BEHAVIORAL ANALYSIS OF IMPLANTED FALSE MEMORIES

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Behavioral Analysis of Implanted False Memories

The aim of this study is to generate behavioral data from implanted memories of events and to determine the effect that misinformation has on a person's ability to recall accurately events that they had previously witnessed. The mechanism of memory has been an area of research studied greatly in psychology over the past 100 years. Memory may be defined as the result of past experiences that have been encoded so that they may be reactivated at any time. Memory is based on the detecting of stimuli (sensation) and subsequent encoding of that information (perception). Ebbinghaus (1913) was one of the first researchers to systematically examine the limitations and capabilities of this mechanism. Research on memory today has focused on using many types of measurements and analytical procedures.

Within psychology great strides have been made in the area of cognition. Cognition is the actual mental processing of information that has been received from the environment. Cognitive psychology has made advances that reflect the 'zeitgeist' of the time over the past decades in regard to comparing memory to that of a computer. With the proliferation of the personal computer and computing technologies various models of memories have been presented.

Perhaps one of the most common information processing approaches of human memory is the computer model. That is, the analogy of the human memory system to that of the components of the computer such as the harddrive for storage or random access memory (RAM) for memory and retrieval. While the memory system is perhaps one of the most interesting aspects of human cognition, it is also among the most complex. Its complexity arises from the inter-connectiveness of the brain and the parallel processing that occurs. Within this framework the creation of false memories, memories that have been distorted over time or by interference, has become a central theme in the study of cognition and memory over the last two decades.

How to differentiate false memories from true memories presently consumes many research programs nationally and internationally. A true memory is one that is accurately recalled by the perceiver without any distortions, while a false memory has been modified in some way and does not reflect an accurate perception of an event. The researcher most influential in this field is Elizabeth Loftus, who pioneered the principle methodological approach in implanted memory research. Loftus' work has focused on suggestibility and its relationship to memory distortions (Loftus, 1979). Her methods have examined the effects of misinformation on recollections of events, the use of one's imagination, bias in retrieval cues, and much more. Although Loftus and the research of many other laboratories is primarily behavioral in nature, there is a dearth of research investigating the biological underpinnings of false and implanted memories (cf., Schacter, 1997).

Studying the fragile nature of human memory is of great importance in understanding many practical legal, ethical and moral dilemmas influenced by the relationship between encoding stimuli from the environment and later retrieval of that information. Research into the production of falsely recalled information begins with an understanding of the human memory system and deriving models of how memory can be distorted or interfered with by the introduction of more recent information. Therefore, research suggesting possible causes and the implications of false memory production must begin with an overview of memory and how such a system is measured. This study seeks to emulate a real life event by subjecting the participant to a series of events and testing how subsequent questioning techniques affect the participant's ability to recall the events that he/she witnessed accurately. The results from this study will enhance the understanding of false memory production relying heavily on methods that can be adopted for future use in modern neuroscience and electrophysiological research.

History of Memory Research

The study of memory has been a topic explored for many centuries. The early Greek philosophers studied the complexity of memory by utilizing various types of theories strongly based on the idea of associations. They described the processes of contiguity, similarity and contrast (Matlin, 1989). Association by contiguity is described as memory traces being related by the temporal arrangement of the ideas. The processes of similarity and contrast describe associations of ideas by linking them directly by either similar or dissimilar properties.

The further study of associations in the seventeenth century was promoted by philosophers such as John Lock and John Stuart Mill. The eighteenth and nineteenth centuries were a time of great strides in the understanding of the basic memory processes. In 1879, Wundt established the first experimental psychology laboratory in Leipzig, Germany. This key development in integrating empirical research into psychology has led to advances in all areas of psychological research. Ebbinghaus was the next major contributor of memory research. In 1885 he set out to examine the entire memory process from encoding to retrieval. In a methodical manner he examined the types of associations that resulted between nonsense syllables to examine the capacity of short term memory as well as long term memory. His methodology involved memorizing a long list of nonsense syllables over time and then varied the time interval between encoding and retrieving to see the effect that time had on memory. Ebbinghaus proposed some of the most profound theories in memory research such as serial position effects, retention and forgetting curves (Spear & Riccio, 1994).

With the focus of memory research being on unseen mental processes, questions were raised as to the existence of these processes, or more specifically, a movement was begun to examine processes that were measurable. This unease in the study of mental life was replaced by a growing group of researchers from an animal/comparative background that dealt only with observable behaviors. This movement, called behaviorism, sought to establish psychology as a more scientific, empirically-based discipline. John Broadus Watson led the attack on mentalism petitioning that only overt behaviors are a valid area of inquiry. This paradigm shift led to many great advances in the study of psychology and the development of theories that hold to this day. Pavlov, and the development of classical conditioning and B.F. Skinner and the advent of operant conditioning led to the great climb and establishment of behaviorism.

Just as behaviorism replaced mentalism as the theoretical approach of choice, another revolution was beginning to take place. Many psychologists during this time felt that the discipline had left the area of the mind and wished to incorporate that aspect back into the field, much to the chagrin of behaviorists then and today. This cognitive revolution was heralded by researchers such as Broadbent (1958), Newell and Simon (1961), Neisser (1960), Chomsky (1959) and many others. The advances in cognitive psychology led to various competing models of memory. One of the first of these was the information processing approach by Atkinson and Schiffrin (1968). This fundamental approach was perhaps the backbone of memory models for today. This model led to the development of neural networks (McClelland & Rummelhardt 1986), a more complex description of cognitive processes such as memory. These models are discussed in the following section. The course of memory research is still in great flux especially with the advent of high-powered computer simulations (neural networks), electrophysiological techniques and imaging. Basic premises of inquiries into memory by the ancient Greeks and philosophers of the 18th and 19th century have led to the development of many strong and heuristic theories of memory that will be explored in the next section.

Table I. Development of Memory Research

Key Figure	Approach
Greeks	Associationism
Wilhem Wundt(1879)	Introspection
Ebbinghaus(1888)	Experimental
JB Watson(1909)	Behaviorism
1950's	Cognitivism
Atkinson & Schiffrin(1968)	Information Processing
Collins & Quillien (1972)	Neural Network

Models of Memory

Memory can be viewed as a tripartite system where stimuli enter a multi-storage system. Atkinson and Shiffrin (1968) described a cognitive model of memory as involving a flow of information that travels through several storage systems. The first area is sensory memory, which automatically registers any stimuli that are presented, then holding this information for a very brief amount of time. For the visual sensory register (iconic memory), this is usually less than one second (Matlin,1989). For the auditory sensory register (echoic memory), 3-4 seconds is common (Matlin, 1989). This information then travels to a working memory where encoding involves a primarily auditory form; rehearsal and elaboration are required to retain information in this short term memory (Baddeley, 1990). The capacity or memory span in working memory has been shown to be seven, plus or minus two bits of information (Miller, 1956). The final stage of this transfer of information is to long term memory which has relatively unlimited storage capacity; the information that was processed in working memory is stored here by the mechanisms of elaboration and rehearsal.

