev and Erwin (1985) made use of these fluctuations to test for the presence of affect-dependent recall in a clinical population of unipolar depressives. In affective disorder patients, one deviance from normalcy is a low level of item clustering in free recall (Calev and Erwin, 1985). Perhaps because they fail to cluster elements in free recall, depressives show a deficit in accuracy of free recall, but not in recognition memory, in comparison to normal controls (Calev and Erwin, 1985). This deficit in memory is not due to lower IQ. The mean subject IQ was not subnormal (Calev and Erwin, 1985). This deficit in free recall parallels a pattern of affect influencing free recall in a state-dependent manner. A possible explanation for the deficits induced in affect-dependent memory may be that different moods lend to different clustering strategies. A deficit in non-matching mood states may be due to inaccessibility of certain clusters or parts of clusters that may have been encoded. The evidence from this abnormal population may be a clue as to what is occurring in state-dependent memories.

Manic-depressives show deficient recall of self-created associations if they are asked to recall these associations while in an affective state that does not match the state in which the associations were created (Henry, Weingartner, and Murphy, 1973, and Weingartner, Miller, and Murphy, 1977). In both studies the natural mood swings of the patients were used instead of imposing moods on the patients. While these studies show strong evidence for affect-dependent memory, they lack a certain amount of generalizability to "normal" populations because of the unusual intensity of the affective states associated with the illness (Weingartner et al., 1977). In addition to the possible strength of the mood experienced in an affective disorder, the states may not parallel other qualities of mood states in the general population. One possible area of dissimilarity could be in the quality of the moods experienced. The patients moods may be more "pure." What they feel may only be one mood, whereas the "normal" person would feel a mixture of similar emotions all at once. Polivy (1981) observed that in mood induction procedures one mood is rarely exclusively induced; rather, several related mood states are induced.

The idea that one mood would evoke or at least increase the likelihood of related emotions being elicited is incorporated in the Bower's network theory of memory:

> Network Hypothesis:
> Each distinct emotion has a specific node in memory that collects together many other aspects of the emotion that are connected to it by associative pointers. Each node is linked with propositions describing events from one's life during which that emotion was aroused. These nodes can be activated by many stimuli. Activation of that node produces the autonomic arousal and behavior usually associated with that emotion. Activation is also spread to memory nodes associated with that mood, creating subthreshold excitation at these nodes. Thus, a weak memory that partially describes an event may combine with activation from an emotion unit to raise the total activation of the relevant memory above a threshold of consciousness. (Bower, 1981).

One implication of the network theory which can be drawn in an affect-dependent paradigm is emotions eliciting similar autonomic arousals should not cause as large a recall deficit as dissimilar emotions because these similar emotions would have overlapping qualities, and, by inference, overlapping nodes in the network. The idea that emotions are not discrete entities, but occur on a continuum with overlapping qualities, was proposed by Plutchik (1980). He suggested that emotions exist on a circular continuum much like a color wheel, with many moods being the composites of eight primary emotions. These primary emotions are analogous to the primary colors, of which all other colors are comprised (Bower, 1981). Thompson attempted to test Plutchik's hypothesis (reported in Bower, 1981). In the experiment, Thompson hypnotically induced four different moods in the subjects during training sessions. While in each of these different moods, the subject learned a different word list. Thompson later tested word list recall across all emotions, crossing moods in a 4x4 design. Word list recall was best in matching mood states and worst in mood states predicted by Plutchik to be direct opposites on his emotion circle. Emotions that were ninety degrees from the training emotion showed levels of forgetting approximately halfway between complete matching mood states and complete non-matching mood states (Bower, 1981). The idea of the emotion circle and the data that Bower reported support the network hypothesis, wherein emotion has a pointer effect, but in addition it has many secondary effects. These secondary effects of emotions overlap and point to each other, making an affective state not a pure clear cut condition, but a mixture of various subsidiary influences. The implications of this overlapping affect for affect-dependent recall are that material learned in one mood will be accessible from not only the original mood, but also from moods similar to the mood at learning.

Affect-Dependent Memory in Adults

Affect-dependent memory has also been observed in "normal" adults. The induction methods used experimentally to elicit the phenomenon of affect-dependent recall include facial mimicry, the reading of affectively valenced prose passages, Velten mood induction procedures, and hypnosis. In the Velten mood induction procedure the subjects read 60 self-referent statements that have an elated, depressed, or neutral affect (Velten, 1968).

The reading of these passages will supposedly induce an affect because the thoughts of the subjects will influence their emotions (Buchwald et al., 1981).

The phenomenon of affect-dependent memory has not appeared in every attempted replication. On at least two occasions the researchers did not observe the effect on their first two attempts and had to use an interference paradigm to produce the effect (Bower, Gilligan, and Monteiro, 1981, and Schare, Lisman, and Spear, 1984). An interfering task is not always necessary to observe affect-dependent recall. The effect was observed by Leight and Ellis (1981) without the use of an interference paradigm. They used the Velten mood induction procedure and tested the recall of a list of trigram doublets (e.g. BONKID or BAMPAC). The effectiveness of the mood induction was checked through the use of a Depression Adjective Checklist (DACL). The DACL is a commonly used method to test the mood a subject is experiencing. The test requires the person to check all the words on a provided list that describe their present feelings (Leight and Ellis, 1981). The list contains both positive and negative adjectives, so as to measure both positive and negative affect. The measures taken through the DACL correlated with the induced mood (Leight and Ellis, 1981). The experimenters ran two replications of their study and on both occasions observed an affect-dependent influence on memory in a delayed recall task. The delay for the recall task was twenty-four hours.

Manipulation of facial expression as a means of mood induction is effective in producing affect-dependent recall (Laird, Wagener, Halal, and Szegda, 1982). This experiment however, has a confound. The experiment crosses the potential effects of affect-dependence with a similar phenomenon called mood congruence. Considered by some to be a specialized subset of affect-dependent memory, mood congruence is the better recall of affectively valenced material either read or experienced when the subject is in a mood during the recall session that matches the mood of the to be remembered material (Blaney, 1986). Mood congruence is thought to be a subset of affect-dependence because the original experience puts the subject in the same mood as the valence of the situation. The subject is considered to be in that mood state. The recall of the experience is then affect-dependent because there are two mood states involved; the mood at encoding, which supposedly matches the affect of the event or material, and the mood at recall, which has been induced to match the memorial mood. Laird et al. (1982) crossed mood congruence and affect-dependence because they induced one mood in the subjects and then had them read a prose passage which had an affective valence of its own, which may or may not have matched the mood that had been previously induced. By crossing the induced affect and the written affect, they observed an effect which was not only mood congruent, but also affect-dependent. The subjects remembered material best from the prose articles not only when recall mood matched the mood induced before reading the article, the affect-dependent portion of their results, but also when the valence of the prose passage matched the mood of the reading and recall states of the experiment, the mood congruence effect (Laird et al., 1982). These results should be viewed as a combination of two related phenomena, affect-dependent recall and mood congruence.

