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The Effects of Alcohol on Semantic Memory

Norman A. Kerbel

THE EFFECTS OF ALCOHOL
ON SEMANTIC MEMORY

by
Norman A. Kerbel

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ABSTRACT

Previous studies have shown that the effects of alcoholic intoxication on memory result from a functional decrease in capacity of working memory (e.g., Petros, Kerbel, Beckwith, Sacks, & Sarafolean, 1985). However, other studies looking at speeds of retrieval of information from long-term memory have brought this conclusion into doubt (Moskowitz & Roth, 1971). The present study presented subjects with decisions to be made regarding word pairs. Three conditions were used, each requiring different amounts of information to be accessed from long-term memory.

Sixty-six male college students, between the ages of 21 and 29 years, were divided into two groups. One group received one milliliter of absolute alcohol per kilogram of body weight in the form of 80 proof vodka mixed with a peppermint masking solution. The second group received an equivalent amount of water mixed in the same masking solution. Subjects were further divided into higher and lower verbal ability groups on the basis of their raw scores on the Wechsler Adult Intelligence Scale-Revised Vocabulary subtest.

Subjects were presented with word pairs and asked to make yes/no decisions as to whether the words were physically identical (PI), the same name (SN), or from the same semantic category (SC). Response times and accuracy of response was automatically recorded by computer.

Two (treatment) x two (verbal ability) x three (decision type) x two (response type) mixed ANOVAs were run on median response times, as well as proportion of errors made. No significant differences were found for treatment effects (alcohol, placebo), but interaction between treatment effects and other factors limiting functional capacity of working memory were found. General support was found for the theory that alcoholic intoxication results in a decreased functional capacity in working memory. Specifically, the speed of the working memory process of accessing information from long-term memory was found to be slowed.

CHAPTER I

INTRODUCTION

Alcohol is a widely-used drug in our society. Recently, several studies have looked at the acute effects of alcohol intoxication on memory processes (e.g., Parker, Birnbaum, & Noble, 1976; Birnbaum, Parker, Hartley, & Noble, 1978; Petros, Kerbel, Beckwith, Sacks, & Sarafolean, 1985). These studies have focused on the effect of the drug upon the memory processes of non-alcoholic social drinkers, rather than examining the permanent disruption that occurs from a long history of abusing the drug.

A better understanding of alcohol's effects on memory will provide important information in two areas. First, it will aid in explaining and describing the specific memory disruptions that occur while intoxicated, and thus provide important information about the acute drug effects. Second, by studying the disruption in memory performance caused by alcohol we can better understand the normal functioning of memory processes, since it allows the components of memory to be examined more directly.

In the material that follows, the literature regarding lcohol and memory processes will be reviewed. This iterature review will examine several areas. First, the physiological effects of alcohol on the human body will be discussed. Second, the model of human memory used in this study will be described. Third, a review of studies using non-human subjects to look at the cognitive effects of acute alcoholic intoxication will be presented. Fourth, studies that have looked at the effects of acute alcoholic intoxication on human memory will be presented and discussed. After the literature review, a study addressing limitations in the existing research will be described and discussed.

Physiological Effects of Alcohol

Alcohol is a drug that has actions beyond the central nervous system. In this section, the pharmacology of alcohol will be examined, followed by a discussion of the process by which alcohol is metabolized in the human body.

Ethanol, the drug contained in alcoholic beverages, diffuses from the stomach throughout the body quickly (Dubowski, 1985). The rate of diffusion can be affected by several factors, including the quantity of food in the stomach and the concentration of ethanol in the stomach (Lieber, 1976). Food in the stomach will slow the absorption of ethanol, and cause the blood alcohol levels to remain significantly lower than if the stomach were empty.

Ethanol easily enters any body area that contains a large concentration of water. High concentrations of ethanol are found in water, while low concentrations are found in body fat. Ethanol easily crosses the blood-brain barrier, and is found in high concentrations in the brain (Lieber, 1976).

Excretion of ethanol involves several chemical changes. Only 5 to 10 percent of the drug is excreted unchanged through the urine, or through exhaling. The first step in metabolism of ethanol is its conversion to acetaldehyde through oxidation in the liver. The primary liver enzyme responsible for the oxidation is alcohol dehydrogenase. Ethanol elimination proceeds at a constant rate, so the greater the concentration of ethanol in the body, the longer it will take to metabolize. The rate of metabolism varies widely among individuals, but as a general rule, 10 milliliters of absolute alcohol can be metabolized by an average size man in one hour (O'Neill, Williams, & Dubowski, 1983). There is approximately the same amount of ethanol (15-20 ml absolute alcohol) in 12 ounces of beer, four ounces of wine, or one ounce of whisky (Goldstein, 1983).

Acetaldehyde appears to have no intoxicating effect, although it is a more potent drug than ethanol. Most acetaldehyde is immediately converted by enzymes into a relatively harmless compound called acetate. Acetate travels throughout the bloodstream, and is converted by bodily tissues into carbon dioxide. Small amounts of acetaldehyde are not immediately converted into acetate, and enter the bloodstream unchanged. Acetaldehyde does not easily cross the blood-brain barrier (Dubowski, 1985).

A Model of Human Memory

In order to understand the effects of alcohol better, the model of human memory used in this paper will now be described and discussed. Numerous conceptualizations of human memory have been hypothesized. In the present paper, a conceptualization of memory as a flow of information between a series of memory stores will be used (Atkinson & Shiffrin, 1968). In this model, information is first received through the senses and placed in a sensory memory. Sensory memory is a very brief memory store, with information remaining in this store for less than one second. The information from this store is lost unless it is transferred to short-term memory. Short-term memory has been shown to have a limited capacity (Atkinson & Shriffrin, 1968). Evidence for this capacity limit has been seen in digit span tests. In such tests, subjects are asked to listen to strings of digits verbally presented at the rate of one digit per second. After all digits have been presented, subjects are asked to recall the entire string of digits in the order presented. Such studies have consistently shown a short-term memory capacity of seven plus or minus two digits (Atkinson & Shiffrin, 1968). Information in short-term memory is lost in approximately 30 seconds unless the information is rehearsed (Glanzer & Cunitz, 1966). The process of rehearsal allows information to remain in short-term memory, and also allows transfer of the information to a third memory store, known as long-term memory. Long-term memory is a permanent memory store. Thus, once the information is encoded into long-term memory, it can be accessed in the future as needed.

Working memory refers to a more active part of the human information processing system. It includes the passive information storage system known as short-term memory, as well as active information processing systems necessary to select, retrieve, process, and store information (Daneman & Carpenter, 1980). Active functions include the process of attending to the sensory store and long-term memory for the purposes of selecting information, transfer of this information to working memory, processing of information within working memory, and storage in long-term memory of the results of processing information. Several specific working memory processes will be discussed later in this chapter.

Empirical support for the distinction between short-term memory and long-term memory has been provided by Glanzer and Cunitz (1966). In this study, subjects were presented with lists of 20 words presented verbally, one at a time. After hearing each list, subjects were asked to recall the words from the list in writing in any order. The experimenters varied the rate of presentation of the words in the list. That is, items were spaced every three, six, or nine seconds. Changing the rate of presentation was assumed to affect long-term storage since it should allow increased repetition of the earlier list items by the subject. In a serial position recall curve, recall of earlier items in the list is assumed to be a measure of successful long-term memory storage, since capacity limitations of short-term memory would have caused later items from the list to replace these early items. For this reason, recall of items presented later in the list can be assumed to be a measure of short-term memory, since the subject has had insufficient opportunity to rehearse the items, in order to transfer the items to long-term memory.

Results from the study showed a clear effect of rate of presentation of the words. That is, the greater the spacing of the items, the greater the improvement of recall of items early in the list. However, no change in the number of items recalled at the end of the list was seen as a function of rate of presentation. This study provides support for the distinction between short-term memory and long-term memory, that they are two separate memory stores, due to the differential effect on the beginning and end of the lists. Due to the recency of presentation, the final items of the list remain in short-term memory. However, the early list items must be repeated in order to be transferred to long-term memory. Increasing the spacing of the words allows the subject to rehearse the items more, increasing the likelihood of transfer from short-term memory to long-term memory (Glanzer & Cunitz, 1966).

Glanzer and Schwartz (1971) attempted to study the distinction between short-term memory and long-term memory further by looking at the effect that mnemonic structure has on free recall. Mnemonic structure refers to the difficulty subjects have in organizing list items. Mnemonic list items are those that are associated, that is, they have characteristics in common. In their study, subjects were presented lists constructed from 16 pairs of nouns, eight of which were associated (e.g., health, vigor) and eight of which were unassociated (e.g., thief, dentist). Words were presented on a screen from a slide projector at a rate of one word every 2.3 seconds with a 1.1 second exposure time for each word. Subjects were instructed to read each word as it was presented and their recall would be tested either immediately or after a short delay. In the immediate condition subjects were instructed to write each of the words from the list in any order. In the delayed condition subjects first engaged in a delay task in which six words were read aloud by the subject to the beat of an electonic metronome at a rate of .67 seconds per word. After completion of the delay task, subjects in the delay condition were instructed to write each of the words from the list in any order, not including the six words presented in the delay task. Serial position curves for each of the four possible conditions (associated-delay, associated-no delay, unassociated-delay, unassociated-no delay) indicated that the degree of association of list items had an effect on the recall of early list items, but had no effect on the recall of the last words in the list. Thus, degree of association was shown to have an effect on long-term memory, while no association effect was seen on short-term memory (Glanzer & Schwartz, 1971). As expected, adding a delay task after presentation and prior to recall had no effect on the initial items of the free recall curve, while showing a clear effect on the ending items of the curve. This indicates that the delay task had no effect on long-term memory, while clearly affecting short-term memory. It was concluded that mnemonic or association effects influence long-term memory, but have no effect on short-term memory (Glanzer & Schwartz, 1971).

Within the model of memory presented in this paper, two major processes have been conceptualized. These are the processes of encoding and retrieval (Tulving, 1968). Encoding involves the formation and storage of a memory trace. Retrieval involves the location of a memory trace and activating it in working memory. The goal of much of the previous research involving the acute effects of alcohol on memory has been to determine whether alcohol disrupts ncoding, retrieval, or both of these processes. Studies xamining this distinction will be presented later in this aper.

Non-Human Alcohol Studies

In the material that follows, studies that have attempted to look at cognitive effects of acute alcoholic intoxication on non-human animals will be presented. These studies have looked at animal behavior that is assumed to be similar to human learning and memory. Non-human analogs of human cognitive processes have been developed to look at many hypothesized human cognitive functions. Examples of these include procedures to look at working memory processes in mice (Alpern & Marriott, 1972), and analyses of serial position effects for rats (Stretch, McGonigle, & Morton, 1964). The goal of these studies of non-human animals has been to aid in understanding the normal and disrupted functioning of human memory. Numerous studies have shown that non-human subjects have changes in behavior while intoxicated that appear to be the result of changes in the way they learn and remember information (Marriott, Alpern, & Crabbe, 1974). For example, Baum (1969) divided 120 female albino rats into four equal groups. The low dose group received .375 cc of a 20% ethanol solution per 100 grams of body weight. The intermediate dose group received .75 cc per 100 grams of body weight of the same solution. A high dose group received 1.5 cc per 100 grams of body weight of this solution. A placebo group received an injection containing no ethanol.