The next model of memory that may be examined is the levels-of-processing approach which suggests that deeper levels of processing produce better retention than shallow levels of processing (Craik & Lockhart, 1972; Craik & Tulving, 1975). The idea of depth of processing is defined as stimuli that are presented may be either examined by associating it with other ideas or thinking about the item in reference to other similar items and characteristics (deep) or by simply skipping over it without any further examination of the details of that stimulus (shallow). Depth of processing begins with the processing of physical characteristics of the stimulus or information to be remembered through acoustic and visual channels and finally in terms of semantics. The depth of processing ranges between shallow level and a deep level, and it is dictated by the degree to which the stimulus is found to be semantically or contextually relevant at that moment. Semantically or contextually related stimuli are processed much more deeply (extensively) than unrelated ones. Elaboration of the information to be remembered and distinctiveness of that information are also important factors in the encoding of information in this model. Moreover, there is a positive relationship between the depth of processing and the subsequent recall of information. The depth of processing theory has received much support in early literature (Bowers, 1981).

Tulving's (1972) memory model focuses on the nature of the information that is stored and distinguishes three kinds of memory based on the content. Episodic memory is information about specific events or episodes that have occurred personally. This type of memory is often referred to as autobiographical memory and will be examined later with regard to memory implantation and testing, specifically as it is related to eyewitness testimony. Semantic memory is simply general knowledge about the world and is essentially all the facts that have been accumulated over time. Semantic and episodic memory make up the declarative knowledge base that is stored in permanent or long term memory. Finally, procedural memory involves knowing how to perform a task, and the underlying formulas used to make automatic decisions/ recognition. For example, knowing how to drive a manual stick shift vehicle relies on knowing when to change gears and many people find it difficult to to explain how to actually do it. This type of memory relates to skill acquisition and the associations between stimuli and motor behavior. Procedural memories are not the subject of the present thesis, however.

Another form of autobiographical memory of events are the flashbulb memories proposed by Brown and Kulik (1982). This type of memory enables people to remember everything that was going on in their lives when a certain vivid or traumatic event occurred. An example of this is when President John F. Kennedy was assassinated or the Oklahoma City bombing of the Murrah Building. Individuals usually are able to recall what they were wearing, the weather, who was there, and/or what they were doing at the instant that they heard about the event. Flashbulb memories are richly encoded when the event occurs and are highly resistant to forgetting owing to the high degree of emotional content. These memories are not immune to the process of reconstruction or malleability of the memory, however. That is, although flashbulb memories seem very accurate and vivid to the individual describing them, these memories are often filled with inaccurate information (Neisser, 1992).

The spreading activation model described by Collins and Loftus (1975) suggests that the memory system is semantic in nature and that the activation of one node (a word or phrase) in the semantic network primes another nearby node. This node, in turn, can prime or activate other nodes in the system. The spreading of activation within an associative network is said to spread by lowering the thresholds of probable semantically related targets or associates. Behavioral reaction times (RT) and the N400 component of the ERP are often used as indexes of the activity related to spreading activation (Rugg, 1984).

Another model of memory is the parallel distributed processing (PDP) model which can be conceptualized as a network in which the elements contain multiple links to other elements or levels (Rummelhart & McClelland, 1986). These links may be abstract in nature where nodes in a hypothetical network are connected by associative links, or biological in nature where neurons are linked synaptically. Units in the system, through their many links, may affect other units in an excitatory or inhibitory fashion by raising or lowering their activation thresholds. Representations (knowledge, memory) exist in the resultant patterns of activation that course through the network distributed across several nodes and layers. Local processes giving rise to these patterns occur in parallel at distributed sites. Every new event changes the relative strength (activation thresholds) of the connections among and between the relevant units. Forward and backward propagation of signals within the network are also mechanisms that contribute to the relative strength of individual nodes.

The various memory models discussed in the current cognitive neuroscience paradigm have combined in the study of the biological basis of memory. Schacter (1989) has been at the forefront of the development of this methodological approach to memory. His recent research includes positron emission tomography (PET) studies of the biological process of memory (Schacter, Curran, Reiman, Chen, Bandy, & Frost 1999).

Models of False Memories

The study of false memories, which are defined as memories that have been distorted over time or by interference, has been under investigation for the past few decades. Based on new evidence using physiological monitoring devices other models of false memories have been developed. Schacter (1999), for example, has developed a model of false memories based on PET studies. This instrument monitors cerebral blood flow and facilitates accurate localization of the areas active during various types of cognitive processing. Research has also shown that false recognition can be localized to the right frontal lobes by the PET scan method (Schacter, 1997).

The model of implanted memories has been demonstrated by Loftus (1993) and Roediger and McDermott (1997) who performed an experiment in which participants were asked to recall words that had been presented to them earlier. The items that were falsely recalled (not presented) by the participants were then examined. The participants were asked how confident they are that the item was in the list. Participants that falsely recalled items indicated that they were very confident that those items were in fact present in the list. The participants were often able to describe where on the list the implanted words were supposedly located.

Others have attempted to explain false memories as perceptual illusions. Payne, Neuschatz, Lampinen and Lynn (1997) described them as memory illusions. That is, there is no real difference between perceptual illusions and memory illusions; both of these processes depend on the internal representations of the external world. Payne et al. also presented a model called 'Reperception' of memory that describes remembering as a reinterpretation of the internal representations. The misinformation effect is said to arise from reperceiving the internal representations of events and is affected by the new (mis)information during the process of reperception (Payne et al., 1997).

A major factor related to the creation of false memories deals with the passage of time. Loftus (1997) has shown that memories are more easily modified if the time between the actual event or stimulus presentation and the subsequent interview of that event is extended. This decrease in accuracy of memory recall based on the degradation and modification of a memory trace is based on the individual's continual rehearsal and elaboration of that memory trace which eventually leads to adding details that were not actually remembered or encoded. The malleability of memory as such can lead one to believe that the memory trace is accurate when in fact it has been modified over time by new information, suggestions or simple elaboration.

The definition of a false memory is: a memory that was subject to distortion (Schacter, 1996) or incorrectly recalled (Roediger & McDermott, 1995). The cognitive and physiological basis of how false memories are generated is not yet fully understood. Bowers and Bekerian (1984), for example, described how retroactive interference might explain false memories from misinformation. In this model, new information i.e., misinformation, interferes with the subsequent retrieval of the older, presumably undistorted information from memory.

The differences between false memories and repressed memories also garners attention among memory researchers. Repressed memories can be defined as events that are not consciously accessible. Whereas false memories are easily remembered by an individual, repressed memories are not remembered fully. Loftus (1993) has conducted research into this poorly defined phenomenon and describes repression as a "mechanism that is highly malleable and probably inaccurate." Schacter, Norman, and Kautstaal (1997) have characterized the act of repression as a Freudian-like phenomenon that as yet is not sufficiently well-explained to effect an examination of the mechanisms that may produce repressed memories. They argue that various forms of retrograde amnesia related to traumatic events fail to explain repression.

Similarly, the normal decay and interference seen in ecological as well as laboratory studies also fail to adequately explain repression. Psychological disorders like dissociation and affective states also fail to provide an adequate explanation or even viable data to study. In short, repression may be characterized as a 'defensive mechanism' that may involve a conscious effort by the individual not to rehearse particular memories of traumatic events or series of events, or, an unconscious defense mechanism designed to insulate the fragile Ego from compromising memories. This latter explanation, of course, has absolutely no basis in any credible laboratory or ecological evidence to validate it. It is unfortunate that laboratory studies can never hope to recreate the "highly threatening or even traumatizing situations" that purportedly give rise to "defensive repression" .

