In I.M. Birnbaum & E.S. Parker (Eds.), Alcohol and human memory. Hillsdale, New Jersey: Erlbaum, 1977.

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What Is Being Counted None the Less?

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Every smallest stroke of virtue or of vice leaves its never so little scar. The drunken Rip Van Winkle, in Jefferson's play, excuses himself for every fresh dereliction by saying, "I won't count this time!" Well! he may not count it, and a kind Heaven may not count it; but it is being counted none the less. Down among his nerve cells and fibres the molecules are counting it, registering and storing it up to be used against him when the next temptation comes. Nothing we ever do is, in strict scientific literalness, wiped out [William James, 1892, p. 150].

Aside from the moral here, at least two important ideas are suggested by this passage. First, that any experience leaves a persisting record, even if its effects are not immediately obvious. Therefore, we ought to be able to detect the effects of our experiences with appropriate measures and paradigms. This idea underlies some of the topics that were considered in detail during the conference. For example, a currently important conceptual and methodological problem is sorting out storage from retrieval deficits in memory (e.g., Birnbaum & Parker, this volume). Similarly, research on state-dependent memory and the role of encoding variability and cue-reinstatement in remembering (e.g., Craik; Goodwin; Keppel & Zubrzycki; Weingartner & Murphy; this volume) suggests that "apparent" forgetting may obscure the essential durability of memory traces.

The second, related, and perhaps corollary idea is that repetitions of similar experiences count or cumulate – again, even though it may not be immediately obvious. There have been a number of especially dramatic illustrations of this point, beginning with Ebbinghaus's (1885) delayed relearning procedure, developed to measure the effects of overlearning. Similarly, Hebb (1961) included a repeated digit sequence in a short-term memory task in order to determine whether transient reverberating traces left any permanent structural trace. Haber and Hershenson (1965) found that repetitions of a word presented at durations at which the word could not be "seen" on the first presentation nevertheless resulted in increases in correct identification over trials. More recently, with a lexical decision task, Forbach, Stanners, and Hochhaus (1974) found that people were faster in deciding a letter string was a word the second time it was presented, even with as much as 10 minutes between repetitions (and decisions about 84 intervening items). Obtaining a "priming" effect over such long intervals suggests that it is not necessarily a temporary phenomenon but may also reflect more permanent changes in memory. It is as if "every smallest stroke . . . leaves its never so little scar."

RECORDING EVENT FREQUENCY

It should not surprise us that one of memory's most remarkable characteristics is its incredible responsiveness to the repetition of events. After all, it is the construct that we make responsible for knowing that something is happening *again*. Without this capacity, it's hard to imagine how perception, thought, and actions could be as orderly as they are. Eddington (1935) suggested that "we should [never] have made progress with the problem of inference from our sensory experience, and theoretical physics would never have originated, if it were not that certain regularities and recurrencies are noticeable in sensory experience [p. 8]." Our perceptual/memory systems have evolved mechanisms for exploiting certain regularities in experience. The nature of these mechanisms is a central, unresolved mystery. But somehow recurrencies are kept track of, and knowledge about the relative frequency of events is the basis for a great deal of our information about the world. Indeed, this is almost certainly one cognitive process underlying learning and memory that we share with most other animals.

Results from many learning situations are consistent with the idea of a mechanism for recording event frequency. For example, pigeons will distribute pecks to two keys in proportion to the number of reinforcements on each (Herrnstein, 1961; Rachlin, 1976). Similarly, children's choices between two alternatives often will match the frequency of occurrence of each (e.g., Messick & Solley, 1957). Adults' predictions about which of two candidates or products will be preferred seems largely determined by which of them has been preferred more frequently in the past (Estes, 1976). Sometimes when two or more responses are possible, one eventually will be made all of the time. Examples would be a rat choosing the arm of a maze that always leads to food rather than the arm that never does, or a pigeon consistently pecking the key that requires fewer pecks per reward, or the child "maximizing" the probability of obtaining prizes. Even in these cases, it seems reasonable to assume that the "sensible" choice reflects stored information about the relative frequency of two or more events.