Prior to receiving the injections, the rats were trained to avoid receiving an electric shock (115 volts AC) on an electrified grid. The apparatus consisted of a large plywood and plexiglass box with an electrified floor and a retracting ledge. Rats were first dropped onto the floor and ten seconds later the shock was applied. To escape the shock, the rats needed to jump on the ledge. After remaining on the ledge for 30 seconds, the ledge would be retracted, forcing the rat back on the floor. The ledge was then returned to its original position. Ten seconds later the floor would once again become electrified. If the rat jumped back on the ledge within a ten second time period it would avoid receiving a shock. All rats were trained to avoid the shock (criterion was ten consecutive avoidance responses) before being administered one of the three alcohol doses or the placebo. Ten mintues after receiving the injection, the rats were placed back on the apparatus, this time with no shock administered. The average number of trials until extinction of the response of jumping on the ledge was measured for each group. Criterion for extinction consisted of the rat not jumping on the ledge within ten seconds on ve consecutive trials. With the exception of the high se, a dose dependent result was found, with rats receiving the placebo dose extinguishing the response most quickly (39.0 trials), low dose subjects extinguishing the response more slowly than the placebo subjects (65.5 trials), and intermediate dose rats extinguishing the behavior most slowly (89.0 trials). Rats receiving the high dose appeared to be unable to jump on the ledge. This degree of intoxication appeared to adversely affect the motor skills of the rats to the point that they were unable to jump. It was concluded that alcoholic intoxication leads to a slower extinguishing of avoidance responses in rats (Baum, 1969). Thus, we can conclude that changes in the behavior of these rats show that the memory processes in certain non-human subjects are affected by acute alcoholic intoxication.

Marriott et al. (1974) conducted a study to determine if a memory disruption occurs in rats as a result of acute alcoholic intoxication. The study was further designed to determine if any disruption found was a result of impaired storage processes, retrieval processes, or both. The apparatus consisted of a t-maze with an electrified grid floor. On the first day of training, the subject was placed in the start position of the maze, and the correct arm was indicated by the presence or absence of high intensity light. A tone sounded, and the subject was then allowed ten seconds to enter the correct maze arm. If the subject failed to enter the correct arm within the ten second time limit, a weak shock would be delivered. The shock would be gradually increased until the animal entered the correct arm, or the maximum level of shock was reached. After this initial trial, the subject repeated the above procedure, without the light cue present. Correct decisions remained the same as in the initial trial. Training for the day stopped when subjects avoided receiving shock on five of six trials, while not receiving shock on the last two trials.

On the second day of training, the correct position was reversed from that of the first day, and the new position was indicated by a light cue on the first trial only. The criterion for stopping training was the same as that for the first day.

The same training process was continued on subsequent days, with one or two position reversals each day. The training phase of the study continued until a goal of no more than one error in five consecutive days for the first reversal of the day was achieved.

A test phase followed in which alcohol dosage, time of alcohol administration, and delay between initial (light cue present) trial, and subsequent (no light cue) trials were varied. All subjects received all levels of each independent variable in all combinations. The order of presentation of conditions was the same for all subjects. Alcohol doses were 1.0 gram absolute alcohol per kilogram of body weight, 1.5 g/kg, 2.5 g/kg, and a placebo condition (0 g/kg). Time delays between the initial (light cue) trial and subsequent (no light cue) trials were 15, 30, 60, 90, and 120 minutes. Time of alcohol administration was either five minutes before the initial trial, 125 minutes before subsequent trials, or both five minutes before initial trial and five minutes before subsequent trials began.

Results indicated that increased levels of intoxication result in a decrease in correct responses. That is, the placebo dosage resulted in the highest percentage of correct responses, the 1.0 g/kg condition had the next highest percentage of correct responses, the 1.5 g/kg condition resulted in less correct responses than the placebo or 1.0 g/kg condition, and the 2.5 g/kg condition resulted in less correct responses than any other condition. Significant effects of delay between initial (light cue) and subsequent (no light cue) trials were found, with longer delays resulting in decreases in correct responses. No significant differences in number of correct responses were found based on time of alcohol administration. The interaction between dose and time delay was also significant. The disruptive effects of higher alcohol doses on percentages of correct responses were greater as the delay increased.

The researchers concluded that alcoholic intoxication affected memory processes in rats. Storage processes were thought to be affected since dose differences were found at the shortest delays. The researchers further argued that this disruption was not due to motivation, perception, or ttention since decreases in correct responses were seen as elays increased in all dose conditions. Since no ignificant differences were found as a result of time of lcohol administration, it was argued that retrieval processes had minimal or no involvement in the observed memory disruption. It was concluded that the observed memory disruption was due to impairment in storage processes, rather than retrieval processes (Marriott et al., 1974).

Human Alcohol Studies

The next section of this literature review will examine the effects of acute alcoholic intoxication on human memory processes. In a preliminary study of the acute effects of alcohol on memory performance, Parker, Alkana, Birnbaum, Hartley, and Noble (1974) administered a high dose of alcohol (1.33 ml absolute alcohol per kilogram body weight), a medium dose (0.67 ml/kg), and a placebo condition (0 ml/kg) to both alcoholic and non-alcoholic human subjects. Subjects were presented auditorily with a list of 30 words. The list consisted of six words from each of five conceptual catagories. Immediately after each presentation subjects were asked to recall the words. Four trials were presented with the same list. Subjects who received alcohol recalled fewer words than sober subjects, and showed less improvement over trials than the sober subjects. Ethanol intoxication was also found to affect the organization of the recall data. Intoxicated subjects' recalls were less likely to be organized by category than were sober subjects. Thus, alcoholic intoxication appears to affect negatively the ability to use a helpful memory strategy, organizing material by category. It was concluded that acute alcohol intoxication has a disruptive effect upon memory processes (Parker et al., 1974).

This study clearly demonstrated that acute alcohol intoxication has a detrimental effect on memory processes. The research that followed attempted to determine which memory processes were affected. Specifically, the next step was to determine whether storage processes, retrieval processes, or both, were responsible for the observed decrement in performance.

Parker, Birnbaum, and Noble (1976) conducted a study to determine if alcohol affected encoding activities. Three dosages of alcohol were used. Subjects received either a high dose (1.0 ml/kg), a medium dose (0.5 ml/kg) or a placebo (0 ml/kg). The authors suggested that in order to study encoding activities, the retrieval demands of the task needed to be minimized so that any differences found between the alcohol and placebo conditions could be attributed to storage processes. Consequently, they used an unpaced paired associate learning task and a forced choice picture recognition task. In an unpaced paired associate learning task, two normally unrelated items are encoded as a pair, that is, a relationship is formed between the two during the presentation of the items. Thus, during retrieval, by presenting the first item of the pair, a pathway is theoretically opened to facilitate retrieval of the second item. The item is either available or it is not. The same is true in the case of picture recognition. Memory tested using recognition procedures is assumed to minimize retrieval difficulties, while recall performance is assumed to reflect both encoding and retrieval processes operating.

In the paired-associate task, 12 stimulus-response items were used. Twelve letters of the alphabet served as stimuli, while the 12 months of the year served as response items. The months of the year were used because they are highly available items and thus should minimize retrieval difficulty. In this task subjects were given one trial in which the stimulus and response items were paired together. The criterion for successful learning was pairing correctly all 12 stimulus-response items once. The dependent variable was the number of trials to achieve the criterion. Subjects receiving the high dose required more trials to achieve criterion than subjects in the medium and low dose condition, who themselves were non-differential.

In the picture recognition task, subjects were exposed initially to a series of photographs of outdoor scenes. During the recognition task, subjects had to pick the target photograph from a series of distractor photographs that were slightly different from the targets. Dose-dependent results were found. That is, recognition accuracy decreased as the dose of alcohol increased. Since it was assumed that the paired-associate task and the picture recognition task minimized retrieval difficulty it was concluded that the encoding phase of memory was disrupted under acute alcohol intoxication (Parker et al., 1976).

The results of Parker et al. (1976) strongly suggested that encoding processes are responsible for the alcohol induced memory disruption observed. These conclusions are based upon the assumption that the tasks used by Parker et al. (1976) minimized the involvement of retrieval processes in the sucessful completion of the task. However, recent evidence suggests that recognition tasks may not be entirely devoid of retrieval processes (Broadbent & Broadbent, 1977; Rabinowitz, Mandler, & Patterson, 1977a; Rabinowitz, Mandler, & Patterson, 1977b; Tulving & Thompson, 1973). For example, it has been shown by Rabinowitz et.al. (1977a) that the accessibility of items, as determined by their retrieval in recall, predicts the likelyhood of correct recognition of the items. However, this conclusion is not universally accepted (Broadbent & Broadbent, 1977). Therefore, it is still possible that the disruption occurred as a result of the disruption of storage processes alone, or from the disruption of both storage and retrieval processes.

In a subsequent study, Birnbaum, Parker, Hartley, and Noble (1978) utilized a procedure that allowed the assessment of the effects of acute alcohol intoxication on retrieval without storage being affected. In the study, all subjects learned both a list of words and a paired associate list while sober. Subjects were either intoxicated (1 ml/kg) or sober (0 ml/kg) during the test trials one week later. Test trials consisted of subjects being asked to recall the word list and being given one test trial through the paired associate list. Alcohol intoxication did not affect the total number of words recalled on either the free recall test or the paired associates test. On the basis of these results, it was concluded that acute alcohol intoxication does not affect the retrieval phase of memory (Birnbaum et al., 1978). This finding is consistent with findings for non-human studies discussed earlier (Marriott et al., 1974).

After determining that acute intoxication had its primary effect upon storage processes, much of the subsequent research attempted to delineate the specific components of the encoding process that were disrupted under acute alcoholic intoxication. Hashtroudi, Parker, Wyatt, & Mutter (1984) conducted a study to determine the degree of vulnerability of different encoding processes to intoxication. Sober (0 ml/kg) and intoxicated (1.0 ml/kg) subjects were presented with four lists of 29 words per list to memorize. Memory for the words was then tested in one of three conditions, free recall, degraded words, or recognition. Subjects in the free recall condition were given five minutes to write down as many of the words as they could remember. In the recognition condition, the 29 words from the list, plus 29 words that were not on the list, were presented again, and the subjects were to decide which words were on the original list. The degraded word condition was a recognition test in which the words were presented incompletely. By using a filtering processs to print the words, random portions of each letter in every word were missing. Thus, the words appeared as if they were photocopied poorly. Subjects were presented with the 29 words from the list, plus an additional 29 words, all in degraded condition. These subjects were then asked to determine which of the degraded words were from the original list. Intoxicated subjects recalled fewer words than the sober subjects, but did as well as sober subjects in the recognition and degraded words condition. Hashtroudi et al. (1984) suggested that recognition of the degraded words represented processes involved in the perceptual components of memory, since the identification of the degraded items was primarily a perceptual process, rather than an elaborative process. Thus, it was concluded that the perceptual components of memory were not affected by acute alcoholic intoxication (Hashtroudi et al., 1984).