Even biological explanations seem to defy discovery, although some laboratory studies featuring NMDA antagonists have been explored (Krystal, Karper, Seibyl, & Freeman, 1994) Thus, production of repressed memories follows the same pattern of susceptibility as does false memory generation, and one can see similarities between the two types. More research needs to be conducted such as this to help locate the putative cognitive and physiological mechanisms that may be involved in these processes.

The process of generating false memories has been demonstrated by utilizing a list of words that subjects had to later recall (Deese, 1959). Among the words recalled, however, is usually one highly probable associate that had never been presented. More recently, Loftus (1995) and Garry and Loftus (1994) and others have used an implantation methodology for generating false memories. The general method relies on structured interviewing techniques derived from the stimulus instrument used in the procedure. For example, if a subject was to view a video of a car accident, specific well-planned leading questions are used that lead the subject to respond to details that were not present in the video or to overestimate the speed in which the accident occurred. Different groups receive either a structured interview which would consist of a set of questions that are asked of the witness or an unstructured interviewing technique which does not use any direct questions but rather general prompts to illciit more detailed information from the witness.

In the present study these two techniques were used to determine the difference in false memory recall. It was found that structured interviews, which include leading questions and suggestions, produce a higher rate of false memories than unstructured interviews. The subjects will recall these falsely reconstructed memories with a larger degree of certainty for that event than if they had not rehearsed the material in some fashion. The biases that are involved in recall such as the availability heuristic and mood effects on memory can play an important part in the development of inaccurate recall based on information that was being presented.

Lindsey (1990) used a paradigm for testing false memories by having a subject view an event and then use misleading suggestions about details of the event. Lindsey looked at whether the subjects believed the suggested details and whether suggestions impair memory. Other research (Loftus, 1979; 1989) has indicated that suggestions or misinformation may overwrite memory and destroy the actual event that occurred, leaving the individual with only the most recent incorrect memory. The following illustrates how easily misinformation can change the memory of an accident. Loftus asked individuals who just watched an accident on video whether they remembered seeing broken glass at the scene. Subjects responded based on the type of question that they were asked. For example, if they were asked if they remember seeing broken glass at the scene after the cars smashed into each other versus when they hit each other, definite differences were seen in the responses. The group that were asked with the term "smashed" in the question responded yes to the broken glass 32% of the time while those that had the term "hit" only 14% responded yes.

Further research by Loftus has produced various experiments that demonstrate the development of false memories. As stated previously, the first step in the memory process is the acquisition stage followed by the retention stage and finally the retrieval stage. Loftus explains that the biases and influence of schemas plays an important role at each stage of the memory process (Loftus,1995). Data obtained from experiments on schemas of memory processing revealed that when subjects were told in advance that words appearing on a screen were related to animals or birds they were more likely to view ambiguous words as being an animal over 75% of the time while the other group that was told the words would be related to travel or transportation would view these same ambiguous stimuli as being related to transportation more than 80% of the time. This demonstrates how expectations and schemas affect encoding of information.

Table II. Loftus Studies and Results

Study Type		Accurate	Inaccurate(misinfo.)
Loftus(1978) Stop sign/yield sign		75%	41%
Loftus (1975) Barn Study		97%	17%
Loftus & Palmer (1974) Car Crash:			
	Smashed	68%	32%
	Hit	86%	14%

Individuals can be primed to remember certain things in the environment simply by biased thinking and expectations. These can be from stereotypic processing or over-generalizing mistakes. The first step of acquisition is inherently based on a number of factors that may occur including the exposure time of the event to be remembered, the frequency of the overexposure, distinctiveness of the event as well as the emotional valence of the stimuli that must be encoded. The more time that the individual has to encode the stimulus the better his/her ability to correctly recall the information will be. Research has also shown that distinctive items or more readily encoded and recalled than neutral items (Craik & Lockhart, 1972). As has been described previously, the emotional aspects of the events can influence subsequent encoding and recall of information as well. Violent or threatening types of environments tend to increase autonomic arousal which causes a decline in overall memory functioning.

Applications of Memory Research

The most direct application of the results of false memory research can be helpful in the area of forensic psychology and law. With growing interest and understanding of the malleability of memory, it is clear how determining the underlying basis of false memory generation can be utilized. Eyewitness testimony is a central theme in use in the judicial systems of the United States and elsewhere. This area has been under heavy scrutiny by Loftus and others. For many years the accuracy of memory has been overestimated, specifically when it deals with eyewitness accounts. Wells and Leippe (1981) found that subjects were very poor at remembering peripheral details of a crime scene if they had focused on the assailant and correctly identified him. The inability to store a large amount of information into long term memory is the underlying factor that influences the production of incorrect recall or recognition. This inability to store large amounts of information accurately is explained by the limited resources in working memory. These limited resources lead to exclusion of specific details in a crime scenario which may be filled in later by leading questions and misinformation.

Other research into eyewitness testimony has revealed that if violent and/or stressful conditions were present during the process of encoding of the memories the subsequent retrieval of these memories were rated as less reliable than situations that were non violent in nature (Clifford & Hollin, 1981). Research on the role of emotions in memory processes has shown that emotionally charged material leads to a disruption in the memory formation and that the mood or state of the individual has to be congruent with the emotional nature of the material being stored (Bowers, 1987).

The misinformation effect presented by Loftus (Loftus, 1979) has been replicated with similar results by other researchers (Wells, 1993). The method used currently for misinformation and memory implantation uses scenarios like hospital stays during childhood that never happened, stories about being lost in a shopping mall, and mechanics holding various tools. Each of these scenarios elicited about a 27% rate of false memory generation. By understanding the principles of memory and developing a means of being able to determine if a memory is in fact inaccurate, would be invaluable to the legal system.

The aim of the present study is to generate behavioral data from implanted memories of events and to determine the effect misinformation has on the subjects ability to recall these events. Previous research in this area has focused on the number of items correctly and incorrectly recalled. This study will also examine these statistics as well as focusing on the reaction times for the various words across the groups. Reaction times are used to assess the level of cognitive processing that is taking place.

The longer the reaction time or response to the stimulus event the more processing must be occurring in relation to the stimulus. One can examine this process in relation to semantic activation that was described earlier. The use of misinformation may lead to activation of information related in some way to the event. By activating semantic associates of the item, accurate recall of the item may be decreased or slowed down since now the individual has to determine which item was actually presented.

The phenomenon of interference on memory will be assessed by examining the reaction times of the participants in each group. The behavioral data that will be obtained will be based on the reaction times of the subjects to the stimulus events and the number of correctly and incorrectly recalled items. The use of the structured items in this study follows the research done previously by Elizabeth Loftus. The questions asked to the participant in the structured interview will produce the misinformation that is expected to interfere with memory and result in the development of false or incorrect memories of the event. The unstructured questions will be used as a measure to determine the extent that the structured questions has on the participants ability to encode and retrieve relevant and accurate information about the crime scene.

It is hypothesized that the group given the most misinformation via the structured interview will have the slowest reaction times overall as well as having more incorrectly recalled items. This hypothesis is based on the data from previous misinformation experiments by Loftus (1979 & 1989), Schacter (1989 & 1997) and Koustaal & Schacter (1997). All these experiments revealed significant differences between the groups that received misinformation and the ones that did not on their ability to accurately recall information as well as the development of falsely recalled information about the event. The following table represents the groups that were used and the expected results from the misinformation.

Table III. Expected Results.