LONG

More direct evidence of the availability of recurrence information comes from tasks in which people are asked to estimate the frequency of events such as words in the English language or to estimate experimentally induced "situational" frequency of items (e.g., Hintzman, 1969; Underwood, Zimmerman, & Freund, 1971). Although the exact values of their judgments may be somewhat in error, the relative judgments are impressively accurate. In addition, judgments about the relative frequency of events seem to be rather insensitive to developmental trends. Very young children show functions relating judged frequency to actual frequency that are very similar to those produced by older children (Hasher, personal communication, 1976). This would be expected assuming that information about the relative frequency of occurrence of events in the environment is among the most fundamental information an organism might have about the environment.

In recent theories of memory, frequency has played a major role in analyses of recognition processes. Many interpretations of recognition assume that it is possible because familiar or old items (targets) have accrued greater frequency than unfamiliar or new items (distractors). According to this view, when the items are studied, situational frequency information is stored each time an item is presented and each time it is rehearsed. This results in a distribution of target items that vary somewhat among themselves in situational frequency value. At the time of the recognition test, the memory representation of each item is checked for situational frequency; since, on the average, targets will have greater frequency values than distractors, this information can be used to discriminate between the two classes of items.

This type of analysis has received considerable experimental support (e.g., Underwood, 1972; Underwood & Freund, 1968; 1970; Underwood et al., 1971; Atkinson & Juola, 1972; Fischler & Juola, 1971). Perhaps because of this, even models that propose that recognition sometimes involves a second process (when the discrimination based on frequency information is difficult and the subject is not sure) usually assume that the primary information used for decisions is related to event frequency (e.g., Atkinson & Juola, 1972; Mandler & Boeck, 1974). That a very fundamental mechanism is involved in recognition is again suggested by the fact that recognition performance of children is very similar to that of adults (see Brown, 1975).

ALCOHOL AND RECURRENCE INFORMATION

In short, processes underlying the monitoring of recurrences, the recording of event frequency, and mechanisms controlling the availability of this information are very likely central memory functions. Therefore, in the context of the conference, it seemed worthwhile to consider the possible effects of alcohol on recurrence information. Perhaps recording event frequency is a particularly stable memory function, relatively immune to swings of fate such as speciesmembership, age, or level of intoxication.[1] Thus, an initial hypothesis might be that tasks depending primarily on event frequency information should be little disrupted by moderate doses of alcohol to nonalcoholic subjects, compared to tasks (e.g., free recall, problem solving) requiring other processes. Although this prediction could be based on a model of cognitive functioning involving a hierarchy of processes ranging from the "automatic" to the "strategic,"[2] this hypothesis might also be derived from the faith that a kind Heaven would see to it that something so useful to survival as recording recurrence information would be the last to go.

This general notion receives some encouragement from the suggestion by Parker, Alkana, Birnbaum, Hartley, and Noble (1974) that perhaps "the more demanding the task the greater the impairment from alcohol [p. 826]." Presumably, demanding tasks are those that involve finding or generating associations, interrelationships, or structures so that the recall of one event leads to the recall of another, and undemanding tasks are those that capitilize on the propensity of our molecules for recording experienced events.

Although a fairly wide range of tasks have been used in investigations of the effects of alcohol on memory (Ryback, 1971), most of them require reproduction of the target material. There do not seem to be any studies requiring subjects to make either absolute or relative judgments about the frequency of events. It would be interesting to have the results of experiments specifically directed at the question of whether recurrences cumulate as effectively under alcohol conditions as they normally do. Similar relative judgments among items

[1] Of course, *how* events are defined (i.e., what constitutes an "event") may vary widely across species, age groups, or levels of intoxication. The present discussion by-passes this difficult, but interesting, problem.

[2] For example, Brown (1975) makes a distinction between "memory facilitated by strategic intervention" and memory that is an "involuntary product of our continuous interactions with a relatively meaningful environment [p. 113]." Craik and Lockhart (1972) note that "after the stimulus has been recognized, it may undergo further processing by enrichment or elaboration." In the levels of processing framework proposed by Craik and Lockhart, "trace persistence is a function of depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting, and stronger traces [p. 675]." In contrast, here it is assumed that all memory traces are durable, but under some conditions, it may be more difficult to detect some of them than others. For example, organizational and elaborative processes produce traces or sets of interrelated traces that perhaps make it easier for subjects to recall information as compared to the traces produced by processes involved in recording recurrences. However, this does not mean that more embellished traces are necessarily longer lasting than less embellished traces. Regardless of the details of the particular models or classification schemes, discussions such as Brown's and Craik and Lockhart's emphasize the importance of acknowledging the variety of mental activities that may occur when a stimulus is presented and the importance of clarifying *which* processes are critical to a given type of performance and which are subject to disruption from various experimental treatments.

of differing frequencies under alcohol and control conditions would indicate a continued functioning of processes involved in recording recurrences. Less directly, it might also be possible to determine whether subjects profit as much under alcohol conditions from repeating "right" items in a verbal discrimination learning task (e.g., Underwood, Jesse, & Ekstrand, 1964).