Several other studies have attempted to look at what specific encoding processes are disrupted under acute alcoholic intoxication. For example, Jones (1973) conducted a study in which the effects of acute alcoholic intoxication on free recall of word lists were studied. The shape of the serial position curve was used to examine subjects' ability to process information while intoxicated. In word recall studies, subjects are presented with lists of several words, presented one at a time. After all words are presented, subjects are asked to recall all the words from the list. A typical strategy used is to recall first the final few words from the list (which are assumed to be stored in short-term memory), then to recall the first few words in the list (which are assumed to be stored in long-term memory), followed by the words from the middle of the list. Failure to recall words from early in the list while successfully recalling words from the end of the list indicates an impairment in the processes used to transfer words from short-term memory to long-term memory (i.e. rehearsal). If fewer words are recalled from the end of the list, short-term memory is assumed to be impaired (Jones, 1973).

Subjects were randomly assigned to either an alcohol condition (1.32 milliliters of 95% ethanol per kilogram of body weight) or a placebo condition (0.0 ml/kg). Subjects were presented with 18 lists of 12 words per list. Words were presented visually for one second with one second between words. After each list was presented, subjects were asked to recall the words from the list. In addition, lists were presented while subjects were in the ascending limb of the blood alcohol curve (that is, while blood alcohol levels were increasing), and during the descending limb of the blood alcohol curve (that is, while blood alcohol levels were decreasing). Alcoholic intoxication was found to have the largest effect on the primacy portion of the serial position curve. Intoxicated subjects on both the ascending and descending limbs of the blood alcohol curve remembered significantly fewer words from the early portion of the word list than did sober subjects. No differences in the recall of the early list items were seen between subjects on the ascending and descending limbs. Differences between the ascending and descending limbs were found in the middle of the serial position curve. Subjects in the ascending limb recalled fewer middle words than subjects on the descending limb. No difference in the recall of middle words was seen between sober subjects and intoxicated subjects on the descending limb. No differences were seen between the three conditions on the recency portion of the curve. That is, intoxicated subjects on both the ascending and descending limbs, as well as sober subjects did equally well in recalling the final words of the list. It was concluded that alcohol affects long-term memory, but has no effect on short-term memory (Jones, 1973). However, the results of this study may also be explained by a disruption in working memory operations. An impairment in one specific encoding process, the process of rehearsal, may account for the observed results. If acute alcoholic intoxication impaired rehearsal, then the process of transferring information from short-term memory to long-term memory would have been disrupted.

Rosen and Lee (1976) conducted a study to determine whether the encoding deficit resulting from intoxication was due to failure to use categorical information when organizing information for long-term memory storage. Intoxicated subjects consumed enough alcohol to obtain blood alcohol levels of 100 milligrams absolute alcohol per 100 milliliters of blood. This averaged ten ounces of an 86-proof beverage consumed over a 2 to 3 hour period. No beverage was consumed in the sober condition. Thus, no placebo was used in this study. Subjects were asked to recall lists of 20 randomly ordered nouns. The nouns were from four different semantic categories. Normal adult subjects are sensitive to the category structure of the list in their recalls, that is, they cluster their recalls into category groups (Rosen et al., 1976). The results of the study showed that sober subjects recalled more categories than did intoxicated subjects. Intoxicated subjects also recalled fewer words per category than did sober subjects. More importantly, intoxicated subjects organized their recalls by semantic categories to a lesser degree than did sober subjects. It was concluded that intoxicated subjects do not transfer information from short-term memory to long-term memory as efficiently as do sober subjects. This is due to a decreased use of efficient organization strategies in working memory. In this case, that strategy would be to cluster words by semantic categories (Rosen et al., 1976).

Birnbaum, Johnson, Hartley, & Taylor (1980) conducted a study to look at other organizational encoding processes that may be affected by acute alcoholic intoxication. This study was designed to examine whether the elaboration process is impaired by intoxication. Elaboration is a process in which information already in long-term memory is accessed by working memory to assist in integrating new information into long-term memory. Elaboration also serves to clarify new information using previous information (Birnbaum et al., 1980). Sober and intoxicated subjects listened to sentences whose meanings were ambiguous. These sentences contained two phrases that initially did not appear to be related. An example of this is the sentence, "The notes went sour when the seam split." Half of the subjects in each group also heard a word or two that clarified the meaning of the sentence. These words described the relationship between the two parts of the sentence. For example, the word "bagpipes" would clarify the relationship between the two phrases in the sentence presented above. The other half of each group of subjects did not hear these extra words. Subjects were then tested for recognition of the sentences. Subjects were presented with either the actual sentences that were previously seen, or distractor sentences composed of pieces of the earlier presented sentences put together in new ways. For example, if the actual sentence was "The notes went sour when the seam sp[illegible], a possible distractor sentence was "The notes went sour when the fire got too hot." Correct recognition was scored when the subjects correctly stated if they had or had not seen the sentence before. Results showed that without clarification words, sober subjects recognized more correct sentences than did intoxicated subjects. However, when clarification words were provided, no significant differences in correct recognition were seen between sober and intoxicated subjects. It was concluded that acute alcoholic intoxication impaired a subject's ability to use the elaboration process to integrate information in working memory. (Birnbaum et al., 1980).

Birnbaum et al. (1980) found that intoxicated subjects failed to use elaboration to integrate information into memory. However, this study failed to differentiate between different types of elaboration. Hashtroudi, Parker, DeLisi, & Hyatt (1983) conducted a study to determine what types of elaboration are affected by alcoholic intoxication. In this study, sober (0 ml/kg) and intoxicated (1.0 ml/kg) subjects were presented with simple sentences and were told they would be asked to remember the sentences after all were presented. The sentences contained either no elaboration (i.e. The short man put up the tent), a precise elaboration (i.e. The short man put up the tent that was two feet high), or an imprecise elaboration (i.e. The short man put up the tent, and then lifted weights). Finally, in a fourth condition, subjects were presented with a base sentence (i.e. The short man put up the tent) and were asked to generate their own elaborations. Subjects in this self-generated condition were told to write a short phrase containing each sentence. That is, subjects in this condition were presented with the base sentences and were asked to write a short phrase that was a meaningful continuation of the base sentence. When all the sentences had been presented, the subjects were given a cued recall test. In this test, subjects were given the base sentence with the word 'blank' substituted for a target word, (i.e. The blank man put up the tent). Subjects were then asked to recall the word for which the word 'blank' had been substituted. Sober subjects were able to recall more of the target words than were intoxicated subjects in all elaborations conditions and in the no elaboration condition. Relative to the no-elabortation condition, sober subjects showed improved recall in the precise elaboration and self-generated elaboration condition. No improvement was seen in the imprecise elaboration condition. For intoxicated subjects, improvement in recall of target words relative to the no-elaboration condition was seen only in the self-generated elaboration condition. No improvement was seen in the precise elaboration or imprecise elaboration conditions. Interestingly, no significant difference was found in the quality of the elaborators generated between sober and intoxicated subjects. That is, intoxicated subjects generated elaborators that were similar to those generated by sober subjects. Therefore, it was concluded that intoxicated subjects access information from long-term memory as accurately as sober subjects. Hashtroudi et al. (1983) concluded that intoxicated subjects could not integrate new information into existing structures as well as do sober subjects. That is, both sober and intoxicated subjects can generate and access semantic information, but intoxicated subjects have difficulty integrating new information with these elaborators (Hashtroudi et al., 1983).

Therefore, the alcohol induced memory deficits may result from a less efficient execution of working memory operations. One memory task that heavily demands the efficient execution of working memory is prose memory. Successful encoding of prose requires that subjects be able to integrate new information rapidly in working memory (Kintsch & VanDijk, 1978; Perfetti & Lesgold, 1977). In order to integrate new information properly, subjects need to be able to determine the relative importance of each idea from a passage to the passage as a whole. Important information must be attended to more closely than less important information in order to remember the gist of the passage. Thus, if acute alcoholic intoxication affects subjects' ability to integrate information into working memory, the ability to recall a prose passage successfully should be severely impaired by acute alcoholic intoxication. That is, subjects would be less sensitive to the relative importance of an idea to the gist of the passage. Petros, Kerbel, Beckwith, Sacks, & Sarafolean (1985) examined the effects of acute alcoholic intoxication on prose memory. Intoxicated (1 ml absolute alcohol per kilogram of body weight) and sober (0 ml/kg) subjects heard six short passages presented on audio tape. The idea units in each passage had been previously divided into three levels according to their importance to the overall theme of the passage. Thus, in previous work, subjects would recall the greatest number of the ideas from the level containing the most important ideas, a lesser number from the middle level, and the least from the lowest level, which would consist primarily of trivial details. This pattern is referred to as the levels effect. If alcohol severely impairs the ability of subjects to integrate information into working memory, a diminished or eliminated levels effect would be found. That is, intoxicated subjects would show less difference in the number of items recalled between the three levels of importance than would the sober subjects, or intoxicated subjects would remember the same number of ideas from each of the three levels.

The rate of presentation of the passages was also varied. Passages were presented at a fast rate (200 words per minute), a medium rate (160 wpm), and a slow rate (120 wpm). This variable was included to determine if the levels effect varied as increasing demands were placed on working memory.

After presentation of the passages subjects were asked to recall the ideas from the passage orally. The proportion of ideas recalled at each of the three levels of importance was then determined. Results showed that intoxicated subjects favored the main ideas of the passage relative to the non-essential details at all rates of presentation. However, differences between the intoxicated and sober groups were seen as a function of rate of presentation and importance level. That is, the size of the alcohol effect was the same at all levels of importance for passages presented at the slow and medium rate. However, for passages presented at the fast rate dose differences were found for the most important and medium importance levels, while no alcohol differences in recall were found for the least important ideas. Thus, it appeared that the alcohol impaired subjects' ability to integrate information rapidly into working memory only when working memory was severely overloaded. It was concluded that acute alcoholic intoxication impaired memory for prose due primarily to a general slowing of the rate at which information can be processed, therefore reducing the efficiency at which information is integrated within working memory (Petros et al., 1985).

One component of the speed of information processing is the speed by which information can be accessed from long-term memory. One study looking at the effect of acute alcoholic intoxication on the speed of accessing information from long-term memory was conducted by Moskowitz and Burns (1973). Intoxicated (.69 grams alcohol per kilogram body weight) and sober (0 grams/kg) subjects were asked to name numbers as quickly as possible after visual presentation. Response times were recorded from the presentation of the numbers to the beginning of the verbal response. Intoxicated subjects were shown to have longer response latencies than sober subjects. It was concluded that acute intoxication results in a decrease in long-term memory access speed (Moskowitz & Burns, 1973).

Moskowitz and Burns (1973) used response time as a measure of how long it takes to execute a mental operation, in this case, accessing information from long-term memory. However, according to Pachella (1974), response time involves both cognitive and motoric operations. That is, in order to respond verbally, subjects must first complete the perceptual and cognitive operations of receiving the stimuli through the senses, transferring information to sensory and working memory, then perform the necessary operations to retrieve the information from long-term memory. The response time also includes motoric operations necessary to respond including movements of the mouth and vocal chords. Thus, in the design used by Moskowitz and Burns (1973) there is no way to determine whether the alcohol differences are due to cognitive differences (such as access speed from long-term memory), speed of motoric operations, or both.