A similar effect was observed in an experiment by Gage and Safer (1985). They looked at recognition differences for emotional faces between the two hemispheres of the human brain. They also crossed mood congruence and affect-dependence. They presented facial expressions to each hemisphere separately while the subject was experiencing a specific mood. The affect-dependence component of the task is the mood-state of the subject, and the mood congruence here is the emotion expressed by the stimulus face, which either matched or crossed with the mood induced in the subject. After a short time the subjects had a mood reinduced and were then tested in each hemisphere for recognition of the facial stimuli. In the right hemisphere there was a strong influence of not only the affect of the stimulus, but also of the affect experienced by the subject at time of recall. There was very little influence of affect of either stimulus face or of the subject observed in the left hemisphere (Gage and Safer, 1985). From this evidence it might seem that it is the right hemisphere that is involved in affect-dependence, but not the left hemisphere. Further work examining more moods and other tasks divided between hemispheres is needed to answer the question as to whether both or just one hemisphere demonstrate affect-dependent recall.

Not every attempt to observe affect-dependent recall has been successful. There are two studies which seriously questioned the existence of affect-dependence, because the effect was only observed after the experimenters used an interference task. The first study was by Bower, Gilligan, and Monteiro, (1978), the second was by Schare, Lisman, and Spear, (1984). An interference task is an activity that occupies the subject with a memory task which has properties very similar to the original to be remembered material is an "interfering" activity. The purpose of this exercise is to conflict with, or "interfere" with the formation, maintenance or recall of the original memory. In both experiments the subjects were tested on their free recall of a list of words they had learned in the training session. The Bower et al. (1978) study used hypnosis as a means of induction and the Schare et al.(1984) study used the Velten method for mood induction. In the first attempts of both groups, the retention interval was very short, less than an hour. This short duration may partially account for the lack of observed affect-dependence. The training session may have been recent enough and unique enough for the subjects that they required no other cues to remind them of the words to be recalled. In the second stage of their experiments, the retention interval was lengthened to twenty-four hours because the level of recall over a short period of time may have been too high to show any shifts in recall (Bower, 1981). Both the Bower et al. (1978) study and the Schare et al. (1978) study did not observe any shift in recall accuracy due to the increased retention interval. The contextual cues of being in a psychology experiment and trying to remember a word list that the subjects had learned yesterday were probably strong enough clues for the subject to be able to "find" all the information that was desired. Another way of looking at the circumstances would be to say that the context of the experiment was so unique that no other cues were necessary to retrieve the desired information. The context was unique because, at first, the subjects were only asked to learn one list of words. In addition to the unique context facilitating high recall the subjects were allowed a great deal of time to learn each word on the list. This could create a situation comparable to the one observed by Overton in monkeys, an effect of overtraining (1964). In the Schare et al. (1984) experiment the subjects were allowed eight seconds per word on a thirty word list. In the Bower et al. (1978) experiment the sixteen words on the list were read twice to the subject, on every five seconds and the subject was then required to orally recall the list. Either of these situations may have been enough for the subject to become "overtrained" on the word list.

The subjects were not only highly trained on the task, but also the context of learning a list was unique. Between these two factors the subjects may have had no need for additional cues, such as the context, drug-state or affective-state, to recall the list very accurately. Interfering stimuli (another list of words) were used to mask these effects in both experiments. The subjects were given two lists to learn and then were tested after a twenty-four hour retention interval (Bower et al., 1978, and Schare et al., 1984). The interpolation of the extra word list reduces the effectiveness of the context of a psychological experiment as a retrieval cue. The interfering list creates a need for additional cues to retrieve the desired material.

The effects of overtraining could mask any influence affect-dependence has on recall. Overtraining may cause a ceiling effect on forgetting over intervals as long as two to three days, as was the case in the experiment by Wetzler (1985). The material may have been so well learned that the measures used were insensitive to any influence of the mood manipulations may have had. An effect similar to the overtraining effect observed by Bliss may have been created because of the procedures used for list learning. On both the first day and second days of the experiment the subjects received a list of twenty words to which they were to generate free associations. They were allowed ten seconds per word for this task (Wetzler, 1985). The time period allowed seems more than sufficient for the subjects to learn the word lists.

The addition of an active thought process which seems quite comparable to rehearsal would intensify any memory of the words. The subject is forced to use an efficient mnemonic technique. By thrusting this mnemonic technique on the subject, Wetzler may have produced an overtraining effect. On the third day the subjects were tested on their recall of their free associations, which are likely to bring the original words to mind almost as if the task were a cued recall task, which is subject to the state-dependent effect (Eich, 1980), instead of a free recall task which is subject to the state-dependent effect (Eich, 1980). While affect-dependent memory is not a phenomenon that appears every time someone looks for it, these failures are frequently due to explainable problems in the methods if you are trying to observe the state-dependent effect. The design of the experiment seems to predispose the subject to a very strong learning of the word lists and in the testing phase provides a situation similar to cued recall. This would cause an encoding that would be very accessible to retrieval because of its many "node" connections and then the conditions at testing provide cues as to at which "nodes" to find the material.

An overtraining effect may also be partially responsible for the failure of Bower and Mayer (1985) to replicate the earlier work of Bower, Monteiro, and Gilligan (1981). Hypnosis was used to induce the mood in the later experiment and this may partially account for some of the failure of replication. If there is an overtraining effect in this experiment it does not result from the length of time the subjects had for the study of the word lists. Immediate oral recall was required of the subjects (Bower and Mayer, 1985). An immediate recall of the list may be enough to cause the subjects to be overtrained on the task. If the memory of the list is strong, then there is no need to access the affective pointers to the item because it has already been retrieved through the use of another cue. If a list does not exist as a strong memory, affective, state, or contextual pointers may be necessary to discriminate between the otherwise ambiguous choices.

Two possible reasons for failure were noted by Bower and Mayer (1985). One of the reasons may have been a difference in interfering capabilities of interpolated tasks between testing and training sessions. Another possibility is the quality of the hypnotic state may have been inadequate, or it may not have been maintained by the subject (Bower and Mayer, 1985). Another possible confound is the experience of the subject with hypnosis. If the state is relatively distinctive, any seemingly slight manipulation induced while in the hypnotic state may seem trivial when compared with possibly distinctive feelings of the hypnotic trance.