Group	Average Reaction Time	Percent Incorrect
Group 1(control)	Second fastest	10%
Group 2(unstructured)	Fastest	1-2%
Group 3(structured)	Slowest	50%

Method

Participants

Eighty-seven subjects participated in this study. There were 42 males and 45 females and the average age was 22.6 years. Twelve participants were dropped because of missing data. Since gender was not a variable in this study the groups did not need to have equal numbers of males and females. There were 25 participants randomly assigned to each of the three groups. Only right handed individuals with normal or corrected-to-normal vision were used as well as those with English as a first language. This restriction is needed since the stimuli used are all English words and individuals not familiar with the language will lead to extraneous variability in the data. All participants were drawn from the Oklahoma State University undergraduate population; they received extra course credit for their participation.

Material/Apparatus

Design of video

The three minute video segment was taken from the movie Double Revenge[Universal Studios Home; copyright, 1975]. The movie is a general action movie with two armed assailants that rob a small town bank and then try to make a getaway in a late model car only to be met with deadly force by the police of the town. After a lengthy gun battle one of the assailants was killed and the other got away. The film then focused on the search and subsequent apprehension of the last assailant. The segment used begins with a vehicle with the two assailants inside approaching a bank. They enter the bank and order the customers and employees at the bank to obey them. A security guard is shot and the segment ends with the assailants leaving the bank and going toward the vehicle in an attempt to escape. This movie segment was chosen since the movie itself is relatively obscure and over twenty years old. The segment had to include some violence and a robbery that lasted at least two minutes to ensure enough items were available to be recalled later. The segment is 3 min and 27s long.

Apparatus for Behavioral Data and Collection

A 19-inch color television monitor and video cassette recorder were used to present the video. A 66Mz IBM-compatible computer was used for stimulus presentation and collecting manual reaction time responses from the participant. The test stimuli consisted of 70 words. Seventy words were chosen to facilitate the introduction of incorrect words in a manner that was not overly obvious. The stimuli were set to remain on the screen for 1000 milliseconds since this was found to be the best length of time for brief encoding of the words from previous experiments done in this laboratory.

There were 25 control words, 25 words accurately related to the video that was viewed, and 25 words that were not related but used as the misinformation, such as blue car for the unrelated words (the car in the video was grey), and shotgun for a related word which was present in the video. See appendix D. The stimuli were presented in a random order on the screen for 1000ms each. The participants responded using either the left or right hand indicating whether they had seen what the word refers to during the video. The 'a' key and 'l' key were used as the trigger buttons for yes and no responses. The counterbalancing of response hand is used to control for hemisphere effects and to take care of any of the "yes effect" phenomenon that may occur. This phenomenon is not actually present in this study since subjects are asked to respond whether or not the stimulus was familiar or unfamiliar. The processing for this recall type of task is more globalize or distributed than a straight 'yes'/ 'no' response. The latency involved with the familiarity response should be longer or more endogenous than a yes/no response because of the depth of processing involved. The behavioral data obtained was analyzed using a C compilation program and stored in coded data files.

Structured Questions

The structured interview questions consisted of 25 questions that were balanced for prosody, syntactic order, word frequency, and reduced to the smallest number of words that can convey the meaning of the question. These questions were presented in the exact same fashion for each participant in this condition by a trained Research Assistant. The questions contained the misinformation in an indirect fashion. A list of these questions appears in Appendix B.

Unstructured Questions

The unstructured interview was conducted by asking participants to recall as much as they can about the video without the experimenter's intrusions/interruptions. The experimenter is to follow a specific list of prodding techniques to help the participant cover everything that they remembered from the video (see Appendix B) after they have finished describing everything that they can remember about the video without interruptions. No new information will be introduced during this interview, however.

Control Group Design

The Control group performed a global/local distracter task requiring approximately three minutes to complete. The purpose of the control group was to have a comparison group for the two interview groups to determine the baseline recall of the items. The global/local distracter is a quick measure of determining the type of processing an individual uses. This measure is used as a means to assess depression. It consists of 30 pages each consisting of three images, a reference and two choices. The individual is to pick the best alternate they think matches the reference. This was used since it required some cognitive processing and can eliminate a subject from rehearsing the test stimuli. The video seen on the previous day was not discussed and any questions pertaining to it were not to be answered. The participant was asked to return the following day to begin the recording of data.

Procedure

All participants filled out the demographic and consent forms. They were then given directions on how to perform the study. The procedure required three separate days described in detail below.

Day 1

Day one of the experiment consisted of filling out the demographic and consent forms, subject instructions, and presentation of the video. There were three groups which viewed the crime scenario video. Subjects left immediately after watching the video with explicit instructions not to discuss the experiment with anyone.

Day 2

Day two required that the participants return to the laboratory and be subjected to only one of the three treatment conditions. Group 1 was the control group who simply performed a global/local distracter task unrelated to the experiment (no interview group). The Group 2 was asked to recall as much as they could about the video using the unstructured interview format (Appendix C). Group 3 was interrogated in a structured interview format using twenty questions about the video (Appendix B). Thus, implantation of misinformation was administered only to Group 3 using the structured interview. This was accomplished by asking specific leading questions. Usually, the question focuses on something that took place in the video but altered in some form. For example, the color of the car in the video may have been yellow, but the interviewer may refer to it as "the white car." Thus, the word "white" has the potential of being implanted. If a subject attempted to correct the experimenter in the structured interview by saying that there was no white car in the scene, the experimenter reminded the subject to just respond appropriately to the question based on what he/she remembers. If he/she did not remember seeing it then he/she responded that they do not remember seeing a white car.

Day 3

Day three involved data collection of the behavioral data. The participant sat in a comfortable chair for recording with a 14-inch computer monitor facing them in the testing suite. The keyboard was placed in the participant's lap and the instructions and practice set was given at that time. The instructions to the participant were to look directly at the center of the screen, and to try to minimize eye blinks. The participant was instructed to use either their left or right index finger for making a positive or negative response when the stimuli appeared on the screen. They were told to respond as quickly and accurately as possible to the words that appeared on the computer screen. After the computer task was finished they were debriefed about the experiment and asked if they had any questions about it. Once the participant had left, the data were cleaned in DOS and the data analyzed and transferred to a data output file that was used for the statistical analysis in SPSS.

Results

Seventy-five participants performed the experiment. The data obtained from the behavioral experiment was screened for normality of distributions, linearity, homogeneity of variances and outliers. Twelve cases were dropped due to missing data in the output file as a result of responding beyond the 2000ms window set as the fixed upper limit for all subjects. Also, if there were more than 10 trials of missing data in the output file then that case was deleted from analysis. There were 25 participants in each group. Twenty five participants were chosen to exceed the minimum cell size needed for power in ANOVA designs (Hair, Anderson, Tatham, Black, 1995). The analyses for this study focused on items correct and reaction times for speed of response. It was expected that the unstructured interview group to have the fastest and most accurate results. See Table IV.

Table IV. Expected Results.

Group	Average Reaction Time	Percent Incorrect
Group 1(control)	Second fastest	10%
Group 2(unstructured)	Fastest	1-2%
Group 3(structured)	Slowest	50%

The first analysis that was performed was a 3 x 3 BW ANOVA. The between factor consisted of the three levels of interview and the word type condition was the repeated measures variable. This first analysis focused on reaction times for incorrect responses between the groups on the type of word that was presented. The ANOVA was performed and subsequent post hoc comparisons were then made for all significant main effects since the interaction was not significant, $F(4, 92) = 1.43$, $p > .05$. The between variable group was significant, however, $F(2, 50) = 3.62$, $p < .05$. Post hoc comparisons among the three levels of group indicated that there were significant differences between the unstructured and structured groups only.

