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Office of Aviation Medicine
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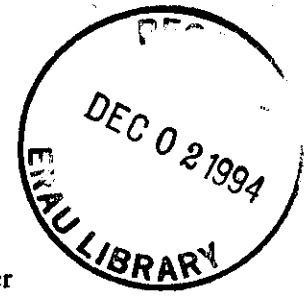
Low-Dose Alcohol Effects on Human Behavior and Performance: A Review of Post-1984 Research



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November 1994

Final Report

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-94/24		

4. Title and Subtitle	5. Report Date
Low-Dose Alcohol Effects on Human Behavior and Performance: A Review of Post-1984 Research	November 1994
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Frank A. Holloway, Ph.D.	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
University of Oklahoma Health Sciences Center Oklahoma Center for Alcohol and Drug-Related Studies Oklahoma City, Oklahoma 73190	11. Contract or Grant No. 92P-13264

12. Sponsoring Agency name and Address	13. Type of Report and Period Covered
Office of Aviation Medicine Federal Aviation Administration 800 Independence Avenue, S.W. Washington, DC 20591	14. Sponsoring Agency Code

15. Supplemental Notes

This work was performed under contract from the Human Resources Research Division of the FAA's Civil Aeromedical Institute in Oklahoma City, Oklahoma, as part of task AAM-A-93-HRR-126. Dr. David Schroeder served as the Contract Officer Technical Representative (COTR).

16. Abstract

The purpose of this review was to survey the literature examining alcohol effects on human behavior and performance, especially low alcohol dose effects. Other comprehensive reviews on this topic from 1975 to 1990 found that alcohol could affect all classes of performance, but that the kinds of performance most sensitive to low dose effects depended on: (a) the analysis of skills or abilities (selective attention), (b) the kind of task (divided attention tasks), (c) task characteristics (multiple tasks with high demand and/or complexity), and (d) categories of alcohol effects (negative subjective effects and controlled performance). This review examined 155 empirical studies dating from 1985 to mid-1993, using the alcohol effect schema of Krüger, and reached several general conclusions that were largely in agreement with previous reviews on this topic. First, sensitivity to the subjective intoxicating effects of alcohol was greater than that for all other performance classes and appeared to display a "threshold" with respect to blood alcohol concentration (BAC), rather than the linear relation evident in performance data. Second, sensitivity to performance impairment in "controlled" performance and simulator tasks was greater than that for psychophysical functions or "automatic" performance. Finally, a variety of task-, subject-, and environmental- characteristics or conditions were found to mediate the magnitude and sensitivity to alcohol effects, particularly at lower doses. This review concluded that since alcohol sensitivity can vary from time to time, person to person and situation to situation, the setting of a "safe" BAC will always be arbitrary, being based on a low, but non-zero, incidence of effects below that level.

17. Key Words	18. Distribution Statement
alcohol, human performance, low dose, low BAC, reviews, subjective effects, performance tasks	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	50	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLES

Low-Dose Alcohol Effects on Human Behavior and Performance: A Review of Post-1984 Research

"The most striking feature to emerge from any review of the effects of alcohol on behaviour is the marked lack of agreement between authors, amounting, in many instances, to direct contradiction. This is especially true for the effects of smaller doses."

G.C. Drew and colleagues (18)

In an extensive 1959 study of 34 males and 5 females, Drew and colleagues (18) examined performance in a driving simulator and found that tracking errors increased linearly with dose and that the threshold for this deficit was below the blood alcohol concentrations (BAC) tested (20-30 mg%). [Note: BAC measurements are determined by dividing the mg% by the milligrams in a liter (1000); therefore, 20 mg% would yield a BAC measure of 0.02%.] This finding frames one key issue for the present review, i.e., is there really a dose threshold for alcohol impairing effects, and if so, on which tasks or functions? The focus of the present review is on low dose alcohol effects on human behavior and performance, on the shape of the alcohol dose-effect curve for each kind or class of behaviors, and on potential mediator factors that may influence individual sensitivity to alcohol. Only empirical studies from 1985 to mid-1993 were examined, principally because of a cluster of major and minor reviews on the topic in the mid-1970s to 1990. The first section summarizes several of these reviews. The second section summarizes the empirical studies from 1985 to mid-1993, and the final section examines possible factors that may mediate or alter alcohol sensitivity at various doses.

Reviews: 1975 to 1990

While the general scope of this review covers the period from 1985 to mid-1993, one 1970s review of alcohol's effects on human performance is worthy of mention for its systematic approach in classifying skills involved in various performance tasks. Levine, Kramer and Levine (75) examined 179 English language studies (sampling period and study references not included). They presented their analysis on a final set of 41 studies after applying an extensive set of criteria, chief of which involved the availability of analyzable performance data and their ability to calculate alcohol dosage in g/kg; no information on blood alcohol concentration (BAC) was used. All the performance tasks in this sample were classified into three specific abilities and three corresponding major domains of abilities required for performance: (a) selective attention (cognitive domain), (b) perceptual speed (perceptual-sensory domain), and (c) control precision (psychomotor domain). Clearly, many of the performance tasks required more than one ability. Their other principal parameters were dose and time since alcohol administration.

When the ability domains were analyzed, psychomotor tasks were found to be the least impaired (8-10% decrements at 0.4-0.5 g/kg) and perceptual-sensory tasks the most impaired (15-20% decrements at 0.4-0.5 g/kg), with cognitive tasks being intermediate (10-15% decrements at 0.4-0.5 g/kg). However, when specific abilities were analyzed as being the predominant ability, selective attention tasks were most impaired (35-40% decrements at 0.4-0.5 g/kg), with perceptual speed and control precision tasks being only mildly impaired (8-10% decrement at 0.4-0.5 g/kg). All tasks were most impaired one hour after alcohol administration. While the review provides an interesting analysis, the study sample is relatively small and the variance at each dose may call into question the authors' performance/dose curve-fitting technique.

In one of the more extensive U.S. reviews of low-dose ethanol effects, the database of Moskowitz and Robinson's 1988 review (123) contained 177 English language citations from the years 1940 to 1985. Their final sample of 158 studies were those in which alcohol produced impairment on at least one of nine behavioral categories and in which blood ethanol concentration could be calculated.

Table 1 summarizes their key findings, presenting three indices of alcohol effect derived from this review's (123) summary tables, i.e., (a) the lowest BAC producing impairment, (b) the percent of studies showing impairment at BACs of 50 mg% or lower, and (c) the lowest BAC producing impairment for the median number of studies. Basically, divided attention and tracking tasks (in that order) proved to be the most sensitive to low doses, and tasks having primarily vigilance and perception components were the least sensitive. The lowest BAC producing impairment (for the median number of studies) on divided attention or tracking tasks was 50 and 55 mg% respectively. The comparable metric for other categories of performance was 70 mg% or higher. This relatively lower sensitivity for such performance as reaction time is highlighted by the fact that the highest BAC for the median number of studies reporting no reaction-time impairment was 55 mg%. A key problem, among others, in interpreting the data presented in this review, was the lack of information concerning the actual doses tested. For example, many of the studies only examined a limited ethanol dose range and sometimes, only one dose. Nevertheless, the authors summarize their review with, "It is apparent that there is no threshold BAC below which impairment effects are absent.... On the basis of present results it can be asserted that BACs of 0.03% or less are sufficient to affect skills relevant to driving, and it is concluded that there is ample scientific evidence to justify the reduction of legal BAC limits to 0.05% or lower." (123, p. 65).

Two other reviews on alcohol's effects on human performance and driving-related skills (77, 114) span the same sampling period as that of Moskowitz and Robinson (123). Mitchell's review was based on 49 alcohol-human performance studies, only 22 of which were also included in Moskowitz & Robinson's criterion sample. Mitchell reached somewhat different conclusions from those of Moskowitz & Robinson (123). Specifically, Mitchell (114) concluded that there is no consistent evidence for alcohol-related impairment in the central nervous system function or in any behavioral skill with BACs less than 50 mg%. He argued that the rare findings of low BAC effects are based on limited dose ranges, reflect small effects (<10%), and may simply reflect differential tolerance effects across tasks. He basically concluded that the studies reviewed support a threshold hypothesis for alcohol-related impairment.

The Linnoila, et al., (77) review more explicitly attempted to relate alcohol's effect on specific functions to driving-related skills, using as an anchor point the increased risk of accidents at BACs between 50 and 80 mg%. These authors noted the increased risk for accidents by younger men and for females at given BACs. They indicated that alcohol's effects on perceptual-motor functions suggest that the following driving-related performance parameters may be disturbed at moderate BACs: attention to events in peripheral visual field, estimation of vehicular speed, range of scanning of visual field, and ability to focus on a target. They cited evidence that in simulated driving tasks, impairment of tracking and driving-simulator performance occurred at BACs as low as 30 mg% and 50 mg%, respectively. Their examination of skilled performance (compensatory and pursuit tracking, etc.) suggested that impairment at BACs below 50 mg% was most likely in multiple task studies involving divided attention, high information load, and/or high stimulus-response complexity. The authors also discussed the speed-accuracy trade-off function, i.e., decreased speed and less errors or maintained speed and increased errors. They concluded that ethanol-induced impairments in laboratory studies begin at BACs of 25-30 mg%, well below the increased accident risk range of 50-80 mg% seen in epidemiological studies. They noted that several individual difference factors may influence the latter discrepancy, e.g., task-, experience-, and/or context-specific tolerance, practice, time-of-day, age, and gender.

One of the limitations of the reviews discussed thus far is the exclusion of non-English language citations. The deficiency has been remedied in part by a massive review of low-dose alcohol effects published by Professor Hans-Peter Krüger and his colleagues at the University of Würzburg in Germany (full text: (68); summaries: (65-66)). An English translation of the full text to be published by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) is now in

press (67). This review, based on the application of strict criteria to approximately 100,000 references, identified 1126 references citing BACs of less than 84 mg%.

Professor Krüger (66) noted that two of the limitations of earlier reviews are their narrow scope (i.e., performance only, and not mood and other behaviors) and their qualitative, rather than quantitative evaluations. Applying more stringent criteria to the original database, 206 papers were used in a second analysis. He proposed a schema that distinguishes between subjective and objective effects of alcohol. **Subjective effects** included **main effects**, relating to the intention to drink, including positive mood (pleasure, arousal, etc.) and social feelings (aggressive, sexual, etc.) and **side effects** relating to undesirable consequences of drinking (intoxication, physical consequences, etc.). The **objective effects** were categorized as **social behaviors** (aggressive, sexual, etc.), **psychophysical functions** (eye movement, binocular vision, vigilance, memory, posture, etc.) and **performances**. Based on cognitive theory, the performances category was further divided into **automatic behaviors** (easy tracking, simple and choice reaction time, mental arithmetic, cancellation and categorization tests, concentrated attention, etc.), **controlled behaviors** (difficult tracking, divided attention tasks, information processing/decoding, eye-hand coordination, etc.), and **driving behaviors** (automobile, aircraft or simulators).

Using this schema, a meta-analysis of the degree of alcohol effects utilizing both regression and survival analysis techniques, was applied to the criterion sample. In the domain of subjective effects and social behavior, Krüger (66) found a linear increase in negative side-effects with increasing BACs, but curvilinear BAC-effect functions for positive mood, (maximum effect at 50-60 mg%), for social behaviors (maximum effects at 40-50 mg%), and for social feelings (maximum effect at 20-70 mg%). The abrupt reduction in the latter effects at higher BACs was interpreted as reflecting an interaction with alcohol's negative side effects.

The survival analyses of performance utilized both survival (proportion of performance intact) and hazard (portion of performance now at risk) function curves (66). Hazard functions for all categories were found to rise sharply at BACs of 50-60 mg%.

Psychophysical Functions. While physiological visual functions could be impaired below 30 mg%, visual perception functions were generally found to be preserved well above BACs of 50 mg% and memory functions were generally intact at BACs below 80 mg%. Generalized sedative-related impairment of psychophysical functions began at about 100 mg%.

Automatic Performances were first impaired at 40-50 mg%, depending on location on the ascending (most impaired) and descending (less impaired) BAC curve. Krüger noted that most of these tasks were highly and/or easily practiced and could be facilitated by the attention-focusing (i.e., reduction of attention to peripheral effects) effect of low alcohol doses. Generally, clear-cut impairment of automatic behaviors were not seen below 50 mg%.

Controlled Performances. Decrements could be detected as low as 30 mg%, especially on the ascending BAC limb and rose sharply, with all task components impaired above 70-80 mg%. Krüger (66) noted that many of these tasks involved multiple loci of processing and control, which must operate in parallel and/or serially on common information. He further suggested that the critical dimension of multiple task performance may be the "horizontal-cumulative" versus "vertical-hierarchical" (affected by BACs of 40-50 mg% and beyond) dimension, rather than "easy/difficult" or "low/high demand."

Driving Studies. Highly-practiced driving performance in eventful, closed-course studies was generally not found to be impaired until BACs of 60-70 mg%. Krüger (66) suggested that the distinction between automatic and controlled behaviors clearly applied to driving in traffic. Alcohol effects on automatic behaviors (e.g., turning) were seen only above 50 mg% and in non-demanding situations, only at 70-80 mg%, while clear effects could be seen at 30-40 mg% in traffic situations requiring controlled processes (e.g., quickly-changing events) or having high social valence (e.g., heavy traffic, passengers, etc.).

