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Alcohol and Elaborative Schemas for Sentences

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Three experiments were conducted to determine whether alcohol-induced impairments of memory would be reduced by providing subjects with elaborative schemas. Anomalous sentences were presented to sober or intoxicated subjects either alone or with context words to facilitate comprehension. Memory was tested immediately with a yes–no recognition task. The results consistently showed that context words did not increase the number of hits for either sober or intoxicated subjects, and sober subjects made reliably more hits whether or not context words had been provided. The accuracy of recognition of distractors, however, was consistently improved by the presentation of context words, and was much more improved for intoxicated than for sober subjects. The results indicate that alcohol intoxication disrupted the production of elaborative schemas for understanding, but that intoxicated subjects were quite successful at utilizing such schemas as long as the schemas had been provided for them.

It has been well established that the acquisition of new information is impaired when it occurs in a state of alcohol intoxication (e.g., Birnbaum & Parker, 1977; Ryback, 1971). There is evidence that the process of storage of new information is impeded by intoxication (Parker, Birnbaum, & Noble, 1976), whereas retrieval of learned information is unimpaired by the same level of intoxication (Birnbaum, Parker, Hartley, & Noble, 1978). The investigations that are reported here grew out of an attempt to understand the ways in which alcohol intoxication impairs memory storage.

Many factors can influence the storage of new information. One of these may be described as *elaboration,* the type of thinking in which prior information is activated in order to integrate incoming information or to clarify new information in light of what is already known (Bartlett, 1932; Bower, 1972; Bransford & Johnson, 1973). Hasher and Johnson (1975) and Hasher, Griffin, and Johnson (1977) have shown that differences in the elaboration of verbal input influence subsequent retention. It is not hard to imagine that the elaboration of new information might be different in sober and intoxicated states. For example, Weingartner and Murphy (1977) found that free associations to words were different when subjects were sober than when they were intoxicated. If alcohol intoxication influences thought processes, then the memory representations that are established under sober and intoxicated conditions are probably quite different. Thus, alcohol may reduce the chances that a subject will produce the type of elaborative information that augments recall. In addition, following a distinction that has been useful in other areas, impairment in function may result from a deficiency not only in the production but also in the utilization of appro-

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priate strategies and information (e.g., Flavell, 1970). Even if they are provided with appropriate elaborative information, intoxicated subjects may not be able to use the information to improve their performance.

In the present experiments, we selected material for which it was likely that the elaboration of the stimuli could be influenced strongly by a simple experimental manipulation. Johnson, Doll, Bransford, and Lapinski (1974) found that memory for sentences that were specially constructed to be opaque in meaning was markedly improved by the presence of context cues at the time of input. The presentation of a word or two before each sentence clarified the meaning and produced a substantial improvement in free recall of the sentences. For example, memory for a sentence such as "the crowd cheered the block," benefited from the context word "football." Presumably, without the contexts, subjects ordinarily take an active role in searching for schemas or trying to create elaborators to improve their understanding of difficult sentences such as these. Intoxicated subjects, on the other hand, might not engage in this type of active elaborative processing and thus should show a marked disadvantage in memory for this material. If the memory deficit is primarily a consequence of the failure to produce effective elaborators, then intoxicated subjects should be able to utilize such information when it is provided. Specifically, the presentation of context cues when the sentences are being studied should have a greater beneficial effect on intoxicated than on sober subjects. In effect, sober subjects may produce their own context for understanding and therefore will not be helped as much as are intoxicated subjects by the experimenter-provided context. If, on the other hand, intoxicated subjects have particular difficulty integrating information or coordinating two sources of information, they should show little or no improvement in memory when context cues are provided.

In the first experiment, all of the sentences were presented either with or without context cues, and subjects were either sober or intoxicated. To make the memory test as effortless as possible, a test of recognition was used. If there are motivational differences between sober and intoxicated subjects, their effects on a recognition test will probably be minimal. This precaution was taken despite the fact that previous research indicates that alcohol's effects on memory are not caused by motivational changes (Parker et al., 1976).