Examining the obtained means showed that the structured group had the slowest reaction time of 1229ms and the unstructured group had the fastest mean reaction time of 1082 ms. These are illustrated in Figure 1. The mean difference was 147ms between these two groups indicating that the unstructured interview groups had much faster reaction times than the structured interview group but did not differ with the no interview group. The critical difference calculated by the Neuman-Keuls test was 132.399ms.

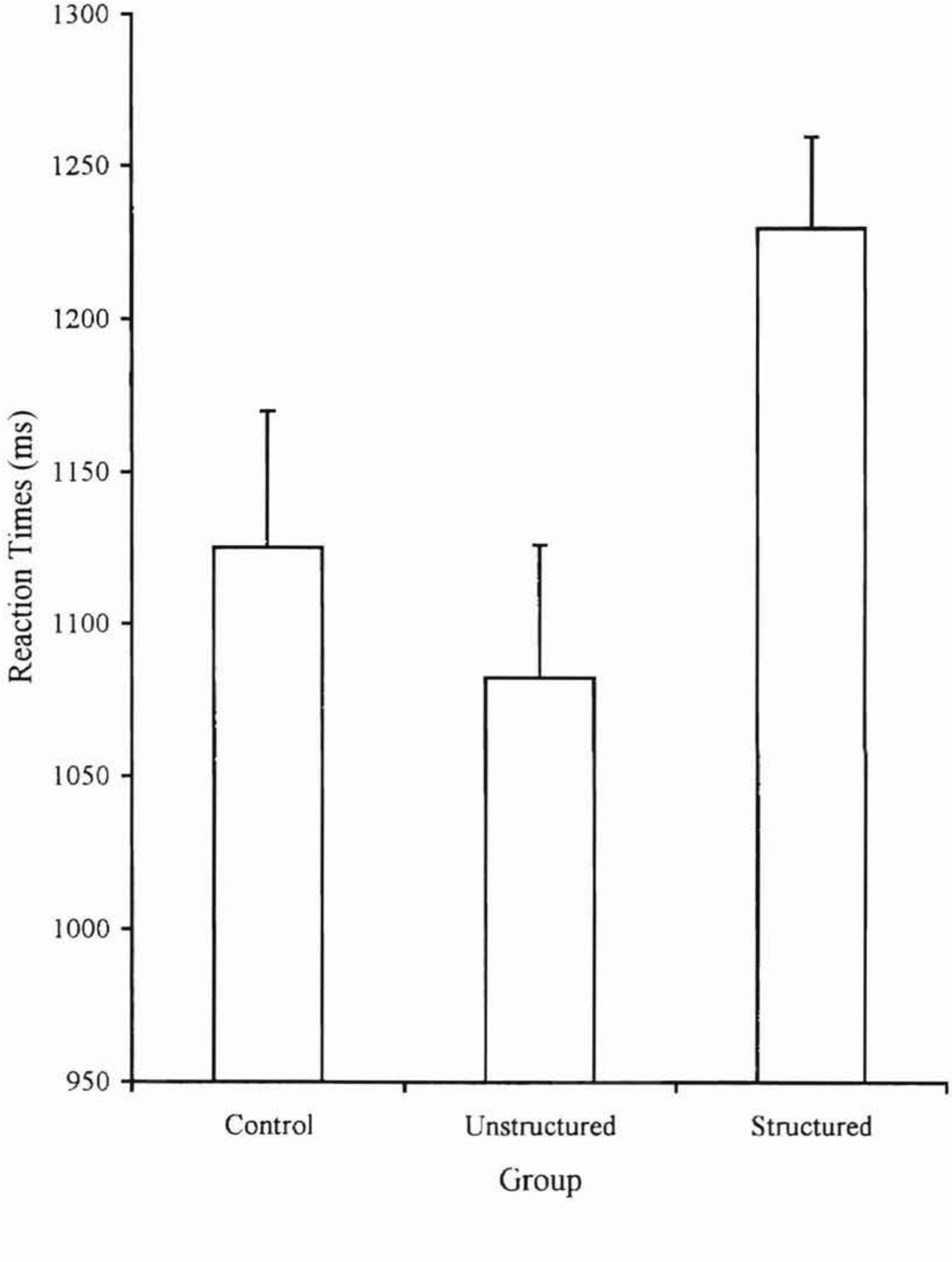

Figure 1. Reaction times for groups for incorrectly recalled items. Error bars represent one standard error of the mean.

The next level of analysis examined the word variable which was found to be significant, $F(2, 100) = 4.29$, $p < .05$. Post hoc comparisons revealed that the control words were responded to significantly faster than the inaccurate words ($p < .05$), while the accurate and implanted words were not significantly different from each other in reaction times. The control words were expected to be faster since there was no interference from other materials. The accurate words were expected to be significantly faster than the implanted words although this was not the case. The control words evoked a mean reaction time of 1091.7ms which was faster than the accurate reaction time average (1164.9) and the inaccurate reaction time average (1180.77). Figure 2 displays the main effect of the reaction times for word collapsed across the grouping variable.