The only other comprehensive review found was that of Finnigan and Hammersley (27), published in 1993. This review examined 138 papers, 90% of which dated from 1980 to 1992. The review covered four basic areas: methodological problems, models of the psychopharmacology of alcohol, basic acute effects

(task analysis), and mediators of alcohol performance relationships. The authors argued that meta-analysis (like that of Krüger (65-68)) may be limited because of study differences in dose, method, and task. Several methodological recommendations were made, including (1) adequate baseline and practice on tasks, (2) use of between, and not within, subjects designs, (3) adequate sample, and (4) use of placebo conditions. They noted that only half of the studies reviewed used between subjects designs and only 40% recorded baseline measures. Like Levine, et al., (75), the authors reviewed articles on acute alcohol effects on various kinds of performance tasks, categorized as motor skills, driving simulations, perception, memory, and reaction-time/decision making. The authors concluded that alcohol produces a general slowing of mental functions, which likely affect the whole range of mental functions. Finally, this review considered several candidate mediators of alcohol effects, including nutritional status (affecting BAC), time since dosing (acute tolerance and hangover effects), judgment of intoxication (how perceived intoxication affected performance), expectancy effects (recruitment of compensatory responses), and individual differences in metabolism or sensitivity (gender, age, etc.). The latter mediators were thought to potentially affect whether low doses produced significant effects or not. The authors concluded that alcohol clearly affected performance on all tasks examined, except perhaps those assessing basic perceptual processes. Thus, in their view, the dose-related slowing of functions would depend on what constellation of functions are necessary in given tasks (see 75).

Summary of Comprehensive Reviews. With the exception of one review (114), all the others concluded that performance decrements and behavioral effects could be produced by low alcohol doses or blood levels. Four of the reviews suggested that the kinds of performance or behaviors differentially sensitive to low alcohol doses or levels depended on: (a) the analysis of skills or abilities (selective attention being most sensitive (75)); (b) the kind of task (divided attention tasks being most sensitive (123)); (c) task characteristics (multiple tasks with high demand and/or complexity (77)); and (d) categories of alcohol effects (negative subjective effects and controlled performance being most sensitive (66)). In a variant of this differential sensitivity hypothesis, one review (27) suggested that alcohol affected all behaviors examined and that apparent differentially sensitivity results from the cumulative effects of alcohol on various aspects or components of different tasks (see 66).

In addition to the latter major reviews, several other articles focused on low dose alcohol effects on selected measures and on other factors which may affect alcohol sensitivity and/or its consequences. These reviews and commentaries are summarized in Table 2. Many of the reviews of alcohol's effects on performance in driving or flight simulators are not comprehensive but rather, are generally based on positive incidence studies, i.e., those in which impairment is found.

In recent years, some alcohol investigators have begun to conduct reliability studies on their assessment measures (4, 88, 126-128, 191, 198). However, a key set of articles by Parrott (139-141) emphasized the general lack of basic reliability and validity studies on human performance tests—points also made in the Finnigan and Hammersley review (27). Another, troublesome methodological problem for human performance is acute tolerance. For example, Radlow and Hurst (151), examined the correspondence between BAC and subjective alcohol effect and found that the subjective measure peaked 24 minutes earlier than the peak BAC and also declined more rapidly. Few human performance studies of this kind have been attempted (see 59). The recent book by Vogel-Sprott (189) also is an excellent source, compiling her two decades of research on the role of practice, reinforced performance feedback and expectancy on the sensitivity of human performance to alcohol's impairing effects.

Post-1984 Empirical Studies on Acute Alcohol Effects

The second objective of this review was to examine empirical studies of "low dose" alcohol effects on human performance from studies published between 1985 and mid-1993. Studies on other alcohol effects was included as concomitant tests. The general literature collection methodology used was a Medline search coupled with extensive cross-referencing when appropriate articles

were found. Generally, non-English articles were not included in the literature sample. In presenting the data, attention was focused on the following pharmacological parameters: single versus multiple dose studies; sampling time and magnitude of BACs, time since alcohol administration, and, where possible, information on ascending-descending limbs of the BAC curve. Remarkably, of the 155 empirical studies reviewed, only seven failed to measure and/or report BACs (15, 35, 53, 55, 109, 118, 146); data from these studies are not included in the present literature analysis. In presenting the data from empirical studies on alcohol effects, an attempt was made to utilize the general alcohol effect schema of Krüger (66), i.e., subjective effects (intoxication and positive effects) and objective effects (functions, automatic behaviors, controlled behaviors, and driving/flying/simulator performance).

Subjective Effects. Tables 3A and 3B summarize findings on alcohol's dose related effects on subjective reports for multiple dose (either between or within subjects) and single-dose studies, respectively. While alcohol's effects are presented separately for single and multi-dose studies in these tables and the following ones, no differences in alcohol sensitivity were noted between single and multi-dose data. From this summary, studies using tests of "negative" effects of alcohol (e.g., "drunk," judgments of impaired performance, "dizzy,") were placed in the category of "intoxication," while those indicative of a pleasant or euphoric state were categorized as "positive" mood. Figure 1 illustrates "dose-effect curves" for intoxication (top) and positive mood (bottom) effects. This type of graphic depiction is not a genuine dose-effect curve, in that the actual magnitude of alcohol's effect is not used. In this and the remaining figures, "% Reporting Significant Effects (or Impairment)" was based on each separate study (or test, in the case of multiple tests within a given study) showing a significant or non-significant alcohol effect at the BAC range listed on the ordinate. A total of 64 tests (38 studies) examined subjective effects of alcohol; 31.2% of these tests were at BACs at or below 40 mg%. Figure 1 clearly indicates that 75% of the tests for subjective intoxication are significant at BACs as low as 21-40 mg%, with an "asymptote" (100% significant tests, i.e., $p<.05$) in the 41-60 mg% range. The shape of the curve also is suggestive of a threshold effect for these negative subjective consequences of alcohol. On the other hand, at the 21-40 mg% BAC range, only 40% of the tests for positive mood were significant, with an asymptote at the 61-80 mg% BAC range. Furthermore, positive mood effects diminished at higher BACs (see Krüger's discussion of this issue (66-67)). Thus, it would appear that an individual's detection of the alcohol state is generally based more on "negative" subjective effects than positive ones, given the apparent differential low-dose effects implied by Figure 1. Furthermore, the alcohol dose-incidence curve for negative subjective effects displays a sharp linear rise to asymptote, while positive subjective effects appear to follow a curvilinear course. The latter set of dose-incidence curves for positive and negative effects is similar to that reported by Krüger (65-68)).

Psychophysical Functions. Tables 4A and 4B summarize the findings of studies examining Krüger's psychophysical function category. Functions here refer to basic physiological effects (e.g., oculomotor, heart rate, etc.), sensory-perceptual functions (e.g., visual critical flicker fusion or CFF or simple vigilance) and other psychological functions, including, for example, memory. A total of 92 tests (41 studies) examined alcohol's effects on psychophysical functions with 29% of these tests sampling BACs at or below 40 mg%. Figure 2 illustrates the impairment in function found for one test of visual function (CFF) and for all other tests of function (including eye movements, memory, vigilance, body sway, psychophysiological responses, etc.). The selection of the CFF task to individually illustrate the alcohol dose-effect function was simply based on the large number of such tests. Neither curve appears to asymptote within the BAC range reported by these studies. While quantitative comparisons are not possible, psychophysical functions as defined by Krüger (65-68), would appear more resistant to alcohol's effects, than "subjective state."

Automatic Behaviors/Performance. Krüger divided performance tasks as described earlier (66), into automatic and controlled performances. Automatic performance tasks would include most types of reaction time (both simple and choice) tasks, simple tracking

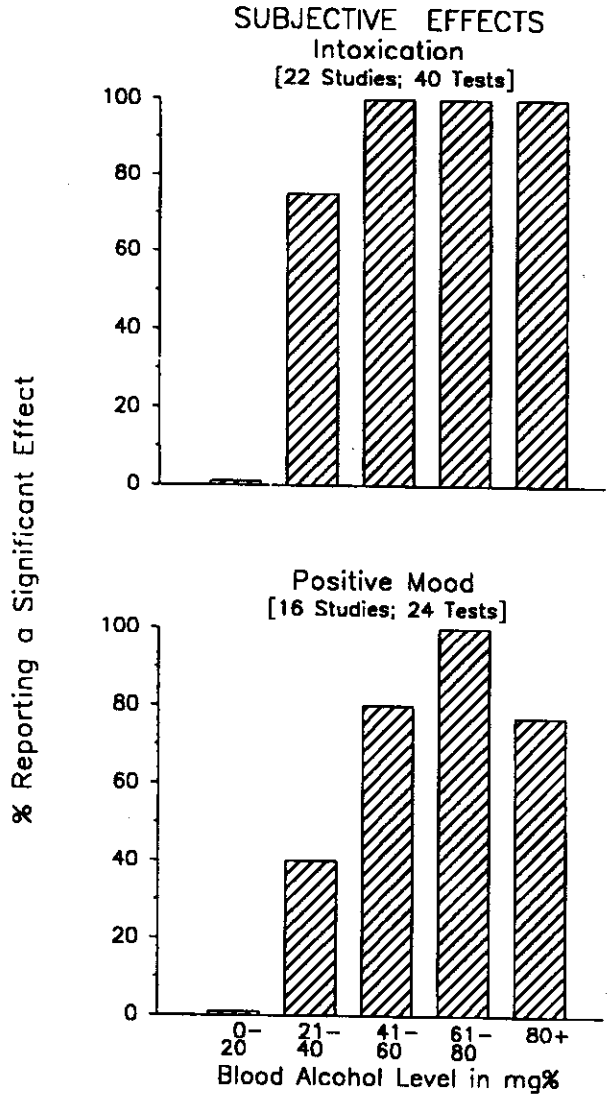

Figure 1. Incidence of subjective effects as a function of blood alcohol concentration: intoxication (top) and positive mood (bottom). For this and remaining figures, % tests reporting significant effects ($p < .05$) at each mg% range [significant tests/(significant + non-significant tests)].

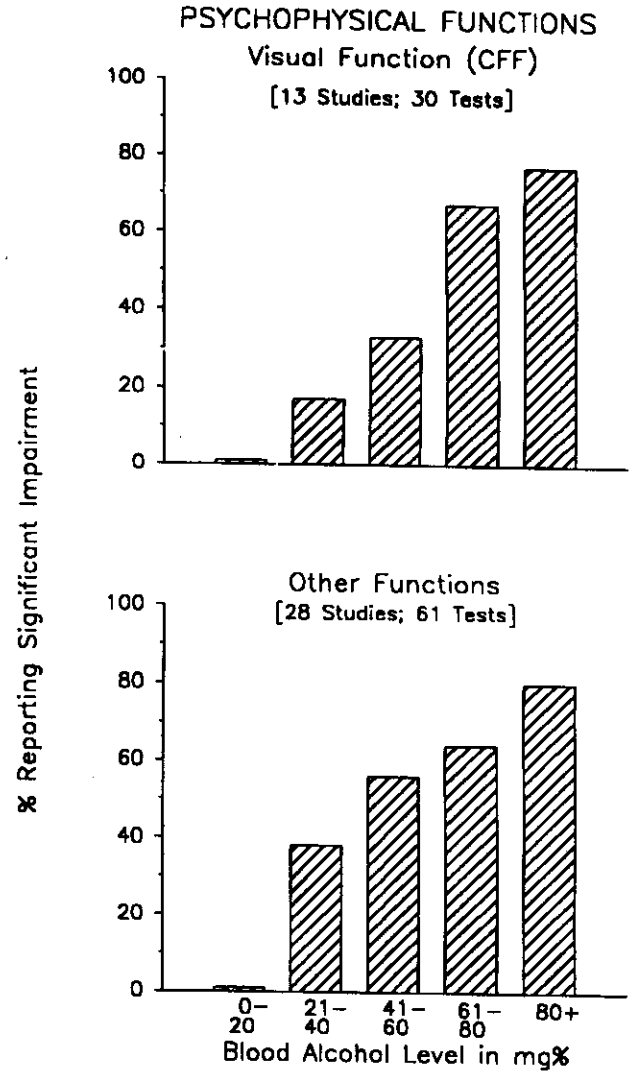

Figure 2. Incidence of impairment as a function of blood alcohol concentration for visual (top) and other psychophysical (bottom) functions.

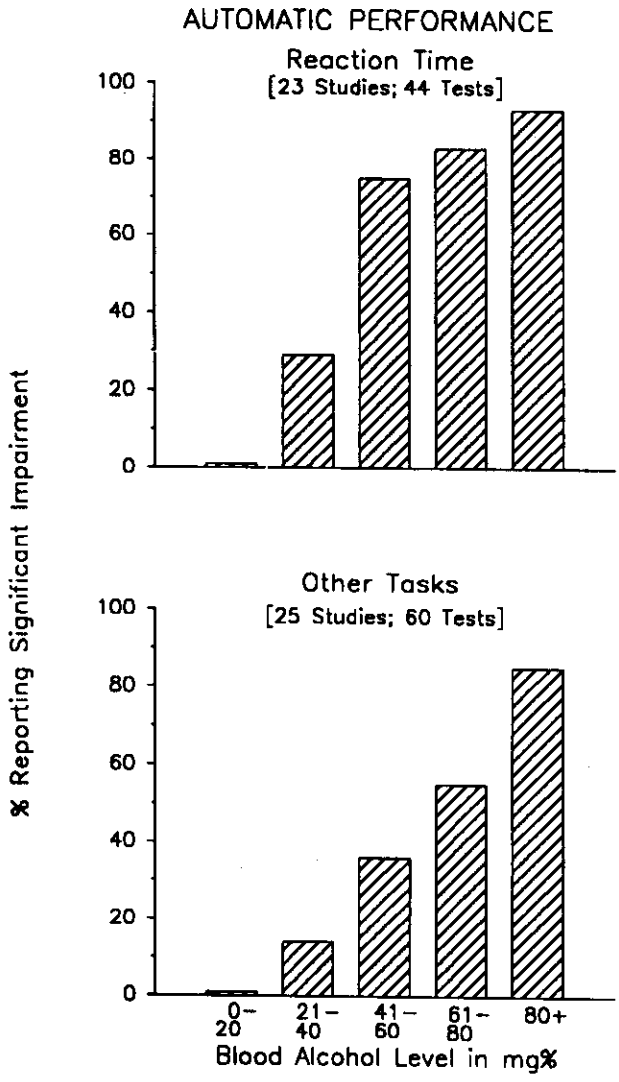

Figure 3. Incidence of impairment as a function of blood alcohol concentration for performance on reaction time (top) and other "automatic" (bottom) tasks.