Experiment 1

Method

Design. The design was a 2 × 2 factorial with group (sober vs. intoxicated) and presentation (context vs. no context) as between-subjects variables. A total of 12 subjects was run in each group. A single study trial was given on a list of 32 sentences, and was followed immediately by a recognition test.

Materials. Twenty-eight critical sentences were used, many of them borrowed from Johnson et al. (1974). Each sentence was grammatically correct, but its meaning was puzzling when it was presented alone, for example, "The notes went sour when the seam split." The presentation of a specific context (a word or two) with each sentence could be used to make the meaning clear; for example, "bagpipes" was the context for the example just given. Four additional sentences of the same type were used as buffers in each study order (first two and last two positions). Each subject studied a total of 32 sentences, 28 of which were to be used on the subsequent recognition test.

For the recognition test, half of the sentences on the study list were unchanged (targets) and the other half were used to create new sentences (distractors). The distractors were constructed by first dividing each sentence into two sections, for example, "The notes went sour . . ." and ". . . when the seam split," and then re-pairing these sections of the original sentences; for example, "The notes went sour when the fire got too hot" was one of the distractor sentences. The 28 critical sentences on the study list were divided arbitrarily into two sets of 14 sentences, designated A and B. On the recognition test, Set A and Set B served equally often as targets and as (rearranged) distractors in each group. There were three different orders of studying the sentences and two possible test orders for each study order. The six combinations of study and test order were used twice in each group. For a particular subject, at least 5 study sentences and 3 test sentences intervened between the study and test of the same sentence (or portion thereof). The sentences were arranged randomly in both the study and test orders, with the following restrictions: One run of 3 sentences from Set A and Set B occurred once in each order; otherwise, no more than 2 successive sentences came from the same set.

Subjects and procedure. Adult males were recruited by advertisement at the University of California at Irvine, and were paid for their participation in the study. Potential subjects were screened, and moderate social drinkers who were in good health were selected for participation. They were instructed to eat a prescribed breakfast on the day of testing and were asked to fast for 3 hr prior to arrival at the laboratory. They were also instructed to avoid all drugs, including alcohol, for 24 hr before the experimental session. The subjects were run individually and were given instructions about the sentence-memory task before ingestion of the drinks. They were told that they would read each of 32 sentences aloud as they were presented on cards, and that the sentences might sound "somewhat strange." If the subject was in one of the context groups, he was informed that each sentence would be preceded by one or two words that were related to the meaning of the sentence. All of the subjects were told that after the sentences had been presented once, a memory test would be given. The requirements of the recognition test were explained, and examples were given that illustrated the construction of the distractor sentences. On the test, the subject's task would be to decide whether each sentence was the same as or different from one of the sentences on the study list.

After the instructions were completed, drinks were administered. Subjects consumed the drinks slowly over a 40-min period. For subjects in the intoxicated groups, the drinks contained equal volumes of vodka and peppermint masking solution; each subject received a total of 1.0 ml absolute alcohol per kilogram of body weight (1.0 ml/kg). For subjects in the sober groups, the placebo drinks contained equal volumes of water and peppermint masking solution, and the rims of the glasses were swabbed with vodka. The volume of each placebo drink was equivalent to the volume that the subject would have received had he been in an intoxicated group. When a 20-min absorption period had elapsed, a breathalyzer reading was taken, the instructions for the sentence task were reviewed, and the study trial began. For each sentence a prepared index card was handed to the subject, he read the material aloud at his own pace, and then he handed the card back to the experimenter. This procedure continued until all 32 sentences had been read and the total time for the study trial was recorded. The subject was briefly reminded of his task on the test trial and was handed a card containing the first test sentence. He read it aloud and decided whether it was the same as or different from one he had read on the study trial. The test was self-paced, and the total time for the test trial was recorded. Each of three experimenters ran an equal number of subjects in each group. One subject was replaced because of a procedural error.

Results

For all experiments, the probability of a Type I error was set at .05 for all of the analyses.