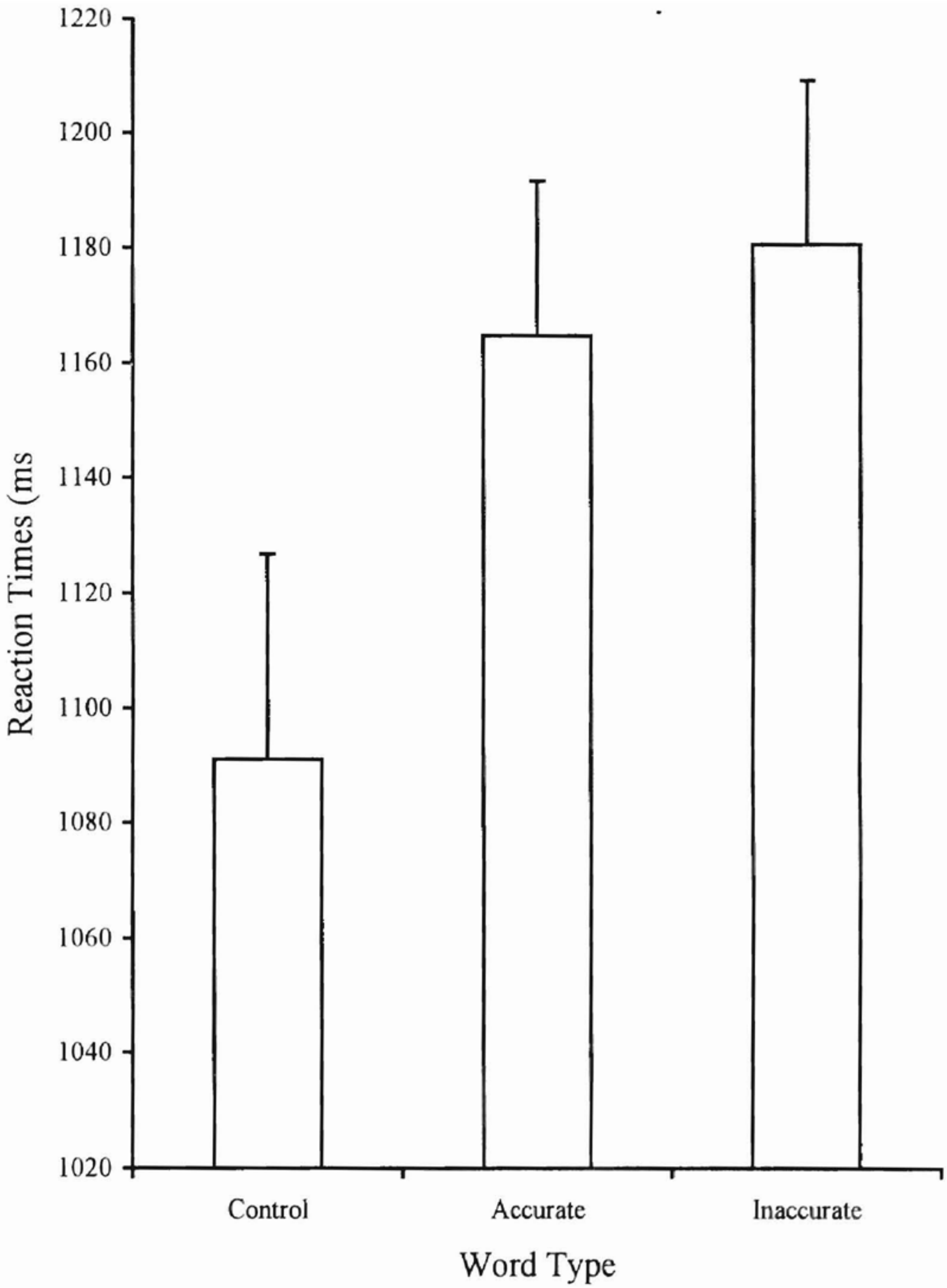

Figure 2. Reaction times for each word type. Error bars represent one standard error of the mean.

The next analysis examined correct responses for the words by group. It was expected that there should be no significant differences among the groups on correct word identification since all groups will have been familiar with these words. The data from the correct trials can also be used to ensure that the response rates of all three groups was similar as well. As expected the ANOVA revealed no significant interactions or main effects between group and word type.

The final ANOVA that was explored was for type of word by group with the dependent measure being number of items incorrect. It was expected that the structured group should make the most errors, while the unstructured group should have the least. The group by word interaction was significant $F = 22.05$, $p < .05$. Since this is an interaction the main effects are not examined as they are subsumed within the interaction even though both main effects were significant. $F(2,144) = 174.77$; $p < .05$; $F(2, 72) = 27.97$; $p < .05$ respectively. This being the case, the cell means were explored in relation to each other. Contrasts were also performed to examine where the significant differences occurred in this analysis. The post hoc contrasts revealed that groups 1 and 2 did not significantly differ in number of items incorrectly recalled. Lines representing groups 1 and 3 were significantly different ($p < .05$) and lines 2 and 3 were also significantly different ($p < .05$). Figure 3 illustrates the interaction graph between group and word.

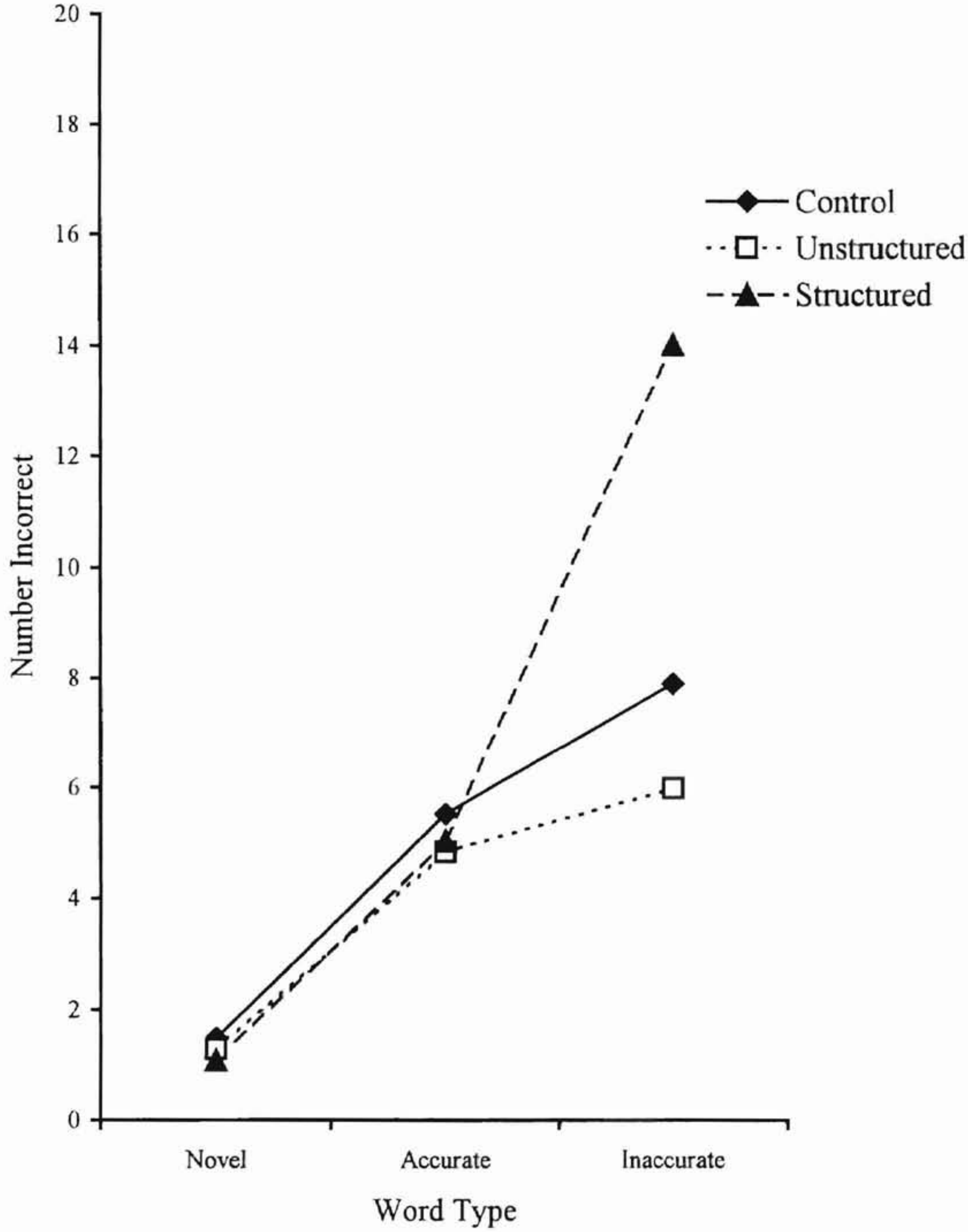

Figure 3. Interaction of group by word on reaction time.

The unstructured and control group lines are not significant from each other while the implanted line can be seen to vary significantly from the other two. The interaction is sustained mainly from the large difference on implanted words for the structured group. The overall interaction can be seen to be derived solely from the large number incorrect, mean =14.04 for the structured group. Simple effects analyses revealed that the other points within the interaction graph were all non significant as well. The marginal means for group revealed once again that the structured group performed more poorly than the other two; these are illustrated in Figure 4.