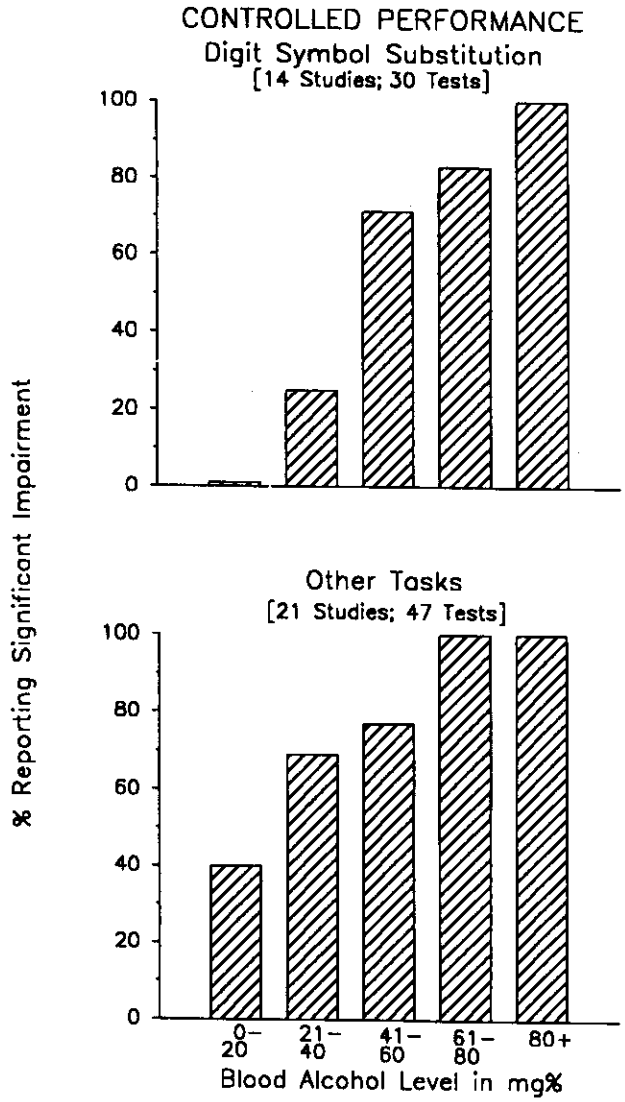

Figure 4. Incidence of impairment as a function of blood alcohol concentration for performance on digit-symbol substitution (top) and other "controlled" (bottom) tasks.

tasks, and other tasks with straight-forward operations (e.g., mental arithmetic, symbol cancellation, or other tasks with repetitive operations). Table 5A and 5B summarize the specific study data. A total of 104 tests (48 studies) examined alcohol's effects on automatic behaviors or performances; 31.7% of these tests sampled BACs at or below 40 mg%. Figure 3 illustrates the incidence of significant tests for reaction time tasks and all other "automatic" performance tasks at each BAC range. Reaction time performance appears to be somewhat more sensitive to alcohol than performance on the other automatic tasks[1], both curves suggest a dose sensitivity profile very similar to those for Psychophysical Functions (Figure 2).

Controlled Behaviors/Performance. Recall that Krüger (66) described controlled performance tasks as those requiring simultaneous attention to multiple tasks or task-features (e.g., difficult tracking, divided attention tasks, etc.), or requiring multi-levels of information processing (e.g., Digit Symbol Substitution Tests or DSST). Tables 6A and 6B summarize the relevant study characteristics and findings. A total of 77 tests (35 studies) examined alcohol's effects on controlled performances; 23% of these tests sampled BACs at or below 40 mg%. Figure 4 illustrates the relative incidence of significant effects for the Digit Symbol Substitution Test (top) and for all other types of controlled performance tasks (bottom). Both curves appear to asymptote. Actually, the significance incidence values for DSST are virtually the same as those for Reaction Time (Figure 3). The bottom graph in Figure 4 clearly shows that performance on the other controlled behavior tasks appears to be more sensitive to alcohol than that on the Digit Symbol Substitution Task.

Summary of Alcohol Performance Effects. Krüger's alcohol-effect classification scheme (65-68) may well differently classify some of the tasks included in the present review (e.g., DSST might have been classified as an automatic performance task). Unlike the more sophisticated analyses of Krüger, the present review did not attempt to examine effect magnitude, but rather, the incidence of significant effects. Nevertheless, in an attempt to make some type of comparison across the effects classes employed in this review, all of the data used for each of Figures 1-4 were reanalyzed and the linear regression functions were plotted as shown in Figure 5. The Psychophysical Functions and Automatic Performance curves indicate virtually identical incidence of significant reports. However, the curve for Controlled Performance is shifted upward, suggesting not necessarily a greater sensitivity to alcohol but certainly suggesting that across dose ranges, alcohol is uniformly more efficacious on this class of performances. Performance in driving and flight simulators (discussed below) is also depicted in Figure 5 for comparison purposes.

In traditional behavioral pharmacological analyses, the ED50 metric (effective dose at which 50% of subjects show some criterion effect) is used to characterize the dose-effect of a given drug on behavior. While the present data set does not represent subjects, but rather studies, it would appear appropriate to determine the similar values for each of the dependent measures. Table 7 presents such an analysis, based both on linear regression and probit techniques (185). Note that the values in all but the last column of the Table represents the estimated blood alcohol concentration (EC in mg%) at which 5%, 25%, 50%, 75%, or 95% of the studies report an alcohol effect significant at least at the .05 level of confidence. The EC50 probit value most closely resembles the ED50 in usual dose-effect analyses and represents perhaps the best single index of the blood alcohol-effect relationship. The EC50 probit values (and 95% confidence intervals) are: intoxication: 27.9 mg% (19.5 - 39.8), psychological functions: 52.9 mg% (40.2-69.6), automatic performance: 53.0 mg% (39.8 - 70.6), and controlled performance: 22.9 mg% (15.1-34.7). Again, these values for the various effects are quite comparable to those found by Krüger (66). It also should be noted that sensitivity to alcohol's intoxicating effects and to its impairment of controlled performances are quite similar, and that the sensitivity curves for psychological functions and automatic performance are virtually identical. Finally, the last column of Table 7 illustrates the incidence of significant alcohol effects at 40 mg% (corresponding to the FAA "0.04%" rule). Note that the significance incidence for intoxication and controlled performance is about 70-80% of the tests, while that for psychological functions and automatic performance is about 30-40%.

[1] Note at the 41-60 mg% range, the incidence of significant tests for reaction time was 75% and for the other tests was 36%.

Simulator Studies: Driving and Flying. Table 8 presents the summary data for studies of alcohol effects on performance in driving and flight simulators. Unfortunately, there have been too few studies to attempt the kind of linear regression and probit analyses used for the previous performance/behavior categories. Further, only four flight simulator studies actually examined low alcohol doses. However, it is clear from these reports that various facets of simulator performance were impaired at low BACs, e.g.: (a) severe course errors at 40 mg% (119-120); (b) VHF Omnidirectional Range (VOR) tracking and collision avoidance errors at 38-40 mg% (163); and (c) departure, navigation, approach and landing errors at BACs ranging from 24-39 mg% (165). The fourth study (8) reported that the number of serious errors were greater at 25 mg% than under control conditions; however, there were fewer serious errors at 50 mg% and the overall comparison of serious errors at 50 mg% with the control condition was not significant. Performance on the simulator used in the Morrow, et al. studies (119-120) also has been found to be sensitive to hangover effects of alcohol (203-204). Only two driving simulator studies were found that examined low BACs. Gengo, et al., (32) found the maximum impairment around the peak BAC, but estimated that the threshold for performance impairment was 40 mg%, noting the performance was most compromised with unexpected events. Finally, Oei and Kerschbaumer (137) found increases in speed but not errors at 40 mg%. Yesavage, et al., (203-204) noted that a significant increase in flight simulator performance variability occurred at low to moderate BACs. Such variability, particularly in experienced pilots, may reflect different kinds or sources of alcohol compensatory strategies. Perhaps, the latter phenomenon could account for the lack of dose-dependent findings in the Billings, et al. (8) study.

Potential Mediation Factors in Alcohol-Induced Impairment

The Locus of Alcohol-Induced Impairment. One approach to model alcohol's effects on human performance (see 27) has been to determine how the level of baseline performance or performance components (e.g., input, storage, output) interact with alcohol. Table 9 (92-104) summarizes Maylor and Rabbitt's work on this problem. In their studies on the role of practice, no interactions with alcohol's effects on performance (using a variety of tasks) were found for prior practice, practice while intoxicated, or state-specific practice. In their analysis of performance components, the picture that emerged is one where alcohol rather non-specifically affects all components, i.e.: stimulus detection, rate of information processing, and response speed are all decreased. However, certain specific processes do not seem to be affected, e.g., response preparation, access to semantic memory, and detection of response speed. Where alcohol appeared to interact with task complexity (100), these authors suggest that, as additional task demands were added, alcohol has a cumulative compromising effect.

Mediator Factors as Predictors for Alcohol Sensitivity. Table 10 summarizes studies that generally examined how expectancy interacts with alcohol's subjective and performance effects. At equivalent BACs subjects preferring alcohol reported positive mood states, while non-preferring subjects reported intoxication (negative) effects (16). Some investigators have found that when subjects expect to receive alcohol, ratings of intoxication are higher than when the expectancy is not present (9, 33, 70, 124, 176). However, other studies reported no expectancy effect (129, 186); interestingly, both of these studies examined performance and subjective effects. As is often the case, expectancy is not a simple variable, but rather one which may co-vary with other factors. For example, intoxication expectancy itself is negatively correlated with the quantity/frequency index of drinking (173), i.e., heavy drinkers have lower intoxication expectancy, possibly reflecting some tolerance phenomenon (29). Also, high alcohol consumers report fewer stress symptoms when intoxicated than low alcohol consumers, even though the high consumers' BACs were higher (130). Further, individuals who typically underestimate their BACs (usually at higher BACs) rate themselves as less intoxicated than individuals who typically overestimate (usually at lower BACs) their actual BAC (145) Consonant with the latter finding, subjects with a low alcohol consumption history tend to over-estimate their sensitivity and those with a high consumption history tend to under-estimate

their sensitivity (29). Also, expectancy effects with moderate drinking have more influence on social behaviors than on non-social behaviors, while the opposite is true with high alcohol doses (33). One study (21) also indicates that men may expect smaller effects than women. Several personality factors may influence expectancy effects, e.g, (a) subjects with high external locus of control scores were impaired when expecting alcohol but given placebo (no effect for low scorers) (9) and (b) subjects with high sensation seeking scores engaged in riskier behaviors when expecting alcohol, while those with low scores became more cautious (108). But, care must be taken in interpreting studies where the expectancy parameter is experimentally-induced (see 63, 71, 87).

Table 11 summarizes how other various antecedent or special task conditions may mediate or influence the magnitude of alcohol-induced effects. Several biologically-related conditions can affect intoxication ratings, e.g.: (a) females tend to report higher intoxication ratings than males at the same BAC (89, 134); (a) higher intoxication ratings are produced on the ascending limb of the BAC curve than on the descending limb (89, 134, 149); and (c) intoxication readings vary with phase of the menstrual cycle (134). Also, stimulant effects are anticipated on the ascending limb of the blood alcohol curve and sedative effects on the descending limb (21). Finally, alcohol-induced reports of sedation or sleepiness are enhanced when the alcohol is given at night when individuals are normally sleepy (193), but virtually absent in fully rested individuals (81).

Some of the same factors that interact with alcohol's subjective effects also influence alcohol-induced performance deficits in a similar fashion (89, 184), e.g., gender and ascending/descending limb of the BAC curve. In the few studies examining the expectancy effect, this variable does not appear to have much of an effect on alcohol-induced performance deficits (129, 176). Time of day is a potentially important, but rarely studied, mediating factor, e.g., alcohol-induced performance deficits are greater in A.M. tests than in P.M. tests (74). In spite of the failure of Maylor and Rabbitt (see previous section) to find a role for "intoxicated practice" in alcohol's performance effects, a number of studies emphasize the potential importance of individual differences in developing acute tolerance (59, 200) and of the development of compensatory behaviors while intoxicated (189). For example, acute "learned" tolerance for alcohol's impairing effect on performance developed more quickly when information feedback was combined with incentives for "good" performance (85, 174). Indeed, in more complex performance tasks like flying-simulators, the performance decline produced by alcohol or drugs is accompanied by an increase in performance variability (204). The latter phenomenon, in the experienced pilots tested, could well reflect different patterns of compensatory behaviors. For example, performance impairment on even simple tasks by BACs in the 50-60 mg% range can be overcome by an "instructional set" to "concentrate" (34). However, at least one study (73) suggests that alcohol may not affect an individual's attentional capacity per se, but rather, the ability to "allocate" attentional capacity to performance demands.

Family History of Alcoholism. Genetic factors are thought to play an important role in governing individual differences in alcohol sensitivity (29-30). One variable frequently used in alcohol sensitivity studies is family history of alcoholism (usually at least one alcoholic parent or three alcoholic relatives, uncles, aunts or grandparents). Table 12 summarizes results from some of the recent studies on this issue. The family history positive (FH^+) effects typically are found in males who are not currently alcoholic. Unfortunately, as can be seen in Table 12, the data appears equivocal on this issue. For example, for intoxication ratings, FH^+ males have been found to be less sensitive than FH^- males (136, 148, 172), more sensitive than FH^- males (105, 107), or not different from FH^- males (190, 199). Using physiologic responses or performance measures, FH^+ males have been found to be less sensitive than FH^- males (148, 171, 172), more sensitive than FH^- males (136, 148, 190), or not different from FH^- males (133, 199). At least from the studies reviewed here, a consensus regarding the family history-alcohol sensitivity linkage is not apparent. However, three studies may be worth further comment. First, "hangover" effects appear to be more severe in FH^+ males (131). Second, further classification into high- versus low-frequency of alcoholism

among relatives may influence study outcomes (105-106). Finally, both gender and age appear to be cofactors in the influence of the family history variable on study outcome (199).