Although frequency judgments are not available, there have been several alcohol studies employing recognition paradigms. One interesting finding that at first fits nicely into the "kind Heaven" hypothesis is that measures of memory based on recognition seem to be less susceptible to state-dependent effects than do measures of memory based on recall (Goodwin, Powell, Bremer, Hoine, & Stern, 1969; Osborn, cited in Overton, 1972; Wickelgren, 1975; see also Eich, this volume). You may not be able to recall all of the people at that cocktail party last night, but you have a fair chance of recognizing them the next day.

Although recognition may not show state-dependent effects, there does seem to be an overall decrement in recognition as alcohol dose is increased (Goodwin et al., 1969; Ryback, Weinert, & Fozard, 1970; Wickelgren, 1975; Birnbaum & Parker, this volume). However, before we conclude that alcohol does disrupt the recording of recurrence information we should consider some of the other possible sources of this decrement in recognition.

One possibility is that alcohol makes it less likely that the interpretation or representation activated during the test is the same as that activated during the study trial (e.g., Light & Carter-Sobell, 1970; Tulving & Thomson, 1973; Hasher & Johnson, 1975; Hashtroudi & Johnson, 1976). If the appropriate trace is not contacted, the appropriate recurrence information will not be available. Some evidence regarding this notion may be obtained from studies in which subjects are asked to generate associates to stimuli and are later asked again to generate the same associates (Goodwin et al., 1969; Weingartner & Faillace, 1971). Although Weingartner and Faillace did not find any impairment in retention of previously given associates from administering alcohol to nonalcoholic subjects, Goodwin et al. did. Insofar as associates give some clue about the stability of encoding of an item, this paradigm is quite interesting. For now, evidence for less stability in the *basic* encoding of stimuli under alcohol does not seem overwhelming; this is consistent with the failure to find marked state-dependent effects with recognition. If the encoding of an item is relatively stable from alcohol to nonalcohol state and vice versa, then it seems likely that it would be relatively stable across two presentations under alcohol.

More central to the present discussion is the possibility that alcohol reduces attention to the stimuli and thus not as many are experienced as in the control condition. Frequency increments cannot accrue to representations that are not activated. That this might not be the entire source of the poorer performance, however, is suggested by the fact that Wickelgren (1975) found a small but significant decrement in recognition with a continuous procedure that required subjects to respond to every item.

Another possibility is that sober subjects may rehearse more during acquisition and thus generate more frequency increments.[3] Covert rehearsal is something that is generally difficult to equate across conditions, but it is critical where tests of frequency effects in recognition are concerned (Raye, 1976). Using incidental orienting tasks during acquisition (e.g., Craik, this volume) might be one technique to guarantee processing of every input, and it might also serve to equate uncontrolled rehearsals in alcohol and control subjects.

In speculating about other factors that might contribute to a recognition decrement, it is worth considering the source of errors – especially false positives – in recognition. There is some evidence that false positives are a consequence of the implicit activation of distractors during acquisition (Underwood, 1965; Kimble, 1968). That is, during study, not only are representations of the presented items activated, but so are ideas that may be associated with the targets. Thoughts other than those directly representing the stimuli are taking place. And, although these thoughts may be conscious, they are not necessarily so. If some of these previously activated associations are among the distractors they may seem familiar, and the subject will make false positive responses. Suppose alcohol increases the number of different implicit responses (i.e., produces less focused thinking) during acquisition. This would increase the difficulty of subsequently rejecting any given set of distractors. Or suppose alcohol produces a tendency during acquisition to give relatively more attention to internally generated events and relatively less to externally generated events. Distractors should then have relatively more frequency increments and targets relatively less, producing not only increased false positives but also decreased hits.