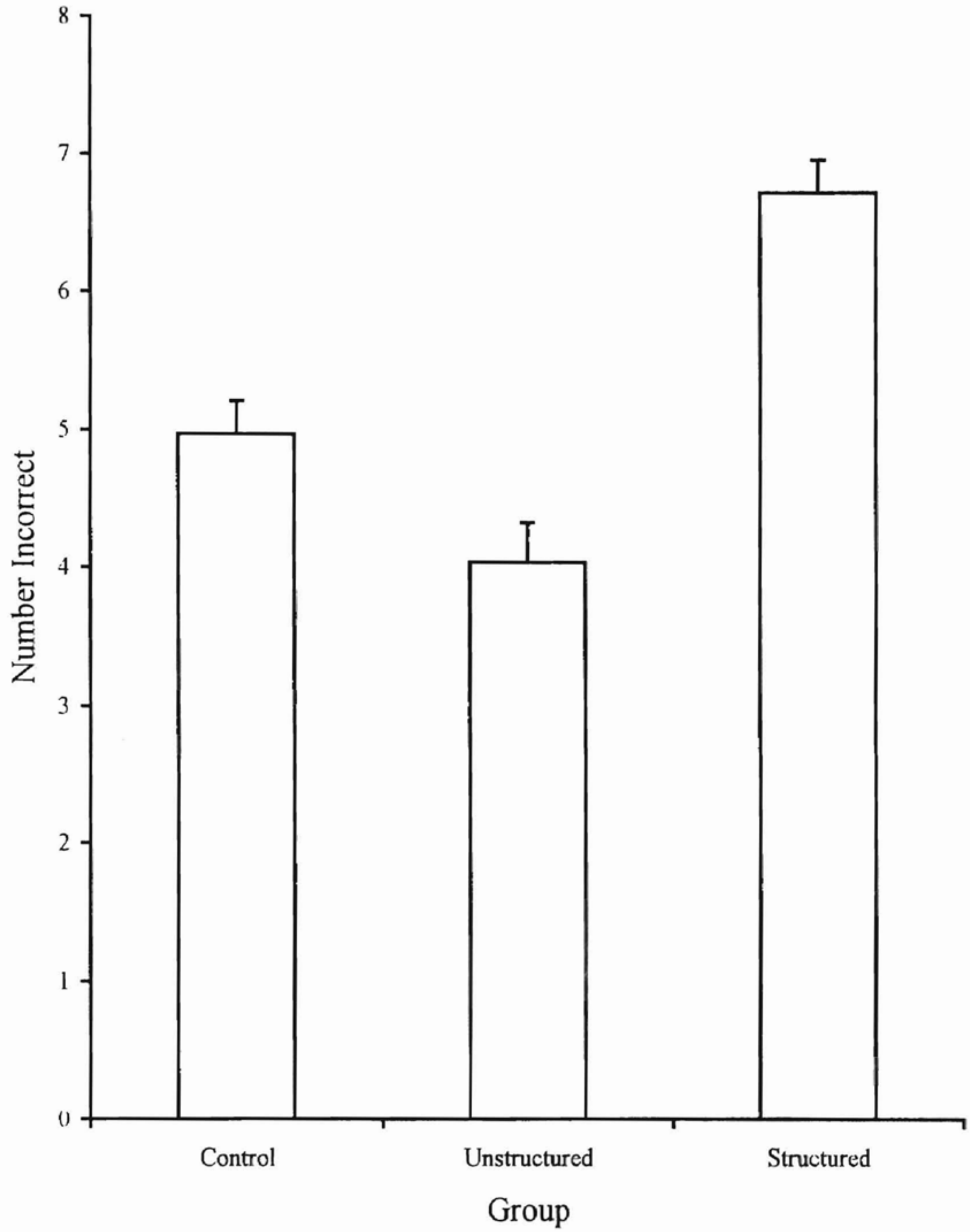

Figure 4. Main effect number of incorrect items by group collapsed across word type. Error bars represent one standard error of the mean.

Discussion

The overall results obtained support the hypothesis that the presentation of misinformation will interfere with accurate memory retrieval. There were clear effects of this as seen in the number of incorrectly recalled items for the structured interview group mean = 14.02 for inaccurate words. The overall reaction times for the participants in the structured group were found to be significantly slower than the other two groups. The examination of specific main effects and interactions are to be discussed next. Table V presents the groups and group labels for use in discussion.

Table V. Group Labels

Group	Type
Control group	No Interview (control)
Unstructured group	Unstructured Interview
Structured group	Structured Interview

Behavioral Findings

The first hypothesis that was examined were the reaction times that were obtained for the groups. The groups reaction times were based on the onset of the stimulus word and when the appropriate response key was pressed by the subject. The control group which had received no information of any kind had reasonably fast reaction times, at least much faster than did the structured group. As expected, the unstructured group was the fastest at the task. This supports the theories of elaboration and rehearsal for faster retrieval of information that was stored in memory. The subjects in the unstructured group were allowed to freely recall the video and attempt to visualize what they had seen the previous day. By recalling this information one strengthens the overall memory as well as reinforcing it by elaborating on the various aspects of what they remembered seeing. It also illustrates that recall was significantly faster for the unstructured group over the structured group ($F(2, 50) = 3.62$, $p = .034$).

The unstructured group was also more accurate than the other two groups as expected ($F(2,72) = 27.97$; $p = .000$). A point can be raised that since this the unstructured group and the control group did not receive any misinformation, then the items that are called 'misinformation items' are really in fact novel items to these two groups. Some of these misinformation items could in some way be linked to the crime scene but were never actually in it.

The structured group on the other hand was given this misinformation which interfered with accurate details of the scenario and during the time interval between the interval and the actual task itself both types of memory distortions took place. The first distortion is decay because of the 48 hours between first viewing the video and then performing the task itself, and the second distortion being interference of the new information on the memory trace.

Since the activity of the mind cannot be observed directly one can often use reaction times and other types of indirect observations of the operations of the human brain as was done here. It can be assumed that the longer the reaction time then the more processing that is taking place. Since the structured group had the longest reaction time it is argued that they were taking the most time processing the information and responding because of decay and interference. This follows the hypothesis that misinformation in some way distorts the actual memory system itself.

The participants in the structured group were able to encode the crime scene and the events adequately, but when the misinformation was introduced the following day this contradictory information was made to fit the existing scenario in some way. With this new information the participants in the structured group had to perform a more complex and exhaustive search in memory to decide whether the stimuli were present in the scene or not. The extent of the processing that these participants went through was very different then the straight recognition recall that the other two groups had to perform. This is illustrated by the almost 105ms difference in reaction times between the control group and the structured group.

The effect of the type of stimulus word was also found to be significantly different across all word types. The novel words had the fastest reaction times as these did not have to be processed as deeply because they were not relevant contextually to the crime scene. The accurate and inaccurate words were about equal in reaction times. This was surprising since the inaccurate words should have had a somewhat faster reaction time for the control group and the unstructured group because they were novel words. The results indicate that this did happen with the structured group being much slower on the inaccurate words which demonstrates an increased depth of processing and more exhaustive search. But this same effect happened to the control and unstructured group. Perhaps the words that were used as the inaccurate items were viewed as possibly being in the video and so all groups tended to have to process this information a little deeper. This is likely to be the case because the inaccurate words had to be related in some way to the video and were not just completely novel. This was so that the structured group who received the inaccurate information through the interview would believe that these items could have been in the video. Basically, the items had to be believable.

Further examination of the data lends support to the notion that an unstructured interview helps in recall of the information. The unstructured group had the fastest times on the novel and accurate words since they were able to relive the crime scene during the interview. This reactivation of the stimulus events led to a decrease in decay and interference as well as speed of retrieval of the items during the recall task.