Age. In their review (27), Finnigan and Hammersley cite only three studies examining age as a factor in alcohol effects and suggest no conclusions could be drawn from these reports. Only a limited set of studies was found in the present literature survey. Collins and Mertens (13) reported that pilots in the 60-69 years old age range perform less well overall than pilots in the 30-39 years old age range, particularly under conditions of high workload. Further, the older group was more negatively affected by alcohol. In their initial study, Morrow, et al. (119-120) also found that older pilots evidenced greater acute alcohol impairment in their flight simulator performance than younger pilots, and interestingly, were more accurate in rating the degree to which alcohol affected their performance. However, in a follow-up study, Morrow, et al. failed to replicate the latter results. The authors cited increased performance variability with both alcohol and age as possible explanations for the failure to replicate. Older pilots in both studies were found to perform the ATC (air traffic control) radio-frequency task during the flight simulations less accurately than younger pilots. Interestingly, the older pilots appeared more accurate in their self-assessment of performance. Finally, at least one other study reports that age may be a cofactor in alcohol effects (199).

Alcohol-Drug Interactions. The presence of other medications also may influence alcohol's effects on human behavior and performance. Table 13 summarizes the alcohol-drug interaction studies included in this review. Among the antidepressive medications, tricyclics (but not the serotonin-reuptake inhibitors) appeared to exacerbate alcohol-induced performance deficits and subjective effects. A similar pattern of worsened alcohol effects was found with combinations of alcohol and other sedative compounds (see second tier of studies in Table 13). One methodological problem apparent in the present sample of alcohol-drug interaction studies is that only one alcohol dose was tested. Specifically, when high alcohol doses are employed, the failure to find alcohol-drug interactions may be due to alcohol's masking of potential interactions with the drug.

Educational and Policy Issues

Finally, two studies did not fit in the earlier sections of this review, being surveys of general and selected populations of individuals. The first (26) suggested that about a third of the individuals from the general population could estimate a safe-limit for alcohol consumption but did not attribute a harmful consequence to drinking above that limit and, in fact, frequently did drink and drive. Individuals in the latter category were described as having "sliding limits" for safe alcohol consumption. In the second study (166), a questionnaire was sent to a sample of 2000 FAA-licensed U.S. pilots with a return rate of 53.4%. These authors found that the majority of pilots returning the questionnaire reported that they were unaware of the FAA's 40 mg% BAC rule and underestimated the amount of alcohol (independent of type) needed to reach 40 mg% BAC (errors for beer and wine were greater than for whiskey). Finally, one commentary (10) concluded that our knowledge about the relationship between alcohol consumption and associated problems (impairment) is insufficient to define the limits of safety.

Summary and Conclusions

The intent of this review was to examine alcohol-related effects using the effect categorization scheme of Krüger (66). Although the present review did not attempt any of the meta-analytical procedures used by Krüger, the general conclusions which can be drawn are similar. Two caveats apply to the following conclusions: (a) the number of tests examining BACs at or below 40 mg% (or 0.04%) represents 96 tests (28.6%) of the 336 tests for alcohol's effects on mood, function, and performance, and (b) the total number of simulator studies examined in this review was quite small, only ten.

(a) Sensitivity to alcohol's subjective intoxicating effects is generally greater than that for alcohol's impairing effects on functions or performances.

(b) The BAC-effect curve suggests a "threshold" for subjective intoxication, but a straight linear relationship for functions and performances.

(c) Sensitivity to alcohol's impairment of performance on "controlled" process tasks appears greater than is the sensitivity to alcohol impairment of psychophysical functions or performance on "automatic" types of tasks.

(d) With respect to low-dose alcohol effects, 70-80% of the studies report significant effects for intoxication ratings and for controlled laboratory performance at the 0.04% level or below - the tasks range from finger tapping (alternating buttons), to paper and pencil information- processing tests (digit symbol substitution), to simultaneously performance on two or more tasks; only one-third of the studies report significant effects for psychophysical function or automatic performance at that BAC level.

(e) Driving and flight simulator studies indicate that performance failures can occur at BACs at or below 0.04%, primarily on more complex and multi-demand segments of the simulator tasks. However, there is also little consistency of significant outcome measures from one study to the next. In addition, in one of these studies (Billings, et al., 1991), where performance was assessed across multiple BACs, the performance decrements were not uniformly obtained from lower to higher BACs.

(f) Several task-characteristics may influence the relative sensitivity of certain tasks to alcohol effects, including: task complexity, multiple tasks, directed attention or concentration, performance feed-back and contingent incentives.

(g) Several subject-characteristics may influence the relative sensitivity to one or more alcohol effects, including: expectancy of alcohol, preference for alcohol, tolerance to alcohol (both physiological and functional), gender, age, and possibly, family history of alcoholism.

(h) Several environmental or contextual parameters may influence the sensitivity of one or more alcohol effects, including time-of-day, phase of sleep-wake cycle, and social context.

In conclusion, this review found general trends for alcohol's effect on human behavior and performance that were remarkably similar to those reported by Krüger (1993), who reviewed the available literature through 1983 (see first section). Low BACs have been demonstrated to affect all of the classes of alcohol effect (i.e., both subjective and objective measures). There is evidence for differential increased sensitivity for subjective reports of intoxication and for more complex, multi-task performance. However, setting any arbitrary "cut-off" or criterion for a BAC, below which may be considered "safe" (i.e., performance unaffected), at best, must be regarded as a probability statement, which, in turn must be weighed against the consequences of such potentially impaired performance. Furthermore, the "main effect" of BACs at or below 40 mg% on performance may not be generally of sufficient magnitude to be evident across all tasks, studies, or populations. The present review clearly indicates that a variety of factors may influence sensitivity to alcohol effects from time to time, person to person, and/or situation to situation. Or, as one commentary (10) noted:

> *"The idea that there is a safe level of alcohol consumption below which there are no adverse effects remains simplistic when based on the evidence we have accumulated to date. What is safe for one individual may not be for another — safety continues to be a relative matter in any discussion of alcohol use."*

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Table1
Moskowitz & Robinson Review (1988)

Impairment Categories (N)	Lowest BAC for Impairment (# Studies)	% Studies Reporting Impairment at BAC's ≤ 50 mg%	Lowest BAC Producing Impairment (Median # Studies)	Type/Parameter Most Affected
Reaction Time (45)	30 mg% (2)	28.8% [a]	70 mg%	Complex RT
Tracking (30)	20 mg% (2)	40.0%	55 mg%	Compensatory
Vigilance (7)	60 mg% (3)	0 %	70 mg%	Delayed Feedback
Divided Attention (15)	20 mg% (2)	60.0%	50 mg%	Primary Task
Information Proc. (24)	20 mg% (1)	16.7%	70 mg%	Decision Time
Visual Function (28)	10 mg% (1)	39.3%	70 mg%	Oculomotor
Perception (17)	10 mg% (1)	11.8%	80 mg%	Decision Time
Psychomotor (28)	20 mg% (1)	32.1%	80 mg%	Steadiness
Driving (22)	30 mg% (4)	31.8%	75 mg%	Emergency

[a] Median highest BAC for studies reporting no alcohol-induced reaction time impairment: 55 mg%.

Table 2
Summary of Alcohol Reviews and Surveys [a]

Review Category	Ref. #	Parameters Examined	Comments/Conclusions
Methodology	[126]	Consideration of source of error in quantifying individual differences in sensitivity	Recommends residual scores from regression analysis be used in lieu of difference or ratio scores
	[138-140]	Reliability & standardization and content-, criterion-, face- & construct-validity for human performance tasks	Cites inadequate attention to these parameters and makes recommendations
	[154]	Variability in physiology and performance effects.	Cites need for distribution and range data
	[156]	Examination of Colorado Twin Database for relation between psychomotor impairment & consumption	Concluded current psychomotor measures are poor predictors of alcohol drinking
	[194]	Methodological examination of meal content on alcohol elimination rate	Detailed analysis of which meal-content constituents affect BAC's and elimination rate
Low-Dose Effects	[62]	Low dose variability factors: task complexity, gender, age, time of day, genetics	Very brief review
	[65-68]	Effect classification and BAC	See text
	[75]	Abilities classification and dose	See text
	[122-123]	Task classification and BAC	See text
Driving and Driving-Related Skills	[10]	Individual knowledge about relation between alcohol consumption and associated problems	Such knowledge insufficient to define limits of safety (very brief review)
	[11]	Auto accident factors: metabolism, gender, age, tolerance, driving experience, human factors	Comprehensive treatment of multiple factors affecting alcohol-related accidents
	[19]	Reanalyzed drinking/driving studies; public attitude; legal limit in Britain	Brief review
	[24]	Traffic crash risk factors: driving skill, speed, and style; hazard-perception latency; personality, etc.	All factors influence risk; willingness to commit driving violations is related to antisocial personality and possibly driving while intoxicated
	[58]	Auto accident and fatality factors; pre-accident and driver factors	Epidemiological Review
	[64]	Brief epidemiological analysis of Canadian alcohol abuse in commercial rail, trucking, maritime, and mass transit transportation; future research needs	Brief review

Table 2 (continued)

Review Category	Ref. #	Parameters Examined	Comments/Conclusions
Driving and Driving-Related Skills	[77]	Comparison of BAC range for accident risk and for impairment of driving-related skills; discussion of mediator factors for low-dose effects.	Brief review; see text
	[114]	BAC and impairment of driving related skills; acute and chronic tolerance	Brief review; concludes complex performance and driving skill impairment begins about 50 mg%
	[177]	Epidemiology analysis of BAC, accidents and fatal injuries among truck and bus drivers in Canada	Brief review; notes fatalities with low BAC's > those with high BAC's in last 3 years
	[192]	Impaired performance, altered mood, BAC, environment, and accidents	Brief review of accident factors & research needs
	[205]	BAC, driver-related skills, legal limit, impairment threshold	See low-dose reviews; concludes there's no threshold effect
Flying	[115]	Low BAC's & impairment of complex & simulator performance; hangover; federal regulations	Brief review; recommends new rules: 10 mg% limit and 12-24 hrs post-drinking
	[116-117]	Low BAC effects on complex performance; low partial oxygen pressure; hangover	Very brief review; notes alcohol narrows attention to most salient task at the expense of other tasks
	[162]	ILS simulator performance of experienced pilots impaired at 40 mg%; secondary tasks increase low dose effects	Brief review; concludes experience counts but not much & any alcohol can compromise safety
	[164]	Review of surveys of pilot attitudes about alcohol & flying; review of simulator studies below 40 mg%, where noticeable effects are found	Brief review
	[196]	Re-examination of Billings *et al.*, 1991 in-flight study; cites problems with simulator studies	Brief review and discussion; recommends 15 mg% BAC as upper limit for flying
	[202]	Very informal comment of residual alcohol effects (80 mg%)	
Cognition	[78]	Alcohol effects on: learning perception & attention, encoding, and retrieval; state-dependency; retroactive facilitation	Generally good review on alcohol's effects on memory, mood, attention and arousal
	[138]	Relationship between alcohol consumption and cognitive abilities when sober	Concludes alcohol consumption & cognition linkage not due to psychological stress
Genetic/ Familial	[132]	Family history positive and negative for alcoholics in family, alcohol sensitivity; ascending- descending limbs of BAC curve.	Review and model proposal: FH^+ individuals show acute sensitization on ascending limb and acute tolerance on descending limb of BAC curve.

Table 2 (continued)

Review Category	Ref. #	Parameters Examined	Comments/Conclusions
Drug Interactions/ Comparisons	[28]	Methodology and design; physiological and performance effects	Both antagonism and potentiation of alcohol effects found; generally driving-related impairment was not antagonized
	[52]	Psychomotor and cognitive performance: low dose alcohol effects	Comparison of relative effects with other drugs (prior studies)
Tolerance	[189]	Practice while intoxicated; reinforcement/feedback while intoxicated; expectancy effects	Book reviews author's research on learned tolerance effects on human performance
Subjective Effects	[195]	Survey of European alcohol related subjective effects	5% report unpleasant effects with small amounts of alcohol (Ss also had lower consumption)
Biological Rhythms, Sleep	[23]	Circadian rhythm for alcohol sensitivity; alcohol disruption of circadian and ultradian rhythms;	Brief review; implication of findings for research and treatment strategies given
	[155]	Chronokinetics: circadian rhythm of drug metabolism; chronodynamics: circadian rhythm of drug sensitivity	Brief review of relevance of circadian rhythms in drug/alcohol effects
	[167]	Alcohol effects on sleep characteristics	Brief review: acute alcohol (85-100 mg%) REM & NREM sleep; repeated alcohol: rebound effects occur; chronic alcoholics: profound sleep disturbances

[a] *Acronyms: BAC - blood alcohol concentration; FH - family history; REM / NREM - rapid eye movement sleep / non-rapid eye movement sleep*

Table 3A
Alcohol Effects on Subjective Reports: Multiple-Dose Studies [a]

[Ref. #] (N)	BAC in mg% (dose-g/kg; min. post-alcohol)	Effect Category—Peak		Lowest BAC (mg%) for significant effect (min.)	Highest BAC (mg%) with no effect (min.)
[2] (6 M)	**30, 55, 125** (.25, .5, 1; 30 min.) [cumulative dose]	Drug-Like (ARCI):	LSD MBG (stimulant) PCAG (sedative)	– – 125 (↑)	125 125 –
[22] (21 F, 21 M)	**30,22** (.33; 30m, 60m) **63,54** (.66; 30m, 60m)	**Intoxication:** (checklist)	Fatigue	30 (↑)	–
[25] (8 M)	**14,37,80** (.2, .4, .8; 30m)	**Intoxication**: (VAS): **Positive Mood** (VAS):	Dizzy "interested"	80 (↑) 80 (↑)	37 37
[32] (20 M)	**24-65** (Target:70) **37-102** (Target:100) **49-129** (Target:140)	**Intoxication:**	Impairment rating	30-40 (↑) [b]	<30
[48] (6 M)	**70, 130** (.6, 1.2; 45m)	**Intoxication** (VAS): **Positive Mood** (VAS):	drunk? Impaired? how high?	70 (↑) 70 (↑)	– –
[50] (5 M, 1 F)	**10, 50-40, 70-80** (.29, .6, .89; 30-70m)	**Intoxication** (VAS): **Positive Mood** (VAS):	drunk? drug effect? how high	40-50 (↑) 40-50 (↑)	– –
[51-52] (9 M, 9 F)	**15-30, 46-58, 68-95, 96-106** (.25, .5, .75, 1.0; 40-95m)	**Intoxication** (VAS): (Leeds/Sidney Battery)		46-58 (↑)	15-30
[135] (12 M)	**33, 86** (.5, 1.0; 60m)	**Intoxication Effects:**	Impairment rating	33 (↑)	–
[143] (6 M)	**69, 110** (.42, peak-40m; .85, peak-65m)	Intoxication Rating:	"drunkenness rating	69 (44% ↑- 35m) 22 (20% ↑-150m)	–