The above discussion has included three main points:

1. We do not have much information about whether recurrences are recorded as well under alcohol as control conditions. If they are not, this would indicate that a very central memory function is disrupted by alcohol. Furthermore, such a disruption could certainly account for a recognition decrement if recognition is based primarily on frequency information. Available data does not allow us to confidently reject the hypothesis that alcohol does not affect recording event frequency.

2. Even if alcohol does not affect the reliability or sensitivity with which recurrence information is recorded, alcohol and control conditions could differ in the number of functional occurrences of target items. That is, thinking again about (or internally generating) recent events is the sort of "self-initiated set" (Parsons & Prigatano, this volume) like semantic elaboration or organization, which seems most easily disrupted by alcohol. [illegible] volume, reported a procedure in which reminding subjects about a recent event during a blackout considerably reduced the usual forgetting obtained.) In fact, organizing information probably depends on a set and the ability to covertly generate previously presented items.

3. Alcohol may affect the number (or range) of occurrences of internally generated items that are *not* part of the target set. Thus one important effect of alcohol may be that it changes what is available to be counted by a recurrence mechanism.

THE PROBLEM OF REALITY-MONITORING

However, as soon as we assume that there are two types of events taking place at acquisition – the activation or establishment of memory traces that more or less directly represent the external stimuli and those that represent other ideas – a critical problem is highlighted. How do we discriminate between these two types of representations? To the extent that this discrimination occurs, a thought might not provoke a false positive during a recognition test no matter how many frequency increments it had accrued. Conversely, any manipulation that makes this discrimination more difficult should increase recognition errors. Thus another possibility (which does not necessarily exclude any of those discussed previously) is that alcohol somehow decreases a person's ability to discriminate the memories generated by perceptual experience from those generated by other processes. The type and frequency of externally and internally generated representations might be similar under alcohol and control conditions, but telling the difference between them later ("reality-monitoring") may be more difficult in the former case.[4] It seems plausible that drinking alcohol might impair a person's ability to distinguish fact from fantasy. (An understandable motivation for social drinking!) Recognition tests are situations in which fairly stringent criteria for distinguishing memories for external and internal events are appropriate, because internally generated items that were not on the target list represent potential errors. If alcohol lowers these criteria, increases in false positives would be expected.

Whether only false positives should increase, or whether hits might be affected also, depends on how the memory representations of external and internal events differ. If memories for thoughts and memories for perceptual "facts"

[3]As previously stated, the assumption of frequency models of recognition is that covert activations of ideas result in frequency increments that may be included in estimates of perceptual event frequency. Some evidence regarding this assumption will be presented later.

[4]The problem of distinguishing fact from fantasy has received special attention in the context of certain clinical problems, such as schizophrenia, and the process by which this is accomplished is sometimes called "reality testing" (e.g., Cameron, 1963). Reality-monitoring is intended to be a more neutral term with respect to the underlying mechanisms for the same general capacity. In addition, "monitoring" also has the connotation (appropriate here) of making judgments about *past* events represented in memory (Hart, 1967).

differ in that thoughts are on the average simply weaker versions of facts, then perhaps lowered criteria should increase both false positives and hits. On the other hand, if they differ more on qualitative dimensions, a shift in criteria would not necessarily have parallel effects on hits and false positives. Including a wider range of types of memory representations in the "acceptable category" might produce an increase in false positives while leaving hits relatively unchanged. Unfortunately, hits and false positives are often not reported separately. In general, this would be interesting information to preserve in reporting recognition results since it might provide some clues about the nature of the effects of specific experimental manipulations.

In discussing results of studies of people with severe amnesia, Warrington and Weiskrantz (1970, 1971) suggested these subjects may "fail to categorise separately the 'new' and the 'old', or . . . there is a tendency for over-generalisation among the alternative items in store [1971, p. 67]." They used a technique in which visually degraded versions of word stimuli were used as cues for recall. As compared to normal subjects, the amnesic subjects did comparatively worse in a standard yes/no recognition task than in the cued procedure. Warrington and Weiskrantz proposed that the cuing technique helped eliminate interference from false positives that occurs in the recognition situation. Their notion of overgeneralization among alternative stored items is similar to the present idea regarding potential effects of moderate doses of alcohol on reality-monitoring, if it is assumed that some of the overgeneralization is between stored representations of external events and stored representations of internal events.

