A Review of Experimental Studies of Low BAC Effects on Skills Performance

H. Moskowitz and D. Fiorentino

Southern California Research Institute, Los Angeles, CA, USA

Key Words
Alcohol, literature review, low BAC’s, experimental studies, skills performance.

Abstract
This article reviews a recent period of 15 years of experimental studies of driving related performance skills under low BAC levels. It concludes that different behavioral areas exhibit sharp differences in both the threshold BAC level at which impairment appears and the magnitude of impairment. Several major areas that are important for traffic safety demonstrate significant impairment at the lowest BAC levels examined.

Introduction
One of the major debates in public policy discussions of drinking-driving countermeasures has been the legal blood alcohol concentration (BAC) permitted for driving. These debates have been influenced by epidemiological studies on the relationships between BAC and collision probabilities, and by experimental studies on the relationship between BAC and skills performance impairment.

In a 1988 report, Moskowitz and Robinson (1) summarized the experimental literature from 1950 through 1985 dealing with alcohol effects on driving related performance. 177 studies which met acceptable scientific standards such as; placebo treatments, statistical significance and the ability to determine BAC levels at behavioral testing periods were included in that report. By .04 g/dl BAC, 21% of the studies reported significant impairment. By .05 g/dl, 34% of the studies reported impairment. 66% of the studies reported impairment by .08 g/dl and nearly all by .10 g/dl.

The BAC’s at which impairment first appeared and the percent of studies reporting impairment at various BAC’s differed by behavioral response area. Studies requiring divided attention, various visual functions and tracking demonstrated impairment beginning at .01 g/dl. Conversely, simple reaction time studies appeared quite insensitive to alcohol treatment. The review criticized many studies for examining performance at only one BAC. Thus, a report of impairment at a single BAC sheds no light on whether a lower BAC might also be impaired. The report also suggested that the description of behavioral areas in many of the studies were inadequate in their description of the experimental task or response measure. This meant placement of the study within a behavioral domain area was often difficult.
Subsequently, Kruger, et al. (2) in 1993, and Holloway in 1994 (3) and 1995 (4) reviewed large samples of experimental studies under alcohol. They also organized the experimental studies into behavioral domain areas, but used categories other than Moskowitz and Robinson. These reviews also concluded that many components of the driving task are impaired by BAC’s below .05 g/dl.

This current paper will summarize a review of the literature published from 1981 to 1998 on driving related behavior under low BAC’s.

**Method**

A computer search of the literature for the 1981 to 1998 time period on the effects of alcohol on driving related skills performance produced abstracts for 1,733 titles. Studies were excluded if they were not reported in English or dealt with more subjective areas of behavior such as motivation, aggression, etc. 358 articles were initially selected for retrieval, but library resources were only able to obtain 285. These 285 retrieved published studies were then evaluated to determine if they met further inclusion criteria. The inclusion criteria required that; behavioral response measures could be seen as clearly driving related, that the experimental procedure specified the BAC at the time of behavioral testing, or that the BAC at behavioral testing time could be calculated from the times of the alcohol administration and the times of the behavioral testing, and that the alcohol effects were not confounded with other drug treatments. At total of 112 studies remain, which met all the inclusion criteria for enrollment in the literature survey. Many of the studies examined more than one behavioral domain and most studies examined these areas at more than one BAC level.

**Results**

Only two of the 112 studies failed to find evidence of impairment at some alcohol level tested. These two only utilized one BAC level. A third study only examined the after-effects of alcohol ingestion without any examination of effects under an active alcohol treatment level.

The remaining 109 studies all reported impairment by alcohol at one or more BAC levels. The majority of studies reported impairment by .05 g/dl. 94% of the studies reported impairment by .08 g/dl.

The studies were organized by the behavioral areas they were presumed to examine. The criterion for inclusion in a behavioral area was determined by the statement of the author or authors of the experimental study. The authors of the literature review often had questions whether a particular study did or did not include the behavioral domain stipulated by the experimenters. However, such a determination was left to those who performed the experiment.

The research reports were placed into 13 behavioral categories or areas. These areas were; after-effects,(that is, impairment after zero BAC has been reached), cognitive, critical flicker fusion, driving in either a simulator or on the road, perception, psychomotor tasks, choice reaction time, simple reaction time, tracking, vigilance, visual functions, and drowsiness.

Similar to the results found in prior literature reviews, the lowest BAC at which impairment was found and the BAC at which 50% or more of the behavior exhibited impairment varied
considerably between the behavioral areas. Critical flicker fusion and simple reaction time studies were the behavioral areas most insensitive to the effects of alcohol. On the other hand, tests in the behavioral areas of divided attention and of driving exhibited impairment by .01 g/dl.

The majority of behavioral tests on drowsiness exhibited impairment by .02 g/dl. The majority of tests of vigilance exhibited impairment by .04 g/dl. Moreover, these areas above exhibited agreement in that nearly all studies produced evidence showing impairment at nearly all of the various BAC levels that were examined. Similarly, there was little variability in the results from the studies of simple reaction time and critical flicker fusion. However, in these studies the strong agreement was in the failure to find evidence of impairment.

There was considerable variability in the reports of impairment at various BAC in studies examining the behavioral area of tracking, perception, visual function, cognitive task, psychomotor skill and choice reaction time. Studies within each of these behavioral areas differed considerably in the BAC level at which impairment appeared. Closer examination of the behavioral tasks within each of these behavioral domains suggested that the criteria utilized by the authors for placing the behavior within that domain were so inclusive that they covered behaviors which truly were quite variable in what they required of the subjects. For example, the following are some experimental tasks included in studies the experimenters identify as cognitive: digit-symbol substitution, serial addition and subtraction, memory tasks, reading comprehension, card sorting, color test, visual backward masking, velocity estimation, grammatical reasoning, mathematical processing, pattern discrimination, spatial orientation, to mention but roughly half the tasks under cognition. It can be clearly recognized that the tasks do not present a homogeneous behavioral requirement for subjects. Thus, it is not surprising that there is considerable variability within the behavioral domain regarding the BAC threshold of appearance of impairment. Many of these behavioral tasks demonstrated impairment at extremely low BAC’s whereas others were far more resistant. Unfortunately it is difficult for a reviewer to break down the tasks within these areas merely by reading the experimenters publication. In fact, part of the difficulty rests on the limitations in the current state of cognitive science in being able to define all the cognitive processes involved in a given behavioral task. It should be noted that most of the six behavioral areas which showed the least degree of variability in results were those with more tightly defined behavioral measures. The more clear-cut and unambiguous the definition of the behavioral demand area appears the less variability and great unanimity of results under alcohol obtained.

From the viewpoint of scientific inquiry into the character of the diverse effects of alcohol on different behavioral areas, there still remains considerable work to be done. There is also clearly a necessity to study alcohol’s effect on less clearly defined and investigated areas such as risk taking, aggression and motivation. However, the results of this literature review confirms that of previous literature review, that there are behavioral areas crucial to driving, such as vigilance, drowsiness and divided attention, to name but a few, that are impaired at any departure from zero BAC. Clearly, even the lowest possible doses of alcohol carry a penalty when consumed in conjunction with the complex task of automobile driving.