Summary of Affect-dependence

Affect-dependent memory has been observed in several different populations: in children (Bartlett and Santrock, 1979, and Bartlett, Burleson, and Santrock, 1982), in people with affective disorders (e.g. Weingartner, Miller, and Murphy, 1977), and in adults (e.g. Bower et al, 1978). Affect appears to act in a state-dependent manner on certain types of memory (e.g Bower and Mayer, 1985, and Wetzler, 1985). The situations where affect-dependent recall is observed are similar to the situations where drug state-dependent recall is seen. State-dependent memory is observed when the task at hand provides insufficient cues for retrieval either because the task situation itself is a strong cue, as may be the case in overtraining, or because cues are provided. These situations in affect-dependent recall have been observed when the testing and training states are not distinctive (Bower, 1981), or when overtraining of the testable material has created a ceiling or floor effect. Either of these two variables could account for all or nearly all failures of replication of affect-dependent memories.

Overview

It is possible that context-dependent recall, state-dependent recall, and affect-dependent recall are all different facets of the same phenomenon. The basic conditions under which they occur are quite similar. When the testing conditions differ from the training conditions, there is a decrement in performance when compared to the times the testing conditions match the training conditions. Altering the external environment, such as changing rooms, may manipulate memorial markers similar to those that alcohol, marijuana or various affects may influence. The influence of these manipulations depends on the strength of the tested memory. The strength of the memory is dependent on how well the material was learned and how unique the material is to the subject. A completely unique memory would be recalled much more easily without the aid of associative pointers in the subject's network than would a memory of material that is common and only distinguishable by the extra associative pointers. Pointers of mood, drug states, or training environment would aid in separating each instance of list learning into a unique experience.

These three influences on memory seem to operate through the same means. They follow the same patterns of influence; they are virtually the same with one exception; context-dependent and state-dependent memory are observed in both humans and animals, yet affect-dependence has been observed only in humans. If these three phenomena are different facets of the same qualities of memory, then affect-dependent recall should be observable in animals, following the same patterns that state- and context-dependent recall follow in animals. The patterns include attenuation by high training levels, by cuing at recall or by a high level of individuality of the training situation. Each of these should eliminate the affect-dependent effect in animals if it exists. The first step is to observe affect-dependent recall in animals.

Memory Tasks

A task for the study of affect-dependent recall should test a memory that persists for at least several minutes, not seconds. The duration of the memory is important for two reasons. The first is that memories in humans are frequently measured in minutes or hours. If this task is to be useful as an animal model of affect-dependent recall, its properties should match human long term memory as much as possible. Many common tests of memory in animals that do not already have an affective valence (e.g. avoidance behavior) have durations measured in seconds. In dolphins the memory does not persist longer than 200 seconds (Honig and Thompson, 1982). A test of something that is less than three minutes long is an inadequate model for memories that last hours and days. A second reason a memory of relatively long duration is required is because of the time necessary for mood induction. The time it would take to change the animal's affect would be longer than the duration of such a memory being assessed.

A useful memory task was developed by Thor and Holloway (1982). The task tests the memory of an adult male rat for a juvenile male rat. In preliminary work, Thor and Holloway exposed adult rats to juveniles in two exposures. These exposures were separated by an interexposure interval, the length of which varied between trials. They measured the adult's investigation of the juvenile in the second exposure. When the same adult saw the same juvenile in both exposures, investigation increased as the interexposure interval increased (Thor and Holloway, 1982). When the adult was exposed to a different juvenile in the second exposure, investigation in the second expo did not differ significantly from that in the first exposure (Thor and Holloway, 1982). The reduction in investigation during the second exposure is not due to either fatigue or boredom experienced by the adult during the second exposure. If the adult were tired or bored, then there would be no difference in investigation whether the same juvenile or a different juvenile were used in the second exposure. The adult is able to discriminate between two similar stimuli (Thor and Holloway, 1982). This is a task in which the animal engages with no prior training. In addition the influence of the memory is observable up to 40 minutes after the first exposure (Thor and Holloway, 1982). The adult's memory for the juvenile was tested across interexposure intervals that varied from 10 minutes to 80 minutes. In the test trials, when the adult saw the same juvenile twice, the amount of investigation in the second exposure increased with increased interexposure duration (Thor and Holloway, 1982). These results suggest that the longer the retention interval, the poorer the adult's memory of the juvenile is. This, then, is a memory test that requires little training and has a duration longer than a few minutes. This test therefore should provide for the study of affect-dependent recall.

EXPERIMENT 1

Interference and training level are two factors that influence other tests of memory. This test of social memory has been observed by Thor and Holloway in 1982 to be influenced by an interfering stimulus in the form of a "noise juvenile". A "noise juvenile" is a third juvenile inserted during the interexposure interval. The "noise" juvenile is there only to act as an interfering stimulus.

My first experiment examined the effects of varying first exposure length. After I had determined the influence of exposure length on this memory, I ran a second experiment to attempt to observe affect dependent recall in animals.

Method

Subjects

The subject animals were two groups of six male Long Evans rats between 60 and 70 days of age. The subject animals were singly housed in clear plastic tubs (20cm x 20cm x 45cm). The stimulus animals were two groups of six juvenile male Long Evans rats between 20 and 25 days of age housed in sibling pairs in the same type of cages as the adults. All tests were conducted in the adult's home cage.

Apparatus

The testing was done in the adults home cage under fluorescent lighting. Behavior was scored using an IBM AT and the multi-channel event recorder program, Eventlog.

Procedure

Each trial was divided into three stages. These three stages were: 1) the first exposure, which was 3, 5, or 7 minutes long; 2) the interexposure interval, which lasted twenty minutes; and 3) the second exposure, which was 5 minutes long. Investigation of the juvenile by the adult was recorded during both exposures. Investigation was scored as the sniffing, following, nosing, or grooming of the juvenile by the adult, while the adult's nose was within 2 cm of the juvenile.

In each memory test trial, the juveniles and the adults were brought into the observation room and allowed to become accustomed to the new room for five minutes. A tone marked the end of the first five minutes, and a juvenile was then removed from its home cage and placed in the adult's cage. Investigation of the juvenile by the adult was scored. At the end of the specified first exposure the juvenile was returned to its home cage. After the end of the interexposure interval, the same juvenile was returned to the adult's cage and investigation was again scored.

In a control trial the procedure was the same, except for the juveniles used. The cagemate of the juvenile used in the first exposure was substituted for the original in the second exposure.