As has been argued elsewhere (Johnson, 1975; Johnson, Taylor, & Raye, 1977), knowledge about the similarities and differences in memories established by perceptual experience and those established primarily via other processes is critical to an adequate theory of memory. Under ordinary circumstances, most of us are reasonably good at sorting out fact and fantasy. For example, subjects rarely intrude their elaborators and mnemonic devices during recall tasks. On the other hand, there certainly are circumstances in which the two are confused and thus the processes that operate to distinguish between memories for fact and for fantasy and the conditions under which they break down are potentially quite interesting.

Carol Raye and I, and some of the students working with us,[5] have been trying to develop a procedure to study confusion between occurrence information for perceptually and internally derived events. We started with the assumption that in order to conclude that the memory representation of an imagination (or internally generated information) has been confused with the memory representation of a perception, both the imagination and the perception must have occurred prior to the test. Our basic paradigm involved manipulating the number of times various items were presented and manipulating the number of times subjects produced these items (either overtly or covertly) during the first phase of the experiment. After this, subjects were asked to estimate either the number of times each item had been presented or the number of times they had generated each item.

For example, in one experiment, 36 items were formed using the name of 36 Battig and Montague (1969) categories as cues and one high frequency instance of each category as to-be-remembered items (Johnson et al., 1977). On a study trial, 18 cue–item pairs were presented; on any given test trial 18 cues were presented and the subjects wrote down the appropriate item in the blank beside each cue. Study and test trials alternated, and individual items were studied a total of either 2, 5, or 8 times and were tested a total of either 2, 5, or 8 times. The sequence of studying and testing items was random, except, of course, for the restriction that no item was tested before it had been studied. Following this phase of the experiment, subjects were presented with each item individually, and half were asked to estimate how many times each word had been presented and half were asked to estimate how many times they generated each word.

The data for those subjects asked to judge the number of presentations are shown in Figure 1. As can be seen, the mean judged frequency of occurrence of

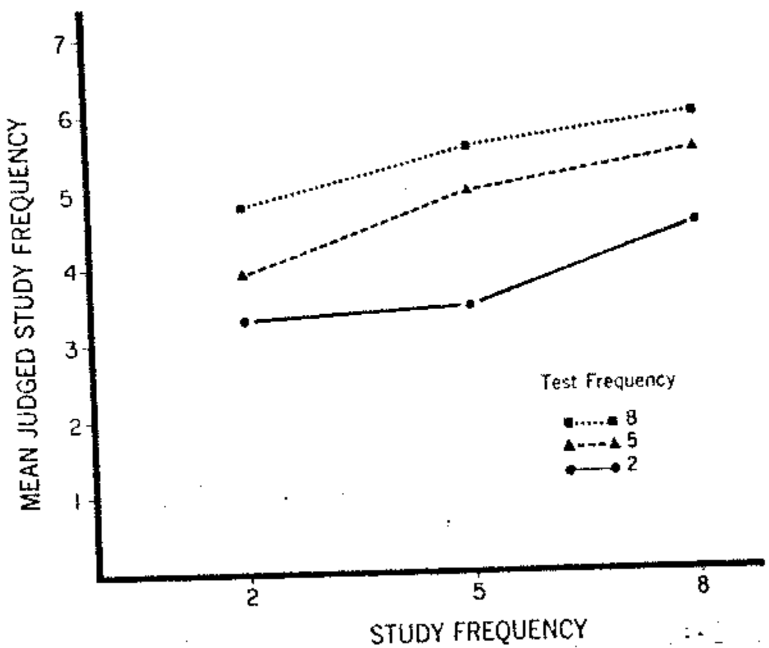

FIGURE 1 Judged study frequency as a function of manipulated study frequency. Each line represents a different test frequency. (From Johnson, M. K., Taylor, T. H., & Raye, C. L., *Memory & Cognition*, 1977, 5, 116–122. Reprinted by permission.)

[5] I would especially like to acknowledge the valuable help of Thomas H. Taylor and Alvin Y. Wang with some of the studies mentioned here.

items increased as the actual frequency of occurrence increased. This replicates previous findings and indicates that subjects are sensitive to the relative frequency of external events in the context of the present procedure. The separation between the lines in Figure 1 indicates that the number of times subjects produced the items resulted in increases in the apparent frequency of occurrence of the items. We call this increase in apparent frequency of external events as a consequence of internally generated events the IFE effect.