The mean blood alcohol level was 0 for each of the sober groups, .072 g/100 ml for the intoxicated-context group, and .065 g/100 ml for the intoxicated–no-context group a minute or two before the task began. A two-way analysis of variance of the number of seconds taken to complete the study trial showed that the no-context condition took significantly less time than did the context condition, $F(1, 44) = 18.27$, $MS_e = 688.42$; intoxicated subjects were not significantly slower than were sober subjects, $F(1, 44) = 2.93$, $p < .09$. The analysis of variance of number of seconds taken to complete the test trial yielded no significant effects ($ps > .12$).

Table 1
Mean Numbers of Hits and False Alarms in Experiment 1

Group	Presentation: Context	Presentation: No context
Hits		
Sober	10.5	12.2
Intoxicated	10.2	9.5
False alarms		
Sober	.8	1.9
Intoxicated	.7	4.6

The mean numbers of hits and false alarms are shown in Table 1. Not surprisingly, there was a greater number of hits in the sober than in the intoxicated group, $F(1, 44) = 7.13$, $MS_e = 4.00$. There was an unexpectedly high number of hits in the sober–no-context group, and the Group × Presentation interaction was significant, $F(1, 44) = 4.38$. Tests of simple main effects showed that the difference between sober and intoxicated subjects was not significant in the context condition ($F < 1.00$) but was significant in the no-context condition, $F(1, 44) = 11.34$. There is a possibility that subjects in the sober–no-context group were better-than-average rememberers. This possibility, of course, will have implications for the interpretation of the results.

The sober–context and intoxicated–context groups had a nearly identical number of false alarms. It is of note that the intoxicated subjects were not worse than the sober subjects when context words had been provided. For false alarms, there was a main effect of presentation, $F(1, 44) = 39.21$, $MS_e = 1.91$, and a significant Group × Presentation interaction, $F(1, 44) = 12.59$. The results indicate that intoxicated subjects' recognition memory was severely impaired in the no-context condition and that this impairment was absent when context words were provided.

An examination of d' (Green & Swets, 1966) substantiates this interpretation. With context, the intoxicated and sober groups were almost identical (mean $d' = 3.77$ and 3.71, respectively). With no context, the intoxicated group was considerably lower than the sober group (mean $d' = 1.07$ and 3.43, respectively). A two-way analysis of variance of d' yielded significant main effects of group, $F(1, 44) = 8.78$, $MS_e = 1.81$, and presentation, $F(1, 44) = 14.67$, and a significant interaction of Group × Presentation, $F(1, 44) = 9.64$. The results for d' were consistent with the results for hits and false alarms. Apparently, the removal of context cues had a greater impact on the memory performance of intoxicated than of sober subjects. This effect may have been magnified by sampling error. In particular, if subjects in the sober–no-context group were better-than-average rememberers, as suggested earlier, then the results may not be replicable. In addition, the absence of any difference between sober and intoxicated subjects when context was provided demands replication.

Experiment 2

The obvious next step would have been to repeat Experiment 1; at the time, however, other work in our laboratory had lead us to plan the next experiment as a within-subjects design with respect to the alcohol variable. Since that experiment involved a task that was completely different from the sentence task, it seemed like a good opportunity to collect additional data on sentence memory. We decided, therefore, to construct two forms of a mixed list for the sentence task; that is, half of the sentences would be presented with context words and half with no context words. It should be mentioned that we had deliberately selected the between-subjects design in Experiment 1 so that a particular subject would experience only context or no context. The potency of this variable, therefore, would not be attenuated by strategies that might otherwise be developed during the presentation trial; for example, subjects might be more likely to generate contexts for no-context sentences when the acquisition list also contained sentences with contexts. Despite this consideration, the availability of subjects and the opportunity of gathering additional data on the effect of providing elaborative schemas to intoxicated subjects led us to run Experiment 2.

Method

Design. The design was a 2 × 2 factorial with group (sober vs. intoxicated) and presentation (context vs. no context) as within-subjects variables. A total of 24 subjects was run in two sessions that were 1 wk apart (sober or intoxicated). The order of administering the placebo or alcohol beverage was counterbalanced across sessions.