In order to determine whether cognitive operations are impaired in response time studies, a condition called a reaction-time control is necessary. This condition attempts to measure the motoric components alone. The time for the cognitive operations involved can then be determined by subtracting the reaction time control latencies from the response times observed during the experimental conditions of interest (Pachella, 1974). Since no reaction time control condition was present in the Moskowitz and Burns (1973) study, their conclusion that long-term memory access speed was impaired by acute alcoholic intoxication is certainly brought into doubt.

Van Tharp, Rundell, Lester, & Wil[illegible] (1974) also looked at the effects of intoxication in number access. However, this study looked at access from short-term memory. Subjects were presented with lists of one to four digits to memorize. Subjects were then presented with a single digit and asked to determine if the digit was a member of the group of digits that had been previously memorized. Subjects pressed one of two buttons, one for yes and the other for no, as quickly as possible. The dependent variable was response time, measured from presentation of the stimuli until one button was pressed. This procedure was conducted during three separate sessions, each session spaced three days apart. During the first two sessions no alcohol condition was used. During the third session subjects were administered either alcohol (1.32 milliliters 95% ethanol per kilogram body weight) or a placebo (0.00 ml/kg). During the third session, no significant difference in response time was observed between intoxicated and sober subjects. However, when difference scores were obtained between session two (baseline session) and session three (alcohol or placebo administration), a small but significant difference was found between dose groups. Compared with the placebo group, average response times for the intoxicated group increased an additional 20 msec from session two to session three. Based on this result, it was concluded that alcoholic intoxication resulted in a small overall loss of speed. A significant interaction between dose and number of digits presented would have provided evidence that access to numerical information for short-term memory was slowed by alcoholic intoxication. This interaction was not significant, suggesting that access to numerical information was not affected by intoxication. However, this conclusion is certainly qualified by the lack of a reaction time control condition.

In a further investigation of the effect of alcoholic intoxication on short-term memory, Huntley (1974) conducted a study in which subjects memorized letter-number pairs. In this study, all subjects participated in both the intoxicated (.95 grams absolute alcohol per kilogram body weight) and sober (0 g/kg) conditions on different days. Subjects were first asked to memorize either two,four, or eight letter-number pairs (ie. d-7, g-3, etc.). After memorizing the letter-number pairs, subjects were presented visually with each of the letters from the pairs, one at a time. In one condition, subjects were asked to name each letter verbally as it appeared on the screen as quickly and accurately as possible. In a second, more cognitively complex condition, subjects were asked to recall the number associated with the letter as quickly and accurately as possible. For example, if the letter-number pair was "D-7" and the letter "D" was presented, the correct response was for the subject to say "seven." Subjects responses were timed from the beginning of the presentation of the letter, to the beginning of the verbal response. No differences between the alcohol and placebo conditions were found in letter naming time. However, dose differences were found when subjects were presented with letters and asked to recall the associated number. Further, dose differences in response time increased as the difficulty of the task increased. That is, the slowing of response times for intoxicated subjects, as compared with sober subjects, increased as the number of letter-number pairs presented increased. It was concluded that alcohol had greater effects on tasks that are more cognitively complex. That is, as the cognitive processing demands increased, the cognitive slowing as a result of intoxication increased (Huntley, 1974).

Successful completion of the tasks used in Huntley's (1971) study required subjects to access information from long-term memory. This information included the names of presented letters, and numbers associated with these letters. Moskowitz and Roth (1971) conducted a study in which subjects were asked to name common objects, a task that also depends on retrieval from long-term memory (Moskowitz & Roth, 1971). Intoxicated (0.52 grams absolute alcohol per kilogram body weight) and sober (0 g/kg) subjects viewed drawings of 30 objects and were asked to name the objects. The time between stimulus onset and the beginnings of articulation was recorded. Some objects were of a high frequency of occurrence in everyday language, while other words had a lower frequency of occurrence. Previous research has shown that high frequency objects are named faster than low frequency objects (Oldfield & Wingfield, 1965). Alcohol increased the time required to name the objects, and common objects were named more quickly than uncommon objects. However, no interaction was found between alcohol and frequency.

It was concluded that acute alcoholic intoxication impairs the rate at which information can be accessed from memory (Moskowitz et al., 1971). However, since frequency of occurrence influences the speed of long-term memory, the absence of an alcohol by frequency interaction certainly qualifies the conclusion of Moskowitz and Roth (1971) that alcohol impairs the speed of accessing information from long-term memory. Another factor qualifying their conclusion is the lack of a reaction time control condition, so that the speed of memory access could be examined unconfounded with motoric response time.

Statement of the Problem

The purpose of the present study was to extend the work of Moskowitz and Roth (1971) to examine more clearly the influence of acute alcoholic intoxication on accessing information about words from long-term memory. One limitation of the Moskowitz and Roth (1971) experiment was that only one type of memory code was examined, that is, the name of an object. When accessing information about words from long-term memory, subjects access the features of the word, the name of the word, and semantic attributes about the word (Rosch, 1975). In the present study, sober and intoxicated subjects were compared on the speed with which they could access these three types of memory codes. Subjects were asked to make decisions regarding word pairs under three different conditions. In the first conditions, subjects were asked to decide whether two words presented were physically identical (PI). Both words were always in the same typeface in this condition. A positive decision would require that the two words be the same (for example, CAR CAR or car car). A negative decision would be correct if the words presented were not the same word (CAR BOAT or car boat). Therefore, subjects made positive decisions based totally on the physical features of the words. A second condition also required subjects to decide if the pair of words presented were the same (SN). However, positive trials presented the same word in two different typefaces so that subjects must go beyond the physical features of the word, and access the name of the words from long-term memory to make their decision (i.e. CAR car or boat BOAT). A negative decision was correct if two different words were presented (CAR boat or car BOAT). The third condition required subjects to decide whether the two words presented were from the same semantic category (SC). A positive decision was correct when the two words presented were from the same category (i.e. cat and dog), while negative decisions were necessary when the words were not members of the same category (i.e. dog and airplane).

Previous studies have suggested that accessing categorical information takes longer than accessing information about the name of the word, which takes more time than accessing the physical features of the word (Chabot, Miller, & Juola, 1976; Petros, Zehr, & Chabot, 1983). Therefore, a hypothesis in the present study is that if acute alcoholic intoxication slows the memory access time of intoxicated subjects, then alcohol differences in retrieval speed should increase as more information needs to be activated from the words. In other words, we should see a greater slowing in time to respond for intoxicated than sober subjects as the tasks require more time to complete. Alternatively, alcohol may have a general slowing effect on memory access speed, in which case the alcohol difference should be of similar size for all three decision types.

If alcohol induced memory impairment results from a slow memory access time, the size of the alcohol differences should then vary as a function of other factors related to memory access speed, like verbal ability. Studies have looked at information processing differences between higher verbal and lower verbal ability subjects (Hunt, 1978). Hunt (1978) reviewed the literature examining verbal ability differences in the speed of accessing letter names. This review clearly demonstrated that lower verbal subjects take longer to decode information in working memory than do higher verbal subjects. For example, if a subject is presented with the symbol "A," lower verbal subjects tend to take longer to attach meaning to the symbol than do higher verbal subjects. It was concluded that higher verbal subjects have greater attentional capacity in working memory than do lower verbal subjects, and this explains verbal ability differences in feature extraction (Hunt, 1978).

Mason (1980) looked at the verbal ability differences in lexical access, or the speed of accessing word names from the lexicon. Mason (1980) reported that higher verbal subjects accessed word names more rapidly than lower verbal subjects, and the difference was not due to any motor response differences between the higher and lower verbal groups.

Hunt, Davidson, & Lansman (1981) looked at verbal ability differences in category access speed. They found that lower verbal ability subjects had longer response latencies than higher verbal subjects when asked to identify whether an item was a member of a category, whether two items belonged to the same category, or whether two words had the same name. It was concluded that slower memory access speed in lower verbal subjects was responsible for the differences found. Also, it was found that effects of verbal ability could be successfully measured with a test of vocabulary skills. That is, vocabulary tests may be successfully used as general measures of verbal ability. (Hunt et al., 1981).

These studies showed that lower verbal subjects process information slower than subjects who have higher verbal ability. Goldberg, Schwartz, & Stewart (1977) found that lower verbal subjects experience a greater increase in time to respond than do higher verbal subjects as processing demands increase. Goldberg et al. (1977) administered the verbal battery of the Lorge-Thorndike Intelligence Test (College Edition, Form 2, Houghton Mifflin). Subjects scoring in the highest quartile of the subject distribution were assigned to the high-verbal ability group. Subjects scoring in the lowest quartile were assigned to the low-verbal ability group. Subjects were then asked to make three types of decisions about pairs of words presented on a video screen. The first decision type was whether the two words were physically identical or not. Subjects were asked to press a key labeled "same" if both of the presented words were the same word in the same typeface (for example: CHAIR

CHAIR). Subjects were asked to press a key labeled "different' if the two words presented on the video screen were different words (CHAIR PLUM). The second decision type was whether the two words were homophones or not. Homophones are different words which are pronounced exactly the same. A "same" decision was correct if the two words presented were homophones (BEAR BARE). A "different" decision was correct if the two were not homophones (BEAR PILOT). The third decision type required subjects to decide if the two words were from the same semantic category or not. A "same" decision was correct if the two words were from the same semantic category (TRUCK VAN). A "different" decision was correct if the two words presented were not from the same semantic category (TRUCK DESK). Each of the three decision types required a different degree of access to information from long-term memory, with the physically identical condition requiring the least, with more information required for the homophone condition, and the most information required for the category decisions. High verbals responded more quickly than low verbals for each of the three decision types. In addition, the difference between high and low verbals was greater for the category and homophone conditions than it was for the physically identical condition. Thus, as processing demands increased, the differences in response time between high and low verbals increased (Goldberg, Schwartz, & Stewart, 1977).

Based on the research reviewed above, a second hypothesis in the present study is that if alcohol impairs processing speed, then lower verbal subjects should experience a greater impairment in performance when intoxicated than higher verbal subjects. Furthermore, we might expect the magnitude of this hypothesized interaction of verbal ability and alcohol to increase as the processing demands of the task increased. For example, we would expect the lower verbal subjects receiving alcohcl to experience a greater slowing in response time when accessing category information as compared to physical information about the words.

Response time is intended as a measure of how long it takes to execute a mental operation. Response time, however, as was discussed earlier, has both cognitive and motoric components. In order to insure that we can estimate the cognitive components in the present study, a reaction time control condition was used. In this condition, subjects were asked to delay their responses in each of the conditions (PI, SN, SC) until after the word pairs were removed from the display (3 second duration). Presumably, all mental operations were completed during this three second delay. Therefore, response times in this condition would merely reflect the time necessary to execute the motor responses, that is, pressing one of the two response keys. If no difference in response times were seen between the intoxicated and sober conditions, then we can assume the differences in reaction times observed in the experimental trials reflect slower cognitive operations, not motor response time. If differences between sober and intoxicated subjects were observed in these reaction-time control trials, then it would be necessary to subtract the motor reaction times from the times obtained in the non-reaction time control condition, in an attempt to remove the component of response times due to motor reactions.