Each adult received a series consisting of three trials, each with a different first exposure length. Two animals were tested with each of the six different possible order combinations of trials. No adult was ever exposed to the same juvenile on two different trials. A series of trials was completed in three days, each adult undergoing one trial per day.

Results

The means for investigation time in the second exposure are presented in Figure 1. A two way analysis of covariance ANCOVA (test type x first exposure duration) comparing the means of the investigation in the second exposure was used; investigation in the first three minutes of the first exposure was the covariate. There was a significant difference between the test trials and the control trials, $F(1,59) = 27.57$, $p < 0.001$. There was no main effect of first exposure length $F(2,59) = 2.49$, $p = 0.111$, nor of test order $F(5,59) = 1.58$, $p = 0.195$. There also was no significant interaction of first exposure length with test type $F(2,59) = 1.61$, $p = 0.209$. Though there was no significant interaction, after examining figure 1, I observed that there seemed to be two different patterns in the two test type groups. The data suggest that there was a great deal of variance in the control group. For these two reasons I decided to run a trend test on the two groups. There was a significant linear trend $F(1,32) = 9.99$, $p = 0.0034$ for the memory test group, but not for the control group $F(1,32) = 0.10$, $p = 0.76$. A post-hoc analysis using a Tukey's HSD revealed that in the memory test group there was a significant difference (alpha = 0.05) between the animals that received a three minute first exposure and those that received a seven minute first exposure.

Discussion

Investigation in the second exposure was influenced by the duration allowed for investigation in the first exposure. As the amount of time in the first exposure increased, the adult performed less investigation in the second exposure in memory test trials, but not in investigation control trials. The trend of a reduced investigation in the second exposure in test trials was linear from three minutes to seven minutes. Since the level of investigation is used as an index of the adult's memory of the juvenile, a reduced level investigation in the test trials when compared to the control trials is interpreted as memory (Thor and Holloway 1982.) These data, however, are not conclusive; even though there was no significant interaction, there was a significant linear trend in the test animals, but not in the control animals. In order to make solid a conclusion, the experiment should be replicated. The hypothesis, that first exposure length is analogous in this test to level of training in other memory tasks, for the moment seems to be true.

The five minute first exposure length was chosen for use in Experiment 2 because the level of investigation allowed for either an increase or decrease of investigation in the second exposure.

EXPERIMENT 2

Both state-dependent and context-dependent recall have been observed in humans and animals (Smith, Glenberg, and Bjork, 1978, Perkins and Weyant, 1958, Hill, Schwin, Powell, and Goodwin, 1973, Bliss, 1973). Context-dependent recall has been observed when the environment was changed between the training and the testing sessions. In humans this change of environment can be as simple as a different room in the same building (Smith, Glenberg, and Bjork 1978). In rats this change of environment can be the changing of the color of a straight alley in which a rat has been trained to run (Perkins and Weyant, 1958).

State-dependent recall is observed when the subject's internal state is changed through drug administration. In humans this state change can be achieved through the use of many different drugs, including marijuana (Schwin, Powell, and Goodwin, 1973). In animals, a wider range of drugs has been observed to have a state-dependent influence, including pentobarbital (Bliss, 1973). In addition affect-dependent recall has been observed in humans (Bower, 1981), but affect-dependent recall has yet to be observed in animals. All three of these phenomena have very similar characteristics. The state, context, or affect, may influence the same condition that is important to memory processing. These condition-dependent recalls follow many of the same patterns, such as the strength of the condition influencing the "state-dependent effect" (Bliss, 1973) and the affect-dependent effect (Bower, 1981). If context-dependent, state-dependent, and affect-dependent recall are all the same phenomenon, then affect-dependent recall should be observable in animals.

In animals one of the easiest affects to induce and observe is fear (Archer, 1973). Fear can be induced in rats with a very mild footshock while they are in a large, brightly lit, open field. In contrast another affect that can be used is a feeling of ease. The rats can be made to feel safe by placing them in a small dimly lit arena. Rats seem to feel more comfortable in a small dark place than in a bright open arena (Archer, 1973). When paired with a mild footshock, the bright arena should become strongly associated with a feeling of unease, and the small dark arena, in contrast, will feel safe. The animals received conditioning trials so that they would associate the two arenas with the appropriate affects.

Method

Subjects

The subject animals were two groups of eight male Long Evans rats between 60 and 70 days of age, singly housed in clear plastic tubs (20cm x 20cm x 45cm). The stimulus animals were two groups of sixteen juvenile male Long Evans rats between 20 and 25 days of age housed in sibling pairs in the same size cages as the adults.

Apparatus

The testing was done in two different arenas under fluorescent lighting. The safe arena was a circular clear acrylic container with black paper on the outside of the walls and underneath the floor. The arena had a diameter of 39cm, and the walls were 30cm high. The unsafe arena was a large open field with a shock grid floor made of bars 2cm apart from center to center. The arena had dimensions of 60cm x 60cm x 60cm. with three white walls and one clear acrylic wall. Behavior was scored using an IBM AT and the Eventlog software.

Procedure

The same general procedure as in Experiment 1 was used in testing the animals for the adult's memory of the juvenile. There was a first exposure in either the safe or the unsafe arena, during which the adult was allowed to investigate the juvenile for five minutes. There was an interexposure interval during which the animals were returned to their home cages. There was a second exposure in either the safe or unsafe arena, during which the adult again was given the opportunity to investigate the juvenile for five minutes. In situations such as this, where the two conditions are either safe or unsafe, there are four different testing conditions necessary to if affect-dependent memory exists. The animals must be tested in a pairing of all four conditions: safe arena in the first exposure, safe arena in the second exposure (s/s); safe arena in the first exposure, unsafe arena in the second exposure (s/u); unsafe arena in the first exposure, safe arena in the second exposure (u/s); and unsafe in the first exposure, unsafe in the second exposure (u/u). Four different orderings of trials were used as determined by a Latin Square design (Keppel, 1982). Th[illegible]fferent order series were: 1) s/s, s/u, u/s, u/u 2) u/[illegible], u [illegible]/u, s/s 3) s/u, u/u, s/s, u/s 4) u/s, s/s, u/u, s/u. Each animal experienced only one trial per day.