Materials. The 28 critical sentences of Experiment 1 were augmented by 12 sentences, for a total of 40 critical sentences. The 40 critical sentences were arbitrarily divided into two sets of 20. Each set was used in the construction of an alternate form of the study list; each alternate form was used equally often in the first and second experimental session and in the sober and intoxicated groups.

Each set of 20 critical sentences was divided into four groups of 5 sentences. Across subjects, the four groups of sentences were rotated through the context–no-context and target-distractor roles. Two lists were necessary to rotate the sentences through the context–no-context roles, and two orders of testing were constructed for each list to rotate sentences through the target and distractor roles. Distractors were formed by re-pairing components of the 5 sentences in a group. Thus, all parts of a distractor sentence had been presented in the same fashion, that is, with or without context.

Each alternate form of the study list was lengthened by adding 11 buffer sentences, some with and some without context words. Buffer sentences occupied the first three and last three serial positions in each list. Also, a buffer sentence was inserted randomly in each block of 4 critical sentences. Altogether, each study list was 31 sentences long.

Testing orders were constructed by randomized blocks; that is, each group of 5 sentences was sampled once before any was sampled twice, and so on. Three restrictions applied: Sentences from the same group could not occupy adjacent positions in the list; the order of sentences in the test list was not correlated with the order of the sentences in the sutdy list; and, for distractor sentences, at least one test sentence intervened between the components of an original sentence.

Subjects and procedure. Subjects were recruited at the University of California at Irvine. The details of the procedure were the same as in Experiment 1 with the following exceptions: Since the list contained both context and no-context sentences, all of the subjects were instructed that some of the sentences would be preceded by a word or two that was related to the meaning of the sentence; between the end of the single study trial and the recognition test, the subjects were engaged in a brief (1.5 min) study of a spatial-memory display of 16 common objects on a 6×6 grid. One subject was replaced because he did not tolerate the alcohol dose.

Results

The mean blood alcohol level was 0 in the sober group and .078 g/100 ml in the intoxicated group just before the sentence task began. Subjects, when they were sober, completed the study trial significantly faster than when they were intoxicated (Ms of 218 sec and 231 sec, respectively), $t(21) = 2.64$ (data were missing for two subjects). The time to complete the test, on the other hand, was not influenced by the subject's state of intoxication, $t(23) = 1.03$.

The mean numbers of hits and false alarms are shown in Table 2. The sober group had a significantly greater number of hits than did the intoxicated group, $F(1, 23) = 7.41$, $MS_e = 1.10$, and there were significantly fewer hits in the context than in the no-context condition, $F(1, 23) = 5.23$, $MS_e = .80$. The pattern of results for false alarms replicated the pattern found in Experiment 1. When subjects were intoxicated, there were significantly more false alarms than when they were sober, $F(1, 23) = 9.91$, $MS_e = .46$; there was a significant Group $\times$ Presentation interaction, $F(1, 23) = 6.41$, $MS_e = .58$, indicating that the misidentification of distractor sentences as targets was especially pronounced for intoxicated subjects in the no-context condition.

Table 2
Mean Numbers of Hits and False Alarms in Experiment 2

Group	Presentation: Context	Presentation: No context
Hits		
Sober	3.5	4.0
Intoxicated	3.0	3.4
False alarms		
Sober	.33	.12
Intoxicated	.37	.95

An examination of d' showed a pattern similar to the one seen in Experiment 1. With context, the intoxicated and sober groups were relatively close together (mean $d' = 2.31$ and 2.78, respectively). With no context, the intoxicated group was much lower than the sober group (mean $d' = 2.01$ and 3.40, respectively). A 2×2 analysis of variance of d' yielded a significant main effect of group (sober vs. intoxicated), $F(1, 23) = 13.35$, $MS_e = 1.56$, and a significant Group $\times$ Presentation interaction, $F(1, 23) = 5.03$, $MS_e = .98$. The severe impairment in recognition memory (false alarms and d') for intoxicated subjects in the no-context condition replicated the results of Experiment 1. The primary difference in results across experiments was the suggestion of a real difference in memory strength (d') between the sober and intoxicated groups in the context condition in Experiment 2. A test of simple main effects, however, indicated that there was no significant difference between these groups in the context condition, $F(1, 23) = 2.47$, $p < .13$. Experiment 3 was run to achieve our original goal of replicating Experiment 1 and to reexamine the possibility that sober and intoxicated subjects do not have equivalent recognition accuracy under the context condition.