Although at first it may be tempting to suppose that the IFE effect is a consequence of writing the items down (and thus as the subject reads his own production another "external" event takes place), we have also found this basic effect under a number of conditions where subjects do not overtly produce the items. For example, we have had subjects covertly produce the words and simply indicate with a check whether or not they could remember them, or subjects have been asked to imagine a representation of the items and rate the vividness of their images. Both of these conditions also produce an increase in apparent frequency as internally generated occurrences increase (Johnson et al., 1977). Similarly, the effect is obtained with picture stimuli and test trials during which the subject attempts to image the pictures (Johnson & Raye, 1976). Thus the assumption in the previous discussion of recognition that implicit activations result in frequency increments that may be included in estimates of external event frequency is confirmed by these data.

The mean scores of those subjects asked to estimate the number of times they produced each item are shown in Figure 2. Estimates of generation frequency increased with actual increases in test frequency. This provides evidence that subjects are sensitive to the relative frequency of internally generated events. In addition, increases in the number of presentations contributed to the apparent frequency of productions. We call this increase in the apparent frequency of internally generated events as a consequence of externally generated events the IFI effect.

Overall, these findings indicate that we have a remarkably sensitive cumulative record not only of external events but of internal events as well. In addition, our data provide direct evidence for confusion between externally and internally generated events in that each increased the apparent frequency of the other. Given the previous discussion and the above data, several questions are suggested.

First, is frequency information for external and internal events disrupted by alcohol, and, if so, are they disrupted equally? Is alcohol more or less likely to affect the way in which similar externally generated experiences cumulate than the way in which similar internally generated experiences cumulate? From this information we might be able, for example, to develop some predictions about whether intoxicated people are more likely to remember acts they initiate or acts initiated by others, or whether they are more likely to recognize repetitions in their own thoughts and behavior or repetitions in the behavior of others.

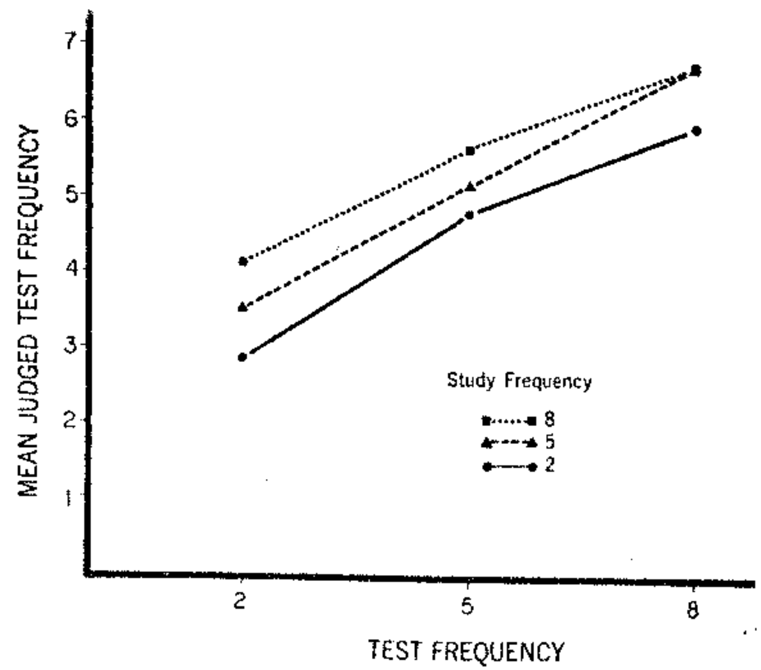

FIGURE 2 Judged test frequency as a function of manipulated test frequency. Each line represents a different study frequency. (From Johnson, M. K., Taylor, T. H., & Raye, C. L., *Memory & Cognition*, 1977, 5, 116–122. Reprinted by permission.)

Secondly, is reality-monitoring affected by alcohol? In general, the criteria for distinguishing among internally and externally generated events may vary from situation to situation. For example, depending on the material or task, subjects may adopt more stringent or more lenient criteria for including a representation in their "frequency count." Alcohol may be a treatment that affects the criteria for distinguishing memories for thoughts from those for perceptions. If so, increasing doses of alcohol should increase the extent to which internally generated productions add to the apparent frequency of items in our paradigm (see Figure 3).