<u>Conditioning Procedure</u>

The animals were assigned to one of four groups, and each group was run through that series of trials over four days. If an animal was in group one, on the first day he was placed in the safe arena for five minutes and allowed to explore. At the end of five minutes he was returned to his home cage. The interexposure interval was twenty minutes long, at the end of which the adult was replaced in the safe arena and again allowed to explore. That completed the first day of training in the animal's series. On the second day the same animal was placed in the safe arena for his first exposure, removed for the duration of the interexposure interval, and then placed in the unsafe arena for his second exposure. While in the unsafe arena the animal was likely at any time to receive a scrambled footshock of 0.5 milliamps with a duration of 0.5 seconds. The animal's probability of receiving a footshock at any moment was determined by a Poisson distribution. The inter-shock interval was 30 seconds. The series was then continued in the same manner as determined by the Latin Square design. The conditioning procedure took four days for each animal. A number of animals was run each day, with at least 4 animals being run on any one day. The animal received footshock only during condition trials.

Testing Procedure

The first day of testing immediately followed the last day of conditioning. The animals were tested in the same groups as they were conditioned except that these groups were subdivided into test and control animals. As described in Experiment 1, in a test trial the adult saw the same juvenile in both exposures. In a control trial the adult saw two different juveniles, who were cagemates, in the two exposures. Investigation was again recorded using the same criteria as in Experiment 1. The end result was two sets of eight series of trials matched across test and control groups.

Results

The means for investigation in the first exposure by arena type are presented in Figure 2. An ANOVA was performed comparing the means of investigation in the first exposure by arena type. There was no significant difference between investigation in the unsafe arena and the safe arena $F(1,89) = 0.65$, $p = 0.42$.

The means for defecation in the second exposure are presented in Figure 3. A two way analysis of covariance with trial day as the covariate revealed that there was no significant effect of test type on defecation $F(8,82) = 0.66$, $p = 0.417$. There was, however a significant effect of trial type on defecation $F(8,82) = 20.49$, $p = 0.0001$. A post-hoc analysis using a Tukey HSD revealed that there was a significant difference (alpha = 0.05) in defecation in the second exposure between 1) the safe/safe and the safe/unsafe trials; 2) the safe/safe and the unsafe/unsafe trials; 3) the safe/unsafe and the unsafe/safe trials; and 4) the unsafe/safe and the unsafe/unsafe trials. There was no interaction of test type and trial type on defecation $F(8,82) = 0.10$, $p = 0.959$.

The means for investigation in the second exposure are presented in Figure 4. A 2x2x2 analysis of variance (test type x arena type in the first exposure x arena type in the second exposure) revealed that there was a significant effect of test type $F(28,62) = 16.84$, $p = 0.0033$ on investigation in the second exposure. There was no significant effect of either the arena in the first exposure, $F(28,62) = 2.32$, $p = 0.132$, or the arena in the second exposure $F(28,62) = 3.33$, $p = 0.072$ on investigation in the second exposure. There was no significant interaction between test type and either the arena type in the first exposure $F(28,62) = 0.15$, $p = 0.702$ or the arena type in the second exposure $F(28,62) = 0.00$, $p = 0.946$. There was no significant interaction of arena type on the first exposure and arena type on the second exposure $F(28,620) = 3.51$, $p = 0.065$ on investigation on the second exposure. There also was no significant interaction of test type with arena type on the first exposure and arena type on the second exposure (test type x arena 1 x arena 2) $F(28,62) = 3.39$, $p = 0.070$.

Discussion

There was no significant difference in investigation between the two arenas in the first exposure, despite the difference in affect observable by the difference in defecation (Archer, 1973). The animal's affect did not influence the level of investigation in the first exposure. Any difference in investigation in the second exposure in either the test or the control trials then is not attributable to how much investigating the adult did in the first exposure.

In the second exposure, the affect or the arena associated with the affect did not have a significant effect on investigation in the test trials as compared to the control trials, though the interaction was close to significant.

The evidence does not disprove or prove the hypothesis that affect-dependent recall exists in rats ($p = 0.07$). This failure to observe affect-dependent recall does not mean it does not exist in animals. There are a number of possible explanations as to why the state-dependent effect was not observed. These reasons include: 1) the adult's memory for the juvenile may have been very strong, either because of an effect similar to the one caused by a high level of training in a task, which would have masked the effect in the same manner as was observed in monkeys treated with pentobarbital (Bliss, 1973), or because test the situation for the rats may have been very special or memorable as was the case in the Schare et al (1984) study of affect-dependent recall in humans; 2) the states induced may not have been distinctive enough to cause an affect-dependent interaction; and 3) the measure of memory may not be sensitive enough to pick up any differences that already exist. There are simple ways to alter the methods of Experiment 2 to account for each of these possible problems.

If the adult's memory for the juvenile is too strong to be influenced by the affect manipulation there are three ways that could be used to weaken the adult's memory. The first method would involve the use of a longer interexposure interval. The level of recall as measured by the adult's investigation of the juvenile decreases over time (Thor and Holloway, 1982). The second method would be to shorten the first exposure length. The adult's memory for the juvenile is influenced by the amount of time he has to investigate in the first exposure (Experiment 1). The third method would be to introduce an interfering stimulus as was done by Bower et al (1978) and Schare et al. (1984). The use of an interfering stimulus, in the form of another juvenile, blocks or interferes with the adult's memory for the juvenile used in the first exposure (Thor and Holloway, 1982).

The methods discussed earlier may make affect-dependent recall observable in this task if the failure reported in this paper is due to the strength of the adult's memory and not due to a lack of distinctiveness in the induced affective states. There are a number of ways to change the methods used that may cause

more distinctive affective states in the animal. One way would be to strengthen the conditioned affect to the unsafe arena.
A few possible methods to induce stronger negative affect would be to increase the intensity of the shock and/or the probability of receiving a shock. The shock stimuli may not have been aversive enough to induce a conditioned affect. Another method would be to increase the length of the conditioning period, because the animals may not have been given adequate opportunity to learn the associations to the two arenas. A more distinctive set of affective states may be induced by making the safe arena more than just safe, but the rodent equivalent of pleasurable. While in the unsafe arena the animals received stimuli that they disliked, while in the safe arena the animals by comparison, received no stimuli, they were just there and nothing happened. The difference between a fearful affect and a non-fearful affect may not be strong enough to allow the affect-dependent influence to be observed. The opportunity for special food or sweetened water while in the safe arena may induce a positive affect as opposed to an affect that may have been neutral. With these procedural changes a stronger interaction between affect and test type may be observed.

One alteration in methods that is necessary regardless of whether the strength of the affective states or the strength of the adult's memory need to be varied is the measure of memory used. The sensitivity of using a sum of investigation over the whole second exposure may be low. The change in affective states may not cause a change in the total amount of investigation in which the adult engages, but the different affective states may cause a change in the pattern of investigation in which the adult engages. A more sensitive measurement would be to look not only at total investigation time, but at the pattern of investigation in both the first and the second exposure. How and when the adult investigates the juvenile may be altered depending on his affect in either exposure or the order presentation of the two affects.