Experiment 3

Method

The method for Experiment 3 was a duplication of the method in Experiment 1. In a 2×2 design,

Table 3
Mean Numbers of Hits and False Alarms in Experiment 3

Group	Presentation: Context	Presentation: No context
Hits		
Sober	11.2	10.5
Intoxicated	9.5	8.8
False alarms		
Sober	.67	2.2
Intoxicated	.67	4.4

group and presentation were between-subjects variables, and 12 subjects were run in each cell.

Results

The mean blood alcohol level was .076 g/100 ml in the intoxicated–context group, .067 g/100 ml in the intoxicated–no-context group, and 0 in the sober groups at the beginning of the study trial. Subject in the no-context condition took less time to complete the study trial than did subjects in the context condition, $F(1, 44) = 5.22$, $MS_e = 818.86$; neither the effect of group nor the Group × Presentation interaction was significant ($ps > .20$). None of the effects in the 2 × 2 analysis of variance of test time were significant ($ps > .12$).

The mean numbers of hits and false alarms are shown in Table 3. The mean numbers of hits showed the expected superiority of sober subjects on the recognition test, $F(1, 44) = 8.47$, $MS_e = 4.13$; the previously observed superiority of the no-context condition was absent for both the sober and the intoxicated groups. Neither the main effect of presentation ($p > .23$) nor the Group × Presentation interaction ($p > .94$) was significant. It should be noted that the failure to find an effect of presentation cannot be explained as a ceiling effect; only 3 of the 48 subjects scored 14 hits, and 1 subject scored 13 hits.

In the two-way analysis of variance of false alarms, there was a significant main effect of presentation, $F(1, 44) = 25.28$, $MS_e = 3.27$. Context words during input facilitated recognition memory (as measured by false alarms), complementing the results of Johnson et al. (1974) on free recall, and extending the results to the state of alcohol intoxication. The main effect of group was also significant, $F(1, 44) = 4.64$. The most striking result with false alarms was the confirmation of the previously observed Group × Presentation interaction, $F(1, 44) = 4.64$. As in Experiments 1 and 2, intoxicated subjects were particularly impaired in the no-context condition. The presentation of context words at input allowed intoxicated subjects to achieve the same level of accuracy as sober subjects in recognizing that distractor sentences were not members of the list. It may be seen that context words do not completely eliminate alcohol-induced impairment of recognition memory by referring again to the hits. The superiority of sober to intoxicated subjects in recognizing target sentences as members of the list was just as large when context words were provided as when they were absent (see Table 3).

An examination of d' substantiated these results. There was a large difference between the sober and intoxicated groups under no-context conditions (mean $d' = 2.96$ and 1.10, respectively) and a smaller difference under context conditions (mean $d' = 4.31$ and 3.81, respectively). A two-way analysis of variance of d' yielded significant effects of group, $F(1, 44) = 6.45$, $MS_e = 2.62$, and presentation, $F(1, 44) = 18.85$, and a nonsignificant Group × Presentation interaction, $F(1, 44) = 2.12$, $p < .16$. Although the interaction did not reach significance, there is support for the contention that the intoxicated–no-context group had the lowest memory strength: A Scheffé test of pairwise comparisons showed that the intoxicated–no-context group was significantly lower than both of the context groups (which did not differ from one another), and the difference between the intoxicated–no-context and sober–no-context group approached significance (the critical difference was 1.93 and the obtained difference was 1.86). As in Experiments 1 and 2, alcohol-induced impairment of recognition memory was particularly severe in the no-context condition. The fact that the sober group was superior to the intoxicated group in d' in the context condition as well as in the no-context condition was in agreement with the pattern found in Experiment 2. A test of simple main effects, however, showed no significant difference between these groups, $F(1, 44) < 1.00$.