The number incorrectly recalled in the group by word interaction is now examined. As expected, the structured group had the largest number of incorrectly recalled items, mean = 14.04 while the unstructured group had the least, mean = 6.0. All three groups made relatively few errors for the novel items. The accurate items were recalled correctly as well.

The results obtained are consistent with previous research that has shown the influence that misinformation has on memory. The results of this study illustrates the fragile nature and malleability of human memory. The magnitude of the effect of the misinformation was actually higher than expected. The introduction of misinformation clearly had an effect on the individuals ability to accurately recall events related to the crime scene. From an ecological perspective one can see how important it is not to introduce any type of information during the questioning and interrogation process.

Another factor that needs to be distinguished in this type of study is the difference between recognition and recall. Most memory research utilizes recognition in that the subject is presented with the stimulus that was presented earlier and asked whether or not they remember seeing it. This is different from recall where the words or items are not presented to the individual to chose from, but rather they must draw all information from memory without any type of cueing stimulus. The results of this study show that as more interfering items are presented via the structured interview, the harder it is for the subject to correctly recognize the correct information. This is based on the much slower reaction times and the number of incorrect responses. A possible direction for future research would be to design a study in which recall and recognition memory were both accessed and a direct comparison between brain activity and reaction times could be assessed.

The next area that can be addressed based on this study is that of memory construction. The results obtained definitely show that individuals when exposed to new information will incorporate this information into their existing memory traces. Humans have a predisposition to fill gaps that exist in memory so that the memory can be seen as a complete and fluid whole. Interference and decay play an integral role in this process and based on results from this study and others one can conclude that this is simply a normal part of the memory process. With this in mind we once again must take this into account whenever memory is used in capacities such as eyewitness testimony or identifications.

Limitations and Future Research

Possible limitations of this study are the use of a video rather than a live event. Since a laboratory scenario is not as threatening as being in a real traumatic situation and therefore the autonomic system may not be as active as it would in a real life event. Due to ethical considerations it is not possible to generate an environment that is very stressful and one that could generate autonomic arousal. Although the event that the subjects witnessed occurred on video the results that were of interest

The design of this study made it possible to examine differences in recall accuracy of an event from a cognitive perspective. Future research can be done using various physiological forms of measurement. As better measures of cognitive functioning are developed these instruments can be used to evaluate the regions of the brain that are most intertwined with the processes of memory retention and retrieval, especially in the formation of false memories.

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Appendix A

Demographic Data Form and Consent Form

IF YOU AGREE TO PARTICIPATE, PLEASE COMPLETE THE FOLLOWING INFORMATION AND SIGN IN THE SPACE PROVIDED BELOW.

SUBJECT CODE ____ ____ ____ ____ ____

1.	Which hand do you write with?	Left	Right
2.	Your date of birth (month / year)	_______ / _______	
3.	Your gender (please circle one) Female	Male	
4.	Any history of neurological disorders or head trauma?	Yes	No
5.	Do you have a prior history of reading disabilities?	Yes	No
6.	Do you have normal or corrected to normal vision?	Yes	No
7.	Education (check highest one)	_____1st year undergraduate _____2nd year undergraduat _____3rd year undergraduate _____4-year College (BA,etc.) _____Post-Graduate Degree	

****

YOUR SIGNATURE BELOW INDICATES THAT YOU HAVE READ THE ATTACHED INFORMATION AND YOU ARE CONSENTING TO PARTICIPATE IN THE RESEARCH DESCRIBED ABOVE.

****

______________________________   ____/____/______
Your Signature   Date

______________________________   ____/____/______
Witness   Date

If you would like to learn about the results of our study when it is completed, please initial below, and leave an address where you would like them sent.

_____   Name (print) ___________________________
Init.

Address:

____

Appendix B

Structured Interview Questions

1. © Do you remember the name of the bank? (Morefield savings)

2. (MI) What type of blue car did the assailants get out of. (car was really gray).

3. © What color gloves was the passenger in the car wearing.()

4. (MI) What type of jacket was the driver wearing.

6. (MI) Do you remember which assailant had the black ski mask.

7. (MI) What color was the blanket that was thrown over the banks video camera.

8. (MI) Did the security guard's scream, when he was shot, make the assailant stop?

9. © What color was the alarm button being pushed.

10. © Was there any money left in the drawer.

11. (MI) What color was one of the assailants moustache

12. (MI) Approximately how many minutes before 2pm were shown on the clock?

13. © Was the pregnant women crouched or standing?

14. (MI) Do you remember the approximate age of the older black man shaking and holding the money?

15. © Did the police or the assailants fire first when they were getting into the car.

16. © Sherrif symbol on policecar door.

17. (MI) Did the paper sack he put the money in have any writing on it?

18. (MI) Did the security guard clutch his chest when he fell forward?

Appendix C

Unstructured Interview Prompt Questions

The experimenter is to prompt the subject into describing in as much detail as possible all the events that the subject can remember about the video. No new information is to be given, just guiding the subject along with general suggestions.

1. Please describe everything you can remember about the crime video starting at the beginning.
2. Do you remember seeing anything else.
3. What else do you remember about the interior of the bank.
4. Do you remember seeing any weapons.
5. What happened as the assailants were leaving.
6. Where did they go?
7. Is there anything that you can remember about the crime scene?

Appendix D

Word List (1=Control 2= Accurate 3= Inaccurate)

BLUE CAR 3
PILLOW 1
ASSAILANT 2
BLANKET 3
CATERPILLAR 1
MOREFIELD 2
DANCE 1
MONEY 2
GUARDS YELL 3
MOUSE 1
PREGNANT 2
MOUSTACHE 3
SHOTGUN 2
2PM 3
AUTHOR 1
SILENT ALARM 2
BLACKMAN 3
PASTE 1
BROWN HAIR 2
ROSERY BEADS 3
CANDLE 1
BAG 2
PAPERBAG 3
MOON 1
WINDSHIELD 2
CARRIAGE 3
BLOUSE 2
FIVE MINUTES 3
OLD 1
BLUEJEANS 2
MALE TELLER 3
RIVER 1
CORVETTE 3
HAT 2
HARRY 3
HORSE 1
KNIFE3
TELLERS 2
GALAXY 1
PLANE 3
FARMER 1

SKIMASK 3
CANCER 1
WHITE BUTTON 2
SANTA 2
LIMP 3
YIELD 3
TRAIN 1
CLOCK 2
NORTHFIELD 3
GROCERY 1
JACKET 2
HANDKERCHIEF 3
LIBRARY 1
STEWARDESS 1
GUARD 2
CIGARETTE 3
SHERIFF 2
BASEBALL CAP 3
CARBOHYDRATE 1
GLOVES 2
CHESS 3
LIGHTHOUSE 1
DOOR 2
MASTERPIECE 1
WATCH 3
LOOPHOLE 1
DOLLAR 2
CAMERA 2
LAKE 1
PUDDLE 3
TEACH 1
SCREAM 2
TRAFFIC 3
SOCCER 1
GLASSES 2

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	February 11, 2000	IRB #:	AS-00-086
Proposal Title:	"NEUROPSYCHOLOGICAL ANALYSIS IF IMPLANTED FALSE MEMORIES"		
Principal Investigator(s):	Charles Abramson Marc Pratarelli Blaine Browne		
Reviewed and Processed as:	Continuation		

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson

Carol Olson, Director of University Research Compliance

February 11, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

VITA

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Master of Science

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