A significant observation of affect-dependent recall with these changes would not prove that affect-dependent recall exists in animals. What could be happening is the memory is just context-dependent. There are two other tests that would need to be performed to strengthen the hypothesis that affect-dependent recall exists in animals. The first would examine whether there is a affect-dependent effect operating on the memory using two arenas for each condition, two safe, two unsafe. The second test would examine whether there is a context-dependent effect operating on this memory. The first experiment would have a procedure similar to Experiment 2, which is described earlier in this paper. The variations are that the animal is conditioned to two arenas for each affect and the animal is tested under conditions of matching affect but not matching arenas. For example, in the safe/safe trials, after the appropriate conditioning trials, the adult would be placed in the first safe arena with the juvenile for the first exposure, removed for the interexposure interval and then placed in the second safe arena for the second exposure. If the memory levels in this experiment are comparable to a successful observation of affect-dependent recall, then it is quite possible that the original observation of affect-dependent recall, which has yet to occur, was not an effect of context, but of affect. This interpretation assumes that all affect inductions are effective, a problem that quite possibly may have prevented me from observing affect-dependent recall in Experiment 2. Whether or not this four-arena experiment is successful, the animals should be tested in the original arenas, with no conditioning trials, to observe if the effect was context-dependent and not affect-dependent. To do either the fourth experiment or the third experiment without the other experiment would not provide conclusive results. A finding of the presence of a context-dependent effect does not preclude the presence of an affect-dependent effect. Nor does the finding of the lack of or the presence of a context-dependent effect prove that an original observation of affect-dependent recall was definitive. In the same manner, if only the third experiment were to be run an observation of affect-dependent recall would not prove that there was no contextual component, and an inconclusive finding of affect-dependent recall, without the results of the context experiment, would not address the question as to what is actually occurring in this situation.

CONCLUSIONS

The findings from Experiment 1 suggest that investigation in the second exposure of the juvenile by the adult in memory test trials is influenced by the duration of the first exposure. This pattern of results could be compared to those observed in other tests of memory when level of training is examined. The findings of Experiment 2 are inconclusive and do not answer the question as to whether affect-dependent recall exists in animals. The methods of the experiment require refinement and any results from improved methodology need to be followed up with work examining the exact nature of the phenomenon. Follow up work is required whether or not a state-dependent effect is observed. If there is a state-dependent effect, then the question to be pursued is whether this is context- or affect-dependent recall; and if no state-dependent effect is observed, the question to be pursued is why no context-dependent effect was observed when less dramatic changes in environment in the Perkins and Weyant (1958) study caused a context-dependent effect

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List of Figures

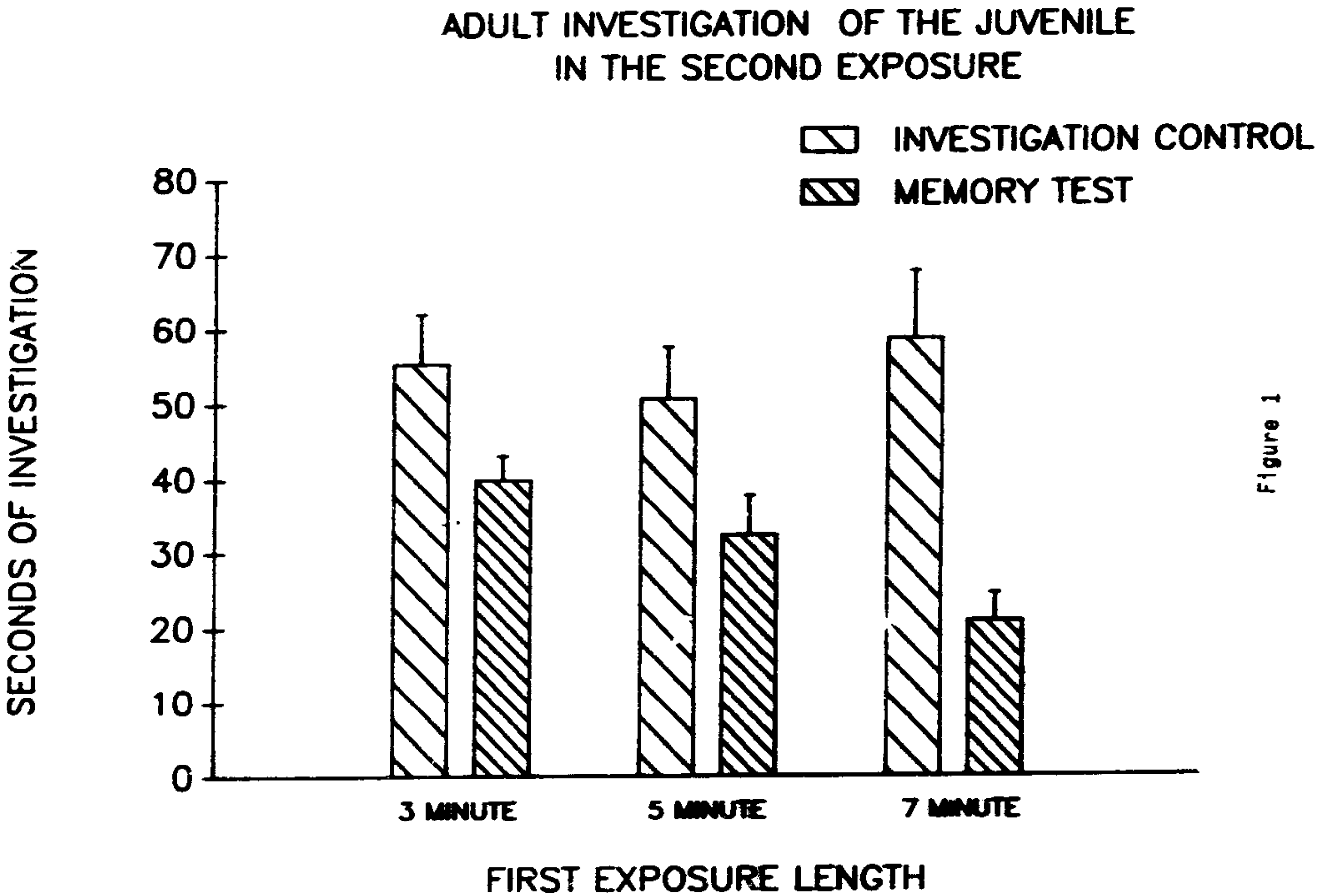
ADULT INVESTIGATION OF THE JUVENILE
IN THE SECOND EXPOSURE
INVESTIGATION CONTROL
MEMORY TEST
SECONDS OF INVESTIGATION
80
70
60
50
40
30
20
10
0
3 MINUTE
5 MINUTE
7 MINUTE
FIRST EXPOSURE LENGTH