[a] Acronyms: ARCI -Addiction Research Center Inventory; VAS - Visual Analog Scale
[b] Greatest effect: ascending limb, 1-hr after peak BAC

Table 3B

Alcohol Effects on Subjective Reports: Single-Dose Studies [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg;min. post-alcohol.)	Effect Category: Task		Significant Effect? (mg%)
[1] (6 M, 6 F)	**81** (Target BAC- 80; 60m)	**Intoxication** (VAS):	drowsy, dizzy, irritable	yes (↑)
		Positive Mood (VAS):	contentment, calm	–
[7] (24 M)	**59** (.57; 60m)	**Intoxication** (VAS):	tension	yes (↑)
		Positive Mood (VAS):	satisfaction	yes (↑)
[12] (7 M, 5 F)	**43** (.38; 30m)	**Intoxication** (VAS):	drunk	yes (↑)
			sedation	yes (↑)
[14] (17 M)	**78-48** (.86; 30m-210m) [Time of day mood effect]	**Intoxication** (R-S)	tense / irritable	yes (↓ / ↑)
[16] (32 M:)	**47** (.5; 30m) [Liked alcohol; did not - NL]	**Intoxication** (POMS):	fatigue	yes (**L**-↓, **NL**-↑)
			confusion	yes (**NL**-↑)/no(**L**)
		Positive Mood (POMS):	elation & vigor	yes (**L**-↑, **NL**-↓)
[46] (12 M)	**37** (.5; 60m)	**Positive Mood** (VAS):	anxious, sad, depressed	yes (↓)
[54] (10 M)	**23** (.4; 60m)	**Intoxication**:	estimation of BAC	yes (↑) [overestimation]
[76] (8 M, 8F)	**100-110** (.75; 50 min; 2.5 hr session) [b]	**Positive Mood**:	verbal activity; euphoria	yes (↑)
		Negative Mood:	expressed mood	yes (↑)
		Other:	self-disclosures; assertiveness	yes (↑)
[80] (18 M)	**32** (.347, .694; @ 20m)	**Intoxication**:	verbal / instrumental	yes (H&L-dose)
		Positive Mood (R-S):	"euphoria"	yes (H-dose)
[91] (7 M, 5 F)	**97, 74, 51, 26** (.8; 90, 180, 290, 360) [c] [DL]	**Intoxication** (VAS):	"mentally slow"	yes (74-↑)
			"clumsy" or "muzzy"	yes (26-↑)
			"alert"	yes (97-↓)
			"good performance?"	yes (26-↓)
		Positive Mood (VAS):	"contented"	yes (74-↑)
				no (97-↓)

Table 3B (continued)

[Ref. #] (N)	BAC in mg% (dose in g/kg;min. post-alcohol.)	Effect Category: Task	Significant Effect? (mg%)
[144] (12M)	**98-20** (.85;60-360 m) [DL]	**Intoxication** (rating): "drunk"	yes (↑)
[147] (6 M)	**50** (.5-.625, 60; 75m) [cumulative dose]	**Intoxication** (VAS): "drunk" **Positive Mood** (VAS): drug liking	yes (↑) yes (↑)
[170] (21 M,21 F)	**59-62** (M-.67, F-.58; 20m)	**Reactivity to negative emotional stimuli:**	yes (↓)
[181] (12 M or F)	**104, 65** (1.0; 30, 150m) [DL]	**Intoxication** (VAS): "inebriated" **Positive Mood** (VAS): "relaxed"	yes (104-↑) yes (104-↑)
[182] (12 M or F)	**80-100** (.8; 60m)	**Positive Mood** (VAS): "relaxed"; "happy"	yes (↑)
[183] (9 M, 3 F)	**82-91** (1.0; 120m)	**Intoxication** (VAS): "inebriated"; impaired **Positive Mood** (VAS): "happy"; "muzzy	yes (↑) yes (↑)

[a] Acronyms: VAS - visual analog scale; R-S - Rating scale; POMS - Profile of Mood States; DL - descending limb of BAC.
[b] Social context: acquaintance also increased alcohol effects.
[c] Possible acute tolerance

Table 4A

Alcohol Effects on Psychophysical Functions: Multiple-Dose Studies [a]

[Ref.] (N)	BAC in mg% (dose in g/kg; min pre-exposure)	Function Category: Task	Lowest BAC: Significant Effect (mg%)	Highest BAC: No Effect (mg%)
[2] (6 M)	**30, 55, 125** (.25, .50, 1.0; 30m)	**Eye Movements** (saccadic tracking): #	–	125
		Vigilance (visual detection): errors	55 (↑, 1 S)	30
[22] (21 F, 21 M)	**30, 22** (.33; 30m, 60m) **63, 54** (.66; 30m, 60m)	**Visual Memory**: Pattern - latency	30 (↓- 8%)	63
		Verbal ST Memory: Digit-Span - errors	30 (↑- 6%)	–
		Perception: pattern recognition- latency	30 (↑-10%)	–
[25] (8 M)	**14,37,80** (.2, .4, .8; 30m)	**Visual Perception**: CFF Δ	–	80
		Posture: Body sway	–	80
[51] (9 M, 9 F)	**15-30, 46-58, 68-95, 96-106** (.25, .5, .75, 1.0; 40-95m)	**Visual Perception**: CFF Δ	96-106 (↑)	–
		Memory (Sternberg task): errors	–	96-106
[78] (28 M)	**20, 55** (.3, .6; 60m)	**Memory**:: free recall - #	55 (↓)	–
		(verbal / image) Priming	–	55
[84] (7 F, 3 M)	**70** (Ses.1: .5 - 45m) **40** (Ses.2: .5 - 45m)	**Body Balance**:	70 (↓)	40
		Immediate, Delayed Memory: # Correct	40 (↓)	–
[90] (21 M)	**65, 130** (?)	**ST Memory:** Benton Tests	65 (↓)	–
[113] (3M, 3F)	**94,126** (target BAC's 90,130; 50-90m)	**Auditory Recall:** ST & LT	94 (↓)	–
		Visual Recognition: ST & LT	94 (↓)	–
[135] (12 M)	**33, 86** (.5, 1.0; 60m)	**Visual Perception**: CFF Δ	86 (↑)	33
		Binocular Visual Function: exophoria	86 (↑)	33
		Eye Movements: Nystagmus- lateral gaze	33 (↓)	–
[143] (6 M)	**69, 110** (.42, peak-40m; .85, peak-65m)	**Physiology:** Heart rate	–	110

[a] Acronyms: S - subject; CFF Δ - critical flicker fusion threshold; ST - short term; LT - long term

Table 4B

Alcohol Effects on Psychophysical Functions: Single-Dose Studies [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Function Category: Task	Significant Effect? (up/↓)
[1] (6 M, 6 F)	**81** (Target BAC-80; 60m)	**Vis. Perception**: CFF Δ ;**Posture:**body sway **Memory:** immediate & delayed recall	yes (↑) yes (↓)
[4] (31 M)	**55,55** (.55; 30,70m) [b]	**Vis. Perception**: CFF Δ ;**Memory:**digit span **Visual Detection:** tachistoscope	no yes (↑)
[5] (I: 6 M, 2 F; II: 6 M)	**77** (.67; 30 m) [c]	**Eye-Movement:** vestibulo-ocular reflex pursuit suppression & compensation	yes (↓) yes (↓)
[7] (24 M)	**59** (.57; 60m)	**Vis. Perception**: CFF Δ ;Posture: body sway **Memory** (pictures): free recall / recognition	yes (↑) yes (↓)
[12] (7 M, 5 F)	**43** (.38; 30m)	**Eye Movements**: smooth pursuit velocity; peak velocity; **Posture**: body sway	yes (↓ 4%) no
[46] (12 M)	**37** (.5; 60m)	**Vis. Perception**: CFF Δ ; **Memory:** images	no
[57] (12 M)	**59, 49** (.7; 30m, 90m) [DL]	**Visual Perception:** CFF Δ	no
[72] (12 M)	**68** (Target BAC- 80; 60m)	**Vis. Perception**: CFF Δ ; **Posture**:body sway	yes (↑)
[82] (45 M,F)	**52** (15; 25m)	**Physiology:** # SCRs; evoked SCR- mag.	yes (↑)
[91] (7 M, 5 F)	**97, 74, 51, 26** (.8; 90, 180, 290, 360M) [DL] [d]	**Binocular Visual Function:** exophoria **Eye Movements**: nystagmus angle **Posture**: body sway / Vis. Perception: CFF Δ	yes (51-↑) yes (26-↓) yes (97 / 74-↑)
[110] (8M,4 F)	**37** (?)	**Binocular Visual Function:** convergence	yes (↑)
[144] (12 M)	**98** (.85; peak at 60m, 60-360m)	**Physiology:** Heart rate Systolic & Diastolic Blood Pressure	yes (↑) yes (↓)
[152] (80 M)	**76** (.65; 70m)	**Temporal Discrimination:** sec./msec. range	no / yes (↓)
[180] (4 F-, 8 M-pilots)	**100** (target BAC)	**Memory:**Sternberg Task; Vis. Number Span **Visual Perception:** Hidden Figures	– –
[181] (12 M or F)	**104, 65** (1.0; 30, 150m) [DL]	**Eye Movements**: Nystagmus Angle **Visual Perception**: CFF Δ	yes (104-↓) yes (104-↑)
[182] (12 M or F)	**80-100** (.8; 60m)	**Eye Movements**: Nystagmus Angle **Vis. Perception**: CFF Δ; **Posture:** body sway	yes (↓) yes (↑)
[183] (9 M, 3 F)	**82-91** (1.0; 120m)	**Eye Movements**: Nystagmus Angle **Vis. Function:** exophoria; **Posture:**body sway	yes (↓) yes (↑)

[a] Acronyms: BAC - blood alcohol curve; CFF Δ - critical flicker fusion threshold; SCR - skin conductance response; DL - descending limb BAC; vis. - visual

[b] Baseline reliabilities: .70, .80. and .52 for each measure respectively

[c] Loss of retinal error feedback

[d] Possible acute tolerance

Table 5A

Alcohol Effects on Automatic Behaviors: Multiple-Dose Studies [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Automatic Behavior Category: Task	Lowest BAC: Significant Effect (mg%)	Highest BAC: No Effect (mg%)
[22] (21F, 21M)	**30,22; 63,54** (.33;.66; 30,60m)	**Critical Tracking** (overall score)	50 (↓)	–
[25] (8 M)	**14,37,80** (.2, .4, .8; 30m)	**Choice RT; Continuous Attention** (errors)	–	80
[32] (20 M)	**24-65; 37-102; 49-129** [b]	**Choice RT (C-RT):** 6 lights	40 [c]	–
[36-39] (8M,11-M,6M,6M)	**22-31, 59, 88** (.26,.52,.79; 15m)	**Simple RT**: auditory, visual; inter-stimulus interval (ISI)=3.75 sec. (#, duration-long RT's)	59 (↑) [d]	22-31
[40] (6 M)	**27, 58** (.26,.52; 15m)	**Simple RT (S-RT)**: visual; ISI=3.75s	58 (↑) [d]	27
[41] (6 M)	**24, 48** (.26,.52; 15m)	**S-RT**:auditory, ISI = 7.5 sec.(#, dur.-long RT's)	24 (↑)	–
[42] (24 M)	**21-23, 50-52** (.26, .52; 15m)	**S-RT**: 40,60 db tone, ISI=3.75s; (#-long RTs)	50-52 (↑)	21-23
[48] (6 M)	**70, 130** (.6, 1.2; 45m)	**Simple Pursuit Tracking:** (errors)	130 (↓)	70
[51] (9 M, 9 F)	**15-30, 46-58, 68-95, 96-106** (.25, .5, .75, 1.0; 40-95m)	**C-RT:** visual; **Easy CP-Tracking**: errors **Mental Arithmetic:** errors	68-95 (↑) 96-106 (↑)	46-58; 68-95 96-106
[104] (18F, 18 M)	**29** (.33; @ 60m) **130**(1.0; @ 60m)	**Serial Choice RT:** Speed / Accuracy **Cancellation:** Speed / Accuracy	130 (↓) / 29 (↑) 130 (↑) / 29 (↑); 130 (↓)	29 / 130 29 / --
[113] (3M, 3F)	**94,126** (Target BAC's 90,130; 50-90m)	**Auditory Serial Addition; C-RT** **Trails Making; Grooved Peg Board**	126 (↓ ; ↑) 94 (↓)	94 –
[135] (12 M)	**33, 86** (.5, 1.0; 60m)	**Easy Pursuit Tracking:**errors; **S-RT; C-RT** **Cancellation:** "#" detects in 4-locations:	86 (↑) 86 (↓)	33 33
[157,159] (12 M)	**37,71,92** (.45,.8,1.05-; 120m)	**Complex C-RT:** motor component	71 (↓)	37
[158] (12 M)	**25-40, 55-70, 80-90** (.45,.8,1.05;60m,120m)	**Vigilance Task** (degraded visual signals): Hit Rate, sensitivity, response bias	55-70 (↓) [d]	25-40
[169] (24 M)	**20,103** (.33, 1.0; 50m, end)	**Signal Detection**: Scanning Rate/ Sensitivity Response Bias	103 (↓) / 20 (↑), 103 (↓) –	20 / -- 103