Discussion

Several aspects of the results of all three experiments were quite consistent. Without a clarifying semantic context, sober subjects showed better recognition memory for sentences than did intoxicated subjects, evidenced by more hits, fewer false alarms, and higher d' scores. Previous work has shown that continuous recognition memory is impaired by acute alcohol intoxication (Ryback, Weinert, & Fozard, 1970; Wickelgren, 1975), and the present results are consistent with the well-established phenomenon of alcohol-induced deficits in learning. Providing context or schemas that helped to clarify the meaning of sentences substantially reduced false alarms, especially for intoxicated subjects. Although sober subjects receiving contexts still tended to have more hits than did intoxicated subjects, their d' scores were not significantly higher than those of intoxicated subjects.

The results are consistent with the notion that the tasks that are most sensitive to the debilitating effects of alcohol are those that are relatively nonautomatized, that is, those that entail conscious strategies (Brown, 1975; Hasher & Zacks, 1979; Johnson, 1977). With no context, interpretation of the sentences requires deliberate, thoughtful effort on the part of the subject. Sober subjects may produce their own elaborators in the no-context condition, in an "effort after meaning" (Bartlett, 1932), whereas intoxicated subjects do not do this as often or as well. When elaborators are provided, however, intoxicated subjects can use them successfully. It seems reasonable to conclude that the alcohol-induced deficit was primarily one of production rather than utilization of elaborative schemas. The equivalence of false alarms (and d') for sober and intoxicated subjects in the context condition should be interpreted with caution, however. Intoxicated subjects might have shown some deficit in recognition accuracy in the context condition if the false-alarm rate had been higher. Nevertheless, for reasons discussed later, we would still expect the difference between sober and intoxicated subjects to be smaller in the context than in the no-context condition.

The results may be viewed in light of available discussions of recognition memory. According to many investigators (e.g., Atkinson & Juola, 1973; Mandler, 1972; Raye, 1976; Underwood & Freund, 1970), recognition decisions are generally based on frequency-of-occurrence information or familiarity. When familiarity does not provide an adequate cue, people are likely to consult other information to make recognition decisions. In our experiments, the distractors were constructed by re-pairing components of the study sentences, in contrast with the more usual practice of including completely new distractors. Thus, familiarity of the words or phrases, alone, would not provide an adequate basis for discriminating targets from distractors, and additional cues would assume greater importance. Context should provide such cues, and should increase the effectiveness of the following decision rule, which may be adopted by subjects when familiarity is not sufficient for a yes–no decision: When a sentence suggests a familiar elaborative schema or referential situation (e.g., "The notes went sour when the seam split," might suggest "bagpipes" on the test), then the decision is *yes*, and otherwise, *no*.

It is clear from the results for both sober and intoxicated subjects that the primary influence of elaborative contexts was on the accuracy of rejection of distractors. The experimenter-provided contexts were designed to be schemas for the entire sentence and were not merely associated with particular words or parts of sentences. Therefore, they would not be appropriate for the distractor sentences. Subject-generated schemas, on the other hand, would be less integrative (especially when subjects were intoxicated), and would be appropriate for the distractors more often than would the experimenter-provided schemas. It seems likely that intoxicated subjects would have more difficulty than sober subjects in constructing integrative schemas, and they would therefore profit more when schemas were provided for them (as in the context condition).

In summary, these experiments are consistent with the idea that alcohol affects the kind of thinking that produces stable elaborators or schemas for incoming information. One important function of these mental products is that they can later serve as the basis for recognition decisions by providing information in addition to familiarity alone. Although alcohol evidently greatly disrupted the production (or quality) of elaborators or schemas, intoxicated subjects were able to utilize contextual information that they were provided with during study on a later recognition test.

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