Figure 1

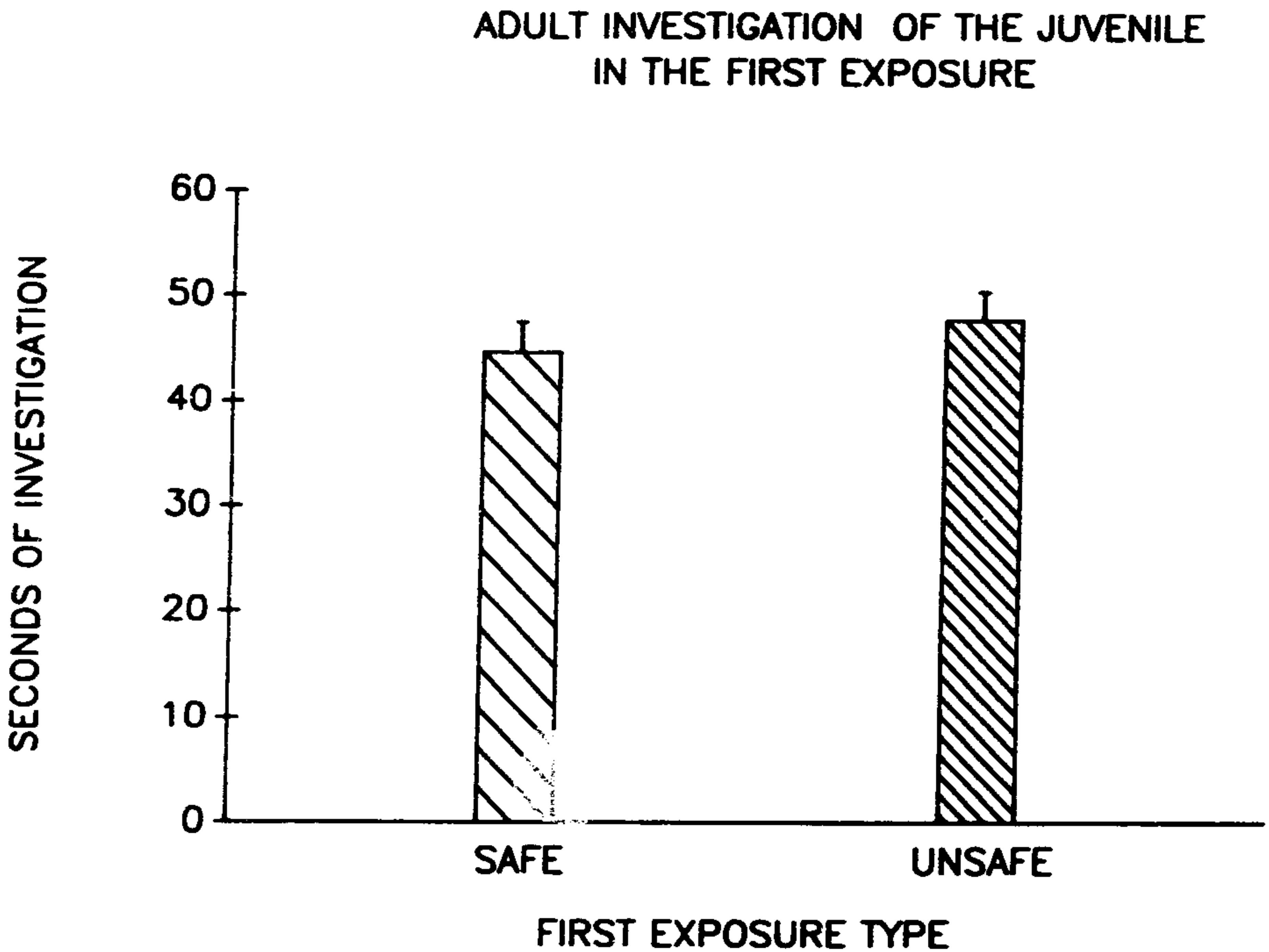
ADULT INVESTIGATION OF THE JUVENILE
IN THE FIRST EXPOSURE
SECONDS OF INVESTIGATION
60
50
40
30
20
10
0
SAFE
UNSAFE
FIRST EXPOSURE TYPE