[a] Acronyms: S-RT/C-RT - simple / complex reaction time; CP - compensatory; BAC - blood alcohol concentration. [b] Target BACs: 70, 100, and 140 mg%.
[c] Estimated Impairment threshold; maximum impairment at peak BAC; BAC-Performance regression: $r^2 > .60$. [d] Alcohol effect increases with long intervals

Table 5B

Alcohol Effects on Automatic Behaviors: Single-Dose Studies [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min.-alcohol)	Automatic Behavior Category: Task	Significant Effect? (mg%)
[1] (6 M, 6 F)	**81** (Target BAC 80; 60m) [b]	**Symbol Copying Test:** # Correct **Finger Tapping:** Speed **Simple Reaction Time (RT):** Auditory	no yes (↓) yes (↑)
[4] (31 M)	**55,55** (.55; 30, 70m)	**Simple & Anticipatory RT**	yes (↑)
[7] (4 M)	**59** (.57; 60m)	**Choice RT:** Visual	yes (↑)
[12] (7 M, 5F)	**43** (.38; 30m)	**Easy Pursuit Tracking:**	no
[46] (12 M)	**37** (.5; 60m)	**Choice RT:** visual	yes (↑)
[54] (10 M)	**23** (.4; 60m)	**Simple RT** (visual; ISI=2-5s); **Easy Pursuit Tracking; Serial Categorization**	no
[57] (12 M)	**59, 49** (.7; 30, 90m) [DL]	**Signal Detection:** High Probability Event Low Probability Event: Sensitivity Response Bias	no yes (↓) no
[72] (12 M)	**68** (Target BAC= 80; 60m)	**Finger Tapping:** Speed	yes (↓)
[82] (45 M,F)	**52** (15; 25m)	**Attention Task:** Novel Stimulus detection	yes (↑ incorrect)
[84] (7 F, 3 M) [c]	**70** (Ses.1: .5; 45m) **40** (Ses.2: .5; 45m)	**Critical Tracking:** accuracy **Movement time task:** RT	yes (↓) yes (↑)
[91] (7 M, 5 F)	**97, 74, 51, 26** (.8; 90, 180, 290, 360) [DL] [d]	**Choice RT:** visual **Visual Tracking:** errors **Finger Tapping:** Speed	yes (97-↑) no yes (74-↓)
[180] (4 F-, 8 M-pilots)	**100** (target BAC)	**Pursuit Tracking:** errors **Maze Tracing:** errors **Visual Scanning:** errors	yes (↑) yes (↑) no
[181] (12 M or F)	**104, 65** (1.0; 30, 150m)	**Tracking:** (fixed speed) errors **Choice RT:**	yes (104-↑) yes (104-↑)
[182] (9M,3F)	**80-100** (.8; 60m)	**Tracking:** (fixed speed) errors	yes (↑)
[183] (9 M, 3 F)	**82-91** (1.0; 120m)	**Tracking:** (fixed speed) errors **Choice RT:** visual/auditory	yes (↑) yes (↑)
[197] (32 M)	**26-41** (.6; 40m, 80m)	**"Copying" task:** listen to digits & write them down	no

[a] Acronyms: RT-reaction time; BAC-blood alcohol concentration; DL-descending limb of BAC-curve; ISI- interstimulus interval

[b] Baseline reliability: r = .89 & .76 for each measure respectively

[c] Middle aged insomniac subjects

[d] Possible acute tolerance effects

Table 6A
Alcohol Effects on Controlled Behaviors: Multiple-Dose Studies [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Controlled Behavior Category: Task	Lowest BAC: Significant Effect (mg%)	Highest BAC: No Effect (mg%
[22] [b] (21F, 21 M)	**30, 22** (.33; 30m, 60m) **63, 54** (.66; 30m, 60m)	**Encoding**: DSST (latency) **Eye-hand Coordination**: Latency **Dual Task:** (choice plus attention) **Finger Tapping** (alternating buttons)	56 (↑) 30 (↑) 22 (↓) 22 (↓)	– – – –
[32] (20 M)	**24-65** (Target:70) **37-102** (Target:100) **49-129** (Target:140)	**Encoding:** DSST (Estimated impairment threshold; errors)	60 (↑) [c]	–
[48] (6 M)	**70, 130** (.6, 1.2; 45m)	**Encoding**: DSST- errors latency **Eye-Hand Coordination:** Circular lights task- errors	130 (↑) 70 (↑) 70 (↑)	– – –
[49] (5 M, 2 F)	**3, 40, 81** (.3, .6, .9; 70m) [cumulative doses]	**Eye-Hand Coordination:** Circular lights task- errors **Acquisition:** complex response sequence- errors	81 (↑) --	40 81
[50] (5M, 1 F)	**10,45,75** (.29, .6, .89; 30-70m)	**Eye-Hand Coordination:** circular lights task- errors	70-80 (↑)	40-50
[51] (9 M, 9 F)	**15-30, 46-58, 68-95, 96-106** (.25, .5, .75, 1.0; 40-95m)	**Difficult CP Tracking:** errors **Encoding:** DSST - errors	68-95 (↑) 68-95 (↑)	46-58 46-58
[73] (36M)	**36, 57** (.55, .78; 30-55m)	**INFO Processing:** global,local cue- errors [d]	36 (↑) {global}	57 {others}
[121] (10 M)	**15, 29, 44, 59** (Target BACs: 15,30,45,60; 30m)	**Dual Task:** CP tracking / visual search- errors **INFO Processing:** Backwards masking- overall index	15 (↑) [e] 15 (↓)	– –
[135] (12 M)	**33, 86** (.5, 1.0; 60m)	**Difficult Pursuit Tracking:** errors **Encoding:** DSST - errors	33 (↑) 86 (↑)	– 33
[143] (6 M)	**69, 110** (.42, peak-40m; .85, peak-65m)	**Multiple Component Task:** accuracy (attention, recognition, memory, RT) latency	90 (↓) 90 (↑)	55 55
[150] (8 F, 8 M)	**M: 50,70,89** (.42,.56,.72- peak) **F: 49,70,89** (.28,.41,.60- peak)	**Complex Psychomotor Task:** electronics assembly: units completed & total errors	49-50 (↑) [f]	–

[a] Acronyms: DSST- digit symbol substitution task; INFO- information; BMT- backwards masking task; RT- reaction time
[b] Statistical power calculations available.
[c] Maximum impairment at peak BAC.
[d] Global items-global bias; attentional, not capacity resources affected. [e] Dual Task was more sensitive.
[f] Females worked faster and made more errors

Table 6B
Alcohol Effects on Controlled Behaviors: Single-Dose Studies [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Controlled Behavior Category: Task	Significant Effect? (mg%)
[1] (6M, 6F)	**81** (Target BAC 80; 60m)	**Encoding**: DSST - errors	yes (↑)
[7] (24 M)	**59** (.57; 60m)	**Encoding**: DSST - errors	yes (↑)
[14] (17 M) [13] (M: 12 Young, 13 Older)	**78-48** (.86; 30m-210m) **88-58** (.86, 30m-210m) [DL]	**Multiple Task Performance Battery:** CP Tracking & Pattern Discrimination- accuracy Vigilance: Auditory & Visual- detections Mental Arithmetic & Problem Solving- accuracy	**Study 1 / 2** [b] yes (↓) / yes (↓) yes (↓) / yes (↓) no / yes (↓)
[16] (32 M)	**47** (.5; 30m)	**Encoding**: DSST - errors	yes (↑)
[45] (24F,M)	**M: 70, F: 96** (.78; 30m)	**Encoding:** Stroop Test- errors & time	70,96 (↑) [c]
[46] (12M)	**37** (.5; 60m)	**Encoding**: DSST - errors	–
[47] (25 M)	**19-65** (.6; 20-180m)	**Complex Pursuit Tracking**: Impairment Performance reinforced: Performance not reinforced:	**start / end:** 54 (50m)/ 65(120m) 29 (20m)/ 49(180m)
[54] (10 M)	**23** (.4; 60m)	**INFO-Processing:** Color/Verbal RT	yes (↑)
[72] (12 M)	**68** (Target BAC: 80; 60m)	**Encoding**: DSST- errors	yes (↑)
[83] (10M,F)	**52, 52, 46** (15m,25m,25m)	**INFO-Processing:** WCST - perseveration errors	yes (↑)
[84] (7F,3M)	**70,40** (Session-1/2: .5; 45m)	**Encoding:** DSST- # correct	yes (70 - ↓)
[91] (7 M, 5 F)	**97, 74, 51, 26** (.8; 90, 180, 290, 360m) [DL]	**Encoding:** DSST- # correct	yes (97 - ↓) [d]
[110] (4F,M)	**37** ("100 ml Vodka"; 30m)	**Dual-Task:** 1-Pursuit Tracking; 2-Vigilance (RT)	yes (↓ / ↑)
[144] (12 M)	**98-50** (.85; peak at 60m, 60-360m) [DL]	**Multiple Component Task:** accuracy (Attention, recognition, memory, RT) latency:	yes (98-50, ↓) yes (98-50, ↑)
[180](4 F- , 8 M-pilots)	**100** (target BAC)	**Dual Task:** Tracking- # correct Sternberg Memory- # correct	yes (↓) no
[181] (12 M or F)	**104, 65** (1.0; 30, 150m) [DL]	**Encoding:** DSST- # correct	104 (↓)
[182] (12 M or F)	**80-100** (.8; 60m)	**Encoding:** DSST- # correct	80-100 (↑)
[186] (20 M)	**28** (.5 in 5m; 10m)	**Visuo-motor Integration Task:** Computer Game "Pong" - errors	28 (↑)
[197] (32 M)	**26-41** (.6; 40; 80m) [AL]	**INFO-Processing/Classification:** errors	26-41 (↑) [e]

[a] Acronyms: BAC - blood alcohol concentration; CP - Compensatory tracking; DSST - Digit symbol substitution task; INFO - information; RT - reaction time; AL/DL - ascending / descending limb BAC; WCST - Wisconsin card sorting task

[b] Performance decrements: increase with workload, greater in AM than PM, and greater in older subjects.

[c] Female impairment greater than that for males (BAC difference ?).

[d] Possible acute tolerance effects.

[e] Performance worse when alcohol was not expected and when subject was in high erotic state.

Table 7

Comparisons of Relative Alcohol Effects: Effective BAC Analyses [a]

Dependent Variable Class	EC 5 (in mg%)	EC 25 (in mg%)	EC 50 (in mg%)	EC 75 (in mg%)	EC 95 (in mg%)	% Significant Impairment at 40 mg%
"Intoxication"	9.9 [b] **15.2** [c]	22.2 **21.8**	37.6 **27.9**	52.9 **35.7**	65.3 **50.9**	59.4% **83.5%**
Psychophysical Functions	8.9 **12.8**	31.7 **29.5**	60.3 **52.9**	88.9 **94.8**	111.7 **219.5**	32.6% **37.1%**
Automatic Performances	12.3 **19.6**	32.6 **35.2**	58.0 **53.0**	83.4 **79.8**	103.8 **143.8**	30.2% **31.8%**
Controlled Performances	-4.8 **4.7**	13.4 **12.1**	36.3 **22.9**	59.2 **43.5**	77.4 **109.8**	58.6% **71.9%**

[a] Acronyms: EC = Effective blood alcohol concentration

[b] References found in revision (not included in analyses or figures) [2, 3, 4, 5]

[c] Based on linear regression analysis through origin **[185, pp. 76-78]**

[d] Based Probit Analysis of quantal data **[185, pp. 119-120]**

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[2] KENNEDY, R.S., DUNLAP, W.P, TURNAGE, J.J. AND FOWLKES, J.E. (1993) Relating alcohol-induced performance deficits to mental capacity: a suggested methodology. *Aviation, Space, and Environ. Med. 64*: 1077-85. [Validation of dose-related alcohol effects on computerized test batteries.]

[3] KENNEDY, R.S., TURNAGE, J.J. AND DUNLAP, W.P. (1993) Diagnosis of alcohol intoxication: effectiveness of cognitive and neurovestibular tests. *Proceedings of the Human Factors and Ergonomic Society, 37th Annual Meeting 37*: 964- 968. [Use of automated test batteries and field sobriety tests to discriminate between performance with BACs below and at 100 mg% and higher.]

[4] KENNEDY, R.S., TURNAGE, J.J., WILKES, R.L. AND DUNLAP, W.P. (1993) *Ergonomics 36*: 1195-1222. [Use of Automated Performance Test System to detect cognitive performance changes at BACs of 50 mg% and higher.]

[5] KENNEDY, R.S., TURNAGE, J.J., RUGOTZE, G.G. AND DUNLAP, W.P. (1994) *J. Studies Alcohol 55*: in press. [Comparison of computerized test battery and field sobriety tests in detecting dose-related alcohol effects on performance.]