CHAPTER II

METHOD

Subjects

The subjects for this study were 66 male students at the University of North Dakota. Subjects were volunteer undergraduate students, who received class credit for their participation. Written, informed, consent was obtained from all participants. Potential subjects were screened prior to their participation to determine their general level of health and drinking history. Only subjects who were in good health, and able to tolerate a moderate dose of alcohol were allowed to participate. Participation was limited to moderate social drinkers, as defined by subjects who reported drinking alcoholic beverages at least once a week, and who averaged at least two drinks for each instance of drinking. No upper drinking limit was established. However, subjects who reported receiving treatment for alcohol abuse were eliminated from the study. Subjects were instructed to avoid taking drugs (including alcohol) for 24 hours prior to their involvement in the study. Subjects were asked to eat a full meal at least three hours before the experimental session. All experimental sessions began between 10 a.m. and 1 p.m.

Materials

The stimulus materials consisted of 24 words chosen from each of eight categories for a total of 192 words. All words were selected from the typicality norms provided by Rosch (1975) so that typicality ranks ranged from 1 to 33.

Prior to the beginning of the experiment, these words were arranged into an initial block of 96 trials. Thirty-two trials of each block required PI decisions, 32 required SN decisions, and 32 required SC decisions. Within each decision type, 16 trials required positive responses and 16 required negative responses. From this initial block of 96 trials, 5 additional sequences were constructed, for a total of 6 sequences. The sequences were constructed so that each word appeared in each condition x response type cell equally often across the six sequences. The average typicality rank was the same for all conditions and for all cells (words used were of high typicality with an average ranking of 12.5).

The experimental session consisted of 3 blocks of 32 trials, each of which consisted of half positive trials and half negative trials. Each block differed in that positive trials presented the word pair in one of three conditions, the same word twice in the same typeface (PI), the same name twice in a different typeface (SN), or two different words from the same category (SC). Each block differed in the type of positive decision required. Negative decisions presented two different words from different categories in the same typeface.

Procedure

Upon arrival for the experimental session, subjects were weighed and their identification was checked to verify their age. Subjects were then administered the vocabulary subtest on the Wechsler Adult Intelligence Scale-Revised as a measure of their verbal ability. On the basis of the raw test score on this subtest, subjects were assigned to the higher or lower verbal group. Upon completion of the study, 34 subjects with the highest raw scores (raw score>50) were assigned to the higher verbal group, while 32 subjects (raw score <=50) were assigned to the lower verbal group. Of the higher verbal ability subjects, 16 were in the intoxicated condition, while 18 were in the sober condition. Of the lower verbal ability subjects, 17 were in the intoxicated condition, while 15 were in the sober condition. The WAIS-R vocabulary subtest raw scores for higher verbal ability, intoxicated subjects ranged from 51 to 66 with a mean of 58.50. Scores for higher verbal, sober subjects ranged from 51 to 68 with a mean of 56.78. Lower verbal intoxicated subjects scores ranges from 38 to 50 with a mean of 45.47. Scores for lower verbal sober subjects ranged from 31 to 50 with a mean of 43.00.

Prior to drinking, subjects were given instructions individually followed by an extensive practice period consisting of one block of 96 trials. Subjects in the intoxicated condition then received 1.0 ml absolute alcohol in the form of 80 proof vodka per kilogram body weight. Subjects in the intoxicated condition received drinks in the form of 1 part vodka and 2 parts of a peppermint masking solution, divided into two equal size drinks. Subjects in the sober condition received water in place of the vodka, and the rims of the glasses were swabbed with 1 ml vodka. All subjects were instructed to consume each drink slowly and evenly, making it last 20 minutes. The two consecutive 20 minute drinking periods were followed by a 15 minute absorption period to allow the blood alcohol level to reach its maximum value (Parker et al, 1976). Previous work demonstrates that these procedures result in an average blood alcohol concentration in men of .07, although a great deal of variability in blood alcohol levels is found (see Birnbaum et al., 1978).

Following the absorption period, subjects were tested individually by an experimenter who did not know whether the subject received alcohol or a placebo. Experimenters also did not know the subjects' score on the WAIS-R Vocabulary subtest. Subjects heard the instructions again, and then were given the experimental trials. These trials consisted of three blocks of 32 trials, with each block consisting of 16 positive and 16 negative decisions. Order of presentation of blocks of trials was counterbalanced across subjects. Each block differed according to the type of decision required. That is, subjects had to decide if the two words were physically identical (PI), had the same name (SN), or belonged to the same category (SC). The specific type of positive decision (PI, SN, or SC) was presented verbally to the subject before each block of trials began. Each block of 32 experimental trials was preceded by eight practice trials. The specific response types were presented randomly to each subject.

To initiate a trial, subjects pressed the space bar on an Apple IIe computer keyboard. Two words were then presented on the screen and subjects were instructed to press one of two buttons on the computer terminal, one button for a "yes" response and one for a "no" response. Subjects were told to respond as quickly as possible without making mistakes.

When the experimental trials were completed, a set of 48 trials was presented as a reaction time control. In this block of trials, each word was presented for three seconds to allow sufficient time for all necessary cognitive operations to occur before a response was required. After a three second time period, the words disappeared from the screen and subjects made their responses as quickly as possible. The same decision and response types that were used in the experimental trials were used in the reaction time control trials. The names of the semantic categories used were given to the subjects prior to the practice trials, experimental trials, and reaction time control trials. Response time and accuracy were automatically recorded by the computer.

Design

The design consisted of two between subject factors and two within subjects factors. The between subjects factors were treatment (intoxicated, sober), and verbal ability (higher, lower). The within subjects factors were type of decision (PI, SN, SC), and type of response (yes, no). The dependent variables were the median response times for each subject in each cell of the design, along with the proportion of errors.

CHAPTER III

RESULTS

The median response times (RT) were computed for every subject for each cell of the design. Median response times were chosen for analysis, rather than using mean response times, in order to reduce the impact of extreme latencies. Also computed were the median reaction time control times (RTC), the median response times minus reaction time control (RT-RTC), and the error rates for each cell. Response times associated with errors were excluded from the above computations. Tests were conducted to determine if violations of the assumption of homogeneity of variance had occurred. (Fmax for medians was 23.5, Fmax for RTC medians was 11.7, Fmax for medians minus RTC medians was 16.2, and Fmax for proportion of errors was 37). Homogeneity of variance may be assumed when Fmax values are less than 4 or 5. Since homogeneity of variance cannot be assumed with these scores, the data were transformed. Logrithmically transformed scores for median, median reaction time controls, median minus median reaction time controls, and arcsin transformation of the proportion of errors data were analyzed using 2 (treatment) by 2 (verbal ability) by 3 (decision type) by 2 (response type) mixed analysis of variance. The significant effects in the analysis of the transformed data also were found to be significant in similar analyses of raw data. Therefore, the results of the analysis of the raw data will be presented, rather than the transformed data.

<u>Response Time Medians</u>

In the analysis of median response times, no significant main effect was found for treatment, $F(1,62)=1.11$, $p>.05$ (see Table 1 for means and standard deviations as a function of treatment, verbal ability, decision type, and response type; see Appendix A, Table 19 for ANOVA Source Table). The mean response time for sober subjects was 386.84, while the mean response time for intoxicated subjects was 946.06. A significant main effect of decision type was found, $F(2,124)=376.43$, $p<.01$. Newman Keuls analysis indicated that response time increased as the processing demands of the task increased. That is, all pair-wise comparisons were significant, with average response times of 704 msec, 779 msec, and 1266 msec for PI, SN, and SC decisions respectively. Also, a significant main effect of response type, $F(1,62)=73.87$, $p<.01$, revealed that negative responses (961.11) took more time than positive responses (871.80).

The two way interaction of decision type and response type was also significant, $F(2,124)=10.52$, $p<.01$ (see Table 2). A Newman Keuls analysis of this interaction indicated

TABLE 1

Means and Standard Deviations for Median Response Times (RT) as a Function of Treatment, Verbal Ability, Decision Type, and Response Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
YES Responses						
Sober	660.22 (100.41)	681.78 (131.55)	1098.00 (258.98)	631.67 (112.62)	733.93 (174.48)	1252.67 (321.64)
Intoxicated	696.06 (171.42)	770.31 (264.53)	1170.31 (340.02)	716.18 (131.08)	808.88 (189.96)	1253.47 (253.08)
NO Responses						
Sober	694.44 (112.75)	754.17 (188.09)	1228.06 (321.64)	713.27 (138.29)	764.80 (131.48)	1470.00 (387.85)
Intoxicated	751.88 (251.72)	825.31 (317.53)	1362.31 (485.69)	766.58 (158.83)	896.35 (271.08)	1329.18 (277.28)

Note: Standard deviations are presented in parentheses

TABLE 2

Response Time and Error Rate as a Function

of Decision Type and Response Type

	PI	SN	SC
YES	676.83 (.026)	747.83 (.042)	1190.73 (.111)
NO	731.23 (.042)	810.45 (.044)	1341.64 (.072)

Note: Error r[illegible]s are presented in parentheses.

that in all decision type conditions, negative responses took longer than positive responses. However, this difference was much larger for the SC condition (11.2%), than for either the PI (7.4%) or SN (7.7%) conditions.

A three way interaction of treatment, decision type, and verbal ability also was significant, $F(2,124)=3.19$, $p<.05$ (see Table 3). Percent differences for dose in each condition may also be seen in Table 3. Newman Keuls analysis of this interaction indicated that in the higher verbal group, intoxicated subjects took longer to respond than did sober subjects for SC decisions, while no treatment effects were observed for PI or SN conditions. In the lower verbal group, intoxicated subjects responded more slowly than sober subjects for SN decisions while sober subjects responded more slowly than intoxicated subjects for SC decisions, and no treatment differences were found for the PI condition. The finding of lower verbal sober subjects taking longer to respond than intoxicated subjects in the SC condition is opposite of the predicted results, as one would expect to see intoxicated subjects taking longer to respond.

A four way interaction of decision type, response type, treatment, and verbal ability also was observed, $F(2,124)=4.18$ $p<.05$ (see Table 4). Newman Keuls analysis shows that in the higher verbal group, intoxicated subjects responded slower than did sober subjects for SN and SC

TABLE 3

Response Time, Error Rate, and Percentage Treatment Difference as a Function of Treatment, Verbal Ability, and Decision Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
Sober						
	677.33 (.033)	717.98 (.030)	1163.03 (.062)	672.47 (.021)	749.37 (.023)	1361.34 (.094)
Intoxicated						
	723.97 (.036)	797.31 (.051)	1266.31 (.128)	741.39 (.045)	852.62 (.066)	1291.33 (.087)
Difference						
	46.64	79.83	103.28	68.92	103.25	70.01
% Difference						
	6.4	10.0	8.2	9.3	12.1	5.1

Note: Error rates are presented in parentheses.