Figure 2

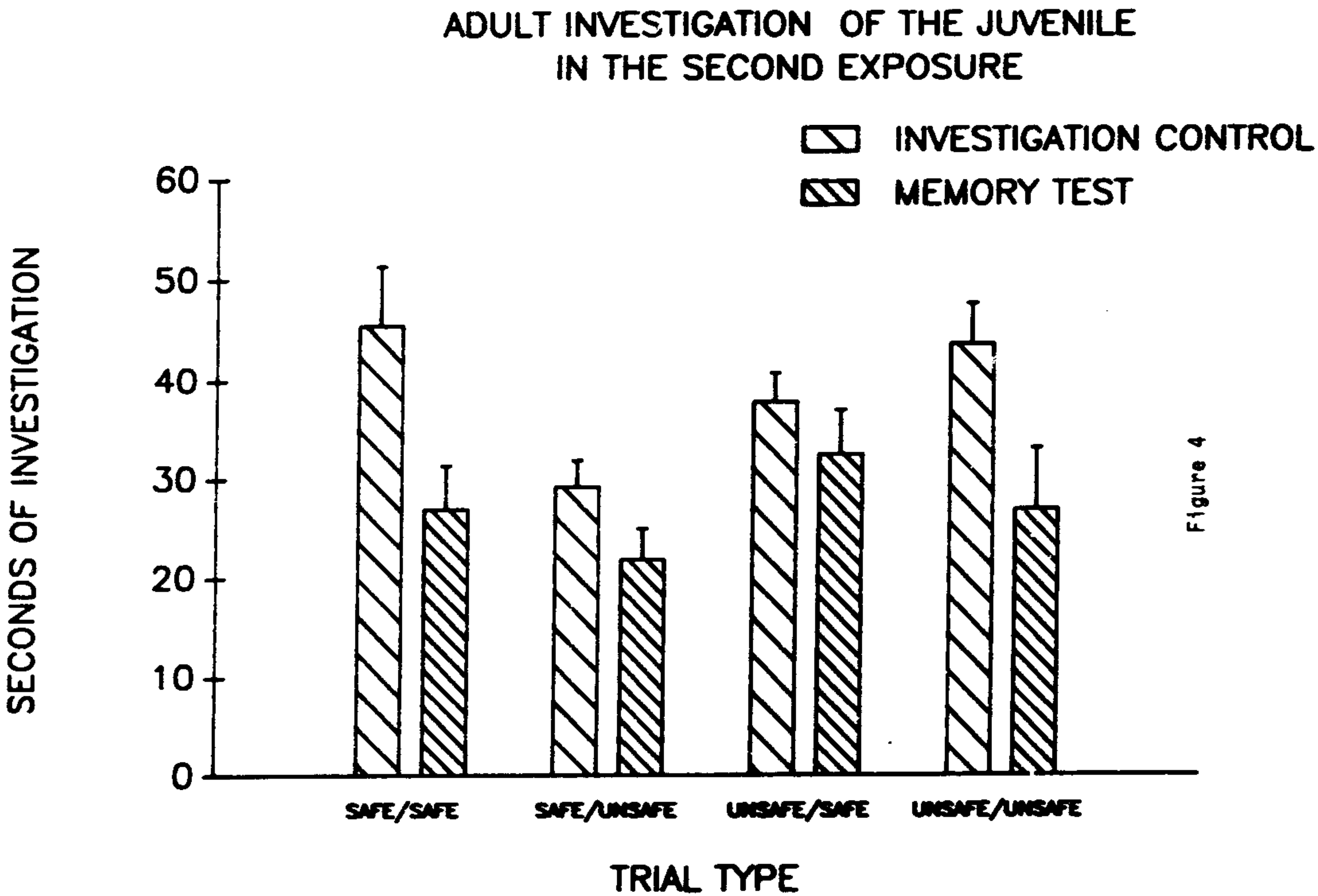
ADULT INVESTIGATION OF THE JUVENILE
IN THE SECOND EXPOSURE
INVESTIGATION CONTROL
MEMORY TEST
SECONDS OF INVESTIGATION
60
50
40
30
20
10
0
SAFE/SAFE
SAFE/UNSAFE
UNSAFE/SAFE
UNSAFE/UNSAFE
TRIAL TYPE

Figure 4

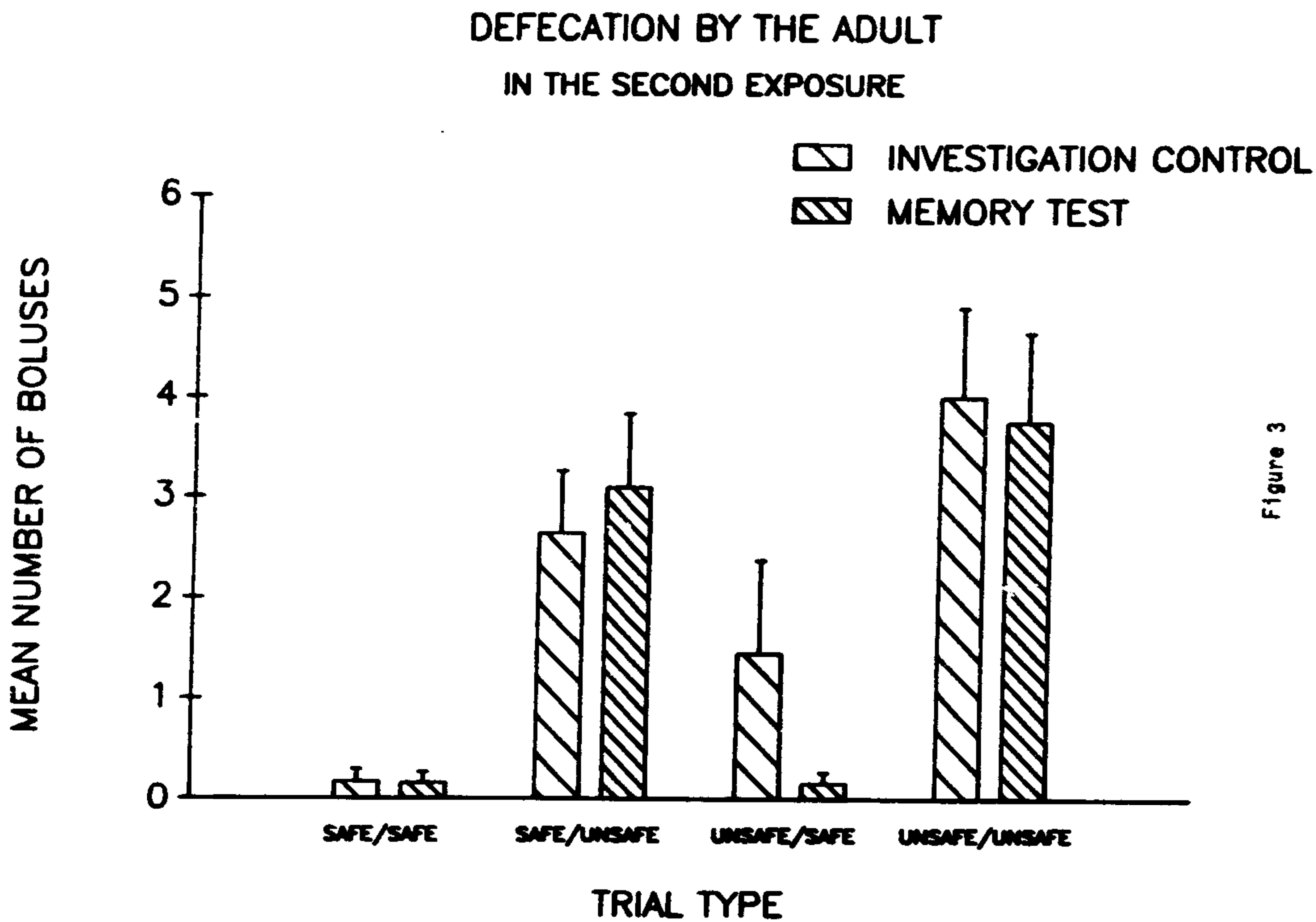
DEFECATION BY THE ADULT
IN THE SECOND EXPOSURE
INVESTIGATION CONTROL
MEMORY TEST
MEAN NUMBER OF BOLUSES
6
5
4
3
2
1
0
SAFE/SAFE
SAFE/UNSAFE
UNSAFE/SAFE
UNSAFE/UNSAFE
TRIAL TYPE

Figure 3