Table 8
Alcohol Effects on Driving, Flight and Simulator Performance [a, b]

[Ref. #] (N)	BAC in mg% (dose in g/kg; post-alcohol)	Performance Category: Task	Lowest BAC: Significant Effect (mg%)	Highest BAC: No Effect (mg%)
[6] (3M, 2F)	**130,170** (1.0,1.5; 45-85 m) [MD]	**Simulated "Driving" Task:** Sub-tests [c] Overall Response time Errors Movement and Contractile time (EMG)	Simple/Discriminated -- /130 (↑) 130/130 (↑) -- / --	Simple/Discrim. 170/ -- -- / -- -- / --
[8] (4 M pilots)	**0, 25, 47, 70** (immediate) [MD]	**Flight Simulator**: Serious errors Planning/performance errors Total, vigilance, & procedural errors	25 (↑) 47 (↑) 70 (↑)	-- (?) 25 47-50
[17] (8M-pilots) **[see 56]**	**82** (Target BAC -90; 20m)	**Flight Simulator:** ILLIMAC Altitude, Turning Control, & Vertical Tracking- Horizontal Tracking of radio signal -	82 (↓) –	– 82
[32] (20 M)	**24-65** (T: 70); **37-102** (T:100); **49-129** (T:140) [MD]	**Simulated Automobile Driving Task:** Unpredictable events (estimated impairment Δ)	40 mg% [d]	–
[119] (14M) **[120]** (same Ss)	**40, 100** (peak; immediate) [MD] {Subjects: 7 younger [Y], & 7 older [O] pilots} [e]	**Flight Simulator:** Course & Communication errors and Perceived Impairment - Severe Course errors & Perceived Intoxication -	100 (↑-O) 40 (↑-Y & O)	40 (O), 100 (Y) –
[137] (18 M, 18 F)	**40** (Target: 40); **80** (Target: 80) [MD]	**Simulated Driving:** (Set: Pro/ Con, Speed- -Driving while Drinking) Errors-	40 (↑-Pro) 80 (↑-Pro)	– 40
[153,31] (12 M)	**70, 120** (Target levels; 30-150m) [MD]	**Driving Simulator:** Overall Score/Objects Hit (Systems Technology) Speed Violations	120 (↓ / ↑) [f] 70 (↑)	70 –
[163] (12 M-pilots)	**38-43** (.5; end & start of testing)	**Flight Simulator:** Additive/multiplicative Model VOR Tracking; Collision Avoidance Vectoring; Descent	38-43 (↓/↓) 38-43 (↓/↓);(↓/--) –	– – 38-43
[165] Exp.: 1- (12 M-pilots) 2- (8 M-pilots) 3- (8 M-pilots) 4- (8 M-pilots)	End & Start of Test **24-35** **29-37** **29-39** **31-38**	**Flight Simulator: Frasca 141** (2-hr flight) [g] Complex instrument departure Demanding Intersection procedure ILS flight with heavy control tasks ILS with difficult approach control conditions	Errors: 24-35 (↑ only on departure) 29-37 (↑ intersec. navigation) 29-39 (↑ approach-commun.) 31-38 (↑ landing, approach)	

Table 8 (continued)

[Ref. #] (N)	BAC in mg% (dose in g/kg; post-alcohol)	Performance Category: Task		Lowest BAC: Significant Effect (mg%)	Highest BAC: No Effect (mg%)
[178] (12 M)	**70, 120** (Target levels; 30-150m)	**Driving Simulator:** (Systems Technology)	Overall Performance[h] # Objects Hit Speed Violations	120 (↓) 120 (↑) 70 (↑)	70 70 –

[a] Acronyms: MD - multiple doses; EMG - electromyogram; BAC - blood alcohol concentration; T - target BAC; VOR - VHF onmidirectional range; ILS - instrument landing system.

[b] References added in revision 6, 7, 8

[c] Highly practiced tasks.

[d] Maximum impairment at peak BAC.

[e] Older pilots were more impaired at baseline, but more accurate in self-appraisal.

[f] Enhanced roadway features reduced alcohol effect.

[g] Errors more likely under heavy workload conditions.

[h] No alcohol-fatigue interaction found.

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6 HYMAN, F.C., TAYLOR, H.L., WELLER, M.H. AND NAGEL, R.J. (1986, April) Effects of alcohol on night simulator and Strenberg memory search task performance. Paper presented at 57th Annual Scientific Meeting of the Aerospace Medical Association, Nashville, TN.

7 ROSS, L.E. AND MUNDT, J.C. (1986) . Effects of a low blood alcohol level on pilot performance. In Proceedings of the 30th Annual Meeting of the Human Factors Society (pp. 1182-1186). Santa Monica, CA: Human Factors Society.

8 WEST, R., WILDING, J., FRENCH, D., KEMP, R. AND IRVING, A. (1993) Effect of low and moderate doses of alcohol on driving hazard perception latency and driving speed. *Addiction 88*: 527-532.

Table 9
Locus of Alcohol-Induced Impairment [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-ethanol)	Performance Task Impaired	Mediator Process for Alcohol Impairment	Nature of Alcohol Effect on Process
[92] (40 M)	**92-107** (.78; 20m-75m)	4-Choice RT: (visual) Errors-Signal Detection:	1. Prior Practice 2. Rate of Error Detection	1. No effect 2. Slower rate
[93] (40 M)	**92-107** (.78; 20m-75m)	Continuous Recognition Task (old/new items): signal detection analysis	1. Sensitivity (d') 2. Responses bias (beta) 3. Rate of forgetting	1. Decrease 2. ↑-more conservative 3. Faster - ?
[94] (40M, 40F)	**59, 63** (.62;20m, 30m)	Computer Game Performance	1. Prior Practice: 2. Improvement with Practice: 3. State-Specific Practice:	1. No effect 2. No effect 3. Not specific
[95] (40M, 40F)	**59, 63, 64** (.62; 20m, 40m, 60m)	Word Categorization and Visual Search Tasks	1. Prior Practice 2. Improvement with Practice: 3. State-Specific Practice: 4. Involvement of attentional control	1. No effect 2. No effect 3. Not specific 4. Not relevant
[96] (22 M)	**63, 71, 60** (.62; 20m, 35m, 50m)	4-Choice RT: (visual) 4 response-stimulus intervals, RSI (RT,errors)	1. Rate of Information Processing 2. Rate of Response Preparation	1. ↑ with long RSI; no interaction with A-slowing 2. A: No effect
[97] (20 M)	**63, 70, 69** (.62; 20m, 35m, 50m)	4-Choice RT: (visual) RT; Detection of Faster RT's	1. Response Speed 2. Detection of Response Speed	1. ↑ with practice; ↓ with A 2. ↑ with practice; A-no effect
[98] (40 M)	**60, 69** (1.0; pre-, post-task)	Text Recall and Recognition	1. Reading Speed 2. Practice 3. Intelligence 4. Recognition Accuracy	1. Slowed 2. No interaction 3. No interaction 4. Reduced
[99] (24 M)	**60, 74, 77** (.62; 20m, 38m, 50m)	Dual vs. Single Tasks (DT, ST): Visual tracking (accuracy) plus auditory detection (speed)	1. Tracking Accuracy (impaired - DT) 2. Detection Speed (impaired - DT) 3. Prior Practice	1. No effect 2. Slowed - DT>ST 3. No Effect
[100] (40 M)	**66, 68** (.62; pre-, post-task)	Variable-Choice RT: (visual; 2, 4, 8 choices)	1. Accuracy 2. RT 3. Task Complexity	1. Decreased 2. Increased 3. ↑ with Complexity
[101] (24 M)	**60,74,77** (.8; pre, post: 20, 38, 50)	Visual Tracking (VT) Auditory Detection (AD)	1. Extended Practice 2. Single vs. Dual task	1. VT & AD ↑; no interaction 2. VT & AD ↓; no interaction
[102] (36 M)	**93-100** (.78; pre-, post-task)	Word Categorization and Recognition Memory	1. Categorization (accuracy and speed) 2. Recognition 3. Surface vs. Deep Processing	1. Decreased 2. ↓ in d', ↑ -beta 3. No interaction
[103] (I: 20M,20F; II: 18M,18F)	**92** (.78; 15m)	Vocabulary Test - correct RT Lexical Decision - correct RT	1. Item Difficulty (A: ↑) 2. Word Frequency (A: ↑) 3. Access to Semantic Memory	1. No Interaction 2. No Interaction 3. No effect

[a] Acronyms: RT - reaction time; A - alcohol;

Table 10
Mediator Factors as Predictors for Alcohol Effects: Expectancy [a, b]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Variables Assessed	Mediator Factors	Nature of Differences in Alcohol Effect
[9] (60 M)	**100** (at test time)	Purdue Peg Board Test	Expected alcohol (A) / placebo (P); internal (I)/ external (E) locus of control Ss	Alcohol: impaired (I- & E- Ss); Placebo: I-Ss not impaired; E-Ss impaired
[16] (32 M]	**46** (.5; 30m)	Intoxication and positive mood	Preference versus Non-preference for alcohol	Non-preferrers report Intoxication effects; Preferrers report positive mood effects
[21] (74M, 92F)	Anticipated drinks: 0 & 1 hr after 2, 4 drinks/ 1-hr.	Q/F Drinking Index Biphasic alcohol effects scale	Expected effects; Ascending/ Descending Limb BAC curve (AL,DL); Gender (M, F); dose	AL:↑ stimulant effects expected; DL:↑ sedative effects on; higher dose: ↑ effects expected; gender: male expected-effects < than female
[29] (208F,179M; 118 iden-twins; 73 frat.-twins)	**100** (1.0; 25m)	Subjective Effects (POMS); Anticipated sensitivity to alcohol	Alcohol sensitivity Drinking history	Low drinking history: overestimated sensitivity High drinking history: underestimated sensitivity (tolerance?)
[30] (19 iden- & 18 frat-twins, 17 unrelated pairs)	**Set:** 2 drinks/hr (60,120m)	Anticipated Sensitivity to alcohol	Genetic-, environmental (Envir.)-influence, expectancy	Genetic: physical symptoms; coordination; not mood, thinking, or driving; Envir: anticipating less sensitivity related to ave. drinks/occasion
[33] (*1*: 85 M, 88 F; 61 M; 113F)	No alcohol; moderate or high dose referent	*1*: Est. A-effects on own behavior; *2*: Same but for someone else	Expected Effect; Self/other referent	*1* & *2*: greater effects of moderate dose on social than on non-social behaviors, and the opposite for high doses
[63] (48 M)	**53** (.63; 15 m)	Estimates of drink content & of intoxication	Expectancy; experimenter (E)-subject (S) interaction	Expectancy effect: confirmed when S thought E knew drink content, but not, if S though E did not know drink content
[70] (M: 10 mod-dependent, 10 severely-dep.; 10 non-dependent)	**est. 75, 110** (.62 + .31 45 min later)	Subjective Effects; Desire to drink Physiological Measures	Expectancy Effects (balanced design: alcohol or placebo); dependence: moderate (M-D), severe (S-D)	*1.* Expectancy Effect > Alcohol Effect; *2.* S-D: higher arousal & greater response when told drink contained alcohol; *3.* Classical Cond. Model supported
[71] (M: 10 mod- & 10 severely-dependent)	**69-77** (.62; 15 min, 85 min)	Subjective Effects; Desire to drink	Expectancy Effects: alcohol or placebo; depedence: moderate (M-D) or severe (S-D)	*1.* S-D: Impaired coordination with alcohol expectancy. *2.* M-D: Impairment with placebo expectancy
[86] Exp.1 (20 M); Exp.2 (28 M)	**1:** Peak-**65** (.66 in 1 hr); **2:** Peak - **77** (.58 in 10 min)	Rate of change for: BAC and intoxication ratings	Drinking rate; time to peak; time from peak to baseline	Slow drinking: BAC & intoxication were parallel; Fast drinking: Intoxication scores peaked & returned to baseline faster than BAC's.
[87] (60 M)	**40-41, 63-67** (.66; 30,60m); placebo	BAC; intoxication ratings	Adequacy of placebo condition & BAC; alcohol (A)/ placebo (P)	BAC ≤40 mg%: Intoxication higher in A-Ss than in P-Ss; BAC>40 mg%: no A-P difference

Table 10 (continued)

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Variables Assessed	Mediator Factors	Nature of Differences in Alcohol Effect
[108] (64 M, 31F)	**70** (.48; 45 min)	Video Driving Task (risk taking - lane changes & time at max. speed)	Alcohol (A) or Placebo (P) Expectancy; High, Low Sensation Seeking (H-S, L-S)	1. No sign. alcohol effect 2. H-S: riskier behavior with A-expectancy; 3. L-S: more cautious with A-expectancy
[124] (40 M)	**20-75** (.6; testing began at 20 mg)	Subjective Effects; Performance Battery; Physiology	Expectancy (double-blind placebo design); alcohol (A) effects	1. A-Effects: ↑ blood pressure, HR, body sway, intoxication, friendliness, impairment; 2. A: Ss expecting ↑ disinhibition felt more intoxicated
[129] (160 M)	**78-81** (.78; 30m)	Memory: LT Recall Confidence Judgments	Alcohol Expectancy	Alcohol impaired recall but not judgement. No effect of expectancy
[168] (93 students)	**Variable** (variable; free consumption)	Estimated BAC & # 10-oz. glasses beer drunk	Party Context; BAC	Higher BAC: Ss overestimated their own BAC and underestimated # glasses of beer drunk
[173] (80 M)	**67** (.59; 15-210 m)	Subjective Intoxication, Body Sway, Cortisol, Prolactin	Quantity/Frequency index of drinking; expected intoxication effect (exp-intox.)	Significant negative correlations: expected and actual subjective intox., but not between exp-intox & body sway or endocrine measures
[176] (98 M)	**100,92,72** (1.0; 15, 60, 120m)	Subj. Intoxication, Mood, Physical Sensations, Speech Perform.	Intoxication; Expectancy; Setting: alone, group; Alcohol (A) effects: high (H), low (L)	A-effects: depend on both expectancy & setting (e.g., greater for H-Expect. Ss in group setting. No expectancy/setting effect on speech
[185] Exp.1 (20 M) Exp.2 (30 M)	**28** (.5 in 5 min; 3-hr session)	Computer game: "Pong" Finger temperature; Activity	Compensatory response; Expectation	1. Impairment & tolerance, but no compensatory or expectation effects. **2.** Support for state-dependency but not habituation or conditioning models of tolerance

[a] Acronyms: Q/F - quantity/frequency; inden/frat -identical/fraternal (twins); POMS - Profile of Mood States;BAC - blood alcohol concentration.

[b] References added in revision [9, 10, 11]

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9 Korytnyk, N.X. and Perkins, D.V. (1983) Effects of alcohol versus expectancy on the incidence of graffiti following an experimental task. *J Abnorm Psychol 92*: 382-385. [No BACs or calculable dose. Young male (heavy social drinkers) show disinhibition with alcohol independent of expectancy]

10 Stockwell, T.R., Hodgson, R.J., Rankin, H.J. and Taylor, C. (1982) Alcohol, dependence, beliefs and the priming effect. *Behav Res 20*:513-522. [No BACs or calculable dose. Less dependent Ss displayed expectancy; severely dependent Ss did not.]