TABLE 4

Response Time, Error Rate, and Percentage Treatment Difference as a Function of Treatment, Verbal Ability, Decision Type, and Response Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
YES Responses						
Sober	660.22 (.017)	681.78 (.024)	1098.00 (.097)	631.67 (.021)	733.93 (.013)	1252.67 (.125)
Intoxicated	696.06 (.051)	770.31 (.051)	1170.31 (.160)	716.17 (.015)	808.38 (.077)	1253.40 (.066)
% Difference	5.1	11.5	6.2	11.8	9.3	0.1
NO Responses						
Sober	694.44 (.049)	754.17 (.035)	1228.06 (.028)	713.27 (.021)	764.80 (.038)	1470.00 (.063)
Intoxicated	751.88 (.020)	825.31 (.051)	1362.31 (.094)	766.59 (.074)	896.35 (.055)	1329.18 (.107)
% Difference	7.6	8.6	9.9	7.0	14.7	9.6

Note: Error rates are presented in parentheses.

decisions for both positive and negative responses. No treatment effects were observed for higher verbal subjects in the PIY and PIN conditions. For lower verbal subjects, treatment differences were found for the PIY, SNY, SNN, and SCN conditions, such that intoxicated subjects took longer to respond than sober subjects, except in the SCN condition where sober subjects took longer to respond than did intoxicated subjects. Treatment differences for lower verbal subjects were not found in the PIN or SCY conditions.

Reaction Time Control Medians

Results of the ANOVA for RTC medians showed no significant effect of treatment, $F(1,62)=.06$, $p>.05$, or verbal ability, $F(1,62)=.41$, $p>.05$ (see Table 5 for means and standard deviations as a function of treatment, verbal ability, decision type, and response type; see Appendix A, Table 20 for ANOVA Source Table). A significant main effect of decision type was obtained, $F(2,124)=12.54$, $p<.01$. Newman Keuls analysis indicated that PI decisions (312.06) required less time than SN (365.58) or SC decisions (349.55), while no significant difference was found between SN and SC decisions.

A significant four way interaction of decision type by response type by treatment by verbal ability, $F(2,124)=4.56$, $p<.05$ also was observed (see Table 6).

TABLE 5

Means and Standard Deviations for Median Reaction Time Controls (RTC) as a Function of Treatment, Verbal Ability, Decision Type, and Response Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
			YES Responses			
Sober	314.39 (86.91)	362.00 (133.35)	353.17 (122.79)	304.33 (146.18)	341.60 (206.74)	345.60 (201.10)
Intoxicated	335.81 (193.02)	378.63 (178.98)	350.00 (156.39)	305.94 (75.37)	362.24 (159.00)	344.41 (113.50)
			NO Responses			
Sober	341.94 (103.26)	394.44 (172.15)	348.39 (133.29)	280.93 (122.54)	330.53 (206.18)	333.93 (240.52)
Intoxicated	307.00 (154.99)	367.50 (180.17)	386.81 (257.21)	300.76 (75.21)	380.18 (146.50)	333.88 (104.10)

Note: Standard deviations are presented in parentheses

TABLE 6

Reaction Time Control Times, Error Rate, and Percentage Treatment Differences as a Function of Treatment, Verbal Ability, Decision Type and Response Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
			YES Responses			
Sober	314.39 (.007)	362.00 (.007)	353.17 (.028)	304.33 (.000)	341.60 (.033)	345.60 (.083)
Intoxicated	335.81 (.039)	378.63 (.031)	350.00 (.102)	305.94 (.007)	362.24 (.015)	344.41 (.081)
% Difference	6.3	4.4	0.9	0.5	5.7	0.3
			NO Responses			
Sober	341.94 (.007)	394.44 (.007)	348.39 (.007)	280.93 (.000)	330.53 (.000)	333.90 (.083)
Intoxicated	307.81 (.008)	367.50 (.008)	386.81 (.055)	300.76 (.007)	380.18 (.037)	333.98 (.037)
% Difference	10.0	6.8	9.9	6.6	13.1	0.0

Note: Error rates are presented in parentheses.

Newman Keuls analysis of this interaction revealed treatment differences for higher verbal subjects in PIN, SNN, and SCN conditions. Sober subjects took longer to respond in the PIN and SNN conditions, while intoxicated subjects took longer to respond in the SCN condition. No treatment differences for higher verbal subjects were seen in the PIY, SNY, and SCY conditions. Treatment differences for lower verbal subjects was seen in the SNN condition, with intoxicated subjects taking longer to respond than sober subjects. No treatment differences for lower verbal subjects were seen in the PIY, PIN, SNY, SCY, and SCN conditions.

<u>Medians minus RTC medians</u>

In the analysis of median response times minus median reaction time control times, no significant main effects of treatment, $F(1,6\ \ =1.21$, $p>.05$, or verbal ability were found, $F(1,62)=3.18$, $p>.05$ (see Table 7 for means and standard deviations as a function of treatment, verbal ability, decision type, and response type; see Appendix A, Table 21 for ANOVA Source Table). However, main effects of response type, $F(1,62)=62.11$, $p<.01$, and decision type, $F(2,124)=290.59$, $p<.01$, were observed. Negative decisions were found to have longer response times (618.07) then positive responses (531.05). A Newman Keuls analysis of the

TABLE 7

Means and Standard Deviations for Medians Minus Median Reaction Time Controls (RT-RTC) as a Function of Treatment, Verbal Ability, Decision Type, and Response Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
YES Responses						
Sober	345.83 (116.32)	319.78 (178.33)	774.94 (254.97)	327.33 (160.54)	392.33 (255.72)	907.07 (294.41)
Intoxicated	360.25 (117.79)	391.69 (168.90)	820.31 (257.23)	410.24 (107.76)	457.24 (178.54)	909.06 (223.01)
NO Responses						
Sober	352.50 (125.42)	359.72 (218.14)	879.67 (302.13)	432.33 (128.59)	434.27 (195.96)	1136.07 (432.22)
Intoxicated	444.88 (138.90)	458.94 (202.44)	975.50 (320.83)	465.82 (124.20)	516.18 (260.02)	995.29 (288.95)

Note: Standard deviations are presented in parentheses

main effect of decision type showed that SC decisions (916.64) required more time than PI (391.97) and SN decisions (415.65), while no significant difference was found between PI and SN decisions.

The interaction of decision type by response type also was significant, $F(2,124)=9.07$, $p<.01$ (see Table 8). A Newman Keuls analysis of this interaction indicated that the size of the response type effect was smaller for SN decisions (11.8%) than either PI (14.3%) or SC decisions (15.0%), with no difference found between PI and SC decisions.

A three way interaction of treatment by verbal ability by response type also was found to be significant, $F(1,62)=4.96$, $p<.05$ (see Table 9). Newman Keuls analysis indicated that treatment differences for higher verbal subjects for both yes and no responses were present, with intoxicated subjects taking longer to respond than sober subjects in both cases. Treatment differences for lower verbal subjects were seen for yes responses (intoxicated subjects responding slower than sober subjects), with no differences found for no responses.

TABLE 8

Reaction Time Minus Reaction Time Control Time as a Function of Decision Type and Response Type

	PI	SN	SC
YES	361.71	389.11	842.33
NO	422.23	441.02	990.95

TABLE 9

Reaction Time Minus Reaction Time Control Time and Percentage Treatment Difference as a Function of Treatment, Verbal Ability, and Response Type

	Higher Verbal		Lower Verbal	
	Y	N	Y	N
Sober	470.18	530.63	542.24	667.56
Intoxicated	524.08	626.50	592.18	659.10
% Difference	10.3	15.3	8.4	1.3

Proportion of Errors

A significant main effect of treatment was found, $F(1,62)=10.57$, $p<.01$ (see Table 10 for means and standard deviations as a function of treatment, verbal ability, decision type, and response type; see Table 22 for ANOVA Source Table). Results indicated that intoxicated subjects made more errors (.053) than sober subjects (.044). A significant main effect of decision type also was found for proportion of errors, $F(2,124)=43.22$, $p<.01$. A Newman Keuls analysis indicated that more errors were found in the SC condition (.091) than in the PI (.034) or SN (.043) conditions, while no difference was found between the PI and SN conditions.

A significant two way interaction of decision type by response type also was found, $F(2,124)=6.48$, $p<.01$ (see Table 11). Newman Keuls analysis indicated that response type differences only were found for SC decisions such that negative responses produced significantly more errors than the positive responses.

The three way interaction of response type by treatment by verbal ability also was found to be significant, $F(1,62)=4.11$, $p<.05$ (see Table 12). A Newman Keuls analysis of this interaction indicated that treatment differences were present for higher verbal subjects only when making positive responses (intoxicated subjects made more errors than sober

TABLE 10

Means and Standard Deviations for Proportion of Errors as a Function of Treatment, Verbal Ability, Decision Type, Response Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
YES Responses						
Sober	.017	.024	.097	.021	.013	.125
	(.047)	(.038)	(.061)	(.031)	(.035)	(.063)
Intoxicated	.051	.051	.160	.015	.077	.066
	(.065)	(.052)	(.105)	(.027)	(.114)	(.075)
NO Responses						
Sober	.049	.035	.028	.021	.033	.063
	(.059)	(.049)	(.038)	(.045)	(.057)	(.041)
Intoxicated	.020	.051	.094	.074	.055	.107
	(.030)	(.047)	(.068)	(.124)	(.066)	(.101)

Note: Standard deviations are presented in parentheses

TABLE 11

Proportion of Errors as a Function of

Decision Type and Response Type

	PI	SN	SC
YES	.026	.042	.111
NO	.042	.044	.072

TABLE 12

Proportion of Errors as a Function of Treatment, Verbal Ability, and Response Type

	Higher Verbal		Lower Verbal	
	Y	N	Y	N
Sober	.046	.037	.053	.039
Intoxicated	.087	.055	.053	.078

subjects). Treatment differences were present for lower verbal subjects only when making negative responses (intoxicated subjects made more errors than sober subjects).

A significant three way interaction of decision type by treatment by verbal ability was found, $F(2,124)=7.74$, $p<.01$ (see Table 13). A Newman Keuls analysis of this interaction indicated that treatment differences were seen for higher verbal subjects in the SC condition only (intoxicated subjects made more errors than sober subjects). Treatment differences were seen for lower verbal subjects only in the SN condition (intoxicated subjects made more errors than sober subjects).

Also significant was the three way interaction of decision type by response type by treatment, $F(2,124)$, $p<.05$ (see Table 14). A Newman Keuls analysis of this interaction revealed treatment differences in the SNY and SCN conditions only. In both cases intoxicated subjects made more errors than sober subjects.