Third, are some people more susceptible than others to a breakdown of reality-monitoring? It seems reasonable to suppose that, under usual conditions, the ability to distinguish internally generated events from externally generated events differs from individual to individual. And perhaps some people are less likely than others to have this capacity disrupted by alcohol. Consistent with this idea is Ryback et al.'s (1970) noting the large individual differences in disruption of recognition performance from alcohol in their study. A finding that would be particularly interesting in light of the present discussion would be that people showing relatively small IFE effects in our paradigm under sober

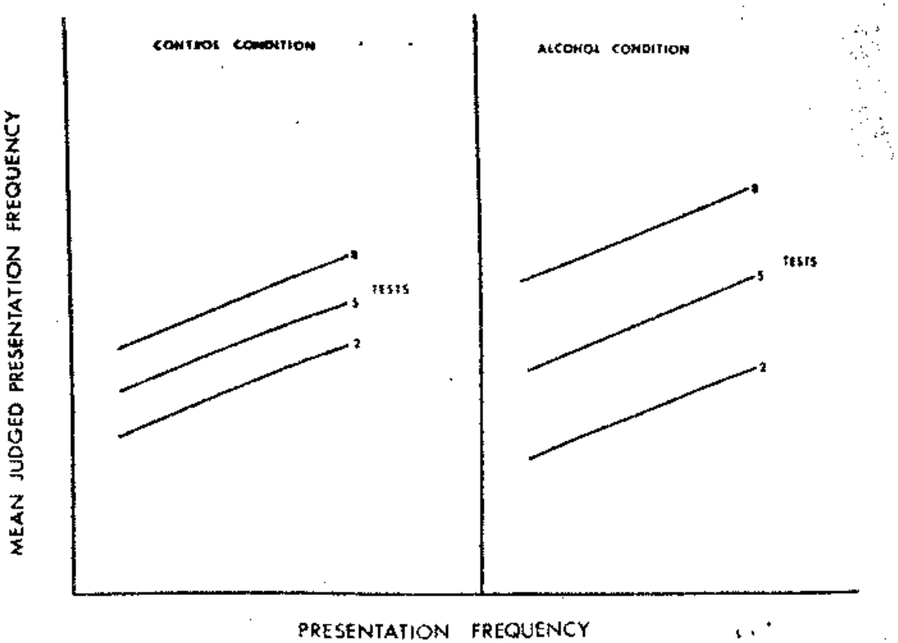

FIGURE 3 Hypothetical data showing a greater increase in the apparent frequency of external events as a consequence of internally generated events (IFE effect) in alcohol than in control conditions.

conditions might also show less effect of alcohol on recognition performance. (On the general importance of individual differences in alcohol research, see also Bahrick, this volume; Jones & Jones, this volume.)

In summary, recording recurrences of events is a fundamental function of memory. Studies of the effects of alcohol on judgments of both external and internal event frequency might augment available information about the types of processes that are susceptible to alcohol disruption. In addition, the paradigm we have been using perhaps could be adapted to alcohol studies to provide evidence about whether alcohol increases confusion between externally and internally generated events. Such a finding might also have implications for analyses of the effects of alcohol on recognition.

A more complete understanding of the source of recognition decrements might also be useful in understanding recall data. In many analyses of recall, recognition tacitly or explicitly plays a role. For example, generate-and-recognize models of recall postulate two distinct phases in the recall process: (1) retrieval of instances that are then (2) evaluated via a recognition process (e.g., Martin, 1975). Thus in recall, the problem of how a person "knows" a retrieved item is a correct item is sometimes relegated to the recognition process. Alcohol might affect not only the processes responsible for retrieving items but might also increase confusion among retrieved items that were and were not on the target list. This should result in a greater number of intrusions in recall (there is some hint of this in Kalin, 1964).

Other consequences of increased confusion between externally and internally generated events from drinking alcohol might be an increase in reports of previous thoughts as having been articulated or acted upon, a tendency to attribute to others things they did not say, and perhaps a breakdown in coordinated conversations because a person does not accurately monitor expressed vs. unexpressed thoughts during the conversation. Parker et al. (1974) mentioned a study by R. C. Smith in which "subjects showed decreased acknowledgment to another's response in conversations [p. 827]." While this certainly could reflect a failure to store or retrieve the other person's comments, or simply bad manners, it would also be consistent with some of the above speculations.

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