11 O'Boyle, D.J., Binns, A.S. and Sumner, J.J. (1994) On the efficacy of alcohol placebos in inducing feelings of intoxication. *Psychopharmacology 115*: 229-236. [BACs 70-80 mg%; repeated measures design with placebo-first yielding greater intoxication scores than placebo-second.]

Table 11

Mediator Factors as Predictors for Alcohol Effects: Other [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Variables Assessed	Mediator Factors	Nature of Differences in Alcohol Effect
[20] (107 M)	No acute alcohol; survey	Drinking History; Experience and disinhibition scales	Personality Factors: Sensation-seeking	LISREL analysis: positive relation between drinking & disinhibition (sensation seeking?)
[34] (24 M)	**51-54** (.7; 28m)	Pursuit Rotor Task	Instructional Set: Concentration	Impairment ↓ during "set" conditions
[43] (6 M)	**75-81**(.78; 30-120m)	Peak BAC	Beverage Type:Beer,Vodka,Wine	**V,B,W:** same peak BAC; **W:**sustained BAC's
[59] (6 M)	**80-100** (.9; 0-360m)	Word recall; steadiness; manual tracking; sedation & intoxication	Tolerance	Tolerance for recall but not for other measures
[60] (12 M)	**80-107** (1.1 in 45 m; 15m) [A,P: Days 1,2]	Purdue Pegboard test (PP); 7 metamemory tests (MT)	Drinking history ("blackouts"-BO); state-dependent Recall (SDR)	PP and MT- impaired; variable SDR; sign-rel betw. SDR & both BO and heavy drinking
[69] (60 M)	**80** (target 80; 45 m)	Problem solving (PS)	Social conflict; alcohol effect(A-E)	A-E: same for PS alone or in group
[74] (20 M)	**60** (.58; 30-90m)	Incoordination (self-report); Choice RT; Problem solving	Time of Day; alcohol effect (A-E)	A-E for all measures; AM-effect on RT and problem solving was greater than PM effect
[81] (18 M)	**71** (.75; 10-120m)	Multiple Sleep Latency Alertness	Time in bed (restfulness)	Alcohol increased sleepiness in restless Ss, but in fully rested subjects, did not
[85] (33 M)	**81 - peak** (.66; 16m-140m)	Tracking: Peak Impairment (P-I); Tolerance (TOL); Cognitions	Information Feedback (IF) and/or Reinforcement (Rf); alcohol (A)	Rf + IF: acquired TOL quickest & had least A-task & most A-general cognitions
[88] (30 M, 12 F)	Peak= **64** (M-.58, F-.51; 71-149m)	BAC; Biphasic alcohol effects scale	Ascending/descending limbs of BAC curve (AL, DL)	AL: stimulant ratings > sedative ratings (52 mg%); DL: sedative > stimulant (49 mg%)
[89] (twins; 213F,199 M)	**Peak: M-101, F-93** (.75)	Psychomotor/physiol. measures; intoxication: impairment (IMP)	Gender (M,F); Ascending/ Descending Limb BAC curve (AL,DL)	IMP: F > M; AL > DL; F report higher intoxication at same BAC
[130,18] (M: 22 High, Low Consumers)	**HC: 66-67; LC: 48-56** (.8; 40-60m)	Mental Arithmetic: errors Physiology: epinephrine, norepinephrine; subjective stress level:	(1) Mental & Physical Stress (2) Tolerance (high/low consumers)	Stress effects and performance decrements: HC < LC, but alcohol levels were higher in the HC's; thus, tolerance in HC's was demonstrated.

Table 11 (continued)

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Variables Assessed	Mediator Factors	Nature of Differences in Alcohol Effect
[134] (11 M, 13 F)	**F:57,68; M:50,59** (.65; 45m, 120m after drinking began)	Peak BAC; Intoxication; body sway; ST Memory; Pursuit Tracking;Divided Attention Task:	Gender (M,F); Menstrual Cycle: Ascending/Descending Limbs (AL, DL) of BAC Curve:	Gender/AL-DL BAC: F Peak & DL BAC > M; AL: M&F- impaired & report Intox.; F- memory impairment & reported intox. on DL. Menstrual Cycle: some effects
[142] (128M)	**50-70** (.42; 20m)	Picture Drawing Test (attention to details?)	Stress (noise)/No Stress; Alcohol /Control	NS: No A/C differences; S: A>C in time & # drawn; Alcohol dampens stress?
[145] (48 M)	**50, 100** (target BAC's; 10-360m)	Intoxication Rating; BAC Estimates; Rating- driving ability	BAC overestimation (OE), under-estimation (UE); **L**ow, **H**igh BAC	L-BAC: OE-errors; H-BAC: UE errors; UE-Ss: ↑ likely to drive & ↓ intox-rating
[149] (28 M, 4 F)	Peak **70-75** (.86; 20-80 m)	Intoxication rating; alcohol-typical responses,ATR; BAC	Light/heavy drinking history (LD, HD); AL/DL BAC-curve	ATRs: AL>DL; ATRs on AL: HD > LD
[174] (30M)	**16-20,38-47,64-71,53-59** (.62; 20,40,60,120min)	Visual tracking; compensatory (CP) performance; tolerance development (T-D)	**Inf**ormation Feedback; Performannce **rew**ard; **P**hysical or **m**ental **prac**tice	T-D: [Info-only, info+rew, or m-prac] > [rew or no rew,no info]. CP performance requires valuable consequence.
[187] (6 M)	**BAC in mM** dose-dependent	BAC and alcohol metabolites	Heavy/light drinkers HD, LD); Flusher/Non-Flusher Ss (F,NF)	Metabolites: present 9-11 hrs post-ingestion; HD/NF levels > LD/NF
[193] (6 M, 8 F)	**69,49,19** (.7; 30,150, 270m)	Multiple Sleep Latency test Sustained Wakefulness Test Stanford Sleepiness Test	Normal night-time sleepiness	Alcohol potentiated nocturnal sleepiness even in more alert individuals
[200] (23 M, 30 F)	**90-93** (.8; 60-180m)	Psychomotor performance, physiology, paper-pencil tests, computer game, & POMS	Individual Differences: Practice effects, acute behavioral tolerance	Much of the variability arises from improvement in performance within sessions. .
[204]	**100**	Flight simulators variables; psychometric tests	Individual differences	Significant increases in variability noted; sources of variation are discussed

[a] Acronyms: (see definitions within each row); BAC - blood alcohol concentration; POMS - Profile of Mood States

Table 12
Family History (FH) for Alcoholism as Predictor for Alcohol Effects [a]

[Ref. #] (N)	BAC in mg% (dose in g/kg; min. post-alcohol)	Effect/Measure Assessed	Alcohol Effect		Family History Effect	
			FH^+	FH^-	Baseline	Alcohol
S1: [105] (M: 16 FH^+, 16 FH^-) **S2: [106]** (M: 16 FH^-, 9 LD^1- FH^+ & 7 HD- FH^+) **S3:** [107] (M:16 FH^+, 16 FH^-)	**94 (ave.)** (1.0; 20-180 min; no group differences)	**Subjective Effects:** "High"; Intoxication **Info. Processing:** DSST; **E-H Coordination:** **Memory:** Numeric Recall **Posture:** Body Sway **Physiology:** Hand Tremor; Heart Rate Skin Temperature / Conductance **S3: Hangover Effects:** Ratings	↑ ↓ – – ↑ ↓ / ↑ ↑	↑ ↓ – ↑ ↑ ↓/↑ ↑	– FH^-> FH^+ – – – – 	FH^+ > FH^-; HD > LD -FH^+ – – **S2:** HD > LD -FH^+ – -- / HD > LD -FH^+ **S3:** FH^+ > FH^-
[131] (M: 13 FH^+, 25 FH^-)	Retrospective study	**Quantity/Frequency Drinking Index:** **Hangover symptoms:**				FH^+ = FH^- FH^+ > FH^-
[133] (M: 9 FH^+/ 9 FH^-)	**28,26,30 / 29,24,27** (3 x: .5; 20-60m)	**Physiology[b]:** Pulse Amp. / SCL, Skin-Temp. **General activity:** level	↑ / ↓ ↑	--/-- –	-- / -- FH^+>FH^-	FH^+ > FH^- / FH^+ > FH^- FH^+ > FH^-
[136] (M: 24 FH^+/ 24 FH^-)	**37-28/ 33-50; 53-63/ 51-69** (.4; 10-35m & .8, 15-65m)	**Subjective:** Intoxication; Impairment/ expectancy **Posture:** Body Sway **Coordination:** Pegboard / **DSST:** Numbers	↑ / ↑ ↑ ↓ /--	↑/↑ ↑ ↓/-	-- / -- – -- / --	FH^+<FH^- / -- – FH^+>FH^- / --
[148] (M: 24 Controls, 42 High Risk)	**36,37; 29,33** (C-& HR-Ss: 0.5; 40 min, 100 min)	**Subjective intoxication; Somatic Symptoms** **Observer Rating:** intoxication **Porteus Maze:** errors, total time / incorrect tries	↑ ↑ ↑ / ↑	↑ ↑ ↑/↑	– – -- / --	FH^+<FH^- – -- / FH^+>FH^-
[171] (M: 32 FH^+, 32 FH^-)	**110-100, 70-60** (.82, .55; 60-135m)	**BAC:** **Posture:** Body Sway	↑	↑	–	FH^+>FH^- FH^+<FH^-
[172] (M: 30 FH/ 30 FH)	**57/58, 91/ 96** (.82, .55; 30-240m)	**Subjective:** Intoxication; **Posture:** Body Sway **Endocrine Effects:** Cortisol-, Prolactin-change	**FH^+- High Dose Factors** - ↓ intoxication, body sway, cortisol; **FH^+ Low Dose Factor** - ↓ prolactin [c]			
[190] (M: 21 FH^+, 22 FH^-)	**63** (.65; 30-130m)	Bead Stringing (completion time) Hand-Steadiness (error time) / Intoxication Rating	↓ ↑ / ↑	↓ ↑/↑	– -- / --	FH^+>FH^- FH^+>FH^- / FH^+=FH^-
[199] (53 M&F FH^+,191 M&F FH^-)	**100** (.8)	Alcohol Metabolism, tolerance / Sensitivity Intoxication / Cognitive Performance	↑ / ↓	↑/↓	/ FH^+<FH^-	-- / FH^+>FH^- [d] -- / --

[a] Acronyms: LD/HD -low/high density; SCL- skin conductance level; [b] Tolerance (↓) or sensitization (↑). [c] Discriminative function analysis. [d] Gender & age dependent.

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[12] LEX, B.W., RHOADES, E.R., TEOH, S.K., MENDELSON, J.H. AND GREENWALD, N.E. (1994) Divided attention task performance and subjective effects following alcohol and placebo: differences between women with and without a family history of alcoholism. *Drug and Alcohol Dependence 35*: 95-105. [Family history positive women had lower subjective responses to alcohol and lower BACs; see author's relerences not included in this review, showing similar effects for family history positive males.]

Table 13
Alcohol (A) -Drug Interactions [a]

Ref #	BAC-mg%	Effect (P,F,S)[b]	Other Drug	Drug Action	Alcohol-Drug Relationship
Interaction Studies: Anti-Depressives					
[1]	81	P, F, S	Fluoxetine/ Amitriptyline (AT)	5-HT reuptake inhibitor/ Tricyclic	Little A-interaction; A ↓ **AT**'s subj-effects.
[7]	59	P, F, S	Moclobemide Clomipramine (Cl)	MAO-A Inhibitor Tricyclic	**Cl** ↑ alcohol adverse effects (body sway); no pharmacokinetic effects
[61]	.6g/kg[c]	P, F, S	Paroxetine (PX)	SSRI; antidepressive	**PX**↓ A-sedation, ↑ A-performance deficit
[72]	68	P, F	Citalopram -	SSRI	No significant interactions with alcohol
[175]	85-110	P, F, S	Indalpine	SSRI (also anti-anxiety)	No significant interactions with alcohol
[181]	65-104	P, F, S	Amitriptyline/ Femoxetine	Tricyclic/ SSRI	**Am** ↑ both A's subjective & objective effects
[182]	80-100	P, F, S	Clovoxamine (CV) Mianserin (MS)	5-HT & NE reuptake inhibitor 5-HT & NE receptor blocker	**CV** ↓ A-body sway; **MN** ↑ A-impairment; A ↓ **MN**'s subjective effects
[183]	82-91	P, F, S	Maprotiline (MP); Doxepin (DX); Zimeldine (ZM)	NE reuptake inhibitor; Sedative anti-depressive; SSRI	**MP & DX** ↑ A- sedation & impairment (MP> DX); **ZM** improved A- tracking impairment
Interaction Studies: Benzodiazepines, Hypnotics, and Antihistamines					
[12]	43	P, F, S	Acrivastine (Ac);Diphenhydramine(DH);Terfenadine(Tf)	Antihistamine	**Ac** & **DH**, but not **Tf**, ↑ alcohol impairment & subjective effects
[84]	40-70	P, F, S	Flurazepam (FZ) Zopiclone (ZP)	Benzodiazepine (long-acting) Hypnotic (short-acting)	**FZ**, but not **ZP**, enhanced alcohol impairment (delirium in one subject)
[91]	96	P, F, S	Remoxipride (RM)	D_2-receptor blocker (anti-psychotic)	**RM** prolonged A-objective & subjective effects
Interaction Studies: Other Drugs					
[1]	97	P, F, S	Piracetam	Nootropic	No significant interactions with alcohol
[111]	66	P, F	Vasopressin (VP)	Neuropeptide	**VP** ↓ A-slowing of reaction times
[143]	69	P, F, S	Marihuana (MH)	THC-active ingredient	**MH** ↑ A-impairment but not other effects
[144]	98	P, F, S	D-amphetamine (AMP)	Stimulant (dopamine releaser)	**AMP** ↓ A-impairment but not other effects
[147]	50	P, F, S	Acetaminophen (AC)	Prostaglandin synthetase inhibitor	**AC** did not alter any A-effect

[a] Acronyms: SSRI - Specific serotonin reuptake inhibitor.
[b] P - performance, F - Function, S - Subjective Effects.
[c] No BAC's reported.

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