A four way interaction of decision type by response type by treatment by verbal ability also was found to be significant, $F(2,124)=3.49$, $p<.05$ (see Table 15). A Newman Keuls analysis of this interaction revealed treatment differences for higher verbal subjects in the PIY, SCY, and SCN conditions. In each of these cases, intoxicated subjects made more errors than sober subjects. No treatment differences were seen for higher verbal subjects in the PIN,

TABLE 13

Proportion of Errors as a Function of Treatment, Verbal Ability, and Decision Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
Sober	.033	.030	.063	.021	.023	.094
Intoxicated	.035	.051	.127	.044	.066	.086

TABLE 14

Proportion of Errors as a Function of

Treatment, Decision Type, and Response Type

	YES Responses			NO Responses		
	PI	SN	SC	PI	SN	SC
Sober	.019	.019	.110	.036	.034	.044
Intoxicated	.032	.064	.112	.047	.053	.100

TABLE 15

Proportion of Errors as a Function of Treatment, Verbal Ability, Decision Type, and Response Type

	Higher Verbal			Lower Verbal		
	PI	SN	SC	PI	SN	SC
			YES Responses			
Sober	.017	.024	.097	.021	.013	.125
Intoxicated	.051	.051	.160	.015	.077	.066
			NO Responses			
Sober	.049	.035	.028	.021	.033	.063
Intoxicated	.020	.051	.094	.074	.055	.107

SNY, and SNN conditions. Significant differences in proportion of errors as a function of treatment were found for lower verbal subjects in the PIN, SNY, SCN, SCY conditions. Intoxicated subjects made more errors than sober subjects in the PIN, SNY, and SCN conditions, while sober subjects made more errors than intoxicated subjects in the SCY condition. No treatment differences were seen for the lower verbal subjects in the PIY and SNN conditions.

Other Analyses

A series of Pearson product moment correlations was computed among medians, proportion of errors, RTC proportion of errors, and medians minus RTC medians. All correlations in the matrix were positive. The correlation between the proportion of errors and the reaction time medians was .66 while the correlation of errors with medians minus RTC medians was .64.

Three additional ANOVAs were conducted to determine if subjects' ages, weights, or WAIS-R raw scores were confounding factors in the study. A two (treatment) by two (verbal ability) ANOVA was conducted using subjects' ages as the dependent variable. No significant main effects were found for treatment, $F(1,62) = .00$, $p>.05$, or for verbal ability, $F(1,62) = .01$, $p>.05$ (see Table 16 for means and standard deviations as a function of treatment and verbal

TABLE 16

Means and Standard Deviations for Age in Years as a Function of Treatment and Verbal Ability

	Verbal Ability	
Treatment	Higher	Lower
Sober	22.67 (2.45)	22.87 (2.26)
Intoxicated	22.88 (2.33)	22.59 (2.69)

Note: Standard deviations are presented in parentheses.

ability; see Appendix A, Table 24 for ANOVA Source Table). No significant interaction of treatment by verbal ability was found, $F(1,62)=.16$, $p>.05$. Sober subjects' mean age was 22.76 years, while intoxicated subjects' mean age was 22.73. Mean age for higher verbal subjects was 22.76 years, while lower verbal subjects' mean age was 22.72 years.

A two (treatment) by two (verbal ability) ANOVA using subject weight as the dependent variable revealed no significant main effects of treatment, $F\ (1.62) = .03$, $p>.05$, or verbal ability, $F(1,62)=2.21$, $p>.05$ (see Table 17 for means and standard deviations as a function of treatment and verbal ability; see Appendix A, Table 25 for ANOVA Source Table). The interaction of treatment by verbal ability was not found to be significant, $F(1,62)=2.05$, $p>.05$. Sober subjects' mean weight was 178.94 pounds, while mean weight for intoxicated subjects was 177.85 pounds. Higher verbal subjects' mean weight was 173.76 pounds, while mean weight for lower verbal subjects was 183.31 pounds.

A final two (treatment) by two (verbal ability) ANOVA was conducted using WAIS-R vocabulary subtest raw scores as the dependent variable. No significant main effect was found for treatment, $F(1,62)=1.11$, $p>.05$ (see Table 18 for means and standard deviations as a function of treatment and verbal ability; see Appendix A, Table 25 for ANOVA Source Table). Mean raw score for sober subjects was 50.52, while intoxicated subjects' mean raw score was 51.79. As

TABLE 17

Means and Standard Deviations for Weight in Pounds as a Function of Treatment and Verbal Ability

	Verbal Ability	
Treatment	Higher	Lower
Sober	170.39 (25.78)	189.20 (29.18)
Intoxicated	177.56 (22.91)	178.12 (26.40)

Note: Standard Deviations are presented in parentheses.

TABLE 18

Means and Standard Deviations for WAIS-R Vocabulary Subtest Raw Score as a Function of Treatment and Verbal Ability

	Verbal Ability	
Treatment	Higher	Lower
Sober	56.78 (4.32)	43.00 (6.36)
Intoxicated	58.50 (4.94)	45.47 (3.89)

Note: Standard deviations are presented in parentheses.

expected, the main effect of verbal ability was significant, $F(1,62)=120.79$, $p<.01$. Higher verbal ability subjects' mean raw score was 57.59, while mean raw score for lower verbal subjects was 44.31. No significant interaction of treatment by verbal ability was found, $F(1,62)= 1.96$, $p>.05$.

CHAPTER IV

DISCUSSION

The present study extends previous findings regarding the disruptive effects of alcohol intoxication on memory. This chapter contains a discussion of the results of the study, the theoretical implications of those results, the limitations of the study, and directions for future research in examining the effects that alcohol has on memory processes.

In the present study, a significant main effect of treatment was expected. That is, sober subjects were expected to respond more quickly than intoxicated subjects. However, no significant main effect of treatment (alcohol vs. placebo) was found for response time medians (RT). Possible explanations for failure to achieve a .05 level of significance for this main effect will be discussed later. However, if the data are more closely examined, it will be noted that, although significance was not achieved, the trends in the data were in the predicted direction. That is, median response times were slower for intoxicated subjects than for sober subjects. More importantly, significant effects involving treatment were seen in several interactions.

It was expected that treatment would interact with other variables involving conditions that result in limitations in the capacity of working memory, such as verbal ability, or in tasks of increasing complexity, such as decision type. That is, intoxicated subjects were expected to show greater increases in response time than were sober subjects, as verbal ability decreased, or as task complexity increased. A confusing pattern of results was seen when interactions involving treatment were analyzed for response times. Two such interactions were found to be significant.

In a three way interaction of treatment, verbal ability, and decision type, higher verbal subjects showed the predicted results. That is, no treatment differences were seen in the two conditions requiring the least amount of processing capacity (PI and SN), while intoxicated subjects responded slower than did sober subjects in the most taxing (SC) condition. Also, as the complexity of the task increased, the cognitive slowing of the intoxicated subjects became more apparent. The results for the lower verbal subjects were not as clear. Consistent with higher verbal subjects, no treatment differences were seen in the PI condition for the lower verbal subjects. Unlike the higher verbal subjects, a significant treatment difference was seen for lower verbal subjects in the SN condition. This difference was in the predicted direction, that is, intoxicated subjects responded more slowly than did sober subjects. This result makes sense due to lower verbal subjects' decreased functional capacity in working memory when compared with higher verbal subjects. However, the SC condition for lower verbal subjects presents an unexpected finding. In this case, sober subjects took longer to respond than did intoxicated subjects. A large treatment difference in the opposite direction was predicted since the lower verbal subjects (those whose functional working memory capacity is less than higher verbal subjects) are faced with the task with the most cognitive complexity.

A similar finding was obtained in the four way interaction of treatment, verbal ability, decision type, and response type. For higher verbal subjects, no difference in response times were seen for the least cognitively complex tasks (PIY, PIN), while intoxicated subjects took longer to respond than did sober subjects in the most complex tasks (SNY, SNN, SCY, SCN). The picture once again becomes more confusing for the lower verbal subjects. No treatment differences were seen for one of the least complex (PIN), and one of the most complex (SCY) tasks. Results in the expected direction (sober subjects responding more quickly than intoxicated subjects) were seen in all other conditions, except in the SCN condition, where sober subjects took longer to respond than intoxicated subjects. This is also a case in which the outcome in the most cognitively complex condition is in the opposite of the predicted direction.

The data discussed above reflects both the cognitive operations necessary to complete the tasks, and the motoric operations involved in making the responses. Therefore, it is not clear whether the obtained data were a result of the changes in the speed of cognitive operations, changes in the speed of motoric operations, or both. In order to examine treatment effects on cognitive operations more clearly, data subtracting out reaction time controls from median response times will now be considered.

In the analysis of the data subtracting out reaction time controls from median response times, no significant main effect of treatment was found. However, trends in the data were in the predicted direction (intoxicated subjects responded more slowly than sober subjects).

The only significant interaction involving treatment when analyzing median response times minus reaction time control times was an interaction of treatment, verbal ability, and response type. In this interaction, high verbal intoxicated subjects took longer to respond than did higher verbal sober subjects for both positive and negative responses. Lower verbal intoxicated subjects responded more slowly than did lower verbal sober subjects only when making positive responses; no differences were seen between these groups when making negative responses. This interaction provides evidence that under certain conditions, the predicted treatment differences were present. That is, in each case, when a significant treatment difference was present, intoxicated subjects took longer to respond than did sober subjects, when reaction time control times were subtracted out.

One likely explanation for the unusual findings in this study was the presence of speed-accuracy tradeoffs. As an initial test for speed-accuracy tradeoffs, correlations were obtained between proportion of errors and both response time medians (RT) and response time medians minus reaction time control medians (RT-RTC). Both of these correlations were positive, suggesting that it was unlikely that speed-accuracy tradeoffs had occurred. However, a closer examination of the data reveals that speed-accuracy tradeoffs may have occurred under certain conditions in the study.

First, a main effect of treatment was found for proportion of errors, with intoxicated subjects making more errors than sober subjects. Thus, it appears that intoxicated subjects were more likely to respond before completing the necessary cognitive operations, than were sober subjects. This finding may explain the failure to obtain a main effect of treatment for both response time (RT) and response time minus reaction time control (RT-RTC). If intoxicated subjects completed the necessary mental operations to the same degree as did the sober subjects, significant treatment differences may have been obtained.

Secondly, a speed-accuracy tradeoff may also explain the most unusual findings of the study, that of sober subjects taking longer to respond than intoxicated subjects in the lower verbal (SC) negative condition for medians, and the finding of no treatment difference in this condition for

RT-RTC. Under the most cognitively complex set of conditions, one would expect to find intoxicated subjects taking much longer than sober subjects if all necessary mental operations were completed. However, the error data show that it is likely that a speed-accuracy tradeoff occurred in this condition. The increase in error rates from PI and SN to SC was much larger for intoxicated subjects than for sober subjects, while the increase in response time was greater for sober subjects than for intoxicated subjects. The increase in errors suggests that intoxicated subjects in the most cognitively complex situation simply "gave up," and many of these correct responses in the data were simply random correct guesses. It is reasonable to conclude that if these intoxicated subjects had completed all of the necessary mental operations, fewer errors would have occurred, and the intoxicated subjects would have taken much longer to respond than would the sober subjects.

Moskowitz & Roth (1971) have previously demonstrated that alcohol has a slowing effect on cognitive processes, resulting in a functional decrease in the capacity of working memory. However, they failed to find an interaction of intoxication with the frequency of occurrence of words, a factor that should limit this capacity. The present study supports their conclusion by finding significant interactions between acute alcoholic intoxication and other factors that previously have been shown to result in a functional limitation in working memory capacity, in this case, verbal ability and decision types of varying complexity. With the exception of the most cognitively complex conditions, the results of this study were in the predicted direction.

In addition, this study provides support to this conclusion through its use of a reaction-time control condition. By subtracting out the motoric processes involved, the results can be more clearly attributed to the cognitive processes involved. Thus, the present study lends support to previous studies reaching this conclusion, but failing to use a reaction time control condition (i.e., Moskowitz & Roth, 1971; Moskowitz & Burns, 1973).

Two unexpected results in the present study suggest that all cognitive operations may not have been completely excluded in the reaction time control condition. The first unexpected result was the finding of a four-way interaction of treatment, verbal ability, decision type, and response type in the analysis of reaction time control times. Differences were expected only for treatment, since the task was presumed to allow time for completion of all mental operations. However, treatment differences were found in some conditions, but not in others. The pattern of results showed no consistency; that is, treatment differences were found for some of the least complex conditions, and some of the most complex conditions. The second unexpected result was the main effect of decision type in the reaction time control condition. If all cognitive operations were completed, no difference in response times between type of decision (PI, SN, SC) would be expected. Therefore, it is possible that the reaction time control condition used in the present study may not have excluded all cognitive operations adequately. That is, the speed of certain cognitive operations, as well as the speed of motoric components, may have been measured during the reaction time control task. If this occurred, the subtractive data may not have been a complete measure of the speed of cognitive operations, since a part of the time required to complete all cognitive operations may have been subtracted out.

Analysis of the data involving decision type and response type provided evidence for the validity of the tasks used in the present study. These data showed that tasks involving greater cognitive complexity required more time to complete.

A strong effect of decision type was seen in the predicted direction. Tasks requiring that more information be accessed from long term memory took longer to complete than tasks requiring less information from long-term memory. Differences between the PI and SN conditions were seen only for medians (with SN requiring more time to respond than PI). For medians minus RTC, post hoc analyses revealed no significant difference between PI and SN decisions, but the data were in the predicted direction. In each of these four analyses however, clear differences were seen between SC and either PI or SN. SC decisions, which clearly require the largest amount of information be obtained from long term memory, took longest.

Significant effects of response type were also found. Negative responses resulted in slower response times than positive responses. This is a common finding in studies requiring positive or negative responses (Petros et al., 1983; Hunt et al., 1981). It appears that the decision process was able to conclude more quickly when the information a subject was searching for was present.

The most important limitations in the present study were the speed-accuracy tradeoffs that occurred under certain conditions. The presence of these tradeoffs certainly qualified the results of the study, and it would be worthwhile to conduct a similar study in the future with changes in the methodology that would be likely to decrease the speed-accuracy tradeoffs that occurred. The first possible change that may accomplish the goal would be to increase emphasis on accuracy when subjects receive instructions. It may also be necessary for experimenters to remind the subjects more frequently that accuracy is important, and that the subjects should not answer before they have determined the correct answer.

A second method of increasing accuracy could involve factors that affect motivation, for example, monetary payment based on the accuracy of responses. This would decrease the number of errors that occur, but may also have an adverse effect on the data. Subjects may not answer as soon as they know the correct answer, instead, taking time to check their answers to assure a maximum payment.

A second limitation in the present study was the large degree of individual variability in the data. A significant portion of this variability may have been due to variations in blood alcohol levels between intoxicated subjects. Even though subjects who received 1.0 ml absolute alcohol per kilogram of body weight in previous studies achieved an average blood alcohol level of .07, the degree of individual variation in blood alcohol level was large (Parker et al., 1976). For example, O'Neill, Williams, & Dubowski (1983) found a large variation in peak blood alcohol levels with a dose of .05 ml/kg, half of the dose used in the present study. Variations in blood alcohol levels would affect performance on the tasks used in this study. One solution to this problem would be to use a breathalyzer to measure blood alcohol levels. Results for subjects whose blood alcohol levels were not within a pre-defined range could be excluded. This presumably would decrease some of the individual difference variability.

The present study sought to answer questions about the functioning of memory processes under acute alcoholic intoxication. Although the findings are unclear, it lends general support to the theory that one effect of alcoholic intoxication is a slowing of access speed of information from long-term memory. Further research is needed to delineate more clearly the effects of alcoholic intoxication on memory retrieval speed, as well as other memory processes.

APPENDICES

APPENDIX A

TREATMENT X VERBAL ABILITY X DECISION TYPE X RESPONSE TYPE ANOVA FOR MEDIAN RESPONSE TIMES

TABLE 19

Treatment x Verbal Ability x Decision Type x

Response Type ANOVA for Median Response Times

Source	Sum of Squares	DF	F		Significance
Treatment (T)	301569	1	1.11		.2955
Verbal Ability (V)	283929	1	1.05		.3102
T x V	44571	1	.16		.6866
Error	16815277	62			
Decision Type (D)	24877900	2	376.43	under	.0001*
D x T	92456	2	1.40		.2507
D x V	187917	2	2.84		.0620
D x T x V	210620	2	3.19		.0447*
Error	4097511	124			
Response Type (R)	802451	1	73.87	under	.0001*
R x T	1715	1	.16		.6925
R x V	10	1	.00		.9753
R x T x V	22757	1	2.09		.1528
Error	673514	62			
D x R	199470	2	10.52	under	.0001*
D x R x T	14666	2	.77		.4637
D x R x V	5503	2	.29		.7486
D x R x T x V	79281	2	4.18		.0175*
Error	1175996	124			

APPENDIX B

TREATMENT X VERBAL ABILITY X DECISION TYPE X RESPONSE TYPE ANOVA FOR REACTION TIME CONTROL MEDIANS

TABLE 20

Treatment x Verbal Ability x Decision Type x

Response Type ANOVA for Reaction Time Control Medians

Source	Sum of Squares	DF	F	Significance
Treatment (T)	7105	1	.06	.8147
Verbal Ability (V)	52031	1	.41	.5266
T x V	4277	1	.03	.8557
Error	7954817	62		
Decision Type (D)	197686	2	12.54	under .0001*
D x T	2780	2	.18	.8387
D x V	774	2	.05	.9521
D x T x V	14302	2	.91	.4066
Error	978171	124		
Response Type (R)	46	1	.02	.8839
R x T	68	1	.03	.8590
R x V	6306	1	2.94	.0912
R x T x V	7793	1	3.64	.0611
Error	132779	62		
D x R	3611	2	.93	.3991
D x R x T	7102	2	1.82	.1664
D x R x V	1692	2	.43	.6491
D x R x T x V	17803	2	4.56	.0123*
Error	241973	124		

APPENDIX C

TREATMENT X VERBAL ABILITY X DECISION TYPE X RESPONSE TYPE ANOVA FOR MEDIAN RESPONSE TIMES MINUS REACTION TIME CONTROL MEDIAN RESPONSE TIMES

TABLE 21

Treatment x Verbal Ability x Decision Type x

Response Type ANOVA for Median Response Times Minus

Reaction Time Control Median Response Times

Source	Sum of Squares	DF	F		Significance
Treatment (T)	225111	1	1.21		.2751
Verbal Ability (V)	590883	1	3.18		.0793
T x V	72146	1	.39		.5353
Error	11508803	62			
Decision Type (D)	23419418	2	290.59	under	.0001*
D x T	86833	2	1.08		.3436
D x V	164884	2	2.05		.1336
D x T x V	126526	2	1.57		.2122
Error	4996663	124			
Response Type (R)	776325	1	62.11	under	.0001*
R x T	1672	1	.13		.7158
R x V	5335	1	.43		.5159
R x T x V	61959	1	4.96		.0296*
Error	775005	62			
D x R	194614	2	9.07		.0002*
D x R x T	34738	2	1.62		.2023
D x R x V	5921	2	.28		.7593
D x R x T x V	26264	2	1.22		.2976
Error	1330403	124			

APPENDIX D

TREATMENT X VERBAL ABILITY X DECISION TYPE X RESPONSE TYPE ANOVA FOR PROPORTION OF ERRORS

TABLE 22

Treatment x Verbal Ability x Decision Type x

Response Type ANOVA for Proportion of Errors

Source	Sum of Squares	DF	F	Significance
Treatment (T)	.05922	1	10.57	.0019*
Verbal Ability (V)	.00004	1	.01	.9351
T x V	.00225	1	.40	.5282
Error	.34737	62		
Decision Type (D)	.26645	2	43.22 under	.0001*
D x T	.00707	2	1.15	.3209
D x V	.00139	2	.23	.7981
D x T x V	.04772	2	7.74	
.0007* Error			.38218	124
Response Type (R)	.00553	1	.93	.3380
R x T	.00164	1	.28	.6006
R x V	.01773	1	2.99	.0888
R x T x V	.02438	1	4.11	.0469*
Error	.36769	62		
D x R	.05294	2	6.48	.0021*
D x R x T	.02728	2	3.34	.0388
D x R x V	.01623	2	1.99	.1416
D x R x T x V	.02849	2	3.49	.0337*
Error	.50683	124		

APPENDIX E

TREATMENT X VERBAL ABILITY X DECISION TYPE X RESPONSE TYPE ANOVA FOR REACTION TIME CONTROL PROPORTION OF ERRORS

TABLE 23

Treatment x Verbal Ability x Decision Type x

Response Type ANOVA for Reaction Time Control

Proportion of Errors

Source	Sum of Squares	DF	F	Significance
Treatment (T)	.03893	1	9.49	.0031*
Verbal Ability (V)	.00001	1	.00	.9576
T x V	.01000	1	2.44	.1236
Error	.25436	62		
Decision Type (D)	.12202	2	16.28	under .0001*
D x T	.01426	2	1.90	.1535
D x V	.00712	2	.98	.3897
D x T x V	.00953	2	1.27	.2840
Error	.46473	124		
Response Type (R)	.04373	1	13.16	.0006*
R x T	.00002	1	.01	.9368
R x V	.00004	1	.01	.9090
R x T x V	.01909	1	5.74	.0196*
Error	.20610	62		
D x R	.03241	2	5.12	.0073*
D x R x T	.00413	2	.65	.5224
D x R x V	.00769	2	1.22	.2999
D x R x T x V	.00233	2	.37	.6927
Error	.39214	124		

APPENDIX F

TREATMENT X VERBAL ABILITY

ANOVA FOR SUBJECTS AGE IN YEARS

TABLE 24

Treatment x Verbal Ability

ANOVA for Subjects Age in Years

Source	Sum of Squares	DF	F	Significance
Treatment (T)	0	1	.00	.9590
Verbal Ability (V)	0	1	.01	.9375
T x V	0	1	.16	.6914
Error	5	62		

APPENDIX G

TREATMENT X VERBAL ABILITY

ANOVA FOR SUBJECTS WEIGHT IN POUNDS

TABLE 25

Treatment x Verbal Ability

ANOVA for Subjects Weight in Pounds

Source	Sum of Squares	DF	F	Significance
Treatment (T)	19	1	.03	.8600
Verbal Ability (V)	1502	1	2.21	.1388
T x V	1394	1	2.05	.1539
Error	681	62		

APPENDIX H

TREATMENT X VERBAL ABILITY ANOVA FOR WAIS-R VOCABULARY SUBTEST RAW SCORES

TABLE 26

Treatment x Verbal Ability ANOVA for

WAIS-R Vocabulary Subtest Raw Scores

Source	Sum of Squares	DF	F	Significance
Treatment (T)	26	1	1.11	.2962
Verbal Ability (V)	2905	1	120.79	under .0001*
T x V	47	1	1.96	.6350
Error	24.05	62		

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